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16. Abstract

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Law enforcement personnel from several agencies in the Dallas/Fort Worth area were interviewed in March 2000. They indicated that drivers' cellular telephone use is increasing, and they have witnessed some of the detrimental effects. Failure to obey traffic signs and signals or maintaining lane position was noted. Road rage was even indicated to be a result of driver-cellular telephone use. All those interviewed agreed that hands-free cellular telephone systems would be advantageous for drivers.

Handheld cellular telephone use among drivers varies by travel lane. The peak travel direction generally exhibited higher proportions of handheld cellular telephone use than the off-peak direction. A conservative estimate of drivers' handheld cellular telephone use on Dallas County freeways during the afternoon peak period is 1 in 20. This estimate does not include the use by drivers of handheld cellular telephones with hands-free adapters, or in-vehicle, installed hands-free cellular telephone systems.

When a driver chooses to use a cellular telephone, both the driving and the cellular telephone tasks demand the driver's limited attention. Using a state-of-the-art high-fidelity driving simulator, the effects of conversation intensity and mode of cellular telephone operation (handheld or hands-free) on driving performance were investigated. Comparisons of workload ratings revealed that handheld, high-intensity conversation was significantly different than the hands-free, low-intensity conversation. Overall, participants reported that using the cellular telephone while driving required more effort than simply driving.

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EXTENT AND EFFECTS OF HANDHELD CELLULAR TELEPHONE USE WHILE DRIVING

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EXECUTIVE SUMMARY

Who is using cellular telephones? The National Highway Transportation Safety Administration (NHTSA), using data from a Motorola survey, estimates that more than 1 in 10 Americans are cellular telephone users. Cellular telephones keep individuals connected to work and home as they travel to and from their destinations. They are used while waiting in line, during dinner engagements, and traveling in a bus, train or car, to a name a few places. The Insurance Research Council (IRC) reported in 1997 that 84 percent of cellular telephone owners felt using the phone while driving increased their risk of having an accident.

Do the benefits of driving while using a cellular telephone outweigh the possible risks? Obviously, for most drivers, the benefits of using the cellular telephone are so great, they are worth whatever risk is involved. Aside from the issue of convenience, most people actually purchase cellular telephones for the purpose of increasing personal safety and security. Clemson University Cooperative Extension Service data suggests that 88 of all cellular phones are bought for emergency use and that 97 percent of phone owners feel safer with a cellular phone. Drivers often call 911 from their cellular telephones to give immediate reports of accidents and/or crimes they have witnessed.

Monitoring traffic flows with cellular telephones began in the early 1990s along U.S. 59 in Houston. Today, research is underway to monitor traffic using cellular telephones, but the users don't have to "call in." An example of using cellular telephones as traffic probes is the Virginia Department of Transportation's (VaDOT) pilot Advanced Traveler Information System (ATIS).

More and more drivers are becoming reliant on the "connectivity and productivity" provided by cellular telephones and other wireless devices. Most studies on the use of cellular telephones while driving seem to conclude that it does contribute to driver distraction. A majority of people agree that cellular telephone use while driving does indeed cause significant distraction, yet many continue to drive while using their phones.

A Network of Employers for Traffic Safety (NETS) survey found distracted driving to be the fourth most serious driving safety issue among employers, surpassed only by drunk driving, aggressive driving and speeding. Their survey results also indicated that 19 percent of drivers have used a cellular telephone while driving.

The conclusions of many studies to date have included a common thread: cellular telephone use while driving does cause driver distraction, and anything that causes driver distraction is a problem. Some studies have correlated driver use of cellular telephones with an increased risk of crash. Other studies have shown hands-free cellular telephones to be just as dangerous as handheld units.

While every state prohibits reckless or careless driving, none specifically prohibit cellular telephone use by drivers. In the United States, since 1995, over 100 bills banning the use of handheld cellular telephones while driving have been proposed. Nebraska was the first state to consider traffic laws specifically regarding cellular telephone use. All attempts to pass state legislation regulating cellular telephone use while driving have failed. In contrast, as of 1997, 13 countries had laws banning the use of cellular telephones while driving.

One impediment to regulation is the considerable support of cellular telephone use and lobbying by the wireless industry, embodied by the Cellular Telecommunications Industry Association (CTIA) and its members. But it appears that corporate philosophy may be changing. In September 2000, Verizon Communications, the largest provider of cellular telephones in the U.S., began to publicly support laws that would ban handheld cellular telephone use while driving.

Measures to improve data collection regarding cellular telephone use and accidents are being considered. In October 1999, only four states—Oklahoma, Minnesota, Tennessee and New York—required such data collection. Because only a few states gather information that might be used to correlate the relationship between accidents and cellular telephone use, it is difficult to measure legislative effectiveness if regulation was adopted.

Local jurisdictions have more successfully regulated cellular telephone use. Brooklyn, Ohio passed the first local ordinance regulating cellular telephone use when driving in March 1999. A poll indicated that about 58 percent of county residents supported some type of regulation, 46 percent being cellular telephone users. Other local entities in the northeast began to follow suit with the success of this ordinance.

Hahn and Tetlock concluded in October 1999 that banning drivers from using cellular phones would have negative results. Instead, alternatives may link automobile insurance rates to cellular telephone ownership, or specific tort liability addressing negligent use of cellular telephones. Another alternative to regulation is increased education. Education has been used to inform drivers about the hazards of distracted driving. For example, the National Public Services Research Institute provides an online Internet test to help drivers better understand the complex relationship between driving and cellular telephone usage. Education efforts should be directed especially toward new and inexperienced drivers.

The Redelmeier/Tibshirani study in 1997 found persons at risk due to cellular telephone use and accidents include: "young drivers; drivers with less than 9 yrs. driving experience; or those with less than 1 year of cellular telephone use experience." Through safe driving programs and driver education classes, teenage drivers should be taught that driving is a privilege not a right. As a privilege, a driver has the responsibility to themselves and other drivers to operate their vehicle in a safe manner, preventing accidents and near-accidents.

While some people have lost loved ones to irresponsible drivers talking on cellular telephones, regulation founded in sympathy is not appropriate. Some express the opinion that, for the average driver, using a cellular telephone is not a problem. Even though they admit cellular telephone use may be a distraction for some drivers, they do not feel the risk outweighs the tremendous personal and professional benefits.

This research identified three objectives to complete. First, collect and compare local law enforcement perceptions on drivers' use of cellular telephones to previous law enforcement focus group results. Second, develop field procedures and assess the magnitude of handheld cellular telephone use by drivers on freeways during the afternoon rush hour. Third and final, investigate the relationship of conversation intensity and cellular telephone operating mode to driving performance.

The first objective of this project was to interview several members of local law enforcement agencies in the Dallas/Fort Worth area regarding their perceptions of driver-cellular telephone use. The responses were compared in the report to results from a previous law enforcement focus group around the Washington, DC, area.

Most people interviewed considered driver-cellular telephone use to be very common, describing it in terms such as regular, daily and widespread. They estimated from 5 to 45 percent of drivers use their handheld cellular telephones while operating a vehicle. Most felt that use has increased, largely due to technological advances making cellular telephones more affordable and available. As technological advances continue, they predicted driver-cellular telephone use would also continue to increase. A majority of those interviewed estimated the driver-cellular telephone demographic as 25 to 45 years in age, though opinions did range from 16 to 60 years of age.

Several interviewees noted that multi-tasking in the vehicle between driving, cell conversation, and other distractions are all contributing factors to near accidents and near collisions. Decreased following distances were often noted to result from a driver-cellular telephone user's lack of attention. Road rage was even indicated to be an effect of driver-cellular telephone use. Other drivers may react in a road rage manner due to frustration with the phone user's inattentive driving; or the phone user misinterprets other drivers' defensiveness, and reacts aggressively.

Though some of those interviewed provided examples of hazardous situations observed, one person noted, "it wouldn't be appropriate to say cellular telephones create hazardous driving behavior…because you don't know how they drive without the phone." Few respondents personally worked traffic accidents where a cellular telephone was thought to play a contributing role. In accident investigations, witnesses generally do not help in determining if cellular telephones played a role. Cellular telephone records are not usually requested in determining fault for an accident; but a fatality would increase the likelihood that those records might be reviewed. All those interviewed agreed that hands-free cellular telephone systems would be advantageous for drivers. This statement shows that they perceive the action of holding or operating the cellular telephone while driving to be more distracting than the conversation itself.

Many benefits of cellular telephones in vehicles were cited. A personal benefit is the driver's ability to be more productive with their time when stuck in traffic. Noted safety benefits are crimes and accidents being reported faster through 911 systems. A secondary safety benefit is that citizens may even follow suspects while law enforcement units are en route.

When asked if they thought the use of the cellular telephone had affected their own driving performance, slightly more than half stated that it had. Of those who noted a change in their driving, it was most frequently described as a defensive response to the cellular telephone use among other drivers. Concerning their own driving, both focus groups noted that they were more careful driving while using the cellular telephone, allowing a greater following distance and reaction time. Questions comparing driving and using a cellular telephone versus a police radio were posed to determine differences and uniqueness between the communication devices. It was generally noted that operating a police radio is less distracting than a cellular telephone; however, rookies do learn to drive and be attentive to the radio concurrently. One person commented that trained officers can use the police radio and drive safely, but the use of new Mobile Data Terminal technology is more comparable to using a cellular telephone.

Concerning regulation of cellular telephone use in vehicles, some noted that existing laws could be used to cite drivers for inattentiveness or careless driving. A small number of respondents did feel that cellular telephone use should be regulated. They cited the increasing volume of urban traffic and widespread cellular telephone use as justification for attempting to improve overall driver safety and prevent accidents.

The second objective of this project was to develop both a procedure for data collection and an estimate of the ratio of drivers using a handheld cellular telephone on Dallas County freeways during the afternoon peak period. This was the first known attempt to assess the drivers' use of handheld cellular telephones on roadways.

Several pilot studies were conducted on freeway sections and on one arterial section. In both the pilot studies and field assessment, vehicles were classified into three handheld cellular telephone use categories: YES, NO, and UNKNOWN. UNKNOWN was used to capture drivers who observers could not be certain were using a handheld cellular telephone or not. Each observation is a proportion of vehicles with drivers using a handheld cellular telephone, to the total number of vehicles observed over a specified time period.

Pilot studies revealed some interesting observations. Handheld cellular telephone use among drivers varies by travel lane. A higher number of users occupy the outside lane, but this proportion varies with traffic volume. Because arterial streets often fail to provide proper vantage points from which traffic in all lanes can be safely and accurately observed, handheld cellular telephone use by drivers on arterials may be estimated by recording data in the outside lane of traffic for two lane sections.

Five randomly chosen locations were observed between 4:00 PM and 6:00 PM during the field use assessment. Three 6-lane highways, one 4-lane highway, and one 8-lane highway represented the study locations. Each direction at each location was observed on different days. Two observers recorded data from the same randomly chosen travel lane. Travel lanes were randomly assigned every 15 minutes.

The total number of vehicles observed for each time interval ranged from 79 to 449 vehicles with an average of 246 vehicles. The peak travel direction generally exhibited higher proportions of handheld cellular telephone. Several interactions were found within the data. The analysis indicated that spatial location, travel direction, observer, and time of day influence the proportions observed. Other unidentified factors (e.g., congested conditions or speed) may also influence handheld cellular telephone use when driving.

Estimates of handheld cellular telephone use among drivers were derived as a weighted average of all observed data. From this, 5 percent of drivers were observed using a handheld cellular telephone on Dallas County freeways during the afternoon peak period. This estimate does not include the use of either handheld cellular telephones with hands-free adapters, or in-vehicle, installed hands-free cellular telephone systems by drivers. Total cellular telephone use might be estimated using electronic monitoring devices, which can detect energy fields of cellular telephones.

The final project objective was to investigate the effects of conversation intensity and mode of operation on driver performance. When a driver chooses to use a cellular telephone, both the driving and the cellular telephone tasks demand the driver's limited attention. An increase in driving difficulty results in lower performance of a secondary cognitive task, as each task competes for a person's limited capacity for attention. When the secondary task is the use of a cellular telephone, the expected result is degradation in either driving performance or the use of the cellular telephone, or both. Numerous researchers exploring the effects of cellular telephone use have implored the secondary task methodology. The concern is that the driver's control of the vehicle will significantly degrade rendering the use of the cellular telephone unsafe.

A number of researchers have also studied collision data to determine whether the use of a cellular telephone while driving affects driving performance. Violanti and Marshall studied 18 attention factors for both a test group of drivers and a control group of drivers, including the amount of time per month each driver spent talking on a cellular telephone. Redelmeier and Tibshirani's analysis of collisions suggests use of the cellular telephone quadruples the driver's risk of being in a collision. Using an epidemiological approach, Violanti examined the statistical association between cellular telephone use and fatal traffic accidents finding a statistical relationship; however, this relationship does not imply that cellular telephone use itself is responsible for fatal traffic collisions, but only identifies the potential influence of cellular telephone use on the increased severity of the collision. The results of these epidemiological studies suggest the use of cellular telephones either increases the driver's risk of being involved in a collision or increases the likelihood that a collision will be fatal. The data available to the researchers may not be complete. The driver's use of a cellular telephone is not a standard item on police reports and even if it were, drivers are not likely to admit their use of a cellular telephone contributed to a collision. Nevertheless, if the use of a cellular telephone degrades the driver's control of the vehicle, an increase in the risk of being involved in a collision is an expected consequence.

From the results of previous simulator studies, there appears to be a relationship between the use of the cellular telephone and the driver's control of the vehicle. The inclusion of the telephone task may increase the driver's response time or the precision of speed and lane control. Casual conversations have been shown to be distracting to the driver and more difficult conversations could further degrade driving performance.

The interaction with other vehicles and an increase in the difficulty of the driving task both appear to contribute to the relationship between the use of the cellular telephone and the driver's control of the vehicle. There is also evidence to infer that the driver's age, level of training and state of fatigue may influence how the use of the cellular telephone could affect the driver's control of the vehicle. The characteristics of the vehicle, or the driver's familiarity with the vehicle, and even the design or mode of operation of the cellular telephone may also be influential.

Based on the results of previous research, it was believed that the driver's control of the vehicle, as measured by lane position, steering input, accelerator input, and speed should suffer from the addition of the telephone task. A simulation experiment was designed and conducted to test this hypothesis.

This experiment was designed to investigate the effects of conversation intensity and mode of operation of the cellular telephone on driving performance. The high-fidelity driving environment simulator (DESi) located at the Texas Transportation Institute on the Texas A&M University campus was used. The cellular telephone used for this experiment was a Samsung SCH-3500 with dual band. The cellular telephone was used in two operation modes, handheld and hands-free. The experience level of the participants with the operation of a cellular telephone ranged from novice to expert, although all participants indicated having some prior experience with cellular telephones.

Each participant was allowed a practice drive. When it began, there was a red vehicle on the right shoulder ahead of the participant's vehicle. The participant then followed this vehicle and became accustomed to the control and response of the vehicle in the simulation environment. Participants then executed five experiment drives.

For the first experiment drive, the participant's performance measures were recorded when there was no telephone call. During experiment drives 2 through 4, the driving measures were recorded while the participant was engaged in a conversation (emotionally charged or casual) with the experimenter using handheld or hands-free cellular telephone operating modes. The last experiment drive included two recording areas. The first was a control condition where no cellular telephone call was made but the driving performance measures were recorded. The second recording area recorded the driving performance measures when the participant was engaged in conversation.

The participant performance measures recorded during the experimental drives were the means and standard deviations of lane position, steering input, accelerator input, and speed. The mean lane position describes the average position of the vehicle in the lane and the standard deviation of lane position described the driver's ability to maintain a constant lane position.

To measure driver workload, participants provided a rating after the first experiment drive to describe how hard they thought they worked to drive through the experiment drive. At the end of the other experiment drives, participants were also given time to provide a workload rating that described how much effort it took the participant to talk on the cellular telephone while driving.

The median of the workload ratings given after the driving task without a cellular telephone conversation in the first experimental drive was lower than the medians of the workload ratings given after the task of driving while talking on the cellular telephone for each of the other four experimental drives. In all other experiment drives with cellular telephone use, the participants felt that using the cellular telephone while driving required more effort than simply driving.

Made in pairs, comparisons of the workload rating medians for each telephone conversation condition showed the handheld, high-intensity conversation was significantly different than the hands-free, low-intensity conversation. Previous studies found that cellular telephone use can negatively impact driver performance. The hypothesis that cellular telephone conversation intensity or the modes of use influences driving performance was not supported by this simulator experiment.

While subject gender was a significant factor in the analysis, conversation intensity was not found to significantly affect driving performance. This latter finding contrasts to an earlier study that found cognitively engaging conversation was more distracting than casual conversation. The experimenter noted that it was extremely difficult to lead the subjects toward highly emotional conversations. This realization may indicate that the study design was not executed as planned and has some impact on the results for this portion of the experiment.

One important finding was the significant change in the steering input standard deviation between the control conditions (when no cellular telephone call was made) and the experimental conditions (when cellular telephones were used). This finding is counter to a previous study that claimed a benefit of hands-free operation to handheld operation. Perhaps the variation in steering input is the first indication that driving performance is affected when the cellular telephone is being used. Under more demanding driving conditions, the decrement of driving performance related to use of the cellular telephone may arise in the other driving performance measures.

In summary, 5 percent of drivers on Dallas County freeways were observed using a handheld cellular telephone while operating their vehicles during the afternoon rush hour. This is a conservative estimate of total cellular telephone use by drivers because technologies allowing hands-free operation of cellular telephones (e.g., ear-microphone pieces, professionally installed accessories, and other manufacturer accessories) were not included in this field assessment. The simulator experiment revealed mode of operation had a significant effect on driving performance measured through steering input. However, since there was no significant effect on any of the other seven participant performance measures; the overall results conclude that hands-free mode of operation has no immediate benefit over handheld operation. Also, while conversation intensity alone did not significantly affect driving performance, workloads combining high-intensity conversations and handheld mode were significantly different than workloads for hands-free, low-intensity conversations.

Additional research is needed to better understand the problem and define its scope. Research elements that should receive attention include: Investigation of Influencing Factors for Cellular Telephone Use when Driving; Improving the Field Measurement Process for Estimating Drivers' Cellular Telephone Use; Estimating Drivers' Cellular Telephone Use on Arterial Streets; Linking Accidents to Drivers' Cellular Telephone Use; Continue Investigating the Effects of Conversation Intensity from Cellular Telephones on Driving Performance; Assess Mental Workload of In-Vehicle Distractions; and Evaluate Driver Response Times for Modes of Cellular Telephone Use when Driving.

The most commonly available personal mobile communication device used is the cellular telephone. Cellular telephones do provide a wealth of safety benefits. However, they are also associated with hazards. Verizon Communications recognizes these hazards and publicly supports regulating the use of handheld cellular telephones when driving. Some will cite that existing regulations for operating vehicles could be used to penalize reckless and irresponsible drivers on their cellular telephones. However, support is growing to adopt specific regulations for cellular telephones in vehicles. Drivers, researchers, device manufacturers, and automobile manufacturers are encouraged not to be cognitively myopic in thinking a decrement in driving performance only occurs when a cellular telephone is used. On the contrary, driving performance can be compromised by the growing number of distractions in and outside of vehicles.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

DISCLAIMER

The contents of this report reflect the views of the authors, who are solely responsible for the facts and accuracy of the data, the opinions, and the conclusions presented herein. The contents do not necessarily reflect the official view or policies of the Department of Transportation (DOT), the Texas A&M University System, or the Texas Transportation Institute (TTI). This document is disseminated under the sponsorship of the Department of Transportation, University Transportation Centers Program, in the interest of information exchange. Mention of trade names or commercial products does not constitute endorsement or recommendation for use. The engineer in charge of the project was Jason A. Crawford, P.E. # 83241.

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CHAPTER I. INTRODUCTION

Once a tool too expensive for common people, cellular telephone prices have dropped dramatically and their affordability has increased beyond expectations. The Cellular Telecommunications Industry Association (CTIA) reports that by 2005 there will be 1.2 billion wireless phone users worldwide. At the rate of reported expansion in the United States, there will be more than 200 million wireless phone users by 2005.

Safety. Connectivity. Convenience. Productivity. These are a few words that come to mind when people begin discussing the prevalence of cellular telephones in our society. People who have cell phones feel much safer, and law enforcement is able to respond to emergencies and other mobile hazards more efficiently. We are connected with family, friends and business associates at the touch of a few buttons to make the drive home more productive.

Etiquette. Near-misses. Accidents. Distraction. These are the negative words used during similar conversations on the topic. Awareness of these effects is very common these days. One cannot miss the print or television articles on the subject. When Dear Abbey posts letters on the subject, you have hit mainstream. Restaurants are asking their customers to move out of the dining area when talking on the cellular phone. Other services such as dental clinics have noted interruptions during their appointments due to the patients' need to utilize their cellular phone.

Much of the same public concern was voiced over the introduction of the radio into the automobile. Unlike the radio, the cellular telephone is the conduit for two-way communication with family, businesses, and services, of which the latter two are defining a market for their services in American automobiles. Today we may hear concern expressed about soccer moms in sport utility vehicles whizzing by talking on their phone unaware of the traffic conditions or events around them. Tomorrow we may hear the same level of concern as people interact through the Internet to gather a variety of information, topical to the driving task or not, and interact electronically with each other as they drive.

It is critically important to the American public, lawmakers, manufacturers, and service providers to be aware of the consequences from adopting these and other distracting devices in our automobiles. In the United States, little hard evidence can link the use of cellular telephones to accidents, injuries, or fatalities. Significant research is beginning at the United States Department of Transportation's (US DOT) National Highway Traffic Safety Administration (NHTSA) on this subject. Their research combined with other independent research in the United States and other countries will help to define the problem, identify the critical and hazardous behaviors or tasks, and recommend remedies. This study and report are but one piece in the effort to clearly understand the effect of the cellular telephone and other like distractions used inside the automobile.

This report is organized into several chapters by discussion area. An extensive review of published and electronic literature is provided in Chapter II. Chapter II summarizes the perceptions held by local law enforcement regarding the impacts of cellular telephones and various other topics. This is followed by a presentation on methods to collect hard field data regarding handheld cellular telephone use. Chapter V discusses the relationship between conversation intensity and driving performance as measured through driver simulations is discussed. Finally, a set of conclusions based on the evidence collected through this study and preparation of this report is presented in Chapter VI. Several supporting appendices are included at the end of the report.

CHAPTER II. LITERATURE REVIEW

The abundance of available literature concerning cellular telephone use while driving seems to be growing in proportion to the growth of the wireless industry itself. Our society is rapidly becoming more reliant on the advantages of "telematics," a new term coined to refer to wireless technology developed for use in automobiles (*1*). Newspapers, magazines and television news programs frequently include articles or stories involving cellular telephone use and its influences, though not always specific to driving. It is also difficult to browse the Internet without running across the topic. News often centers on the latest gadgets for automobiles: hands-free telephones, computerized navigation, web access, the list goes on and on.

Most often the benefits like personal convenience and safety, or increased networking and productivity for business are extolled. Broader benefits to society are also coming into play, such as cellular telephone users assisting law enforcement and emergency services by locating and reporting incidents. The FHWA also ordered an October 2000 deadline for enacting a national enhanced 911 (E911) system using cellular telephone transmissions to plot locations. Similar technologies are being developed which will aid in monitoring and controlling traffic problems. However, as with any new technology, controversy has risen over the issue of benefits versus hazards.

Growing concern over the contributing role of cellular telephone use (and other wireless devices) to driver distraction is reflected in the media as well as the world of academia. There have been studies made of the subject, ranging from intense government research by the National Highway Traffic Safety Administration (NHTSA) to informal, localized surveys, forums and opinion polls in newspapers, magazines, television, radio and the Internet. Much of the controversy centers not on whether the problem exists, but on what to do about it: to regulate or not to regulate, that is often the question.

In reviewing the literature on this subject, all related topics were considered, while retaining as much focus as possible on the issue at hand: the *Contribution of Handheld Cellular Telephones to Vehicular Accidents.* This literature review provides an overview of the type of material currently available to the public. However, there continues to be a constant influx of new data representative of the constant growth, changes, and influences taking place in our society as the wireless industry advances and expands into everyday life.

RISE OF CONNECTIVITY AND PRODUCTIVITY: CELL PHONE USE & SOCIETY'S INCREASING DEPENDENCE

According to estimations by the Cellular Telecommunications Industry Association (CTIA), in June 2000, there were almost 100 million people subscribing to wireless services in the United States (*2*). This figure is almost twice the estimated number of subscribers in CTIA's June 1997 survey, as shown in Figure 1.

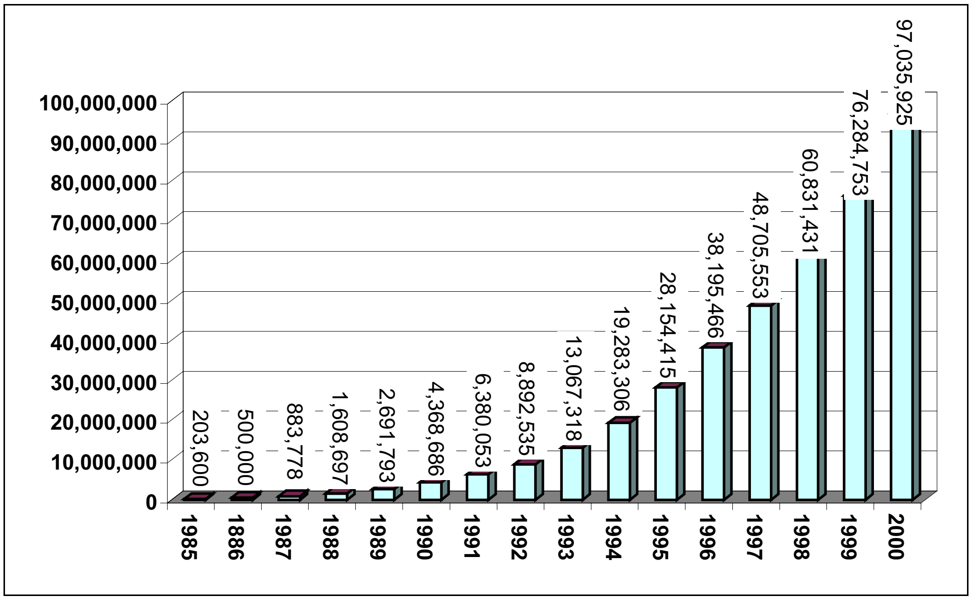


Figure 1. Wireless Subscribership: June 1985 – June 2000.

[Source: CTIA, 6/00 (*2*).]

These figures meet and exceed predictions by NHTSA in 1997 that there would be a growth rate of 40 percent a year, with more than 40 thousand new users signing up every day. So who are all these people? The demographics are changing as the number of users increases, and, as shown in Table 1, income does not seem to be as much a factor as was once thought (this will be discussed in more detail later in this paper). In their 1997 report, NHTSA included data collected in The Motorola Cellular Impact Survey 1, conducted by the Gallup Organization in the spring of 1993, and sponsored by the Motorola Cellular Subscription Group. Results of interviews with 660 cellular telephone users were compared to a similar survey they had done in 1991(*3*). A survey by Peter Hart Research Associates for CTIA in 1998 resulted in demographics for wireless users, shown below in Table 2, that seem to reflect that of the average American population (*4*).

Table 1. Motorola Cellular Impact Surveys.

Income Distribution of Respondents		
Income	**1991**	**1993**
Less than $25K	N/A	15%
$25K-$45K	30%	27%
$45K-$60K	20%	16%
$60K-$75K	14%	7%
More than $75K	36%	28%

Employment Status of Respondents		
Employment	**1991**	**1993**
Full-Time	83%	78%
Part-Time	6%	5%
Homemaker	11%	4%
Self-Employed	N/A	4%
Retired	N/A	5%

[Source: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

Table 2. Wireless Users Compared to American Adults.

		Wireless Users %	All Adults %
Sex:			
	Men	45	47
	Women	55	53
Age:			
	18-34	31	29
	35-44	27	23
	45-59	26	25
	60 and over	15	22
Income:			
	Under $30K	16	25
	$30-50K	27	25
	$50-75K	19	18
	Over 75K	16	16
Occupation:			
	Professionals/managers	36	23
	White collar/sales workers	20	20
	Blue collar workers	22	19
	Retirees	11	20
Education:			
	High school or less	33	37
	Some college/vocational	33	28
	College degree or more	33	34

[Source: Peter D. Hart Research Associates. "The Evolving Wireless Marketplace," 2/98 (*4*).]

"Who is using cellular telephones?" Tables 3 and 4 below reveal that NHTSA, using the Motorola data, estimated more than 1 in 10 Americans were cellular telephone users. Of the then estimated 50 million users in the U.S., 9 percent of the owners were less than 24 years old (*3*).

Table 3. Motorola Cellular Impact Surveys.

Age of Respondents		
Age	**1991**	**1993**
18-24	6%	6%
25-34	26%	30%
35-44	34%	30%
45-54	20%	23%
55-59	6%	3%
60 or older	4%	8%
No response	3%	0%

[Source: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

Table 4. NHTSA Survey, Nov. 1996-Jan. 1997.

Estimates of Age-Related Cellular Telephone Usage:	
Age 16-20	26%
Age 21-24	28%
Age 25-34	32%
Age 35-44	36%
Age 45-54	39%
Age 55-64	23%
Age 65 +	16%

[Source: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

Also in 1997, an article by the Insurance Research Council (IRC) reported that their survey showed 84 percent of cellular telephone owners felt that using the phone while driving increased their risk of having an accident (*5*). However, 61 percent continued to use their cellular telephone at least occasionally, 30 percent fairly often or frequently, despite being aware of the increased risk. As startling as those statistics might be, when they compared them to those for younger drivers (18-24) who, because of their age and lack of driving experience, are already at a higher risk for having accidents, the results are more alarming. Of these younger drivers, only 72 percent thought talking on a cellular telephone increased their risk of accident, and 50 percent continued to use their cellular telephones frequently or often, despite the accepted risk increase. The Executive Director for IRC commented in the article that, "…the urge to mix talking on the phone with driving on the road is a powerful combination which few can totally resis."(*5*) Figure 2 exhibits the typical satire reflected in the media when addressing this issue.

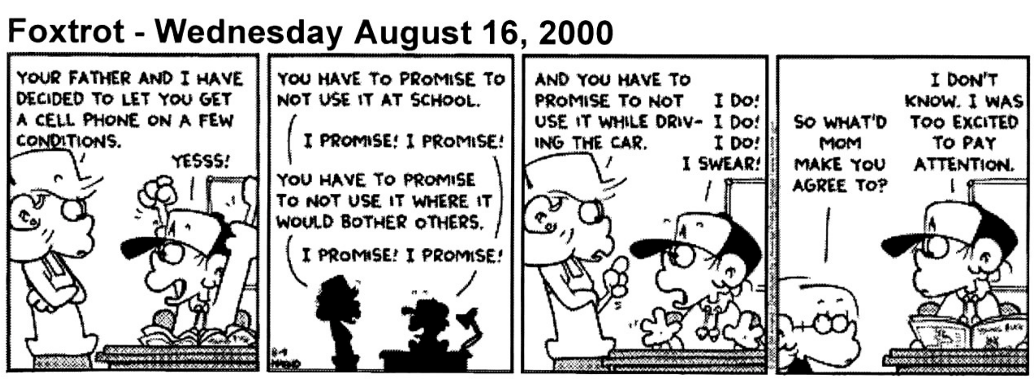


Figure 2. Example of Satirical Comment in the Media.

Personal Benefits

Wireless technology is here to stay. For a growing number of people, it is an integral part of both work and personal environments. With any new technological development, however, there is a period of experimentation and adjustment that follows. Adaptations are made, and technology improves, becoming more accessible and hopefully, more beneficial to the general public. But this early period is often a time of controversy, and frequently the negative impacts seem to overshadow the positive. The growing concern surrounding cellular telephone use while driving is typical of this phenomenon. Do the benefits of driving while using a cellular telephone outweigh the possible risks? The frequently cited 1997 article by Redelmeier and Tibshirani, published in the *New England Journal of Medicine*, opened the floodgates for negative criticism of driver-cellular telephone use (*7*). However, the trend of use has continued and shows no signs that it will change. Obviously, for most drivers, the benefits of using their cellular telephone are so great, they are worth whatever risk is involved.

Immediate Contact

This is the age of personal convenience, and today's society strives to squeeze as much use out of every precious minute of their time as possible. In the attitude of quality of time vs. quantity of time, the cellular telephone industry has flourished since its introduction in 1983. Urban populations have increased, therefore vehicle traffic, particularly in metropolitan areas, has too. This, combined with the rise in economics and advances in technology, has set the stage. The cellular telephone has become the perfect solution for making productive use out of time normally wasted in traffic, trying to get from one place to another. Families can coordinate schedules, making better use of their available time. Business people can increase their productivity by making themselves constantly accessible. Fast cars, fast food, and express lanes; swipe a card to make purchases, or buy items online without ever leaving home. Immediate contact provided by cellular telephones has become essential to achieve the instant gratification society expects as part of their modern lifestyle.

Personal Safety

Aside from the issue of convenience, most people actually purchase cellular telephones for the purpose of increasing personal safety and security. Toward that end, the idea of "immediate contact" takes on a whole new meaning. In the event of a vehicle breakdown or accident, emergency services or other help can be contacted without having to leave the scene. Cellular telephones are also useful during emergency situations where the land telephone lines are disabled, such as natural disasters. In an article, "Cellular Phones Provide Safety on the Road," Clemson University Cooperative Extension Service cited the following statistics in Table 5 as "**Cellular Facts**" (*8*).

Table 5. Cellular Facts:

- 88 percent of all cellular phones are bought for emergency use.
- 50 percent of all cellular users called for help during their first year they had service.
- 50,000 emergency calls are made daily.
- 97 percent of phone owners feel safer with a cellular phone.

[Source: CTIA 4/96, 5/96 and Cellular Marketing 7/95; adapted from AAA Go Magazine, March-April, 1998. Cited by Clemson University Cooperative Extension Service, 2/19/98 (*8*).]

Benefits such as safety and security are the most often cited reasons for initially obtaining a cellular telephone, however, people have admitted to using them more for convenience once they have them. Concerning the use of cellular telephones for personal safety benefits, the Motorola Cellular Impact Surveys revealed the statistics shown in Table 6.

Table 6. Motorola Cellular Impact Surveys.

Safety Related Uses of Cellular Telephones		
Safety Benefits	**1991**	**1993**
Called for help for another's disabled vehicle	38%	40%
Called for help for own disabled vehicle	25%	39%
Called for assistance for own medical emergency	7%	13%
Called for assistance for another's medical emergency	23%	28%
Called police to warn of hazardous road conditions	24%	28%
Considered buying another cell phone for other family member as safety precaution	N/A	52%
Have purchased an additional phone for other family member as safety precaution	N/A	28%
Encourage my teenagers to use phone while out at night	N/A	26%

[Source: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

Technological Advances

As is often the case with new technology, advances in cellular telephones have followed almost faster than the market can keep up. From the days of the first "mobile phones" which were cumbersome and expensive to own and operate, today's wireless cellular telephones have developed into much more versatile units conveniently sized and priced for any and all types of use.

Cost & Availability

When they first came on the market, cellular telephones were not as readily available to the average person as they are now. The cost for equipment was high at first and has gradually decreased to affordable levels. Another factor in the change is that the calling plans themselves are becoming more flexible and affordable. According to an article in *Forbes Magazine*, "Wireless penetration in the United States…barely hit 30% [in 1999]…[because] service here…costs too much. In Europe, 70 percent of new subscribers [signed] on through prepaid calling plans…to catch up, Middle America is the market to go for…"(*9*). Table 7 below reveals the percentages of users based on household income.

Table 7. Percentage of United States Population That Uses Cellular Phones, by Household Income:

• $50,000 or more	54%
• $35-50,000	36%
• $20-35,000	27%
• $20,000 or less	17%

[Source: Forbes Magazine, 12/13/99 (*9*).]

ABC News reported in February 2000, that "…2 percent of the 86 million wireless subscribers use their mobiles as their only phone…[usually due to convenience, but also because]…wireless companies offer a flat rate plan that can save its users up to 50 percent over traditional service [combined, monthly local and long distance bills]." In some areas where it is difficult to obtain landline service, wireless has managed to "leapfrog" more traditional options. However, "…some wireless carriers face serious strain on their networks, especially in dense urban areas."(*10*)

Even though CTIA reported a slight rise in the cost of average local monthly bills for wireless service from June 1998 to June 2000, the latter cost is still less than half of what it was in June 1988. It should also be noted that the length of average calls for June 2000 was up 6 percent for local, and 20 percent for roaming calls, over the average lengths for calls in June 1998 (*2*). This data is shown below in Figure 3.

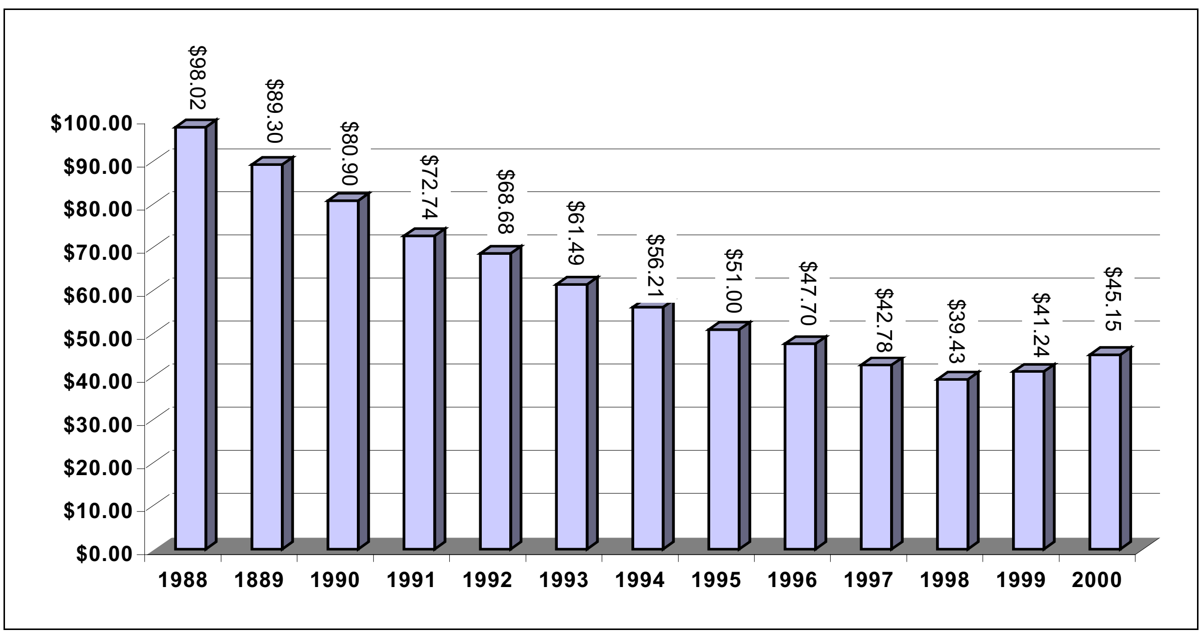
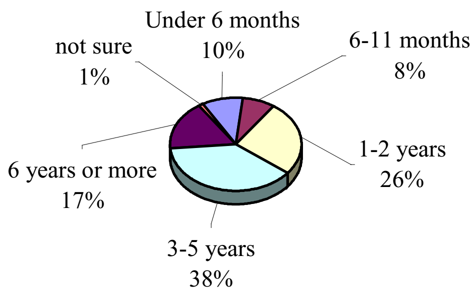


Figure 3. Average Local Monthly Bill: June 1988 - June 1999.

[Source: CTIA, 6/00 (*2*).]

As shown in Figure 4, the Hart Research report for 2000 found that wireless phones were not just for the elite anymore (*11*).

How long have you used a wireless telephone?



New Users:
- personal users
- age 18 to 34 *(esp. women)*
- income under $50K
- some college/less

Longtime Users:
- business users
- age 35-59 *(esp. men)*
- income over $75K
- college graduates
- men

Figure 4. Profile of Wireless Phone User.

[Source: Hart Research, "The Wireless Marketplace in 2000," 2000 (*11*).]

Size & Portability

Fortunately, as the costs for cellular telephones and other wireless devices decrease, the quality of the technology increases. The first cellular telephones were bulky, bag-phones with inadequate batteries/power sources. Today, the new wireless units are sleek and streamlined, and some even come in designer colors. Most are small enough to fit in the palm of the hand and no longer have the clumsy cords and wires that tie them to the automobile. And that is just the beginning. Technological advances have gone far beyond the ability to make phone calls from any location. The world of cellular miracles is fast being displaced by one of "cyber" miracles.

New Technology

The whole concept of the "car phone" is evolving into what are now being dubbed "e-cars," "cyber-cars," and "network vehicles." Even this seemingly space-age technology is rapidly becoming more available to the general driving public. "Telematics systems have been aimed at the luxury car markets…[because] they have been expensive…but prices are starting to drop." The price may be as low as $300, and systems may be available in more mid-sized and compact model vehicles (*1*).

Personal computing has advanced from desktop units to portable laptops and now, to tiny, handheld units called Personal Digital Assistants (PDAs). Cars are being manufactured with computers that will navigate, warn of impending collisions, some even offer all the advantages of an on-board personal computer (PC), sometimes by offering the ability to interface with other devices. Now drivers can check and send e-mail, surf the Internet, check their stocks, and perform any function from their car that they would from a desk. They can even send and receive faxes. It seems that for more and more people, the automobile is becoming the office of the future. Even if a PC packed automobile exceeds the average person's needs, just having a cellular telephone with them in the car is making it possible to be connected to the Internet.

However, “a survey by Exxon USA [in 1999] found the number one item young drivers want in their car of the next millennium is e-mail and Internet access.”(*12*)

A Presidential Statement released by the White House Press Office on October 13, 2000 discussed “Third Generation Wireless Technology.”(*13*) The President has signed an Executive Memorandum “directing federal agencies to work with the FCC and the private sector to identify the radio spectrum needed for the ‘third generation’ of wireless technology.” Such 3-G systems will provide high-speed mobile Internet access from anywhere, anytime, allowing consumers to enjoy a wide range of wireless tools and technologies. According to this statement, “Over the past five years, the information technology sector has accounted for nearly one-third of U.S. economic growth, and has generated jobs that pay 85 percent more than the private sector average.”(*13*)

PROPOGATION OF BENEFITS TO EMERGENCY SERVICES AND TRAFFIC ENGINEERING

Some of the greatest benefits of having cellular telephones in automobiles may have nothing to do with personal or business use, but rather the possible benefits to the public. An article in *Public Roads Magazine* states that, “The benefits of a wireless program are self-evident, and the public benefits in several ways. The wireless communications needs of the public are served; the fielding of some intelligent transportation systems is facilitated; and future highway improvements are funded by the additional income received by the state highway agency. This is a win-win situation for the public, state government, and for the wireless providers.”(*14*) There is a fair amount of literature available regarding the benefits to law enforcement and emergency services; as well as a great deal about new technology being developed to help in traffic management and transportation network monitoring.

Much of the information concerns the Federal Communications Commission’s (FCC) Enhanced 911 (E911) mandate, requiring that wireless carriers have automatic location capability to pinpoint a caller’s location within 50 meters, and relay that information with the emergency call, by October 2001. This mandate has emphasized the need for advances in telematics that are making cellular telephones and other wireless devices more versatile and more useful to the driving public.

Assisting Law Enforcement

As previously noted, cellular telephones are most often purchased with the user’s personal safety in mind. Increasingly, however, law enforcement and emergency services are finding that drivers who have cell phones can be of great assistance to them as well. In an article for Public Works Online, the cellular telephone is referred to as “a godsend in terms of reporting accidents or distress calls on the highways.”(*15*) Drivers often call 911 from their cellular telephones to give immediate reports of accidents and/or crimes they have witnessed. This allows law enforcement and/or emergency personnel to respond much more quickly and efficiently. Officers can often correspond while in route, with witnesses who are keeping the person(s) or situation under observation, receiving crucial details from the caller. Frequently, specific areas of crime prevention are enhanced by cellular telephone calls, such as reporting drunk or reckless driving and assisting in spotting suspects following a kidnapping. Further comments supporting the benefits to law enforcement can be found in the interview section of this report.

There are occasions, however, when emergency services may receive so many repeated or invalid 911calls that they tie up the phone lines and interfere with more important concerns. NHTSA, in their 1997 report, states that Maryland was the first state to try to implement a "311" line for non-critical calls. The report noted that, in 1997, "cellular telephone calls [were] directed to the emergency communications centers which may have [had] as few as three lines," and further suggested that "the misuse and overburdening of emergency exchanges is a problem that could be addressed through education and technology."(*3*) The problem with the overburdened lines could be due in part to the original E911 mandates in 1996, which required service providers to relay all emergency 911 calls from cellular telephones directly to PSAPs (Public Safety Answering Points). There is usually no charge to the caller for these 911 calls, which may be why some cellular telephone users call the line for trivial purposes such as checking to see if their phone is working.

While problems have occurred due to irresponsible 911 calls, in most cases, the calls are considered quite helpful. These "cellular Samaritans" can enable emergency services to efficiently respond to the needs of the public (*8*).

In 1996, the only state that had attempted to gather data regarding the increase in cellular 911 calls was California. The data collected reflects a growth factor of almost 100 during the previous 11 years, as shown in Table 8 (*3*).

Table 8. California Highway Patrol Report, Cellular 911 Traffic Growth.

Year	Total Cellular 911 Calls
1985	29,000
1986	94,200
1987	171,333
1988	333,600
1989	575,000
1990	747,500
1991	971,655
1992	1,400,000
1993	1,644,760
1994	1,829,077
1995	2,176,400
1996 *(estimated)*	2,800,000

[Source: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

Incident / Detection Management

Cellular telephone users can provide yet another important service to the public by being the first to call and inform enforcement or transportation authorities of incidents or debris on public roadways. In the instance of a wreck or disabled vehicle, items that may have fallen off a vehicle, or anything which could block roadways, cellular telephone users can give immediate notification to authorities. Within congested urban areas, their calls mean faster response times and clearing of roadways, which can prevent costly delays and assist in keeping traffic flowing smoothly.

In many densely populated urban areas, radio as well as some television stations accept cellular telephone calls reporting traffic problems. These stations frequently use such calls to supplement their rush hour traffic reports.

The days of radio and television traffic alerts may be numbered, however, as more cellular telephone users become connected to the Internet. “The proliferation of wireless technology across the U.S. is providing Intelligent Transportation Systems (ITS) with an enormously valuable tool to improve transportation. Instant access to communication is enabling transportation managers and service providers to provide real time travel information.”(*16*) Drivers can receive real-time personalized reports on traffic and road conditions via their cellular telephone, helping them to plan their routes, avoiding costly delays for themselves as well as lessening the overall congestion at the problem sites.

The FCC’s E911 mandate has spurred much of the urgency behind the new developments in telematics, particularly in the area of location-based technology. The mandate, however, provides the wireless industry with no technical specifications or guidelines for meeting the requirements.

Because wireless technology is constantly evolving, it is difficult for service providers to choose the best long-term technical investments. In addition to the obvious safety provisions, there are other advantages to the development of the E911 system. There is potential for ITS (Intelligent Transportation Systems) to share the responsibilities as well as the benefits of establishing an E911 system, particularly in the areas of technology, services, finances, and public policy / education (*16*).

One factor that could impede the wireless industry’s compliance with E911 is neither technological nor financial. “The most daunting challenge [to achieving E911 compliance] may be convincing the public that [location-based systems] will not violate their privacy.” Researchers have stressed that the technology will not enable the monitoring of phone calls or identify callers (*17*).

Transportation Network Monitoring

Monitoring traffic flows with cellular telephones began in the early 1990s along U.S. 59 in Houston. At that time drivers would “report in” when arriving at specific cross points along a predetermined route. This information allowed researchers to develop travel time patterns from many vehicles within the corridor. Today, research is underway to monitor traffic using cellular telephones, but the users don’t have to “call in.” Advanced monitoring systems track the intermittent locator signals given off by wireless devices.

The ability to locate and monitor traffic congestion by tracking cellular telephone usage could help improve the flow of the traffic itself by indicating shifts in demand. Research is being done to develop technology capable of triangulating the position and movement of the cellular telephone user, thereby monitoring the movement of the traffic along a roadway. This allows better management of problems as they occur. An example of using cellular telephones as traffic probes is the Virginia Department of Transportation's (VaDOT) pilot Advanced Traveler Information System (ATIS) (*18*).

In February 2000, CNN reported that over the following year VaDOT would begin providing "traffic news that reflects real-time conditions from interstates as well as major arterials" via ATIS (*18*). One of first programs of its kind in the U.S., ATIS utilizes a location-based system. Vehicles essentially operate as traffic probes, with their positions and speeds being tracked through wireless phone signals. "The purpose is simply to follow the energy pattern generated by thousands of cell phones...only 1to 2 percent of [commuters] using their phones at a given moment…represent thousands of points of information…to measure traffic…[and,] in congested areas…cell phone use increases as traffic slows."(*17*) However, researchers do acknowledge the possible hazards of using their cellular telephones while driving.

Earlier, in a December 1999 article for the *Washington Post*, state officials acknowledged the possible hazards of cellular telephone use while driving, but said the "pilot project" in Virginia and Maryland (The Capital Beltway Project), "is not designed to encourage or condone cell phone use while driving. It takes advantage of a social trend that is already occurring [and will provide a lot of data at low cost]. The breadth of information generated…eventually could be used to ease congestion by better calibrating ramp meters…linking traffic signals with actual conditions…[and] could make [the use of]…electronic signs more effective. Traffic researchers in the U.S. and Europe are optimistic that such detailed information could ultimately make it possible to forecast backups an hour before they happen."(*17*) Transportation experts believe that this technology, if it works, will take off very quickly.

Another significant benefit is expected for drivers as they plan their daily trips or are traveling toward congested traffic locations. "The service will not only highlight delays caused by accidents, breakdowns and construction, but will offer average speeds and estimated travel time on many roads. Information [will be available] over the phone, on the Web, and the old-fashioned way--by radio. You could receive a personalized route by e-mail just before leaving the office, [or be] paged when your normal route is clogged." (*18*) Though it did not elaborate on estimated costs, the article noted that some of the personal services might carry a user fee.

The idea of providing personalized "real time" traffic information has been a long-term goal of the transportation profession. While the option for getting traffic reports via cellular telephones has been around for only a few years, it hadn't previously been considered very useful. In 1998, in the *Capital Beltway Update,* NHTSA asked members of one of the test groups how they got traffic information. Several answered that they got information from radio and television news reports, and one said he occasionally used his cellular telephone to obtain information. When asked specifically if they used their cellular telephones to get traffic information, only seven in that test group owned units at that time. Of those, only two used them occasionally to obtain traffic reports; and both used the American Automobile Association (AAA) as their source. The report noted that, “They [did] not totally trust the information they [got], remarking that all sources are somewhat unreliable because traffic conditions change so quickly.”(*19*) Other partnerships are developing to begin providing services to drivers.

In May 2000, it was announced that nationally based TrafficStation had partnered with AT&T Wireless to combine “customized traffic information with…wireless service, to provide proactive, real-time and route-specific traffic alerts to users of…AT&T Digital PocketNet Services.” This announcement forecasted that, “With the convergence of Internet and wireless devices, consumers will now become more reliant on mobile technology for daily information, work management and entertainment.”(*20*)

A new line of wireless products and services for the transportation industry was made available in September 2000, from MyPeople Networks. The core of their product line is a wireless dispatch and tracking system. Such two-way communication provides real-time data and is expected to lower costs and increase the efficiency of this industry (*21*).

The advent of location-based technology coupled with the widespread and unregulated use of personalized data services may result in roadside billboards being displayed on drivers’ cellular telephones. Many mobile commerce and wireless advertising companies are undecided about using location-based services. “Proponents of the technology say ads are about positions location, perishable inventory and impulse purchasing, [and] location services make the wireless experience unique.”(*22*) Those not in favor say that wireless ads can’t compete with Internet shopping because consumers aren’t going to buy something off a tiny screen when they could make purchases from the desktop. Still other wireless advertisers feel location-based services aren’t going to last “because they bombard people with more information than they can absorb at one time. Rather than arbitrarily send out ads to all wireless users when they are nearby, they [prefer to] deliver targeted ads, coupons and promotions to wireless Internet devices.”(*22*) In spite of this argument, The Strategis Group conducted a survey that revealed location-based services are gaining favor. “Of the 500 consumer wireless users surveyed, 77 percent said they are willing to receive advertising on their handsets to reduce or eliminate other charges.”(*22*)

These and other technologies providing a multitude of information outlets via the cellular telephone or other telematics devices are on the cusp of becoming commonplace. Noble Carmen states that the FCC schedule is that “By October 2001, 50 percent of new phones sold must be equipped with the location capability, a figure that increases to 95 percent by 2002.”(*23*)

RISE OF PUBLIC CONCERN: MEDIA ATTENTION

More and more drivers are becoming reliant on the “connectivity and productivity” provided by cellular telephones and other wireless devices. However, as with most major advances in technology, wireless technology, though wildly popular with many, has still met with a great deal of opposition. Along with the rising use of, and growing dependence on cellular phones while driving, there is also mounting concern.

> “Some states don’t want to permit them at all—say they distract the driver and disturb the peace. The whole problem is getting very

> complex, but the upshot is that you'll probably be allowed to take your radio anywhere, with possibly some restrictions on the times when you can play with it."(*24*)

Sound familiar? This quote from The Old Farmer's Almanac in 1930 appeared in an article for The Washington Post (*24*). Substitute the word "telephone" for "radio" and that sums up the attitude a lot of people have toward cellular telephones today, especially in vehicles. According to an InsWeb Special Report, driver distraction caused by using a cellular telephone "is an issue that brings out a variety of reactions—from the anger of victims of gabby drivers, to the demands of researchers for more data on the issue, to the denials that there is a problem from some…members of the cellular telephone industry."(*25*) There is a great deal of literature relating to this issue of cellular telephone use while driving, from newspaper articles to formal, in-depth studies. An excellent indicator that an issue has become a real public concern is when it begins to show up in syndication. When news programs like NBC's Good Morning America are discussing the issue, editorial cartoonists start expressing it in their caricatures, and columnists like Ann Landers add their support to the argument, the issue is indeed a major concern (*26*).

Most studies on the use of cellular telephones while driving seem to conclude that it does contribute to driver distraction. However, while such studies may have a great deal of public support, the industry continues to expand by leaps and bounds. The controversy is one of convenience and productivity versus safety. Interestingly, much of the literature involving public comments reveals a paradox. The majority of people agree that cellular telephone use while driving does indeed cause significant distraction, yet many continue to drive while using their phones.

Most of the news articles and general publicity also seem to reflect the view that cellular telephones have a negative impact on the average driver's ability to safely operate the vehicle. Figure 5 is an example of the media's satirical view on cellular telephone use while driving. In a June 2000 article for HealthScout.com, Neil Sherman writes that "Highway collisions are grim evidence of a nationwide epidemic of distracted drivers…[and the coalition, the Network of Employers for Traffic Safety (NETS), points out that] Driver inattention is estimated to be a factor in between 25 and 50 percent of highway accidents, costing the United States between $40-80 billion annually…That's between 4,000-8,000 crashes every day."(*27*) Despite these and other similar statistics, the convenience of using a cellular telephone while driving appears to outweigh any danger involved. And there are many people who do feel that using the cellular telephone contributes no more to inattentive driving than other in-vehicle distractions.

Figure 5. Example of Satirical Comment in the Media.

[Source: Hitch, David, Editorial Cartoonist for Telegram & Gazette, 12/6/99 (*28*).]

In 1994 and 1995, Prevention Magazine conducted surveys addressing the issue of cellular telephone use while driving. They were published as Auto Safety in America in 1995 and 1996. The magazine claimed that the telephone interviews, conducted by Princeton Survey Research Associates, Inc., were representative of the U.S. population. The studies involved 1260 adult respondents. The usage patterns of the Prevention Magazine respondents shown in Table 9 are very similar to those revealed in the 1997 NHTSA Survey, shown in Table 10, and seemed to reflect that 9 out of 10 cellular telephone owners used their devices while driving (*3*). Tables 11 and 12 reveal survey results regarding distracting activities, other than cellular telephone use, which drivers admit to performing while operating a moving vehicle.

Table 9. Prevention Magazine Survey, 1995.

Frequency of Car Phone Use While Driving	
Response	% of Responses
Most Trips	17%
About Half	10%
Less Than Half	12%
Very Few	46%
Never	15%

[Source: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

Table 10. NHTSA Survey, 1997.

Do You Talk on the Phone While Driving?	% of Responses		
	Male	Female	Total
Most Trips	16	5	11
About Half	10	9	9
Less Than Half	17	12	15
Very Few	49	59	54
Never	7	14	11

[Source: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

Table 11. NETS Survey.

The NETS survey says that out of 1,026 drivers surveyed:

- 70 % talk to passengers,
- 47 % adjust car controls, and
- 29 % admit eating or reading while driving

[Source: Sherman, Neil. "Driving Yourself Distracted…," HealthSCOUT@Yahoo, 6/27/00 (*27*).]

Table 12. Prevention Magazine Survey, 1994.

Distracting Activities Performed While Driving	
Listen to music or news	95%
Drink beverages	71%
Eat	66%
Change tape or CD	64%
Read a map	33%
Talk on Cellular Phone	18%
Comb hair	16%
Put on make-up	14%
Read a newspaper or magazine	6%
Shave	4%

The percentages for each category were generally higher for drivers under 30 years of age.

[Source:: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

As a result of their survey, NETS found that, "distracted driving ranks as [the] fourth most serious driving safety issue, behind drunk driving, aggressive driving and speeding." Their survey further pointed out that "19 percent of drivers…have used a cell phone while driving."(*27*) Similar results were reported by NHTSA in their survey of 660 drivers.

The problem of driver distraction, recognized by safety officials and some law enforcement agencies, is often referred to as "cockpit overload." Not all of them feel hands-free devices are the answer because "cellular phones and other electronic devices occupy a driver's attention even as his eyes are fixed on the road."(*12*) In fact, a European study revealed that, "'most people' answer cell phones in their cars within 2 seconds, which means the phone has priority."(*12*) Mantill Williams, Director of Public Relations for National AAA in Washington, DC, states, "You can have a passenger beside you, or a kid in the back seat…or you can be thinking about a project at work. It's the intellectual distraction that causes the distraction, not the physical devices [cellular telephones] themselves…it's the improper use of the devices that's the problem."(*27*)

CONNECTING USE TO ACCIDENTS: OVERVIEW OF AVAILABLE STUDIES AND LITERATURE

As more and more emphasis is placed on the issue of driver distraction caused by cellular telephone use, there will be more investigation into the subject. The conclusions of most studies to date have included a common thread: cellular telephone use while driving does cause driver distraction, and anything that causes driver distraction is a problem. But therein lie the seeds of controversy, as well as the focus for much research, past, present and future. By what parameters is driver-cellular telephone use judged? How are the possible hazards weighed against the benefits? What are the options for dealing with this problem? If cellular telephone use is distracting, then what about in-car computing? There are a lot of questions, and for every response, more questions seem to arise. However, as with all new discoveries and technological advances, researchers are studying the effects and influences to find answers to the inevitable questions.

As early as 1969, researchers were studying the effects of using a telephone while driving. A report, "Interface Between Concurrent Tasks of Driving and Telephoning," by Brown, Tickner and Simmonds, appeared in the *Journal of Applied Psychology* (*29*). This work, ahead of its time, involved 24 males as test subjects, a closed course track with an instrumented vehicle and hands-free cellular telephones. A precursor for current research, it found that talking on a cellular telephone did adversely affect driving behavior, also noting that the severity depended on other variables such as driver characteristics and the type of conversation.

This particular field of study began to take hold in the late 1980s, following the introduction of the cellular telephone to the general public (1983). However, in the mid-1990s, research into the effects of cellular telephone use became more focused. According to Robert W. Hahn and Paul C. Tetlock, there had been over 20 studies that examine the relationship between cellular telephone use and vehicle accidents by October of 1999, when their paper was published. Studies, largely experimental with some epidemiological background, usually involved control groups, with either laboratory tests, driving simulators, test tracks or courses, or on-road tests (*30*). Their results have relied on observing and measuring test subjects' responses and performances under controlled conditions and comparing them to statistics. However, coming up with accurate background material is difficult at best.

To date, no means of tracking statistics regarding the contribution of cellular telephone use to traffic accidents has been established. Law enforcement officers may suspect or even be positive that cellular telephone use was a causative factor, but they usually have no procedure for documenting the information on accident reports other than making a notation. Most studies have commented on this lack of data and have included in their conclusions, the need for systematic data collection.

All motor vehicle related fatalities that occur within 30 days after crashes, and which are recorded by police reports, within the 50 United States and the District of Columbia are included in a census by The Fatal Analysis Reporting System (FARS). Each year this data file records approximately 40,000 deaths. A total of 36 cases in 1994 and 40 in 1995, listed cellular telephone use as a "possible distraction inside the vehicle."(*3*)

In 1994 and 1995, Minnesota and Oklahoma were the only U.S. states that included data elements relating to cellular telephone use in their police crash reports. As shown in Table 13, the FARS data for those years suggests that over half of the fatalities occurred in Oklahoma.

Table 13. 1994-1995 FARS Possible Cellular Telephone Related Fatalities.

	1994		1995	
State	Frequency	%	Frequency	%
Arizona	1	2.8	0	0
California	3	8.3	4	10
Illinois	1	2.8	3	7.5
Indiana	1	2.8	0	0
Louisiana	0	0	2	5
Maryland	1	2.8	0	0
Missouri	0	0	2	5
New Jersey	0	0	1	2.5
North Dakota	1	2.8	0	0
Oklahoma	21	58.3	26	65
Oregon	1	2.8	0	0
Pennsylvania	1	2.8	1	2.5
Texas	4	11.1	1	2.5
Washington	1	2.8	0	0

[Source: NHTSA's An Investigation of the Safety Implications of Wireless Communications in Vehicles, 1997 (*3*).]

Meanwhile Minnesota showed no cellular telephone or CB radio related fatal crashes for 1994 or 1995. It is probable that the lack of data from states with densely populated urban areas, such as New York, are also attributable to the limited data sources (*3*).

There have been a great many studies done on cellular telephone use and driving, a few of which are mentioned in a bit more detail in this section (for a listing of studies, see the bibliography). No literature review on this topic would be complete however, without including the well-known and often cited study, the "Association Between Cellular Telephone Calls and Motor Vehicle Collisions," by Donald A. Redelmeier and Robert J. Tibshirani. Since its publication in the *New England Journal of Medicine* in February 1997, it has been referred to in articles and studies throughout the world (*7*). In contrast to most studies, it is epidemiologic and involves no actual test results. The study involved 699 drivers who had cellular telephones and had been involved in automobile accidents with substantial property damage but no personal injuries. They examined each driver's cellular telephone use in the week prior to their accident, specifically the day of and day before, and compared that to the time of the accident. They concluded that using a cellular telephone while driving multiplied the risk of having an accident by four. However, it suggested that any regulatory measures should be weighed against individual responsibility as well as technological benefits.

A series of reports on the subject of cellular telephone use, based on public opinion surveys of consumers regarding their cellular telephones and service, have been commissioned by CTIA. Surveys have been conducted and results reported by Peter D. Hart Research Associates every year, beginning in 1996. These papers provide useful demographic material concerning use of cellular telephones for marketing.

The topics for the Hart Research reports are:

- 1996 – Attitudes Toward Wireless Phones (*31*),
- 1997 – Competition in the Wireless Market (*32*),
- 1998 – The Evolving Wireless Marketplace (*4*),
- 1999 – Dynamics and Trends in the Wireless Marketplace (*33*), and
- 2000 – The Wireless Marketplace in 2000 (*11*).

(These Hart Research papers may be accessed via the CTIA website: [http://www.wow-com.com/search.cfm])

Considering the controversy over whether or not to impose regulations on cellular telephone use, more research is being conducted on the subject. One such report published by Hahn and Tetlock in October 1999, "The Economics of Regulating Cellular Phones in Vehicles," offers "an economic analysis of regulatory options for addressing cellular phone usage by drivers of vehicles."(*30*) The study concludes that, "banning drivers from using cellular phones is a bad idea." They suggested that banning cellular telephone use was unlikely to prove beneficial for three reasons:

1. Costs of a ban are likely to exceed benefits by more than $20 billion annually.
2. If regulations are enforced, drivers may simply switch to other risky behaviors.
3. Technology is already moving in the direction of voice activation, which is likely to reduce risks.

They further suggest that "less intrusive regulation" such as a hands-free device mandate would fail to be economically sound. They recommend instead, the government focus on gathering systematic information to improve estimates of the number of accidents and fatalities associated with cellular telephone use.

The Hahn-Tetlock study is cited in another recent publication, which states, "The risks [of using a cell phone in a car] appear to be small compared to other daily risks in life."(*30*) The study, released July 24, 2000, was funded by AT&T Wireless and analyzes the dangers of cellular telephone use on the road. It follows a government hearing on the phoning-while-driving danger. This risk-benefit study by the Harvard Center for Risk Analysis estimates that a driver talking on a cellular phone has a six in one million chance of dying in an accident each year compared to a 31 in one million chance for a person who drives drunk. It further notes that U.S. traffic fatalities continue to decline, even as cellular telephone use grew 17-fold from 1990 to 1998, as revealed in Figure 6 (*34*).

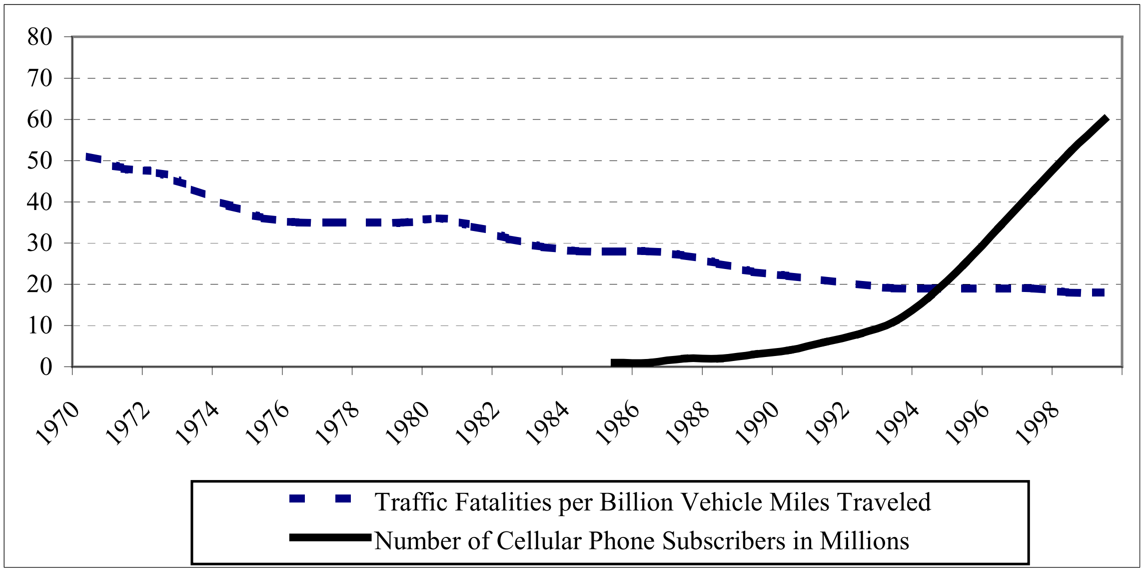


Figure 6. US Traffic Fatalities per Billion Vehicle Miles Traveled and US Cellular Phone Subscribers in Millions, 1970-1999.

[Source: "Cellular Phones and Driving: Weighing the Risks and Benefits, " The Harvard Center for Risk Analysis, 7/24/00 (*34*).]

The study also emphasizes the benefits of cellular telephone use on the road. Donald A. Redelmeier believes that because the Harvard Study was funded by a phone company, observers may consider it biased. However, Karen Lissy, director for the Program on Motor Vehicles and Public Health at Harvard Center for Risk Analysis, says "the study was reviewed by many leading researchers, including Redelmeier."(*35*)

Another recent report on driver-cellular telephone use is "The Influence of the Use of Mobile Phones on Driver Situation Awareness," by Andrew Parkes and Victor Hooijmeijer (*36*). This paper focuses on how individual driver characteristics affect reaction and awareness while on a cellular telephone. In the introduction, after pointing out how difficult legislature has been on this issue worldwide, it states that, "At one point, it looked as though the problem for legislators would become easier…it seemed that the market was leading toward…[integrating] well-designed hands-free telephones into their vehicles…Unfortunately the market has gone in a different direction…So the use of handheld devices is actually increasing."(*36*) It acknowledges that, until more specific data is available, legislation will likely concentrate on handheld devices only—an important, but incomplete approach to the problem.

With all the interest concerning the effect of cellular telephone use on driver attentiveness, it is not surprising that the federal government has funded a great deal of research. The National Highway Traffic Safety Administration (NHTSA) has performed numerous studies for the Federal Highway Administration (FHWA)(*37*). Their well-known, thorough research has provided the groundwork for much of the work done by other researchers. NHTSA's studies began with *The Truck Driver Workload Study*, which took place from 1992 to 1995 by Tijerina, Rockwell and Tornow (*38*). "Its major objectives were to establish a relationship between workload and safety and develop workload assessment methods to determine safety implications of the use of in-vehicle technologies while driving."(*37*) The tools developed in this project are widely used by researchers today.

NHTSA's second project in this field, and possibly the most widely known and cited, is *An Investigation of the Safety Implications of Wireless Communications in Vehicles,* published in 1997 (*3*). Compiled by Goodman, Bents, Tijerina, Wierwille, Lerner and Benel, it is very thorough and has been an excellent source for following research. This report "assessed the current state of knowledge with respect to the impact of wireless phone use while driving and explored the broader safety implications of phone use while driving…the report concluded that the use of wireless phones did increase the risk of a crash, 'at least in isolated cases.'"(*37*) This project encouraged changes in data collection methods to improve the ability to estimate the amount of risk involved, and "to assist the public, the states, and industry in making informed decisions about how and when to combine wireless phone use and driving."(*37*)

Recently, NHTSA has begun experimental research into the distraction potential associated with route navigation systems. They have approached the research from three angles (*37*):

1. *Destination Entry Study*: concluded that manual destination entry while driving is ill-advised.
2. *Individual Driver Differences Study*: concluded that drivers who differ in eye-hand coordination capabilities will differ in their rate of interaction with in-vehicle technologies, affecting their risk factors.
3. *"15-Second Rule" Study*: concluded that the rule itself--a recommended time frame in which an in-vehicle task can be completed safely while the vehicle is in motion, developed by The Society of Automotive Engineers (SAE)—and the ideas behind it, may suggest areas for improving the development of objective test procedures for a variety of ITS information systems.

Other current research by NHTSA includes two studies that focus on questions related to driver distraction. One is an AutoPC Test Track Study, to compare voice versus visual/manual interfaces and assess the distraction potential of selected AutoPC transaction. Another is a Wireless Telephone Interface Study to conduct long-term naturalistic studies, in which subjects are given instrumented vehicles to use for extended periods of time (*37*).

Future research being developed by NHTSA includes the most technically advanced driving simulator in the world. The National Advanced Driving Simulator (NADS) will provide a unique tool for a wide range of driver-vehicle-environment research, including those related to driver distraction. NHTSA is also sponsoring research into night vision systems, to investigate the trade-off between increased object recognition and driver distraction (*37*).

LEGISLATIVE EFFORTS

There has been much speculation about how to effectively approach the growing problem of driver-cellular telephone use. Out of this speculation, another controversy has emerged, centering on the issue of whether or not cellular telephone use should be regulated through legislation. Even among those who support regulation, it is not clear just how it could be accomplished.

Cellular telephone use has been regulated in some other countries, and by the close of 2000, legislation had been proposed in at least 22 of these United States. But the success of such regulatory attempts has been very slight. "Because so few states regulate wireless telephones in motor vehicles, it is very difficult to measure the effectiveness of state legislation."(*39*)

According to the *1999 State Legislative Update,* "several recent studies correlate driver use of cellular telephones with an increased risk of crash." (Redelmeier and Tibshirani, and NHTSA studies, both in 1997, were cited among others.) Moreover, future developments in telematics, such as navigation systems and fax machines, could further intensify driver distractions, increasing the risk of accidents (*40*). An article in *The Urban Transportation Monitor* (11/26/99) claims that study results show hands-free cellular telephones are just as dangerous as handheld units. Also, because a 15 minute "zone of risk" remains even after a call, pulling over while on the phone does not help either (*41*).

Proponents of such studies argue that, "phones are no more distracting than a radio, food, or vanity mirror…[and] people who drive carelessly while using a car phone should be covered by the same reckless driving laws as any other driver."(*40*) However, as more reports of near misses with drivers using cellular telephones surface, the pressure on lawmakers mounts for legislation that specifically restricts cellular telephone use in automobiles.

Worldwide, as of 1997, 13 countries had passed laws banning the use of cellular telephones while driving (*30*). In 2000, a ban was begun in Germany on cellular telephone use while driving, except for hands-free units (*41*). Russia also passed legislation in March 2001. In response to an Internet Forum last year (2000) on whether or not to regulate cellular telephone use, four foreign responders supported bans, in the US and in their own countries: Melbourne, Australia; Vienna, Austria; Oxford and Bristol, England (*41*). In their report, Hahn and Tetlock included the following information in Table 14, compiled from data found in NHTSA's 1997 report.

Table 14. Legislation in Other Countries.

Country / State	Legislation	First Year Proposed
Australia	Ban handheld phones	1996
Australia / New South	Ban handheld phones	1935
Australia / Victoria	Ban driver use of all types of phones	1988
Brazil	Ban handheld phones	N/A
Chile	Ban handheld phones	N/A
England	Ban handheld phones, Strict inattentive	1992
Germany	Ban handheld phones	N/A
Israel	Ban handheld phones, Strict inattentive	1970
Italy	Ban handheld phones, Strict inattentive	N/A
Portugal	Ban handheld phones	N/A
Philippines	Ban handheld phones	N/A
Russia	Ban handheld phones	N/A
Singapore	Ban handheld phones, Ban phones in public service vehicles, Strict inattentive driving	N/A
Spain	Allows headset or earpiece use	1990
Switzerland	Ban handheld phones, Strict inattentive	1996

[Adapted from Source: Hahn, Robert W., and Tetlock, Paul C. "The Economics of Regulating Cellular Phones in Vehicles," 10/99 (*30*).]

In the United States, since 1995, over 100 bills banning the use of handheld cellular telephones while driving have been proposed. All of these bans have failed, due mainly to the difficulty of enforcing such laws (*43*). As of early 1998, 18 states had proposed legislation to improve data collection, as well as placing prohibitions on the use of handheld units while driving (*39*). The *1999 State Legislative Update* states that, "In 1999 alone, 15 states proposed measures to restrict cellular telephones in motor vehicles. Legislation varied in severity from proposals that would ban all use in vehicles, to requirements for hands-free devices, phone call length restrictions, requirements to keep one ear free, solicitation restrictions and improved data collection." Although, at the time that report was published, none of the state bills had passed (*40*). A spokesperson for AAA says, "Its easier for municipalities to pass laws…[because] cities have more flexibility…can move faster…and they're more easily swayed."(*44*)

Table 15 lists laws and proposed legislation in the U.S. as of 1997 regarding the regulation of cellular telephone use while driving. Following the table are various articles on legislation in the U.S. found in currently available literature.

Table 15. State Laws and Proposed Legislation for Regulating Cellular Phones in Vehicles.

State	Legislation	Proposed Legislation [a]	Year [b]
California	Safety information	Ban on handheld	1987
Colorado		Discourages negligent phone use	1998
Connecticut		Ban on handheld	1999
Delaware	Inattentive driving law [c]		1996
Georgia		Ban handheld, Discourages negligent use	1997
Florida	One ear free to hear		1992
Hawaii		Ban handheld	1995
Idaho	Inattentive driving law		1996
Illinois		Ban handheld	1997
Iowa		Total ban [d]	1997
Louisiana		Data collection	1999
Maine		Ban handheld	1999
Maryland		Total ban	1999
Massachusetts	One hand on wheel		1990
Minnesota	Data collection		1991
Nebraska		Total ban	1997
Nevada		Total ban	1995
New Jersey	Data collection	Total ban	1996
New Mexico	Inattentive driving law		1996
New York	Data collection	Total ban [d], Ban handheld, Warning labels	1996
Ohio	Inattentive driving law	Total ban, Data collection	1997
Oklahoma	Data collection		1992
Oregon		Total ban, Ban urban, Ban handheld, Data	1997
Pennsylvania		Ban handheld, Inattentive driving law	1995
Rhode Island		Ban handheld	1999
Texas		Total ban, Ban handheld	1999
Utah		Total ban [e], Inattentive driving law	1998
Virginia		Ban handheld, Ban phones in school buses	1995
Washington		Allow headset / ear-piece	1996
Wisconsin	Inattentive driving law	Total ban	1995

[a] Proposed legislation may refer to more than one piece of legislation. Bans refer to bans on handheld cellular phone use in moving vehicles, exempting emergency calls.
[b] Identifies the year in which legislation was first proposed or adopted.
[c] All States have inattentive driving laws. These States were judged to have strict laws in accordance with NHTSA (1997).
[d] Allows a grace period of two minutes for pulling off to the side of the road.
[e] Utah's ban proposal would exempt phones with voice-activated technology.

[Sources: NHTSA (1997), State Net search through Lexis and personal communication with ComCARE Alliance (1999). Cited in Hahn and Tetlock, "The Economics of Regulating Cellular Phones in Vehicles," October 1999 (*30*).]

Lincoln, Nebraska, was the first state to consider traffic laws regarding cellular telephone use. Introduced in 1997 by Senator LaVon Crosby, the bill was killed by the Transportation Committee because it would be too difficult to enforce. The law would have assessed a small penalty on anyone involved in an accident police attributed to cellular telephone use. When this bill was proposed in 1997, five other states had provisions (Colorado, Florida, Massachusetts, New Mexico and West Virginia, according to this article), and New York had legislation pending as well. In Nebraska, following the failure of this proposed bill, a fatality accident occurred as a result of a driver distracted by cellular telephone use (*45*).

The ambitious bill proposed in 1997 in New York also failed. The bill was proposed by Senator Stavisky of Queens. This piece of legislation had proposed: fines in excess of $200 (3rd offense) for drivers using cell phones committing a traffic infraction; a 60 second "grace period" to make or receive calls before safely pulling off road and parking; provisions for lone drivers in emergency situations; and all handheld cellular telephones sold, leased or rented in Queens would be required to have a notice affixed regarding restrictions (*46*).

In California, a bill proposed by State Senator John Burton in 1997 was "tabled to allow time for research". That year, a compilation of California Highway Patrol studies determined that "eating, using a radio, and reading a map are all as dangerous as using a phone."(*47*)

In January 1998 The Colorado House Transportation Committee, on a 9-1 vote, killed a bill to increase driver's license penalty points for infractions involving the use of cell phones from four to five years for "careless driving."(*48*)

By March of 1998, Congress had enacted no statute or mandate governing wireless telephones in automobiles. "Traffic laws and enforcement are traditionally part of state law…federal government may impose mandates regarding traffic safety issues…[but] plays no active role in traffic enforcement."(*39*) While every state prohibits reckless or careless driving, none specifically prohibit cellular telephone use by drivers. In 1998, five states (California, Florida, Massachusetts, Oklahoma and Minnesota, according to this article) imposed minor restrictions that required police to record data about cellular telephones in accident reports. Such "changes in data collection and reporting clearly offer promise for increased understanding of the relationship between cellular telephone use and vehicle crashes."(*39*)

Legislation to prohibit use of mobile telephones while driving proposed in Harrisburg, Pennsylvania in January 1999 also failed to pass (*49*). However in December of that same year, in the township of Hilltown, Pennsylvania, "officials, reacting to the death of a 2-yr-old girl in a traffic accident…passed a measure prohibiting motorists from using handheld cell phones."(*50*)

Also in 1999, a bill was filed by Democratic House Representative Paul Moreno of El Paso, Texas, after he was almost hit by a "talker-drivers." He did not expect the bill to prohibit cell phone use to pass because "It's hard to beat the argument that driving and talking saves time…[Rep. Moreno said he was] 'just trying to save lives.'"(*51*) Rep. Moreno also says the bill failed because of lobbying by telephone industries (*52*).

The first law regulating cellular telephone use to pass was in Brooklyn, Ohio in March of 1999. If caught talking, drivers are charged with a misdemeanor and fined. This was the same community that pioneered seatbelt regulations (*53*). The ordinance was proposed five weeks after the Brooklyn police chief was hit by a driver talking on a cellular telephone. Brooklyn Mayor Coyne stated that "Government is not in the business of taking away personal freedoms, but sometimes it must act responsibly."(*47*)

In response to the Brooklyn, Ohio ordinance, a spokesman for CTIA said, “We’re a new technology, an easy target…there are laws to go after distracted drivers, whether they misuse a whopper or a map.” Even Dear Abby devoted a column to the issue of driver distraction due to cell phones (*54*). “Some states once drafted legislation to ban radios from cars…[and] when windshield wipers were first introduced…” people thought they were too ‘hypnotic.’(*55*) In spite of the defensive remarks from the wireless industry, Mayor Coyne says he has responded to more than 60 requests nationwide, for details on Brooklyn’s legislation (*56*).

A year and a half after the ordinance was passed in Brooklyn, the township of Marlboro, New Jersey, voted to ban drivers from using handheld phones. This came two days after a Pennsylvania judge ruled that Hilltown, Pennsylvania, “could not pre-empt state motor vehicle laws.”(*57*) Only the second community in U.S. to ban the use of handheld cellular telephones while driving, Marlboro, population 34,000, is located between New York and Philadelphia, and has four state highways running through it. It was noted that, while lawmakers “can’t legislate common sense” this would hopefully be a good preventive measure against the rise of cellular telephone use. However, “to be effective…the rest of the state [would] need to get involved in the enforcement.”(*58*)

In spite of these small but significant successes, some communities have “no appetite for any bill that would ban cell phone use.” Republican House Representative Reed Hillman, former head of Massachusetts State Police, said in August of 1999, no legislation is pending for Massachusetts. This was attributed to the “lack of data connecting cell phone use to accidents,” and “state legislators also point out that the pervasiveness of the technology may be a factor in preventing an outright ban.”(*59*)

In April of 2000, The Colony, a small Texas town near the Dallas/Fort Worth Metroplex, proposed an ordinance to ban drivers from using handheld phones. City Councilman, Jeff Meyers called the proposal a “knee-jerk reaction” to a council official’s death in an accident which police suspect was caused by his cell phone use. Emotional debates erupted what some people considered attempts to try to “regulate the way people act.” “Police already stop and cite motorists for driving erratically…” regardless of what is causing their behavior. According to Meyers, an ordinance would mean that drivers would be stopped if police saw them on a cellular telephone, even if their driving were normal. The local *Star-Telegram* Newspaper ran a poll, “Should the use of cellular telephones be restricted while users are driving?”, in May following the proposal (*60*). The poll results indicated that about 58 percent of county residents supported some type of regulation, 46 percent being cellular telephone users. In spite of the support, Meyers expected the ordinance to fail, which it did (*52*).

The data listed in Table 16 were included in a *1999 State Legislative Update* concerning cellular telephones and driving, and reveal the status of the issue in 1999.

Table 16. 1999 State Legislation.

State	Type of Legislation	Bill Status *(as of August 1999)*
Connecticut	HB 5177: Prohibits handheld devices. HB 6314: Develops guidelines for cell phone use. SB 612: Prohibits handheld devices.	All three bills failed the joint favorable deadline and died in committee.
Georgia	HB 310: Requires exercise of due care with mobile telephones.	Carried over to next session.
Illinois	HB 1363: Requires hands-free device.	Carried over to next session.
Louisiana	HB 1151: Authorizes cell phones on school buses. SB 352: Requires Dept. of Public Safety and Corrections to collect and publish data on cell phone use in crashes.	Both bills died in committee.
Maine	HB 68: Prohibits handheld devices.	Recommended ought not to pass.
Maryland	HB 37: Prohibits driver from using cell phone in motor vehicle that is in motion.	Reported unfavorably.
Nevada	AB 328: Prohibits person from using portable telephone while operating moving motor vehicle.	Died in committee.
New Jersey	AB 2694: Prohibits use of car phone while driving.	To Assembly Committee on Transportation.
New York	12 cell phone bills proposed in 1999 would prohibit cell phone use while driving, prohibit handheld devices, require studies on the danger, require information in accident reports, and require warnings about dangers. ABs 50, 1435, 2302, 3016, 3684, 4361, 4947, 5838, 6120; and SBs 1435, 1767, 2134	Many bills still pending.
Ohio	HB 251: Prohibits use of cell phone while driving.	Died in committee.
Oregon	HB 2616: Prohibits use of handheld device. HB 3262: Requires information on accident report. SB 478: Creates offense of driving while using mobile telephone.	All died in committee.
Pennsylvania	HB 395: Prohibits handheld device.	To House Transportation Committee.
Rhode Island	HB 5573: Prohibits handheld device.	Held for further study.
Texas	HB 994: Creates offense of driving while using mobile telephone.	Died in committee.
Virginia	HB 737: Prohibits school bus drivers from using cell phones while operating a school bus.	Died in committee.

[Source: "Cell Phones and Driving: 1999 State Legislative Update," National Conference on State Legislatures: Environment, Energy and Transportation Program, 8/99 (*40*).]

A recent article on Yahoo.com's *HealthScout* News site claims, "A Gallup Poll says about two-thirds of Americans support outlawing cell-phone use on the road. Half of those…would ban them in restaurants too."(*35*) Peter Laufer, editor of *Wireless Etiquette* says, "People who tend to be rude and discourteous in life are often rude and discourteous with mobile phones."(*61*) In response to this discourtesy, which sometimes results in "phone rage" toward the users, requests rather than bans are being established in some public areas. "New technologies require new etiquette," and "Phone Free Zones" are being designated in theatres and restaurants. Some theatres hand out glow in the dark cards to patrons who receive or place calls, asking them to turn their phones off. Others use screen slides, which tell users to either turn their phones off or silence the ringers (*62*). A New York restaurant was one of the first to designate a “cell phone lounge” for people who are determined to use their cellular telephones, so they can do so without disturbing other patrons. “Cell phone rudeness has become diners’ top complaint at one restaurant.” This new addiction causes “ear pollution” and seems to have become “the cigarettes of the ‘90s.”(*63*)

The debate over whether or not the government should impose regulatory measures on cellular telephone use is not likely to disappear any time soon. Matt Sundeen, transportation policy specialist for NCSL (National Conference on State Legislatures), receives as many as 20 calls a day asking for information about the issue of driver-cellular telephone use (*43*). As time passes however, some of the issues are becoming more defined. Legal restrictions have not had much success because, even if such laws were passed, they would be difficult to create (too many exceptions would be needed) and almost impossible to enforce. Regardless of their conclusions on the use of cellular telephones while driving, most studies done to date have at least acknowledged the problems with legislation. With few exceptions, researchers report that, until there is a system established to collect and record information regarding cellular telephone use and driving, no clear, reliable conclusions can be drawn. In October 1999, only four states—Oklahoma, Minnesota, Tennessee and New York—required data collection regarding cellular telephone use and accidents. (See Table 16)

Another impediment to passing regulations is the considerable support of cellular telephone use by the wireless industry. For example, an ordinance was passed in Aspen, Colorado, but shelved a month later because wireless companiesAT&T, Sprint and US Westpromised to start an education campaign encouraging drivers to use hands-free systems. This occurred in spite of the fact that a survey of 1,000 Colorado residents by AAA revealed that 90% supported legislation (*43*).

In contradiction, a very recent (September 2000) turnover in the driver cellular telephone controversy found Verizon Communications, the largest provider of cellular telephones in the U.S., supporting laws that would ban handheld cellular telephone use while driving. Verizon’s break from the industry occurred simultaneously with the postponement of an ordinance vote in Chicago. If passed, the ordinance would make Chicago the largest U.S. municipality yet to make it illegal to talk on a cellular telephone while driving. Fines up to $100 could be assessed if the use of a cellular telephone was determined by law enforcement to have contributed to an accident. The law would also allow drivers to use “hands-free” cellular devices, an act which actually contradicts an Illinois State law that bans the wearing of any type of earphones while driving. Verizon would support repeal of the State law governing earphones. Then they would “lobby for passage of a state-wide ban on anything but ‘hands-free’ cellular use by drivers… [suggesting] phasing in the law over 3 yrs to allow the market to modernize and make hands-free devices even cheaper.”(*42*)

In response to the debate over whether or not to legislate and the call for more data on the subject of driver-cellular telephone use, federal highway safety regulators began a series of public hearings on what, if anything, should be done. In addition, USDOT (United Sates Department of Transportation) and NHTSA set up an ongoing *Driver Distraction Internet Forum* on the subject, which began July 5, and ran through Aug. 11, 2000 (*64*). During that period, anyone could access the site and review the information, which included links to various studies. They could then choose from several discussion areas and read other people's comments as well as adding their own points of view. The site is still accessible at [www.nhtsa.dot.gov] and, though it is no longer interactive, all the information, including the comments of those who participated, can still be read (*65*).

Another Internet forum, *ZDNet News Talkback* invited public comments on the issue of cellular telephone use restrictions while driving (*42*). Following are some of the comments:

<u>Against ban:</u>

- "How about higher insurance rates if you have a cell phone of any type? If I look at an e-mail on my wireless PDA while I'm at a stop-light, I'm breaking the law. Lawmakers are two steps behind technology."
- "It would be better for police to arrest drunk drivers and other criminals…and enforce the seat belt and child seat law. Let's not create laws just to create them, let's enforce the ones that already exist regarding hazards to driver safety."
- "Some people can use a cell phone while driving without endangering themselves or those around them. People who can't should know and act responsibly. Instead of banning cell phone use, the fine for (any) driver distraction should be much greater. A law that prohibits cell phone use but allows other forms of distraction is discriminatory."
- "You can't pass a law against stupidity."
- "If I couldn't use it in the car, I wouldn't need my cell phone. The wireless industry would lose $50 a month from me and others. That should be taken into account."

<u>For the ban:</u>

- "I work for AT&T wireless, but I support Verizon. If you are using public roads you have a responsibility to use them safely, not selfishly."
- "They are missing the point when they allow hands free cell phones. Talking on the phone distracts drivers, and cell phones in autos should be banned completely."
- "There is no data because nobody actually reports at the scene of an accident if cell phones were probable cause. Manufacturers are pushing hands free as a panacea it is not, the biggest problem is the mental distraction."
- "People eating, putting on makeup or shaving will stop what they are doing faster than someone on the cell phone will stop talking and put down the phone. How do you shift a manual transmission while holding the cell phone to your ear? Unless they are an exception to human nature: many people are not as careful as we would wish; and it is very difficult to be an independent observer of their own actions.
- "Roads are for transportation, not communication."

A recent article in *Popular Science* magazine (October 2000) supports the view that legislation is not the answer. It states the idea that current "high tech distractions will simply replace traditional ones." According to the author, Chris O'Malley, "…the man-machine relationships we enjoy with our vehicles is a complex one and not given to easy cause-and-effect interpretations."(*66*)

As was shown in Tables 15 and 16, most of the attempts to pass legislation regulating cellular telephone use while driving have failed. This is evidence that a great deal of uncertainty exists about whether or not there is a problem and, if there is, how it should be handled. It is an issue that weighs the considerable benefits of the technology against the possible dangers to the driving public. Even among those who believe that driver-cellular telephone use is definitely hazardous, it is not clear whether or not legal restrictions are the appropriate solution. In fact, research often recommends against government regulation, at least until more reliable data can be collected. "When all the benefits and risks are considered, limiting cell-phone usage may not be as cost effective as other measures [such as]…reducing the speed limit and installing daytime running lights. For each life saved because of new anti-cell-phone laws, society may lose $700 thousand worth of benefits."(*35*) Judging from the growing number of wireless subscribers, such values and priorities today seem centered more on the benefits of cellular telephone use, than the possible dangers of using them while driving. As research continues to develop better information-gathering techniques and examine the results, other solutions for dealing with the problem of driver-cellular telephone use are needed. The following Tables 17 and 18 show some of the cost estimates regarding cellular telephone regulation.

Table 17. Benefits and Costs of Policies Regulating Cellular Phones in Vehicles.

Ban the Use of Cell Phones While Driving

	Best Estimate	*Range* [a]
Benefits	*$1,200*	*$110 to 21,000*
Costs	*$25,000*	*$10,000 to 87,000*
Net Benefits [b,c]	*($23,000)*	*($87,000) to 6,800* [d]

Mandate Hands-Free Devices

	Best Estimate	*Range* [a]
Benefits	*$180*	*$0 to 6,300*
Costs	*$410*	*$100 to 600*
Net Benefits [c]	*($230)*	*($600) to 6,200*

[a] Ranges are determined by taking maximum and minimum values of key parameters.
[b] Numbers in parentheses are negative.
[c] Number may not add due to rounding.
[d] The upper bound on benefits and the lower bound on costs cannot occur at the same time because they assume different levels of penetration. $6,800 represents the maximum net benefits when the penetration rate in the cost and benefit calculation is the same.

[Source: Hausman (1997), NHTSA (1996, 1997, 1998, 1999). Cited in Hahn and Tetlock, "The Economics of Regulating Cellular Phones in Vehicles," 10/99 (*30*).]

The Harvard Study on cellular telephone use risks and benefits included this table of cost comparisons:

Table 18. Cost Effectiveness of Selected Highway Safety Investments.

Intervention	***Target Population***	***Net Cost Per Life-Year* Saved***
Lap/shoulder belts (assuming 50% use)	*Front seat occupants*	*< $0*
Daytime running lights	*All motor vehicles*	*< $0*
Front-crash airbags	*Drivers only*	*$24,000*
Front-crash airbags	*Front-right passengers*	*$61,000*
Side door beams	*Light trucks*	*$53,000*
55 mph speed limit (compared to 65 mph)	*Rural interstate travelers*	*$82,000*
Add shoulder belts to lap belts in back seat (assuming 9% usage)	*Passengers in rear outboard seats*	*$160,000*
Cellular phone restrictions	*All drivers*	*$700,000*
Add shoulder belts to lap belts in back seat (assuming 9% usage)	*Passengers in rear center seats*	*> $2,400,000*

*Life-years saved have been adjusted to account for both longer life expectancy and improvements in quality of life due to reductions in functional impairment due to trauma. The adjustments are based on the quality-adjusted life year (QALY), a preference-based system that accounts for trauma severity and the subjective health preferences of consumers for quality of life. [Source: Harvard Center for Risk Analysis. "Cellular Phones and Driving: Weighing the Risks and Benefits," for AT&T Wireless Communications, July 24, 2000 (*34*).]

Other Solutions

Despite the growing evidence to support the idea that cellular telephone use while driving can be dangerous, the advantages are too seductive for most people to resist. The literature available today reflects the importance of this issue and its potential. With the advances in technology bringing out new ways to increase the productivity and efficiency of our busy society, "wireless telephone use among drivers will continue to [increase, and] state legislatures will be…challenged to balance safety…against…benefits."(*40*) Measures to improve data collection are being considered, as well as "ways to link cellular telephones to insurance and tort liability, and restrict use of wireless telephones in motor vehicles. Future proposals might improve driver education, increase investment in research and development, and limit driver cellular phone use."(*40*)

The study by Hahn and Tetlock published in October 1999, which analyzes the economics of regulatory options regarding driver-cellular telephone use, concludes that banning drivers from using cellular phones would have negative results. Though uncertainties surround the issue, they estimate that the "costs of a ban are likely to exceed benefits by more than $20 billion annually." They further suggest that, "less intrusive regulation, such as requiring the use of a hands-free device" is not likely to be "economically justified." According to this study, legislation banning or restricting cellular telephone use in automobiles would probably fail to provide overall positive results for three reasons:

- Costs are likely to exceed benefits.
- Estimates of net reductions in accidents and fatality might be overstated because they do not take into account how drivers would alter their behavior in response to regulation [drivers could resort to other risky maneuvers].
- Technology is already moving in the direction of voice activation, which is likely to reduce risks.

Hahn and Tetlock suggest that, rather than regulating, federal government and state agencies "should collect more systematic information…to improve estimates of the number of accidents and fatalities associated with cellular phone use." They further recommend assessing the "benefits and costs of introducing promising new technologies that could reduce the risks of accidents associated with drivers using cellular phones in vehicles. As a result of their study, Hahn and Tetlock estimate that there are approximately 100 deaths related to collisions caused by cellular telephone use each year in U.S., and that number could continue to rise as cellular telephone use increases (*30*).

In an Associated Press news release October 17, 2000, regarding safety concerns over new, in-car computer systems, Paul Green, a senior research scientist at the University of Michigan Transportation Research Institute, said, "'At this point, safety and human factors efforts lag far behind electronics development…If action is not taken a significant number of information system-related deaths and injuries will result.'"(*67*) The manufacturers are touting voice activation as a remedy for driver distraction. However, "a number of papers being presented at Convergence 2000, a convention for the auto electronics industry, suggest that voice-controlled systems pose serious safety concerns."(*67*) GM President, Larry Burns says more research is needed because "'driver distraction is different under different workloads.'"(*67*)

With the increasing number of automobiles on the road, the number of driver-cellular telephone users is also growing. These "wired" drivers cover a wide demographic range, and their ability to multitask safely also varies widely. One of the arguments against legislation focuses on the variance in driver capabilities. The same law that might prevent unsafe driving behavior by some, may also deny other, more capable drivers of the benefits of technology they can safely operate. One measure that could potentially meet the varying needs of drivers would be education.

Many people feel that one of the best ways to reduce the negative impact of cellular telephone use on drivers is through education. Internationally, this approach ha already begun. In February 2000, the Netherlands began a campaign to "raise awareness among motorists of the risks of using mobile telephones while driving." The slogan, "hands free phoning is safer" is being used on roadway signs, radio spots, brochures, and an Internet site in attempts to adjust driver behavior (*68*).

In the United States, the idea of educating people about the possible hazards of cellular telephone use while driving is beginning to gain interest. The National Public Services Research Institute has developed an online Internet test to help drivers realize the possible hazards of driver-cellular telephone use, called "Cell Phones and Driving, How Distracted Are You?"(*69*) This test takes into account that every driver is unique in their capabilities as well as their vehicle and its features. The test asks for variables such as age, driving speed and telephone usage to help predict the driver's ability to respond to hazardous driving situations. The test is designed to help drivers understand the complex relationship between driving and cell phone usage by estimating their response to unexpected road conditions such as construction, traffic jams and signals (*69*).

In July 2000, a nationwide campaign for public awareness was launched in the U.S. by the Coalition, a Network of Employers for Traffic Safety (NETS). Their campaign proposes a training and education program to develop tools for managing the growing problem of driver inattentiveness (*27*). To help drivers focus on the important task of driving, NETS teamed up with AT&T Wireless Services and Motorola to develop a plan to educate drivers on strategies and techniques for dealing with potential distractions. The NETS program can be used by driver training instructors, employers, and highway safety organizations, and the training materials will be dispersed by means of the media and NETS members, including employers, the highway safety community and government agencies. "Millions of Americans take advantage of the convenience, safety and value offered by mobile wireless communications, but they must exercise good judgment."(*70*) NETS, founded in 1989, "is a public-private sector partnership dedicated to reducing traffic deaths and injuries in the nation's work force. By helping employers implement well-developed policies, dynamic workplace-programs and compelling community activities related to traffic safety, NETS enhances the quality of life and significantly reduces the cost of doing business for member organizations."(*70*)

Education is probably the most practical solution for reaching one particularly high-risk group. According to the Academy of Pediatrics, "Traffic crashes are the leading cause of death for teens and young adults. Drivers who are 16 years old are more than 20 times as likely to have a crash as are other drivers."(*71*) The two major reasons teens are at a higher risk are:

1. Lack of driving experience—Teens drive faster and do not control the car as well as more experienced drivers, and their judgment in traffic is often insufficient to avoid a crash.
2. Tendency to take risks while driving—Teen drivers are more likely to be influenced by peers, stresses and distractions, which can lead to reckless driving behaviors such as speeding, driving while under the influence of drugs or alcohol, and not wearing safety belts.

State and local laws, safe driving programs, and driver education classes all help contribute to safety of teenage drivers by teaching them that "driving is a privilege and a big responsibility."(*71*)

Throughout driver education history, however, debate has focused on the dilemma over what to include in the curriculum. According to Maurice Dennis, Ph.D., of Texas A&M University, two schools of thought exist. The first theory is that any activity not consistent with sound decision making and safe vehicle handling (i.e., drinking and driving, or the use of a stereo or telephone) should not be included in the curriculum. Classroom instruction on these topics would support a "do not" perform approach. A second theory is that, if drivers are likely to perform activities which have the potential to cause safety problems, driver education teachers should address them. It is unrealistic to ignore actions or decisions which may take place in spite of a "just say no" approach. Classroom instruction *about* these topics does not translate into support *for* them (*72*).

The Redelmeier/Tibshirani study in 1997 found persons at risk related to cellular telephone use and accidents include: "young drivers; drivers with less than 9 yrs. driving experience; or those with less than 1 year of cellular telephone use experience."(*30*) Those characteristics commonly describe young drivers who take driver education courses. Instructors of such courses realize "the leading cause of accidents is human error related to improper look out, speed, inattention, improper evasive action, and internal distractions."(*73*) Various methods have been used in driver education courses to "prepare young drivers to deal with inattention, distractions, etc. with varying measures of success."(*72*)

It was noted that the easiest way to protect young drivers would be to ban cellular telephone use completely, or at least while the vehicle is in motion. However, the growing use of cellular telephones and similar devices may cause public opinion to outweigh safety concerns. Therefore driver education programs "can and should incorporate basic safety information related to mobile phone use."(*72*) Courses should teach basic principals, instruction on the use of the devices, and present information on the increased risk of accidents. Since the latter data is limited and studies are ongoing, such information should be monitored and updated frequently. This is not to say that young drivers are the only ones who need education. Most drivers seem to fall "within a normal experience level."(*72*) Nevertheless, experience itself has shown that nothing should be taken for granted and that "even seemingly simple information must be taught concerning safety."(*72*)

CONCLUSION

The debate on whether or not to regulate cellular telephone use by drivers is not likely to be settled in the near future. There is a great deal of argument on both sides. While some people have lost loved ones to irresponsible drivers talking on cellular telephones, "sympathy rarely is the basis for sound legislation." On the other hand, "how much technology behind the wheel is too much?"(*66*) Charles Hamlin, President of Insight Express, which claims to be the world's first fully automated, online market research service, says, "'This is clearly a situation where people believe common sense, not government regulation, should be the guiding factor.'"(74) Another article claims that cellular telephones "make common sense uncommon."(75)

Proponents of legislation admit that any distraction to drivers is dangerous, but most place cellular telephone use in a class by itself; at least in part, because it requires various amounts of both physical and mental distraction. Such legislative supporters are often public activist type groups who rally around specific cases in which there have been tragic fatalities or near-fatalities caused by driver-cellular telephone use. Many of these legislative supporters are cellular telephone users themselves and agree the benefits are fantastic; however, they believe there is a need for regulation that will restrict drivers' use to some degree. They feel that driving is a privilege, not a right, and all drivers should take the responsibility of operating their vehicle seriously, with respect to others on the road. They often cite statistics which researchers claim are dangerously low because of the lack of reliable data collected to date. Many want across-the-board bans on any use of wireless devices in moving vehicles, while others would be satisfied with a mandatory hands-free regulation. "Anything that takes a driver's concentration off the road presents a problem and increases the possibility of an accident. At 55 miles per hour, a vehicle travels the length of a football field in 3.7 secondsless time than it takes to dial a phone number."(76)

Those who oppose legislation have their arguments as well. With some recent exceptions, these opponents of regulation are often backed by the wireless industry, which provides considerable strength to their cause. Individuals who oppose legislation believe that any regulation would stifle their personal freedom. Many feel that, for the average driver, using a cellular telephone is not a problem. People have different abilities and they believe that a bad driver is a bad driver, with or without a phone. Even though they admit that cellular telephone use may cause some drivers distraction, they do not feel the risk outweighs the tremendous personal and professional benefits. They argue that wireless technology is an undeniable part of society's advancement, and to restrict it only slows down the inevitable march toward the future. They claim the statistics are insubstantial and account for only a fraction of all the in-vehicle distractions that drivers deal with on a daily basis. Some even propose alternatives to new legislation like raising insurance rates, or higher fines for inattentive driving, in the event of an accident. However, it is noted that this should be practiced toward any distraction, not just cell phone use. "Cellular telephones are 'lifesavers' in emergency situations, and 'life-enhancing tools' in non-emergency situations, when used sensibly…"(*25*)

The jury is still debating. So far, most studies, like those by NHTSA, above all recommend the need for more research. Particularly necessary is the collection of data from accidents, to gain a clearer picture of the relationship with driving and cellular telephone use. In the meantime the argument will continue, as will technological advances. It is interesting to note, when looking at the logistics of the debate over whether or not cellular telephone use while driving is a hazard worthy of legislative regulation, it is similar to other high-profile debates going on today. Like the debates over tobacco and gun control, this issue seems to be taking the shape of "Joe Public and the emotional activists" versus the "Big business-Big money industry." If that is the case, the debate will not go away any time soon. Dr. Donald Redelmeier says of the Harvard study, which is backed by AT&T, that it "is trying to influence public policy, [but] laws are 'a question not just of scientific data, but of your own values and priorities.'"(*35*)

CHAPTER III. LOCAL LAW ENFORCEMENT PERCEPTIONS OF DRIVER-CELLULAR TELEPHONE USE

Selected law enforcement agencies in the Dallas/Fort Worth metropolitan area were interviewed during March 2000. Observations, perceptions, and opinions of individual officers representing each agency were recorded and synthesized. Interviewees are not named and specific comments are not related to interviewees or agencies.

Questions for these interviews were developed from (1) previous NHTSA police focus group sessions held in the Washington, DC, metropolitan area, and (2) the results of this project's literature review and related tasks. Answers from these interviews are compared and contrasted to the previous NHTSA focus groups (*3*).

DRIVER-CELLULAR TELEPHONE USER ESTIMATES

Most considered driver-cellular telephone use to be very common, describing it in terms such as regular, daily and widespread. Estimates ranged from 5 to 45 percent for drivers who use their handheld cellular telephones while operating a vehicle. This assessment was the same as that previously recorded in the Washington metropolitan area. The NHTSA police focus group recorded perceptions of use in Northern Virginia at 50 percent among drivers (*3*). Though these estimates of use seem high, they spotlight the perceived magnitude of the problem. Perhaps the estimates are high because the driver-cellular telephone behavior is singled out and perceived differently in comparison to other types of driving behavior.

All departments believe that driver cell use has increased in the past three years. There was disagreement about the percentage of increase, but some suggested that use may have doubled or tripled in this period. Others suggested that the increase has been minimal over the past 3 years compared to the initial influx. Most felt the increase was due to technological advances making cellular telephones more affordable and available, and as advances continue, it was felt driver-cellular telephone use would also increase.

When asked what age group best represents a driver-cellular telephone user, a majority of responses included the 25 to 45 year age group, though opinions ranged from 16 to 60 years of age. The majority of users were considered to be "working adults" and "established people," with the financial resources to purchase a cellular telephone, as well as the interest in technology. One respondent also felt that users were 60 percent women versus 40 percent men, and that most male use was business related, while female use was family oriented.

OBSERVED CHANGES IN DRIVING BEHAVIOR

Nearly all respondents have noticed changes in driving behavior when drivers use their cellular telephones. The most common reason given was driver inattention to the task of operating the vehicle. It was noted that drivers become more focused on the phone call than what is going on around them, especially in the event of an emotional call. One respondent noted that this behavior could sometimes mimic DWI or drowsy driving because of lane deviation. Several respondents noted that the multi-tasking in the vehicle between driving, cell conversation, and other distractions are all contributing factors to near accidents and near collisions.

Commonly, the type of behavior observed included: lack of courtesy and lane discipline—weaving and running off the road; failure to signal intent; failure to maintain safe following distances, and failure to heed traffic flow and/or regulation devices. The latter includes behavior such as: sitting through green lights, running red lights and stop signs, failure to yield, failure to turn left when traffic flow permits, and driving below posted speeds. Decreased following distances were often mentioned in combination with the driver-cellular telephone user's lack of attention. The inattentiveness frequently causes drivers to delay braking, thus reducing the time they have to react to a hazard. Such behavior could contribute to increased rates in rear-end collisions—the risks increasing with driving speed. Road rage was even designated as a result of driver-cellular telephone use. Other drivers react in frustration to the phone user's inattentive driving; or the phone user misinterprets other drivers' defensiveness, and reacts aggressively.

The NHTSA focus groups recorded similar observations of driver performance. Those law enforcement personnel noted driver inattention as the main reason for "aberrant driving behavior." The driver inattention results in lane drifting or weaving and drivers speeding up or slowing down. When drivers dial their cellular telephones, the focus group noted a reduction in lane tracking ability and failure to maintain adequate headway, especially in heavy traffic.

HAZARDS RELATED TO CELLULAR TELEPHONE USE

Asked when using a cellular telephone and driving, what the most hazardous task was (dialing, answering, conversing), an overwhelming majority agreed dialing was the most hazardous because it requires the driver to take his eyes off the road. The second greatest concern was the actual conversation itself, resulting in divided attention considered critical because it "impairs a driver's judgment, perception and reaction." A couple of respondents thought answering was most hazardous because the phone's ringing may startle the driver, causing sudden braking or swerving. It was also noted that reaching for the phone might also affect driving performance.

Mixed responses were received when asked if increased familiarity with a driver's cellular telephone would improve their driving. Some respondents thought dialing numbers stored in memory would decrease the time of looking away from the road and, along with voice activation, could help by reducing distraction. Other respondents felt that increased familiarity would not benefit the driver, noting that the driver's attention would still not be focused on the operation of the vehicle. The NHTSA groups also had conflicting views on this subject. Some of their participants believed that drivers would become more accustomed to the "cellular telephone while in traffic just as police become more adept at using their radios." Other participants disagreed, noting that drivers would become more relaxed using the cellular telephone while not improving their driving performance.

Though some respondents provided examples of hazardous situations observed, one person noted further that "it wouldn't be appropriate to say cellular telephones create hazardous driving behavior…because you don't know how they drive without the phone." Another said that, though he had made no personal observations, he knew officers who had heard of or had their own experiences, and he felt that such occurrences were likely to occur in the future, unless technology improves, e.g., hands-free, voice-activated units. In one case observed, a driver talking on her cellular telephone turned a corner on a local street and traveled approximately 600 feet before striking a disabled vehicle with hazard flashers on and hood up in the travel lane. Many respondents had not personally seen an accident caused by cellular telephone use; however, many had heard of related stories. Some people have hit utility poles or other vehicles when they used their cellular telephones. Many of the same poor driving behaviors were noted, such as failure to maintain a single lane of traffic, failure to stop at stop signs or traffic signals, sitting at a green light, driving excessively below the speed limit, and failure to yield. One respondent noted that it is more hazardous to use the cellular telephone on the freeways traveling at 60 mph than on local streets where most people travel 30 mph. The increased speed means they have a shorter reaction time and cannot afford a delay due to inattention.

Few respondents personally worked traffic accidents where a cellular telephone was thought to play a contributing role. Most respondents remarked that such data is not recorded and tracked. One example given was a driver who pulled out in front of a truck and was killed. The only witness to the accident was the victim’s child in the back seat who said the parent was on the cellular telephone. A non-fatality incident involved a woman on a cellular telephone, driving 60 mph, who hit a stopped police car from behind. The patrol car had all the emergency equipment on, but according to witnesses, the woman never even applied her brakes. This was further evidenced by the lack of skid marks at the accident site.

All respondents agreed that it is very difficult to determine if a cellular telephone contributed to an accident unless the driver admits to it, a witness comes forward, or it is simply very obvious. An incident was recalled where a woman’s cellular telephone antennae became impaled in her eye. In another case, the victim actually saw the driver-cellular telephone user bearing down before the impact. Such cases are hard to refute, however, respondents noted that, even when there is proof that the driver was on a cellular telephone, it is still reported as only a “contributing factor to driver distraction” or simply listed in the narrative. It’s not illegal to be on the phone when driving; the actual violation occurs when the traffic codes are broken. Generally, witnesses do not help in determining if cellular telephones played a role in the accident. One respondent mentioned that because the witnesses are busy or don’t want to get involved, they are typically not present when the investigating officer arrives.

Overall, cellular telephone records are not requested in determining fault for an accident. The records are difficult, if not impossible to obtain without a subpoena. A couple of the interviewees noted that, if there were a serious injury or fatality accident, it might be a consideration, but it would still be difficult at best.

Few respondents relayed horror stories about cellular telephone use. One respondent recalled a driver-cellular telephone user who tailgated a unit, almost running them out of their lane. The officers pulled in behind the vehicle and activated their emergency equipment, but followed the vehicle for five or six miles before the driver noticed them. Another respondent cited an incident where a driver dropped their cellular telephone while talking, reached to pick it up and lost control of the vehicle. They struck a concrete median barrier, flipping the vehicle on its roof, and the antennae of the cellular telephone stuck in the driver's eye. Another story was the loss of a rape suspect during pursuit, because a vehicle struck the patrol car stopped in an intersection with lights and siren activated. A couple of respondents had heard of a fatality accident where the driver was killed, and the cellular telephone line was still open when responding emergency units arrived on the scene.

Respondents were asked how they felt about the increased availability of handheld wireless devices such as PalmPilots and Web-enabled cellular telephones, and their effects on driving safety and operations. Most respondents indicated that the negative impacts these devices have on safety and operations far outweigh any positive benefits they offer. Again, driver inattention was the primary cause of concern, and one respondent stated that such devices would only intensify the impacts already seen with cellular telephone use.

All those interviewed agreed that a hands-free cellular telephone system would be advantageous for drivers. The specific advantages most often noted were having both hands free to maneuver the vehicle, and not having to take your eyes off the road. However, about half added that the "mental distraction" caused by the conversation itself would still result in driver inattention. The high cost of hands-free technology was frequently cited to be a disadvantage, though one interviewee noted that as technology advances, it should become more affordable. Previously, one NHTSA participant stated that the cellular telephone manufacturers should address the "shortcomings of current equipment by designing voice-activated systems."(*3*)

An additional topic came up during the first couple of interviews and was added to the rest of the surveys. Respondents were asked to rate the distraction caused by a cellular telephone in comparison to other common activities which often take place while driving, such as kids in the back seat, eating, tuning the radio, or reaching for something. Overall, eating was most often considered to be the biggest distraction, and cellular telephone use was next. Of those who gave a specific rating, cellular telephone use was designated as "high," or "fairly high…right behind…eating [which] is number one," in the "top quarter percentage" and "in the top 10 percent." Most seemed to agree that any distraction is a hazard, one person stating that, "when anything is a hazard, you need to eliminate it" and "I'd like to see a law that blankets the moving vehicle." A couple of the respondents mentioned that younger drivers, even among officers, were more frequently affected by distractions; though one added that "its not just younger people any more, its middle aged and older who are not paying attention." It was noted that some people can "multi-task" better than others do, which affects how well they can maintain safe driving behavior amid distractions. It was also noted, however, that today "the sheer volume [of traffic] almost mandates you pay super close attention, yet we've introduced new technology that takes away more from that, as if making the cars smarter makes the driver less accountable."

BENEFITS OF CELLULAR TELEPHONES IN VEHICLES

Many benefits of cellular telephones in vehicles were cited. The common thread among those cited was the ability to make immediate contact with another person. Primarily the focus was on safety benefits such as calling for help in the event of car trouble or an accident. Just as often, respondents mentioned crime prevention and crime reporting. Almost all those interviewed noted the advantage to emergency services of having witnesses call in, providing immediate reports and details on a crime, sometimes even keeping the suspect or situation under surveillance until help arrives. Half of the NHTSA focus group participants stated the benefit of the having the public report "crashes, drunk drivers and other hazards" via the cellular telephone (*3*).

About half also referred to personal benefits for family and business use. When drivers are stuck in traffic, they can be more productive with their time. Business people may be able to call clients or check in with work. Families benefit because it allows parents to coordinate their schedules, as well as keeping track of and being more available to their children.

ASSESSMENT OF LAW ENFORCEMENT USE OF CELLULAR TELEPHONES

All respondents had a cellular telephone assigned to them through their jobs, and most also owned one for personal use. A few said their phones are primarily used for business purposes however, as in the NHTSA study, most claimed to use their phones for anything needed at the time: business, personal, or emergency. It was generally noted that they are a convenient way to save time. Among the participants in the NHTSA focus groups, 50 percent also reported making all kinds of calls when driving (*3*).

All respondents stated that they use their cellular telephone at some point while they drive, but most stated that they made an attempt to pull off of the roadway or use the phones while stopped if possible. This correlates to the previous findings from the NHTSA police focus groups in which 75 percent of the participants regularly use a cellular telephone while driving (*3*). In both cases, it is interesting to note that although they understand the effect of cellular telephone use on driving performance, these devices have often become integrated into their business as well as personal lives. The NHTSA police focus group found that 10 percent of their participants "reserved phone use for what they considered to be emergency situations."(*3*)

When asked if they thought the use of the cellular telephone had affected their driving performance, slightly more than half stated that it had. Most of the NHTSA participants did not report having any actual experiences in which they felt their driving performance was affected. Though 40 percent of that group did express concern over difficulties driving when dialing the phone. Of those who noted a change in their driving, it was most frequently described as a defensive response to the cellular telephone use among other drivers. Concerning their own driving, both focus groups noted that they were more careful driving while using the cellular telephone, allowing a greater following distance and reaction time.

Answers varied in response to a question about comparing driving and using a cellular telephone versus a police radio. Most answered that there were differences, relating both to how the devices operate as well as to their purpose. It was generally noted that operating a police radio is less distracting than a cellular telephone. There is little if any dialing involved, and it doesn't have to be held up to the ear. The only time a problem with the actual physical use of the police radio was noted involved "rookie" officers who are unfamiliar with it. Over half the responses involved the purposes for the two forms of communication. It was noted that, "the police radio has a necessary function to provide for the public's safety and well-being," while a cellular telephone is basically a "convenience." Another person pointed out that the radio is used almost solely for business; and the phone is more often for personal use. This difference in purpose affects how the units are used. Conversations by police radio are generally shorter and the subject matter is crucial to their job. It was noted that "cellular telephones [are used] for extended periods of time" and the subject matter is more often conversational and/or personal. Because, "people become more involved in personal than they do [in] business [conversations]," this was considered more distracting. An important feature discovered in this comparison between police radios and cellular telephones was the use of police MDT's, or Mobile Data Terminals. Two respondents stated that these mobile computers supply police with most of the information they need to pursue a case, and they have frequently been the cause of problems related to driver distraction. One commented that "a trained officer can use the radio and drive safely…[but] using the Mobile Data Terminals is more comparable to using a cellular telephone." They both stated that no serious accidents have resulted, but they added, "it has definitely affected the person's driving" and "we realize that it is a potential problem." Both also stated that, while officers are encouraged to stop if possible, they do use the equipment while driving.

OPINIONS ON REGULATION OF CELLULAR TELEPHONE USE

The majority of respondents did not feel that it would be possible to effectively regulate cellular telephone use. Many stated that even if necessary, it would be difficult to enforce and might result in another law with good intentions but no working benefit. One respondent noted, "yes it probably would decrease accidents, but it would also create a burden on patrol officers;" and another that, "it would be such a complicated law, it would be practically unenforceable. We would need exceptions for hands-free and…for emergencies." Others stated that existing laws could be used to cite drivers for inattentiveness or careless driving. One respondent said that the motoring public should be sensible. A comment was made that additional staff would be needed to enforce such a regulation.

A small number of respondents did feel that cellular telephone use should be regulated. They cited the increased volume of traffic and cellular telephone use as a reason for attempting to improve safety of all drivers so that accidents are avoided.

The NHTSA police focus groups were unanimous in their opposition to any regulation of cellular telephone use. In fact, some of their groups cited the lack of regulation for citizen band radios, taxi radios, and police radios; though, one of their groups did note that dialing the phone was a unique activity not present in the other cited communication devices.

CHAPTER IV. FIELD ASSESSMENT OF DRIVERS' HANDHELD CELLULAR TELEPHONE USE

Problems can be identified through casual observation of specific events or objects. However, the extent or scope of a problem should be evaluated, using methods beyond anecdotal evidence or casual observation. This report documents problems that exist due to driver distraction caused by using handheld cellular telephones while operating vehicles. Although attitudinal or opinion surveys may gather information about a populations' general use of cellular telephones while driving, the random nature of data such as caller locations, frequency of calls, and duration of calls does not lend much weight to real-world assessments of actual use along roadways.

The objective of this assessment was to develop both a procedure for data collection and an estimate of the ratio of drivers using a handheld cellular telephone on Dallas County freeways. Dallas County is shown in Figure 7. The City of Dallas comprises most of the land area in this county and is the eastern anchor of the Dallas/Fort Worth metropolitan area. In 2000, the population estimate for this entire area, defined by the North Central Texas Council of Governments' boundaries, was 5,119,963; the population of Dallas County was estimated as 2,070,704. In July 1999, the US Census Bureau estimated the populations of the Dallas-Fort Worth Consolidated Metropolitan Statistical Area (CMSA) at 4,909,523 and Dallas County at 2,062,100.

Figure 7. Dallas County, Texas.

To meet the objective of this field use assessment, functionally classified freeway and expressway segments in Dallas County were inventoried. These segments were defined as sections of freeway and expressway between other freeway and expressway interchanges. Dallas County has 51 such segments. With two directions of travel for each segment, a total of 102 directional-segments were potentially available from which to sample.

Some segments were removed from the preliminary list due to various factors. The safety of personnel was a priority; therefore, many sites were not used because they failed to provide secure viewing positions for observers. Still other locations were removed from the list because they did not offer vantage points from which to effectively view traffic. Pipeline structures, overhead signing and other obstructions interfered with the field of view. In some cases, both directions of travel on a segment were removed from the list. In other cases, only one direction was deleted. Table 19 lists all of the preliminary segments and denotes those removed from the final list.

The effort documented here is the first known attempt to assess the use of handheld cellular telephones by drivers while on roadways. As such, several experimental data collection methods were tested and evaluated. Several pilot studies of these methods were performed on freeway sections in Dallas County and at one arterial location in Tarrant County. The pilot study sites were selected from the final segment list. Table 20 shows a brief summary of location, date, time, and notes for the pilot studies.

At the beginning of this project, several cellular telephone service providers were contacted regarding hourly and daily variations in the use on their networks. They all declined to share any information, citing that such data is proprietary in nature. Information such as aggregate use, normalized to some reference for their networks, would have improved the design of the pilot studies for this project. Ultimately, this information would have allowed for a better understanding of the relationship between cellular network patterns and vehicle traffic patterns.

In conducting the pilot studies and field assessment, vehicles were classified into three handheld cellular telephone use categories: YES, NO, and UNKNOWN. Vehicles were also divided into two groups: CARS and TRUCKS. Trucks were defined as any commercial 2-axle, 6-tire truck or heavier. In order for use to be categorized as a YES, the observers must have seen a handheld cellular telephone or seen behaviors resembling use by a driver. UNKNOWN was used to capture drivers who observers could not be certain were using a handheld cellular telephone or not. Proportions of use were defined as YES responses divided by all responses. This produced a conservative use estimate by segregating UNKNOWNS and treating them as NO responses during proportion development.

FREEWAY PILOT STUDIES

Many pilot studies were conducted on freeway segments in Dallas County, the primary focus of this investigation. The earliest pilot studies were conducted to assess the observers' perception of the data collection effort's procedures and techniques. The design of the later pilot studies was directed toward gathering statistical information to be used in the final statistical data collection plan. Each of the pilot studies is summarized below, in chronological order.

Table 19. Preliminary Highway Segment Listing Showing Rejected Segments.

ID	Facility	W/S End	E/N End	Rejected
1	DNT	I 35	I 635	
2	DNT	I 635	Co Line	
3	I 20	Co Line	S 408	
4	I 20	S 408	US 67	
5	I 20	US 67	I 35	
6	I 20	I 35	I 45	
7	I 20	I 45	US 175	X
8	I 20	US 175	I 635	X
9	I 20	I 635	Co Line	
10	I 30	Co Line	L 12	
11	I 30	L 12	I 35	
12	I 30	I 35	I 45	
13	I 30	I 45	US 80	
14	I 30	US 80	I 635	X
15	I 30	I 635	Co Line	
16	I 35	Co Line	I 20	
17	I 35	I 20	US 67	
18	I 35	US 67	I 30	
19	I 35	I 30	S 366	X
20	I 35	S 366	DNT	X
21	I 35	DNT	SH 183	X
22	I 35	SH 183	L 12	
23	I 35	L 12	I 635	
24	I 35	I 635	Co Line	
25	I 45	Co Line	I 20	
26	I 45	I 20	I 175	
27	I 45	I 175	I 30	X
28	I 635	Co Line	I 35	
29	I 635	I 35	DNT	
30	I 635	DNT	US 75	
31	I 635	US 75	I 30	
32	I 635	I 30	US 80	
33	I 635	US 80	I 20	
34	L 12	I 30	SH 183	
35	L 12	SH 183	SH 114	
36	L 12/ S 408	I 20	I 30	
37	SH 183	Co Line	L 12	
38	SH 183	L 12	SH 114	X
39	SH 183	S 482	I 35	X
40	S 366	I 35	US 75	
41	S 482	SH 114	River	X
42	SH 114	Co Line	L 12	X
43	US 175	I 20	SH 310	X
44	US 175	Co Line	I 20	
45	US 67	Co Line	I 20	
46	US 67	I 20	I 35	X
47	US 75	I 30	S 366	X
48	US 75	S 366	I 635	
49	US 75	I 635	Co Line	
50	US 80	I 30	I 635	X
51	US 80	I 635	Co Line	

Table 20. Summary List of Pilot Study Locations and Parameters.

Pilot #	Location	Date	Time	Notes
Freeway Tests				
1	I-635 at Rosser Rd	2/16/2000	2:00 PM – 6:00 PM	Oblique view, 2 lanes/obs
2	I-635 at Rosser Rd	3/28/2000	4:00 PM – 6:30 PM	Overhead view, 2 lanes/obs
3	I-635 at Rosser Rd	4/24/2000	7:00 AM – 9:00 AM	Overhead view, 2 lanes/obs
4	US 67 at Pleasant Run Rd	7/19/2000	7:00 AM – 7:00 PM	Blind, 4-hr shift, 2 lanes/obs
5	US 67 at Pleasant Run Rd	7/31/2000	7:00 AM – 7:00 PM	Blind, 3-hr shift, 2 lanes/obs
6	US 67 at Pleasant Run Rd	8/2/2000	11:00 AM - 2:00 PM	ANOVA, 1 lane/obs
7	US 75 at Southwestern Blvd	8/7/2000	6:30 AM – 9:00 AM	ANOVA, 1 lane/obs
8	SH 360 S of Abram St.	8/9/2000	1:30 PM – 2:30 PM	Video test
Arterial Tests				
1	Collins St. S of Lamar Blvd	4/19/2000	4:00 PM – 6:30 PM	Oblique view, all (2) lanes
2	Collins St. S of Lamar Blvd	5/30/2000	4:00 PM – 7:00 PM	Outside v. inside, 1 lane/obs

Site A: I-635 at Rosser Road

The first three pilot studies were conducted on westbound traffic traveling along I-635 at the Rosser Road overpass. This site was chosen for many reasons: (1) it has a high volume of traffic (>120,000 ADT), (2) variability of speeds prior to congested conditions, and (3) location relative to dense commercial and residential development along the I-635 corridor. At this site, I-635's westbound section is comprised of four freeway mainlanes and one concurrent-flow HOV lane. The posted speed limit is 60 MPH. This site is shown in Figure 8.

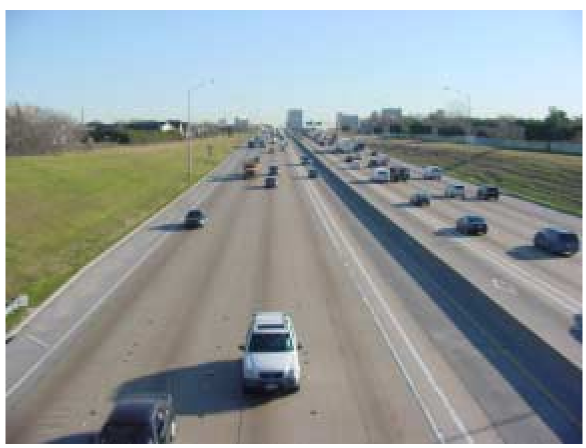


Figure 8. I-635 at Rosser Rd (westbound lanes).

February 16, 2000

The objective of this pilot was to test the limits of the data collection personnel and to begin gaining experience collecting driver use of handheld cellular telephones. The initial pilot was performed on February 16, 2000, between 2:00 PM and 6:00 PM. This time period was selected because it would provide the observers experience collecting the data in both freeflow and congested conditions along a roadway expected to have a larger incidence of handheld cellular telephone use.

As expected, the vehicle density was relatively low at the beginning of the time period with the freeway operating in a freeflow condition. Vehicle speeds were estimated to be approximately 70-75 MPH. The vehicles operated at these speeds until shortly after 3:00 PM. At that time the traffic density increased, eventually degrading the roadway to operational failure. By 4:30 PM, average vehicle speeds were estimated to be 20-25 MPH with a sporadic stop-and-go condition observed. These extremely congested conditions continued until nearly 6:00 PM.

Observers were located in vehicles on an embankment adjacent to the roadway. Their position was elevated approximately 15 - 20 feet above the freeway and approximately 60 feet from the outermost freeway mainlane. This location provided a perspective higher than oncoming traffic and also at an oblique view.

Three observers were used on a rotating shift with two observers collecting data at any given time. One observer was assigned the two outside lanes (outside [O], middle-outside [MO]) and another would count the two inside lanes and the high-occupancy vehicle (HOV) lane (middle-inside [MI], inside [I], HOV). An observer would count for a period of one hour, in two consecutive 30-minute intervals, followed by a 30-minute break. The rested observer would then rotate back in relieving the third person, as illustrated in Figure 9.

Observer 1	Observer 2	Observer 3
COUNT	COUNT	rest
rest	COUNT	COUNT
COUNT	rest	COUNT
COUNT	COUNT	rest

Figure 9. Rotation of Observers.

The observers were instructed to count drivers or vehicle operators both using AND not using handheld cellular telephones. This was done to eliminate vehicles where the driver was not observed from being added to the total count and skewing the data.

The count was broken down by: Cars Using, Cars Not Using, Trucks Using, and Trucks Not Using. Within this project, a car is defined as car, pick-up truck, van, or sport utility vehicle (SUV). Some vehicles that are considered cars are tow trucks, police cars, taxis, and 15-passenger vans. A truck is defined as any vehicle larger than a normal car, truck, SUV or van. For example semi-trailer trucks, fire trucks, step vans, and normal van chassis modified to hold extra cargo are all considered trucks. Motorcycles and vehicles not providing a clear view of the driver (dark tinted windows) were ignored (not counted).

High speeds of vehicles made it difficult to clearly see in vehicles and required some period for the observer to become accustomed. The personnel eventually made adjustments and developed individual methods for gathering the data. Some looked in the vehicles as they approached and others looked in the vehicles as they quickly passed.

At high speeds and volumes, two lanes is the maximum that can be accurately counted. By attempting to also count the HOV lane with the two inside lanes, the observer would occasionally become overwhelmed and miss vehicles. This would primarily occur when the freeway would near capacity and a speed differential between the mainlanes and the HOV lane would be significantly noticeable (approximately 15 MPH).

Observers reported difficulties assessing use because of factors such as poor contrast due to tinted glass and obscured vehicles due to the oblique viewpoint. As a result of this feedback, the data collection plan was modified slightly for subsequent pilot studies.

Over the time period observed, 4 percent of the drivers (cars and trucks) were using a handheld cellular telephone. Of all cars, 5 percent of the drivers were observed using a handheld cellular telephone whereas 2 percent of truck drivers were observed using a handheld cellular telephone. Trends over the time period are shown in Figures 10 and 11. Figure 12 shows how handheld cellular telephone use by drivers varies over two defined lane groups at this site.

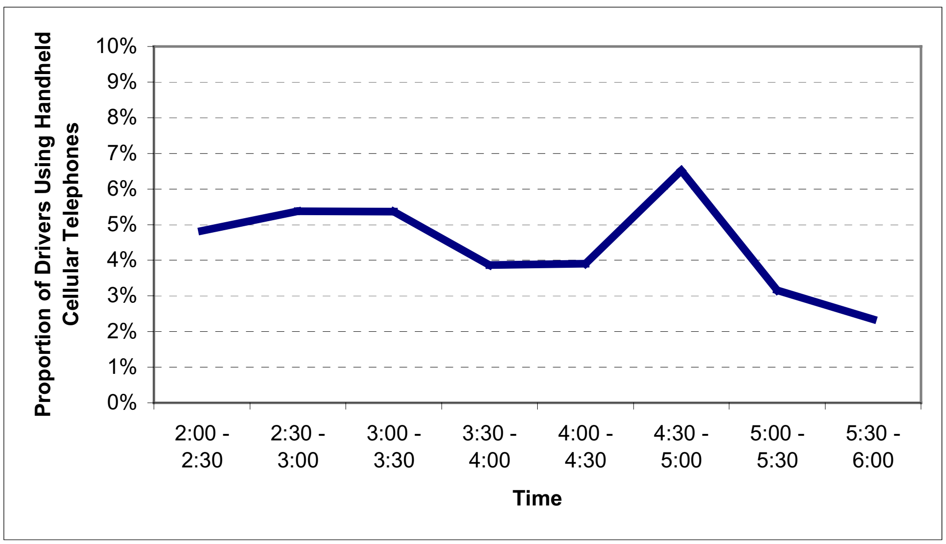


Figure 10. Observed Proportion of Driver-Handheld Cellular Telephone Users on I-635 (LBJ Freeway) at Rosser Road on February 16, 2000.

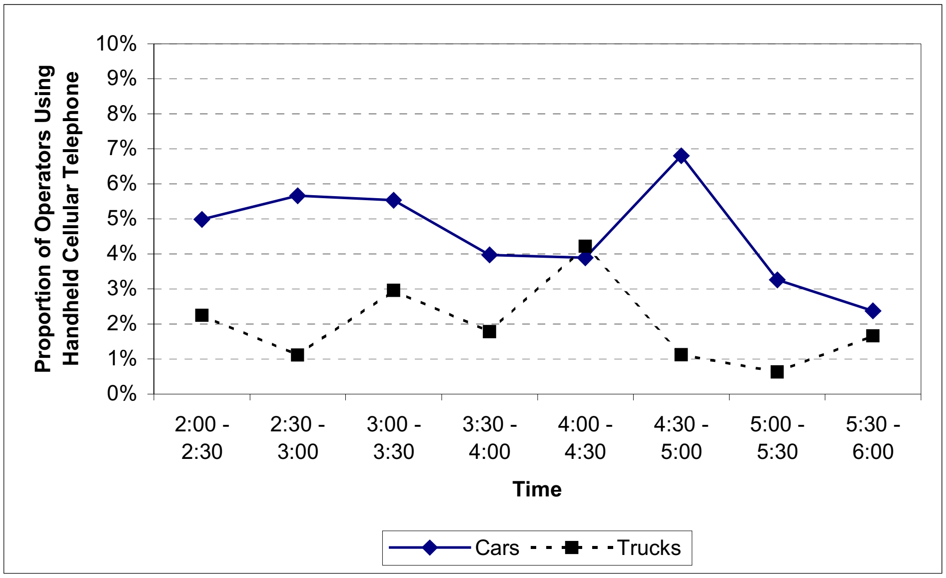


Figure 11. Handheld Cellular Telephone Use Among Car and Truck Operators on I-635 (LBJ Freeway) at Rosser Road on February 16, 2000.

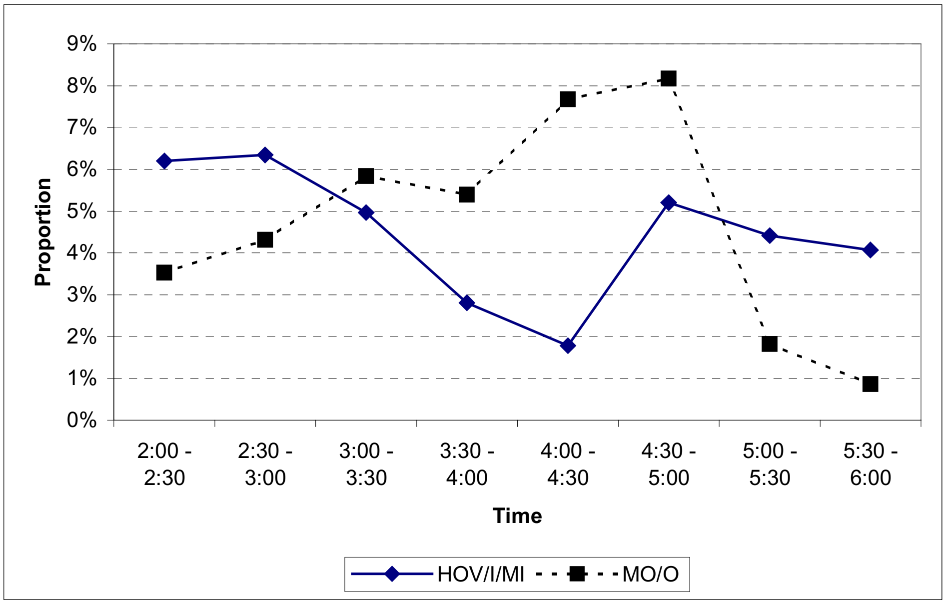


Figure 12. Handheld Cellular Telephone Use Among Vehicle Operators by Lane Groups on I-635 (LBJ Freeway) at Rosser Road on February 16, 2000.

March 28, 2000

The second pilot study at this location was conducted on March 28, 2000, between 4:00 PM and 6:30 PM. For this pilot, the observers were located on the Rosser Road overpass structure viewing oncoming traffic from a much higher perspective. This perspective allowed the observers to view drivers from the clear front windshield. Though perception problems continued to persist with tinted glass, they were greatly minimized.

Observational notes were made. In the morning hours, the sunlight angle helped to provide contrast within vehicles moving away from the sunrise. In the afternoon, challenges arose when working with sun glare from passing vehicles' windshields.

Again, 4 percent of all drivers were observed using a handheld cellular telephone. Of car drivers, 4 percent were observed to use a handheld cellular telephone. Again 2 percent of truck drivers were observed using handheld cellular telephone. Figure 13 shows the observed proportion of handheld cellular telephone use among drivers and the total traffic volumes recorded by time period.

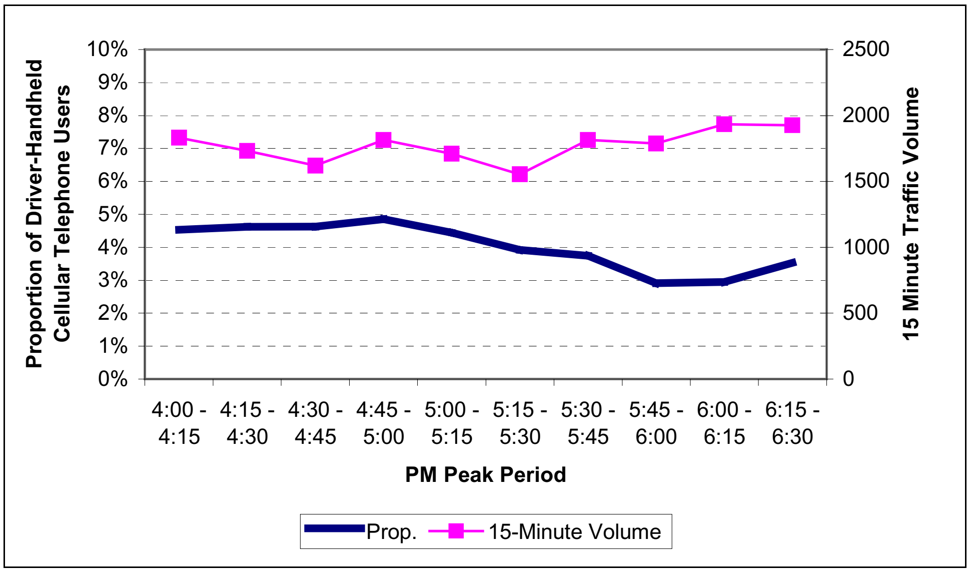


Figure 13. Observed Proportion of Driver-Handheld Cellular Telephone Users on I-635 (LBJ Freeway) at Rosser Road on March 28, 2000.

April 24, 2000

A final pilot study was conducted at this location on April 24, 2000, between 7:00 AM and 9:00 AM. The objective of this pilot was to assess data collection conditions in the early morning hours and to also provide point mean and variance estimates for use.

The proportion of use observed was lower for this pilot than the two previous. For all traffic, only 2 percent of drivers were observed using a handheld cellular telephone. The proportion of drivers observed using a handheld cellular telephone was 2 percent for both cars and trucks. Figure 14 shows the recorded use for this pilot over the study period.

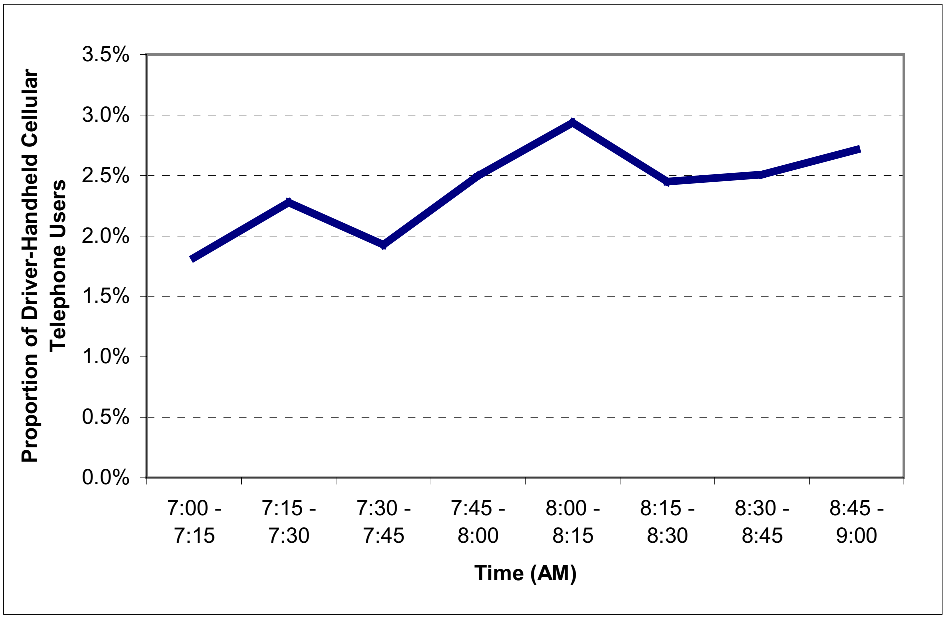


Figure 14. Observed Proportion of Driver-Handheld Cellular Telephone Users on I-635 (LBJ Freeway) at Rosser Road on April 20, 2000.

Site B: US 67 at Pleasant Run Road – Blind Studies

The site located at the intersection of Pleasant Run Road with US 67 is a four-lane, divided highway. A view of the southbound lanes is shown in Figure 15. Here the ADT ranges from 11,000 to 18,000, depending on direction of travel.

Figure 15. US 67 at Pleasant Run Road (southbound lanes).

Two blind studies were conducted on southbound traffic traveling on US 67 at the Pleasant Run Road interchange between 7:00 AM and 7:00 PM. The first blind study was conducted on July 19, 2000, from separate vehicles parked adjacent to the side of the Pleasant Run Road overlooking the travel lanes. Observers were asked to conduct the data collection independently in separate vehicles parked near the edge of the structure. Each observer collected data on both lanes of traffic for a period of four hours. Upon initial review of the data, displayed in Figure 16, there was too significant a difference between observers to warrant further statistical review. A review of total traffic volumes recorded between observers revealed that they were more representative of one another. Because of this difference, identifying correct YES responses is more difficult than recording total vehicles passing a point. A review of the data collection method with the observers led to slight changes in the protocol:

(1) shorter shifts to reduce fatigue (from four hours to three hours), and
(2) allowing the observer to position themselves closer to the travel lanes by standing or sitting next to the guardrail or structure edge to improve identification.

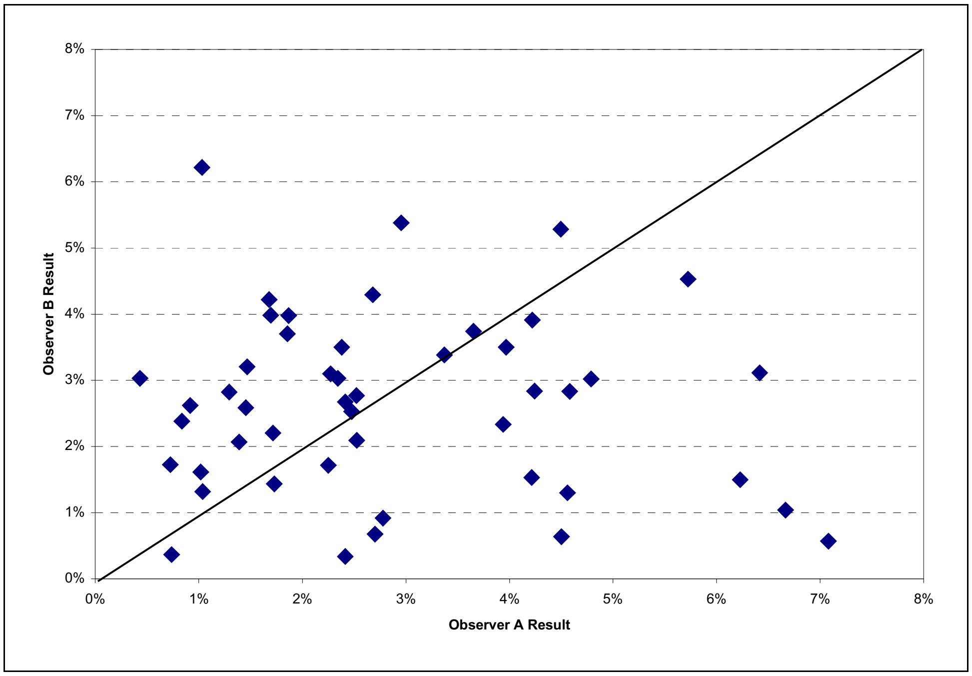


Figure 16. Scatter Plot of Drivers' Handheld Cellular Telephone Use Proportions on US 67 at Pleasant Run Road Blind Study on July 19, 2000.

The second blind study was performed on July 31, 2000. The location and duration of the experiment was not changed from the previous single blind study. Again upon initial inspection of the data received from this study, a conclusion was formed that significant differences were present among the data collectors, though it appears there was an improvement in the data collection protocol. These differences may be due to either individual perception-reaction time or visible detail available to and perceived by the observer, among other factors. Their data are shown in Figure 17.

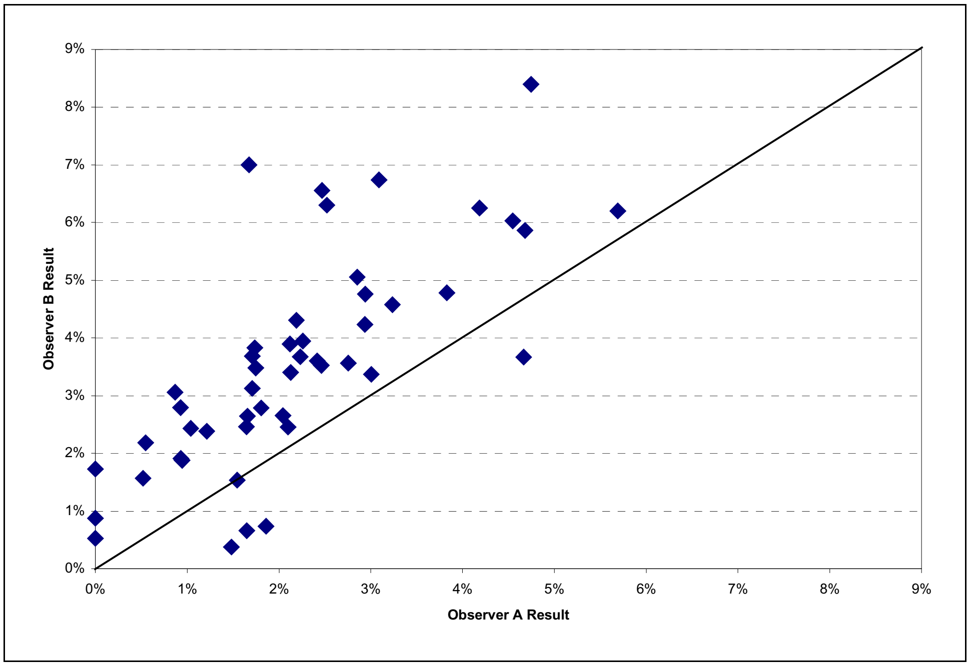


Figure 17. Scatter Plot of Drivers' Handheld Cellular Telephone Use Proportions on US 67 at Pleasant Run Road on July 31, 2000.

The failed single blind studies led to better defined statistical studies to measure the variances between observers, handheld cellular telephone use in travel lanes, and 15-minute traffic volumes (a surrogate variable for observer workload).

Analysis of Variance (ANOVA) Study

An ANOVA study was designed and conducted to assess the variances identified at earlier pilot sites. The goal of the ANOVA study was to understand both the quality of the data generated by observers and the nature of the data generated from each lane of a two-lane roadbed.

The data was collected on August 2, 2000, from 11:00 AM to 2:00 PM in 15-minute intervals. The time of day for this pilot was chosen because previous studies at this location indicated that the traffic volume was relatively constant. The southbound direction was observed.

The observers were randomly assigned a single lane for each 15-minute interval and were asked to observe the total volume of cars and trucks as well as the usage of handheld cellular telephones by the drivers of these vehicles. Each observer was directed to collect data in only one lane of travel. At least two observers recorded data for each lane at all times. Four observers were at the study location during all 15-minute time intervals; and a fifth observer recorded data for the last five of twelve time intervals.

The subsequent analysis was divided into two parts corresponding to the number of observers present. The first part analyzes the results generated by the four observers present through all twelve time periods. The second analyzes the data generated during the last five time intervals.

Part One. As demonstrated by the boxplots shown in Figure 18, results indicate that there is no significant difference in the number of handheld cellular telephone users recorded between the observers. Though Observer 2 and 5 did record outliers, their median (represented by the white bar) and 50 percent of data (represented by the dark areas) were similar to other observers.

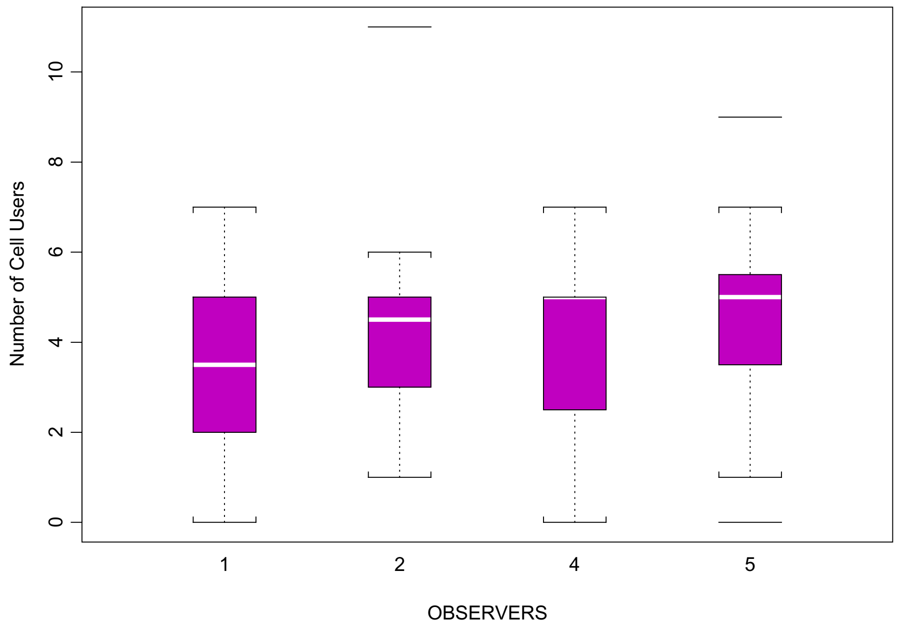


Figure 18. Comparisons of Number of Handheld Cellular Telephone Users by Observers.

Figure 19 shows boxplots for the number of handheld cellular telephone users observed in each lane. It shows a significant difference between the outside lane and the inside lane. Though this figure does not show differences between the ratios of use, it is interesting to note that more users choose to drive in the outside lane. This may represent their concern for safety by deciding to drive in the slower lane, allowing faster traffic to pass to their left. However, there are safety implications when using the outside lane. Drivers may be distracted from the cellular conversation and may not be able to react appropriately to traffic entering the highway.

The corresponding proportions of use by travel lane were 4.43 percent on the inside lane, 3.22 percent on the outside lane, and 3.61 percent across all travel lanes. Though the outside lane had a significantly higher number of drivers using handheld cellular telephones, the inside lane had a significantly higher proportion of users to lane volume. The cause for the lower proportion on the outside lane is from a higher volume of vehicles using that lane than the inside lane. This dilutes the number of users resulting in a smaller proportion.

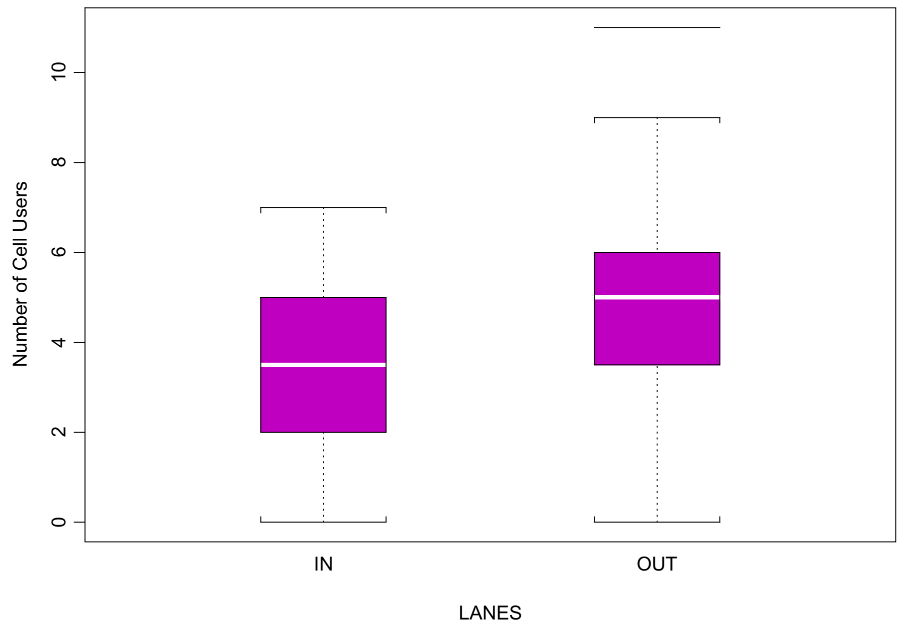


Figure 19. Comparison of Number of Handheld Cellular Telephone Users by Lane.

Table 21 shows the Analysis of Variance (ANOVA) for this particular study. The table shows there is not sufficient evidence (p-value = 0.61) to conclude the results from the observers are different. Table 21 does show that there is sufficient evidence (p-value = 0.013) to indicate a significant difference in results by lane.

Table 21. ANOVA Table for Part One of the Study.

Source	Df	Sum of Squares	Mean Square	F Value	Pr(F)
COUNTER	3	8.2500	2.75000	0.611111	0.6117514
LANE	1	30.0833	30.08333	6.685185	0.0134716
COUNTER:LANE	3	14.9167	4.97222	1.104938	0.3583977
Residuals	40	180.0000	4.50000		

Note: Critical p-value < 0.05

Part Two. As demonstrated by the boxplots shown in Figure 20, there is a significant difference in the number of handheld cellular telephone users between the observers. Observer 3 clearly recorded more positive responses than the other observers for the same traffic.

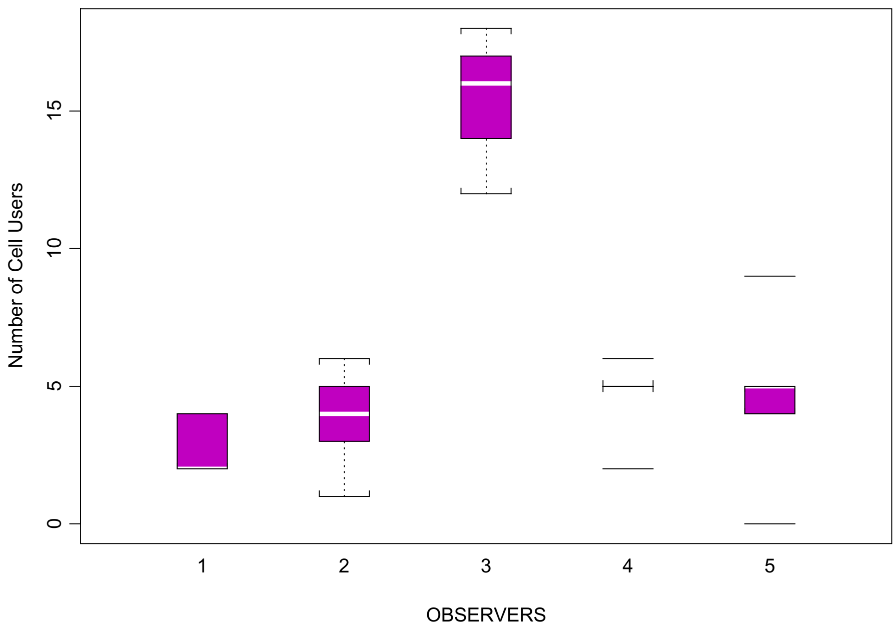


Figure 20. Comparisons of Number of Handheld Cellular Telephone Users by Observers.

There is no clear explanation for the significant difference between Observer 3 and the other observers. Only speculation may be noted. Because the observer began counting late during the study period, a period of adjustment might have been necessary to become accustomed to the mental workload required to process vehicles. However, this does not explain the differences noted between Observers 1, 2, 4, and 5.

Table 22 shows the Analysis of Variance (ANOVA). The table reveals that sufficient evidence (p-value = 0.000001) exists to indicate the results from the observers are different. Table 22 shows that there is not sufficient evidence (p-value = 0.144) to indicate a significant difference in results by lane. It is interesting to note that the difference between observers is so significant in this case that it greatly overshadows the difference in lanes exhibited earlier.

Table 22. ANOVA Table for Part Two of the Study.

Source	Df	Sum of Square	Mean Square	F Value	Pr(F)
COUNTER	4	535.3600	133.8400	27.78685	0.0000009
LANE	1	11.4286	11.4286	2.37271	0.1443002
COUNTER:LANE	4	9.5214	2.3804	0.49419	0.7402502
Residuals	15	72.2500	4.8167		

Note: Critical p-value < 0.05

Summary. The first part of the ANOVA study demonstrates that no difference exists between those four observers, but there is a significant difference in the number of drivers using handheld cellular telephones by travel lane. The second part of the study shows that the counts were significantly different by observers. One particular observer was so statistically different from the other observers that it overshadowed the differences between travel lanes noted earlier.

Site C: US 75 at Southwestern Boulevard

A second ANOVA study was designed to measure the response variance for high volume conditions on a multi-lane freeway section. After review of previous volume studies of selected sites, the northbound travel lanes of US 75 at Southwestern Boulevard were selected, shown in Figure 21. The ADT for this section is > 72,000. Data were collected on August 7, 2000, between 6:30 AM and 9:00 AM.

Figure 21. Site C – US 75 at Southwestern Blvd (northbound lanes).

The objective of this particular pilot was to understand both the quality of the data generated by observers and the nature of the data generated from each lane of a four-lane, urban roadbed. The auxiliary lane at this location, shown in the far left of Figure 21, was not included in the analysis.

Observers were randomly assigned to observe a single travel lane for each 15-minute interval of the study and were asked to record the total volume of cars and trucks, as well as the usage of handheld cellular telephones by the drivers of these vehicles. Observers were directed to record data for 12 minutes then record, reset, relocate, and rest during the next 3 minutes, to resume recording at the 15-minute mark.

At least one observer was assigned to each travel lane for all time intervals of the study. A total of five observers were present at the study location during all 15-minute time intervals. One observer erred in moving to the next randomly assigned lane and recorded data from the wrong lane during two different time intervals, 7:45 AM to 8:00 AM and 8:00 AM to 8:15 AM. This did not affect the quality of the dataset.

The variables under investigation were:

LANE = one of the four lanes: outside (OUT), middle outside (MID OUT), middle inside (MID IN), and inside (IN),
COUNTER = each of the five counters,
VOLUME = total volume of vehicles for each 12-minute time interval, and
USERS = total number of drivers observed using a handheld cellular telephone for each 12-minute time interval.

Table 23 displays a summary of the activity in the travel lanes per 12-minute interval over the study period.

Table 23. Average Lane Data per 12-min Interval.

Lane	Average Users Per Lane	Average Volume Per Lane	Percentage of Users Per Lane
Outside (OUT)	9.3	457.8	2.0
Middle Outside (MID OUT)	6.3	412.5	1.5
Middle Inside (MID IN)	8.5	416.7	2.0
Inside (IN)	7.4	472.4	1.6

Figure 22 shows the differences between LANES through boxplots. The outside lane and the middle inside lane are significantly higher than the middle outside lane and the inside lane. As in the earlier ANOVA study on US 67, significantly more users are observed in the far outside travel lane than the inside lanes.

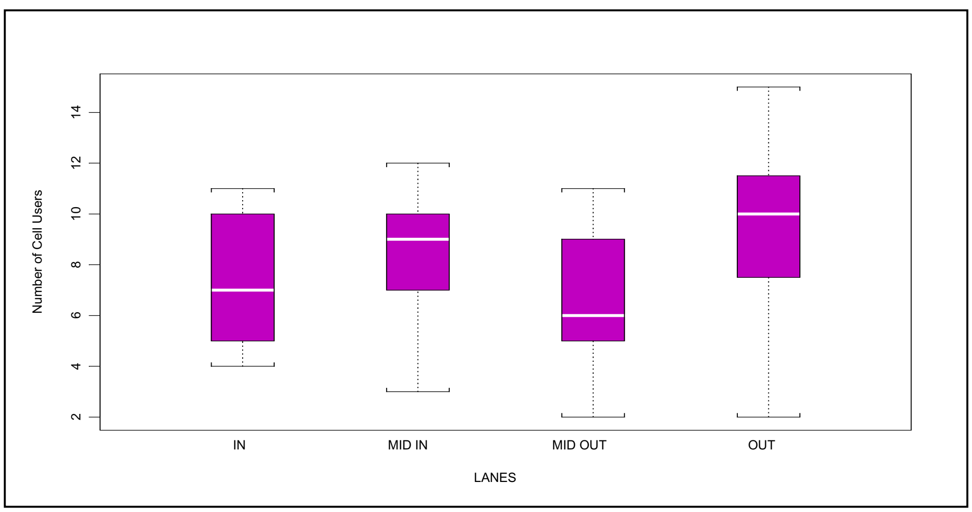


Figure 22. Number of Handheld Cellular Telephone Users by LANES of the Four-Lane Highway, Northbound US 75 at Southwestern Blvd.

Table 24 shows that VOLUME, COUNTER, and LANE are important in determining the number of USERS. Both the average number of users recorded by each COUNTER and the average number of users recorded in each LANE are significantly different from each other. There is a significant relationship between VOLUME and USERS.

Table 24. Analysis of Variance.

Source	Df	Sum of Squares	Mean Square	F Value	Pr(F)
VOLUME	1	127.0377	127.0377	23.29518	0.00001956
COUNTER	4	86.4028	21.6007	3.96097	0.00827995
LANE	3	62.2505	20.7502	3.80501	0.01702190
Residuals	41	223.5890	5.4534		

Note: Critical p-value < 0.05

Figure 23 illustrates the differences between COUNTERS. Multiple comparisons were performed using Fisher's Least Significant Difference (LSD). A significant difference appears when the averages between two observers is greater than 2.02. In Figure 24, the line under a group of numbers indicates that there is no significant difference between them. The line under 1, 6, and 2 indicates that there is no significant difference between Observers 1, 6, and 2. The line under 2, 3, and 5 indicates that there is no significant difference between Observers 2, 3, and 5. This also shows that Observers 3 and 5 are significantly higher than both Observers 1 and 6.

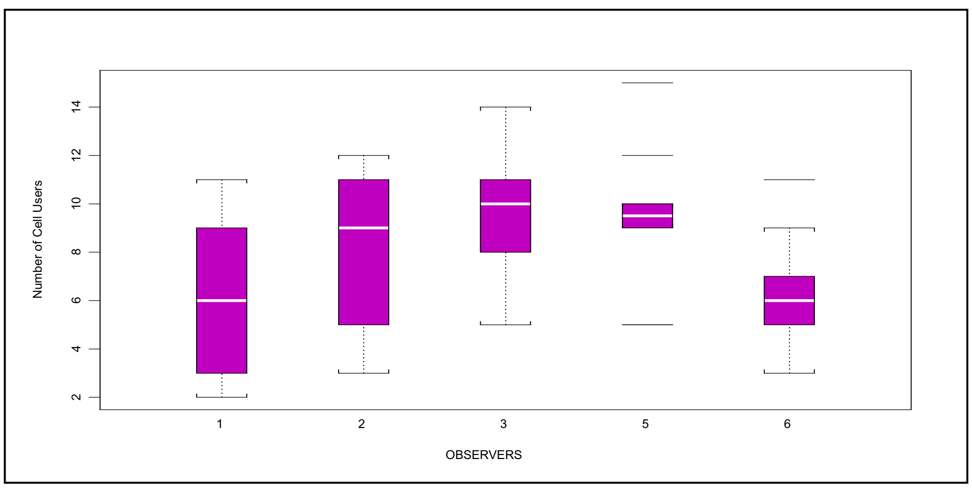


Figure 23. Number of Handheld Cell Users by the COUNTERS (Observers).

Average	6.1	6.3	7.8	9.8	9.4
Observer	1	6	2	5	3

Figure 24. Fisher's LSD Multiple Comparison of Average Counts of Users by COUNTER.

Because the median observations were very similar compared to other observers, Observers 2, 5, and 3 were selected to continue collecting data through this study. Also, the results obtained for travel lanes were used to modify the data collection protocol. Data collection by travel lane was integrated into the data collection protocol.

Site D: SH 360 South of Abram Street – Video Recorded Traffic Pilot

Finally, a test of data collection techniques using video recorders was conducted on August 9, 2000, on SH 360 south of Abram Street. Twelve configurations were tested according to the characteristics in Table 25. The recorded traffic was then assessed in the office for quality and functionality in collecting handheld cellular telephone use data.

Table 25. Camera Setup Characteristics.

Characteristic	Variables
Location Over Lane	Directly over 6' Offset to left 12' offset to left
Zoom	Close In Wide Out
Pan	Down 20 from horizon Down 45 from horizon

The results of this test revealed that sharp angles (45º from horizon) looking down onto the travel lanes were not functional for adequate data collection. The top of each vehicle obscured the majority of the driving cabin from view. Also, the amount of time the vehicle was available in the frame was not sufficient for a data collector to efficiently record traffic. Smaller angles (~20º from horizon) from the horizon to the roadway with close in zoom produced better results at approximately 600 feet upstream from the data collection site. However, difficulty with tinted windows and sun glare from windshields continued to present problems during data collection. Because of the fixed field of view, these vehicles were recorded as unknowns. In each video recorder configuration, the rate of unknowns greatly increased from that recorded by observers in the field.

ARTERIAL PILOT STUDIES

Two pilot studies were conducted on an arterial roadway in Arlington, Texas (Tarrant County), to assess differences between the amount of use on freeways and arterials and to test a modified data collection protocol. The arterial segment selected was Collins Street between a major arterial-arterial intersection (Collins Street and Lamar Boulevard) and an interchange with I-30. Collins Street is a four-lane arterial with an AADT of 47,000 (combined directions).

The first arterial pilot study was conducted on April 19, 2000, between 4:00 PM and 6:30 PM to assess a point mean and variance estimate of handheld cellular telephone use among drivers. Observers were stationed adjacent to the southbound departure of the intersection of Collins Street and Lamar Boulevard, as shown in Figure 25. This location provided an oblique view of oncoming traffic at ground level, observed in Figure 26. Observers recorded data from both traffic lanes.

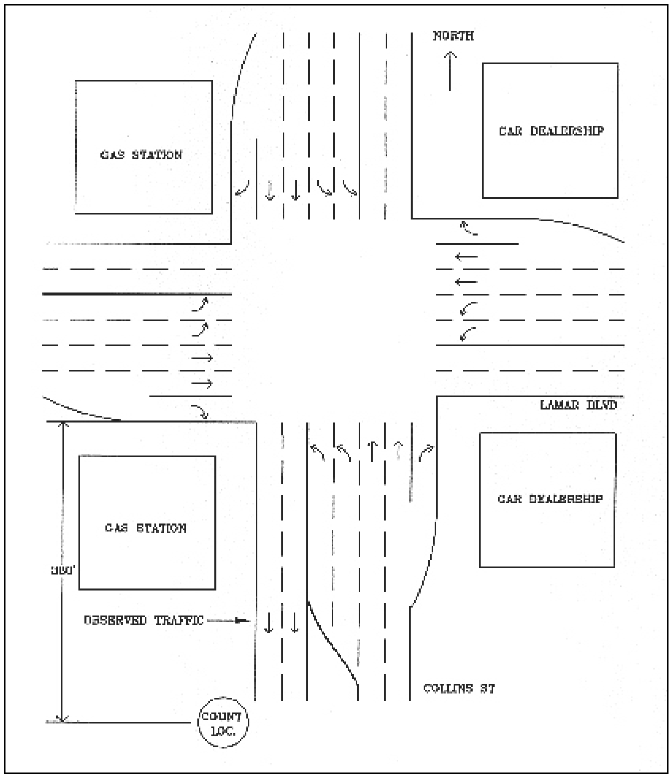


Figure 25. Schematic Drawing of Lamar Boulevard and Collins Street Intersection, Arlington, Texas.

Figure 26. Photograph of Collins St Southbound Traffic (looking north toward Lamar Boulevard intersection).

Total driver use of handheld cellular telephones at this site was 3 percent, use in cars was 3 percent and use in trucks was 1 percent. The rate of unknowns increased at this location from previous pilot studies on the freeway sections. This increase was due to commercial trucks, and large personal vans and SUVs traveling in the outside lane obscuring vehicles traveling in the interior lane. The handheld cellular telephone use of drivers recorded from this study is shown in Figure 27.

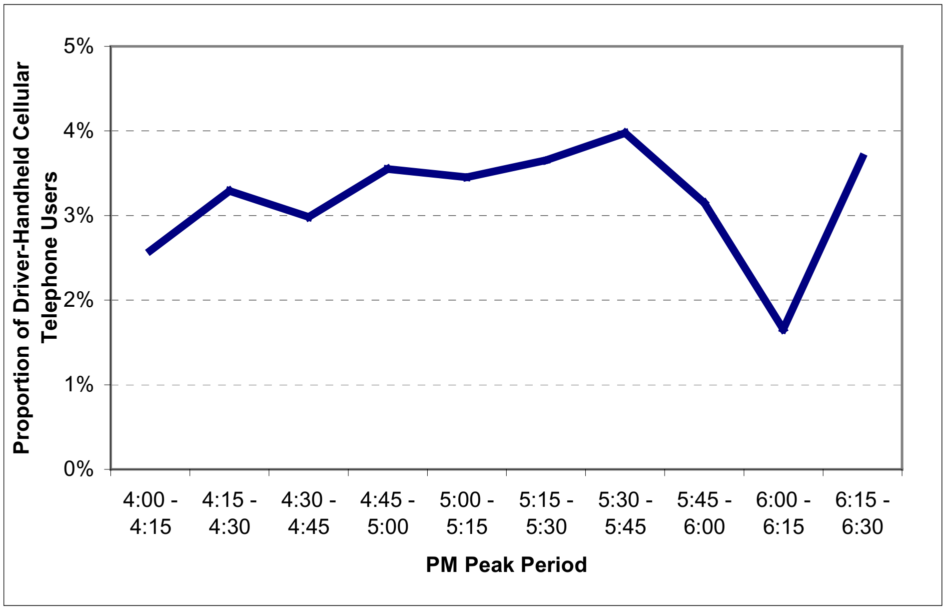


Figure 27. Observed Proportion of Driver-Handheld Cellular Telephone Users on Collins Street at Lamar Boulevard on April 19, 2000.

A second pilot study at this location was conducted on May 30, 2000, between 4:00 PM and 7:00 PM to assess differences in use by travel lane. Two observers were located at the previous point adjacent to the roadway.

They were each instructed to count a single lane of traffic in the southbound direction. Total use of handheld cellular telephones among drivers observed for this pilot study was 4 percent. Use among car drivers was 4 percent and use among truck drivers was 3 percent. The total use rate is similar when comparing the results of these pilots. Figure 28 shows how the handheld cellular telephone use among drivers varied by lane. Both lanes averaged 3.83 percent of drivers using handheld cellular telephones. Applying the Odds Ratio test to the pilot data showed that no significant difference of use existed between the lanes ($\theta = 1.0001$ and 95 percent confidence limits of 1.305 and 0.767). Based on this one location and the limited data collected, handheld cellular phone use of drivers in the outside travel lane may be used to approximate the use over all lanes in the travel direction.

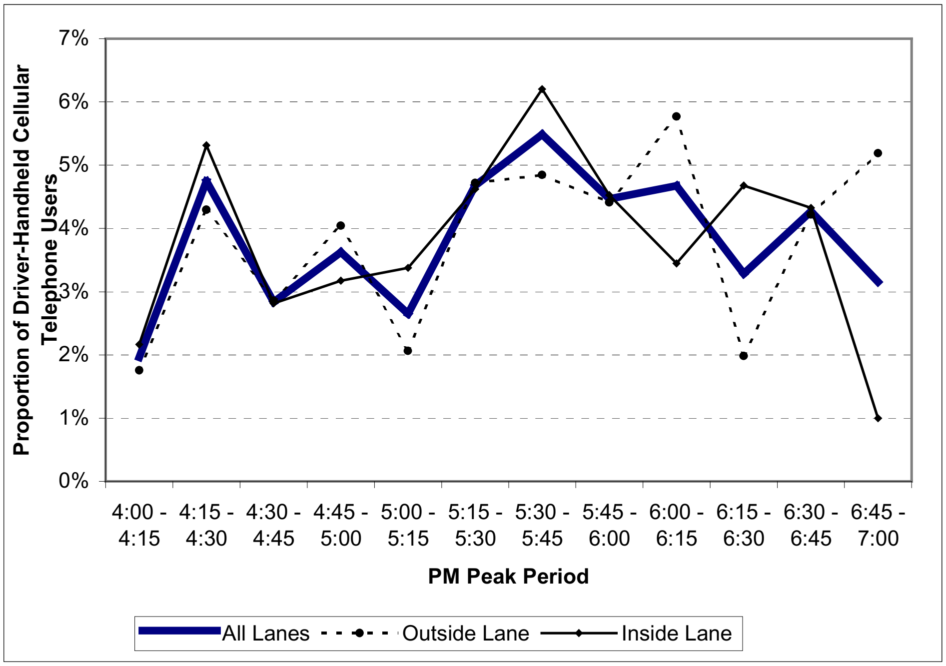


Figure 28. Observed Proportion of Driver-Handheld Cellular Telephone Users on Collins Street at Lamar Boulevard on May 30, 2000.

FREEWAY USE ASSESSMENT RESULTS

At the conclusion of the pilot tests, a final data collection protocol was developed and executed to estimate the ratio of drivers on Dallas County freeways using a handheld cellular telephone during the evening peak period (4:00 PM to 6:00 PM). Data were collected Monday through Thursday beginning on August 29, 2000, through September 18, 2000. Fridays, weekends, and holidays were excluded from the counting schedule because of their atypical nature.

Description of Study Sites

Five freeway segments were randomly selected from the list of available segments previously introduced. At these five locations, each direction of travel was observed on different days. Table 26 below shows a summary of the study sites. The relative location of each site within Dallas County is shown in Figure 29. Photographs of the study sites are shown in Figures 30 through 33.

Table 26. Study Sites for Freeway Assessment.

Site	Lanes	AADT (direction)	
		1995	1996
1: I-635 at New Market Rd	4	48,141 (NB) 48,141 (SB)	56,210 (NB) 54,660 (SB)
2: US 67 at Pleasant Run Rd	2	Not Available	15,610 (NB) 17,880 (SB)
3: Dallas North Tollway at Meaders Ln	3	Not Available	Not Available
4: I-30 at Cockrell Hill Rd	3	51,922 (EB) 51,922 (WB)	Not Available
5: I-35E at Kirnwood Dr	3	38,110 (NB) 36,870 (SB)	33,917 (NB) 33,917 (SB)

Figure 29. Location of Freeway Study Sites in Dallas County, Texas.

Figure 30. I-635 at New Market Road (southbound lanes).

Figure 31. Dallas North Tollway at Meaders Lane (northbound lanes).

Figure 32. I-30 at Cockrell Hill Road (westbound lanes).

Figure 33. I-35E at Kirnwood Drive (southbound lanes).

Methodology

The goal of this project was to determine an overall proportion of drivers who use handheld cellular telephones on Dallas County highways during the afternoon peak period.

Of the 51 highway segments in Dallas County, five were randomly chosen from those locations from which the traffic could be safely observed. Table 27 shows the segments sampled, the directions observed, the observers, and the date of each observation period. Data were collected on the variables listed and described in Table 28.

Table 27. Data Collection Sites.

Location	Loc ID	Direction	Observers	Date
US 67 at Pleasant Run Rd	US67	Northbound	1 and 2	08/29/2000
Dallas North Tollway at Meaders Ln	TOLL	Southbound	1 and 2	08/31/2000
I 635 at New Market Rd	I635	Northbound	1 and 2	09/05/2000
I 30 at Cockrell Hill Rd	I30	Westbound	1 and 3	09/06/2000
I 35 at Kirnwood Dr	I35	Southbound	1 and 3	09/07/2000
I 635 at New Market Rd	I635	Southbound	1 and 3	09/11/2000
US 67 at Pleasant Run Rd	US67	Southbound	1 and 2	09/12/2000
I 35 at Kirnwood Dr	I35	Northbound	1 and 3	09/13/2000
Dallas North Tollway at Meaders Ln	TOLL	Northbound	1 and 3	09/14/2000
I 30 at Cockrell Hill Rd	I30	Eastbound	1 and 3	09/18/2000

Table 28. Variables in the Experiment.

Variable	Description
LOCATION	One of the five sites listed in Table 2
TYPE	4-lane, 6-lane or 8-lane divided highway
LANE	4-lane: inside and outside lanes 6-lane: inside, middle and outside lanes 8-lane: inside, middle inside, middle outside and outside lanes
OBSERVER	Each of the three counters.
TIME	Eight 15-minute time periods (12 min counting, 3 min rest) starting at 4:00 PM and ending at 6:00 PM,
PEAK	Whether the observed direction was the peak direction for that site.
VOLUME	Total volume of vehicles for each time interval.
USERS	Total number of drivers using a handheld cellular telephone for each 15-min time interval.

Observations were made from 4:00 PM to 6:00 PM for each date. The data were collected in eight 15-minute time periods (see description of TIME in Table 28), giving eight observations for each date. Appendix A shows the instructions given to the observers. There were two observers for each time period, both observing the same randomly selected travel lane for each 15-minute interval throughout the observation period. This yielded 16 observations per date. A total of 160 observations were made over the ten dates. Each observation is a proportion of vehicles with drivers using a handheld cellular telephone to the total number of vehicles observed.

Results

The total number of vehicles observed for each TIME interval ranged from 79 to 449 vehicles with an average of 246 vehicles. The field assessment data is provided in Appendix B. A scatter plot of proportion of drivers using handheld cellular telephones to traffic volume is shown in Figure 34. Site 3, *Dallas North Tollway at Meaders Lane*, was observed to have higher proportions at much higher traffic volumes than the other sites. Figure 35 shows the scatter plot comparing results between observers throughout the final field assessment. The data in this figure are more compact than similar figures shown previously, though outliers are present.

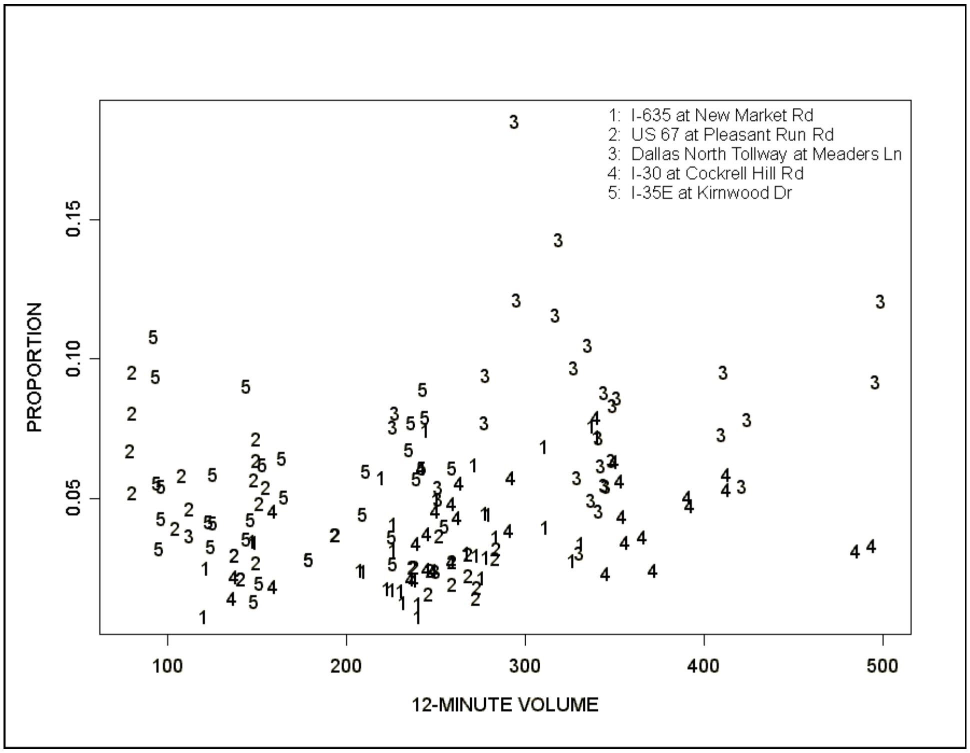


Figure 34. Scatter Plot of Proportion of Handheld Cellular Telephone Use v. Traffic Volume by Site Number.

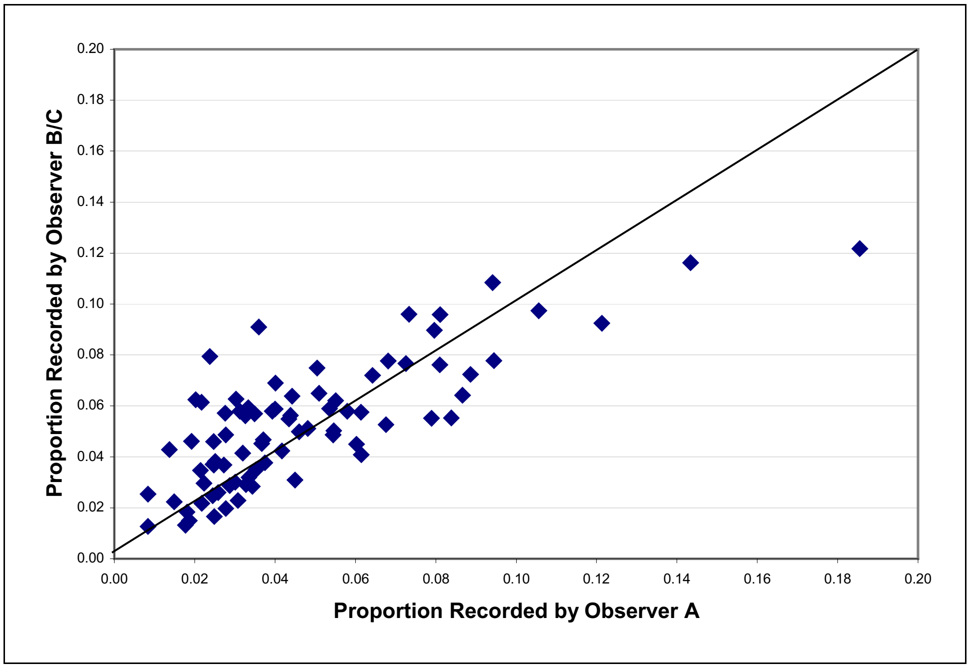


Figure 35. Scatter Plot of Observer Results for Freeway Field Assessment.

Figure 36 illustrates the distribution of the observed proportions. The histogram of the 160 proportions is right skewed. The proportions range from 0.8 to 18.5 percent. The average is 5.0 percent, and the median is 4.5 percent. The maximum value here was observed at *Dallas North Tollway at Meaders Lane*.

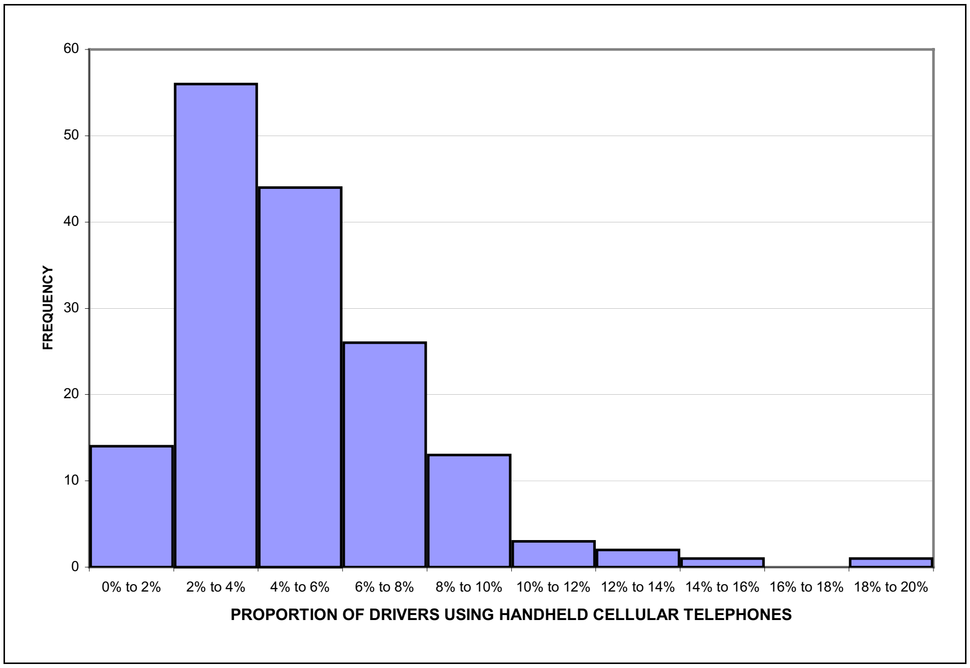


Figure 36. Distribution of the Proportions.

Figure 37 shows the distribution of the proportions for LOCATION through boxplots. The proportions for the location *Dallas North Tollway at Meaders Lane* are higher and have more variance than the other locations. The area north of this site is more affluent than other areas in which assessment sites were randomly selected, which may have influenced the number of cellular telephones observed.

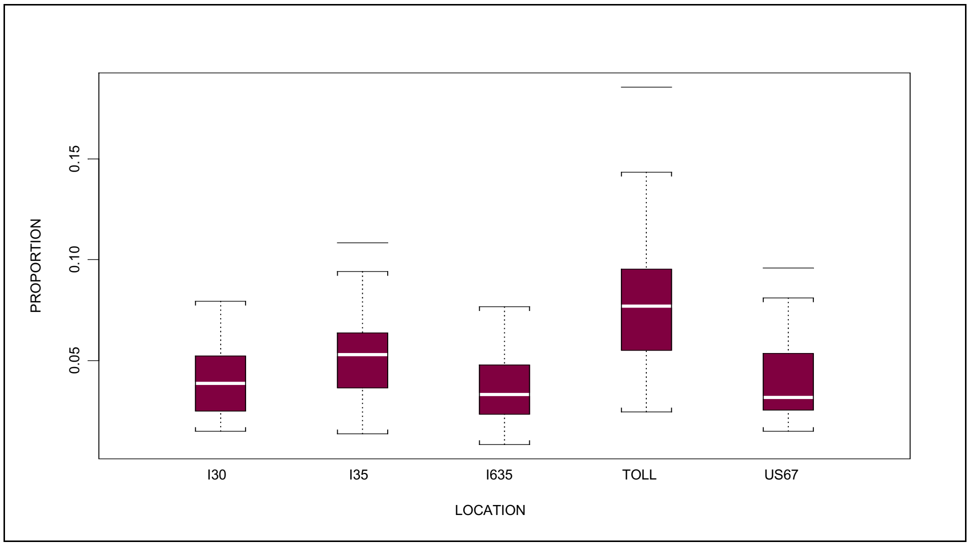


Figure 37. Boxplots of the Proportions per LOCATION.

For each location, the peak direction of travel was determined. Only one site (*I-635 at New Market Road)* was not located on a radial freeway segment where peak travel directions are obvious. For this location, the peak direction was assumed to be southbound for the afternoon peak period. Figure 38 examines the proportions for peak and off-peak traffic directions. The proportions for the peak directions are slightly higher than for off-peak directions; the median is higher and the interquartile range (IQR) is also higher. The outliers (the lines outside the brackets) are more extreme as well.

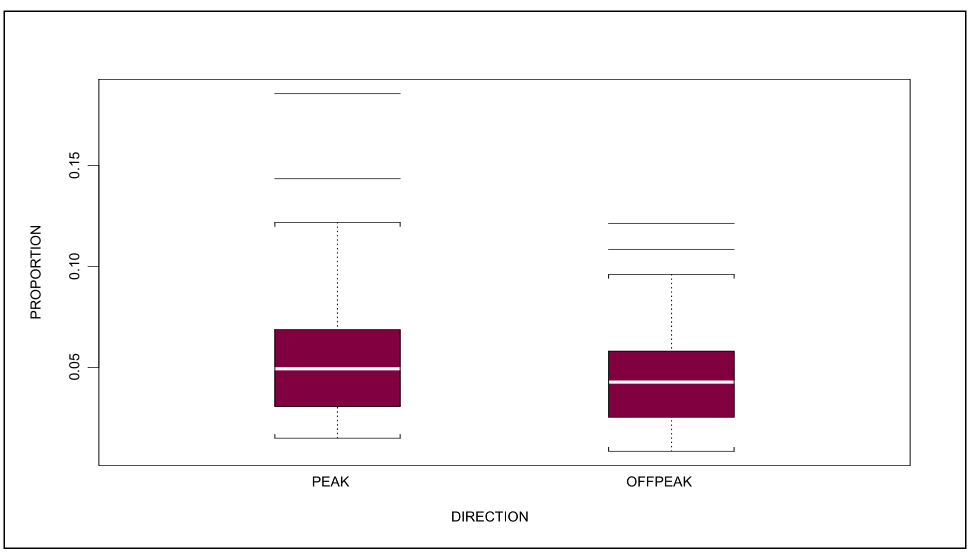


Figure 38. Boxplots of Proportions for PEAK.

Figure 39 illustrates the proportions distributed through TIME for all five locations. The medians of all time periods are below 5 percent except for time period F (5:15 to 5:30 PM).

Time periods G (5:30 to 5:45 PM),and H (5:45 to 6:00 PM) have more variability than the other time periods with outliers above 10 percent. The outliers were primarily from the *Dallas North Tollway at Meaders Lane* location. The increasing variance through time may be due both to general traffic patterns and to driver behavior associated with the end of the workday. These might include calls to a spouse, family or friends, or coordinating plans for the evening.

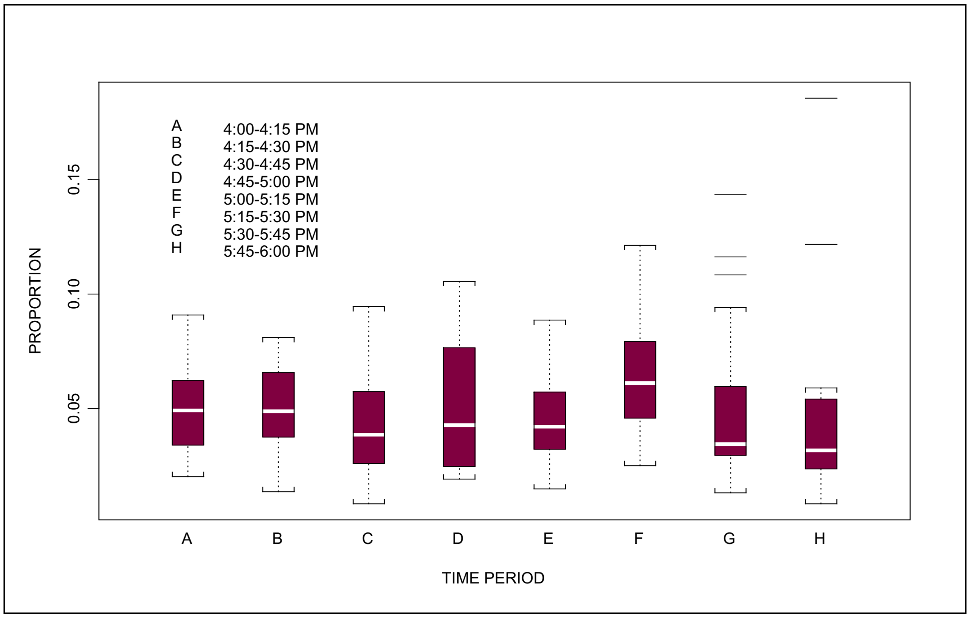


Figure 39. Boxplots of Proportions for TIME.

Figure 40 displays the proportions in relation to the number of travel lanes (LANE) on the roadbed of the highway segment observed. Three 6-lane highways, one 4-lane highway, and one 8-lane highway were observed. The 6-lane highways exhibit higher proportions than the 2- and 8-lane highways, and also have more variance. Given that there were more 6-lane highways observed, a variance less than the 4- and 8-lane highways would be expected. Yet the observed variance is greater since the range of the proportions is much larger than the other types of highways. The 6-lane highway includes the location *Dallas North Tollway at Meaders Lane*. As stated previously, data from this location are higher than the other similar sections observed resulting in an increase of the average.

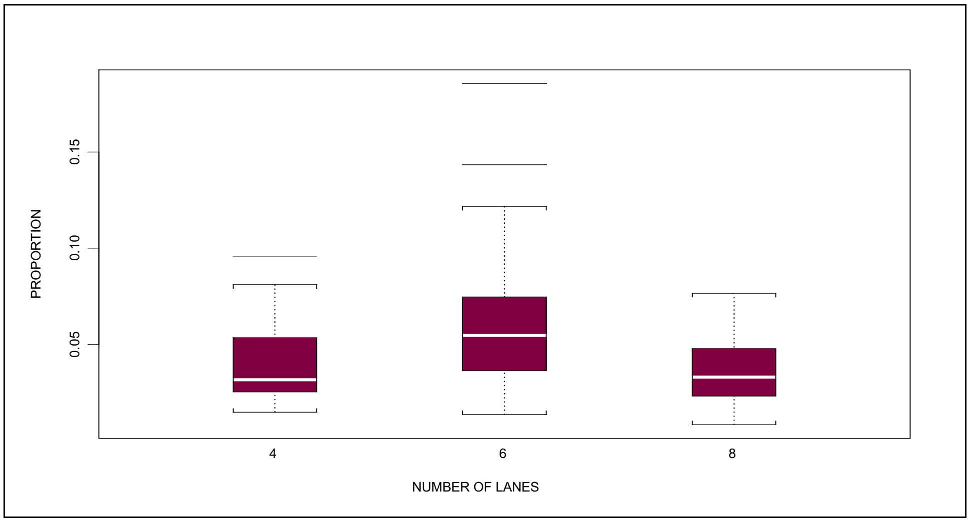


Figure 40. Boxplots of Proportions for TYPE of Highway.

The data collection protocol intended to have only two observers count throughout this assessment. Due to scheduling constraints of personnel, three observers were used (see Table 28). Observer 1 was used for each date, and the other two observers were split between locations, maintaining only two observers for each date and each watching the same lane. Figure 41 shows two plots. The left plot shows the distribution of the proportions for locations counted by Observers 1 and 2. The right plot shows the distribution of the proportions for locations counted by Observers 1 and 3. Figure 41 indicates that Observers 1 and 3 have slightly higher proportions. Though the locations were randomly assigned for each date, Observers 1 and 2 counted at the two locations with the lowest observed proportion while Observers 1 and 3 counted at the two locations with the highest observed proportions.

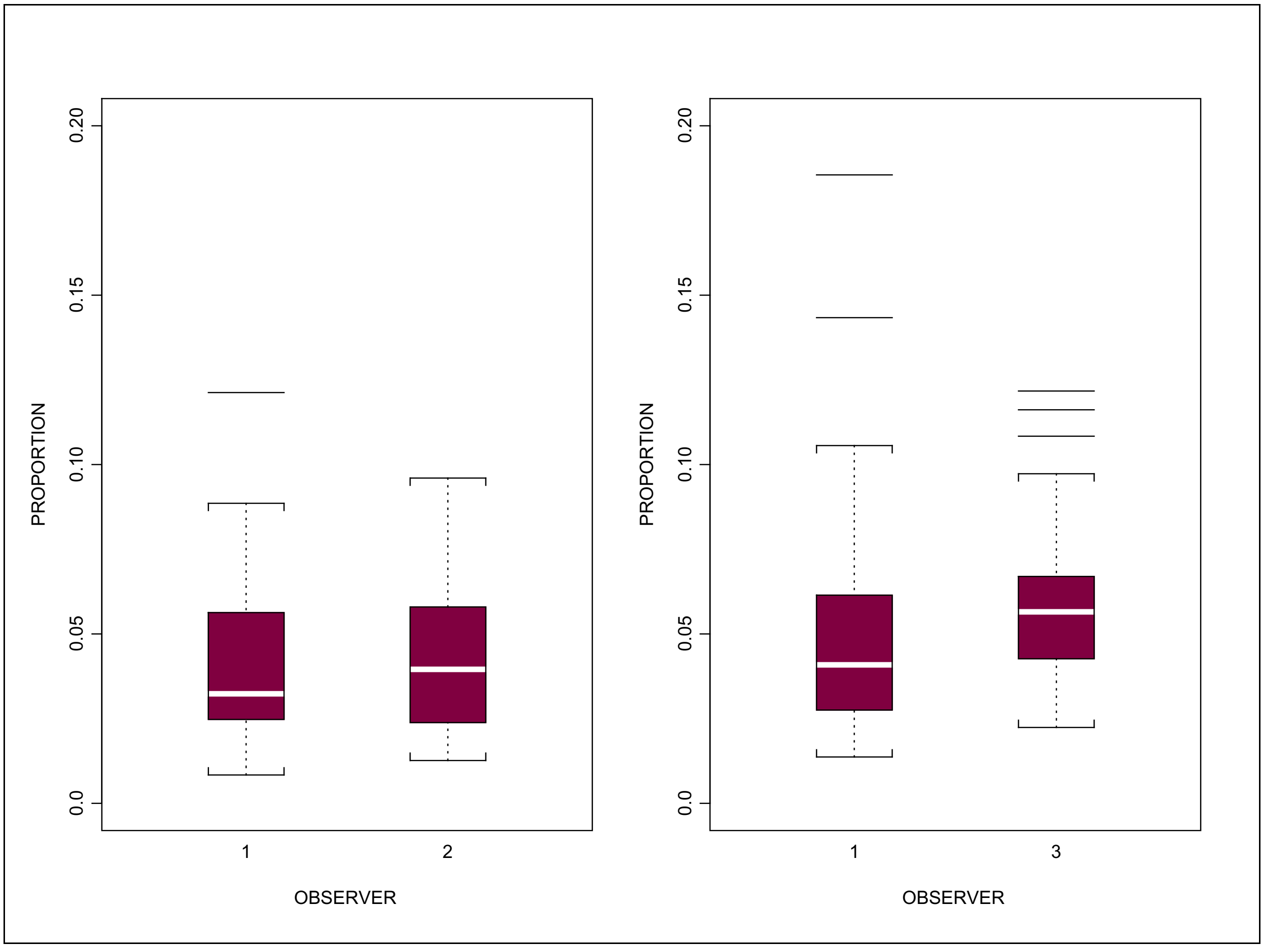


Figure 41. Boxplots of Proportions for OBSERVER.

An analysis determined the source of the differences observed in the proportions. Regression analysis on the original dataset was performed; however, the residual diagnostics implied non-constant variance. A second regression analysis was performed and analyzed on the log of the original proportions as the response variable. The log function was used on the dataset both to transform the right skewed distribution (Figure 36) to a more normal distribution and to reduce the impact of the non-constant variance.

Analysis

Statistical analysis, shown in Table 29, indicates that LOCATION (p-value=0.000), PEAK (p-value=0.000), OBSERVER (p-value=0.000), and TIME (p-value=0.000) are all significant in determining why the proportions vary. The interactions between LOCATION and PEAK (p-value=0.000), PEAK and OBSERVER (p-value=0.000), PEAK and TIME (p-value=0.000), LOCATION and TIME (p-value=0.000), and the three-way interaction of LOCATION, PEAK, and TIME (p-value=0.000) are also significant. The variables listed in Table 29 explain 90.2 percent of the variation of the transformed proportions observed.

Table 29. ANOVA Table with the Log of the Proportions as the Response Variable.

Source	Df	Sum of Squares	Mean Square	F Value	Pr(F)
LOCATION	4	14.15950	3.539875	54.49275	0.00000
PEAK	1	1.25713	1.257130	19.35222	0.00003
TIME	7	3.30908	0.472726	7.27713	0.00000
OBSERVER	2	2.86868	1.434340	22.08023	0.00000
LOCATION:PEAK	4	4.16393	1.040983	16.02487	0.00000
PEAK:OBSERVER	2	1.19330	0.596650	9.18480	0.00027
PEAK:TIME	7	1.88434	0.269191	4.14393	0.00066
LOCATION:TIME	28	8.38138	0.299335	4.60796	0.00000
LOCATION:PEAK:TIME	28	8.22836	0.293870	4.52383	0.00000
Residuals	76	4.93699	0.064960		

Note: Critical p-value < 0.05

Interactions

Significant interactions indicate that transformed proportions are different for a particular variable with different levels of another variable. There are several significant interactions within this data (see Table 29, identified by variable1: variable2). The interactions were examined using graphs. In the previous figures of boxplots (see Figures 37 through 41), several possible outliers were indicated. Interaction plots are usually discussed using means; however, because there were many possible outliers, medians are examined in this analysis.
Figure 42 shows the interaction between LOCATION and PEAK. The variable PEAK has generally higher proportions of handheld cellular telephone users except for the location *US 67 at Pleasant Run Road*. The series cross one another, confirming the interaction and revealing that spatial location and direction of travel influence each other.

Figure 42. Interaction Plot for LOCATION and PEAK.

Figure 43 shows the interaction between LOCATION and TIME. The lines crossing each other indicate the interaction between these variables. Clearly, the variable TIME makes a difference in the proportions observed for each location. For example, proportions for Period H (5:45 to 6:00 PM) are very low compared to the other periods except at *Dallas North Tollway at Meaders Lane*, where proportions are among the highest. Spatial location and time of day interact to influence the data.

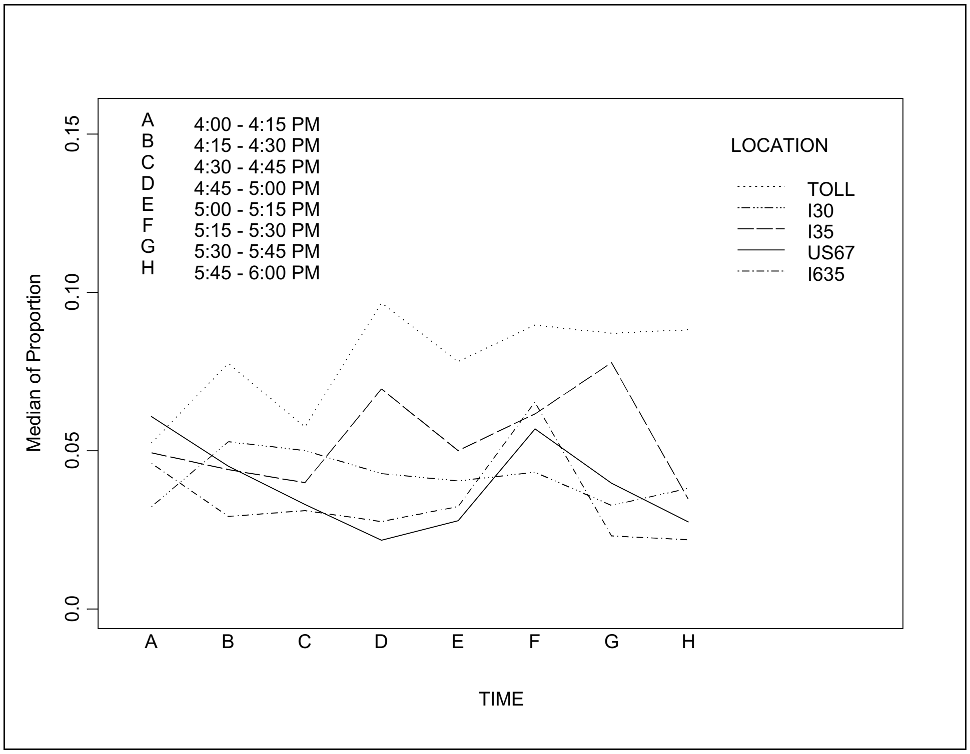


Figure 43. Interaction Plot for LOCATION and TIME.

Figure 44 shows the interaction plot for variables PEAK and TIME. During time period A (4:00 to 4:15 PM), the median proportion is higher for the peak direction of traffic. Period B (4:15 to 4:30 PM) also has the higher proportion during peak traffic; yet the median proportions are closer in value. Period C (4:30 to 4:45 PM) has the median proportion for the peak traffic less than the median for off-peak traffic. These results show an interaction between travel direction and time of day.

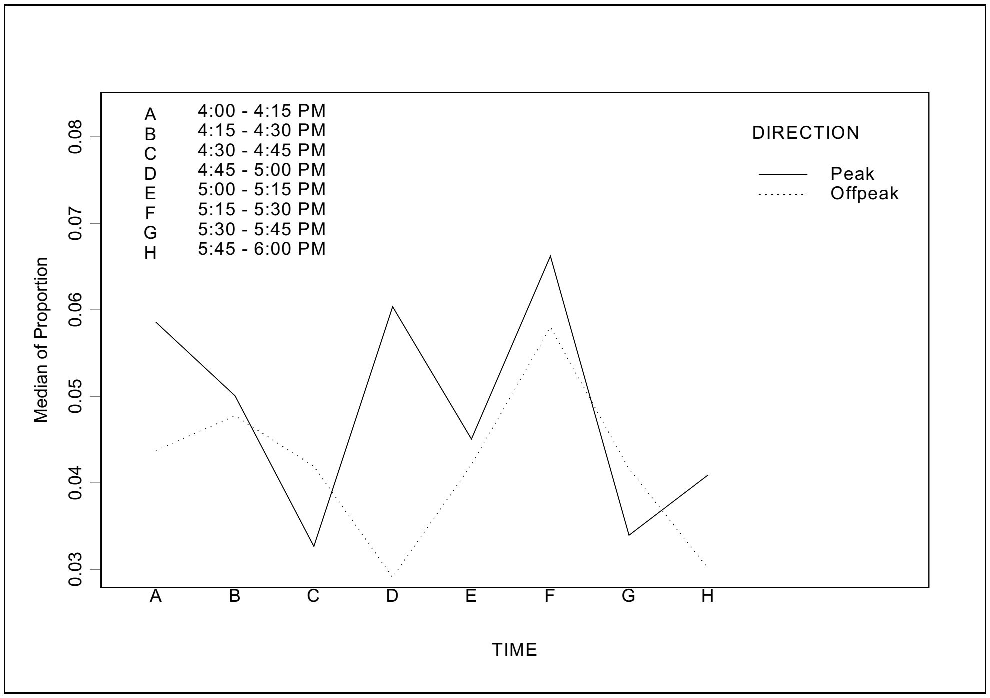
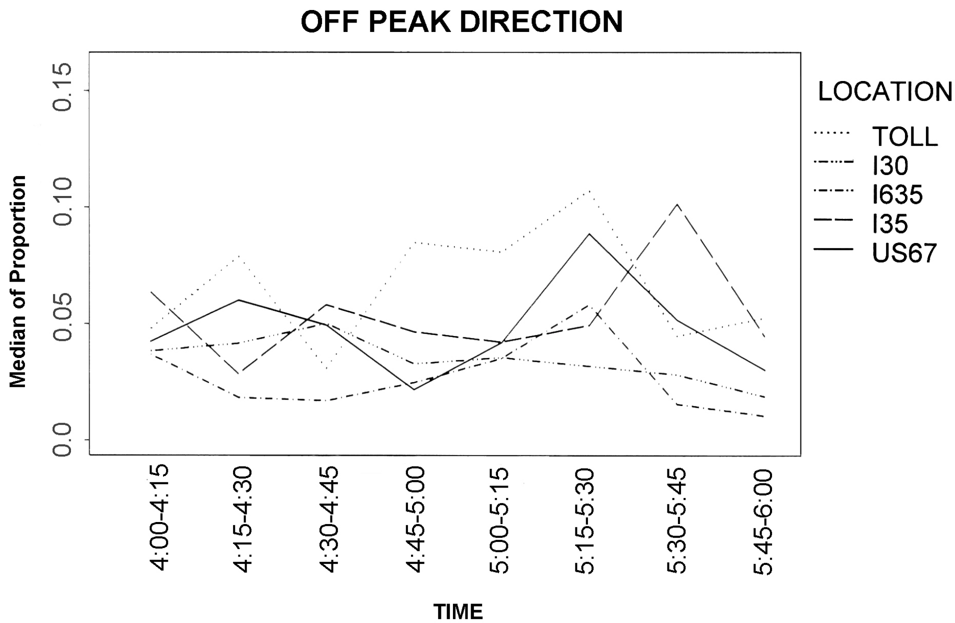


Figure 44. Interaction Plot for PEAK and TIME.

Figure 45 shows the three-way interaction between TIME, LOCATION, and PEAK. There is a substantial difference between the plots. For example, consider the line for the Dallas North Tollway segment (TOLL). For time periods G (5:30 to 5:45 PM) and H (5:45 to 6:00 PM), proportions during the peak traffic direction are almost three times as high as the off-peak traffic direction. These plots confirm that time of day, spatial location, and direction of travel influence handheld cellular telephone use.



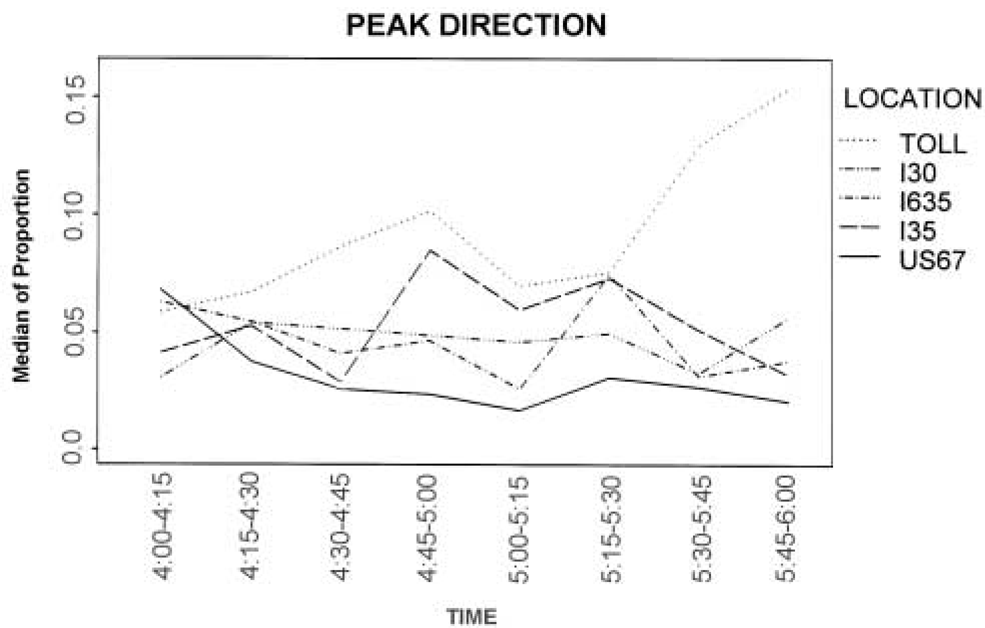


Figure 45. Three-way Interaction Plot for PEAK and TIME and LOCATION.

Due to the many interactions, it was difficult to appropriately estimate the overall proportion of drivers using handheld cellular telephones on Dallas County Highways in the afternoon peak period. The following sets of tables present the data in different ways. Table 30 summarizes each location in both peak and off-peak directions. Summing all the observed users and dividing by the total number of vehicles observed from 4:00 PM to 6:00 PM generates the proportions for each location and direction. Table 31 shows location estimates by taking the number of observed users for each location for both directions, divided by the total number of vehicles observed for each location. Table 32 shows direction estimates by totaling the number of observed users in each travel direction and dividing this by the total number of vehicles observed traveling in that direction. Table 33 reduces the estimate to one number by summing all users observed by the total number of vehicles observed.

Table 30. Proportions by Location and Direction.

Location	Direction	Peak	Proportions
US 67 at Pleasant Run Rd	NORTHBOUND	NO	4.3%
Dallas North Tollway at Meaders Ln	SOUTHBOUND	NO	6.5%
I 635 at New Market Rd	NORTHBOUND	NO	2.6%
I 30 at Cockrell Hill Rd	WESTBOUND	YES	4.3%
I 35 at Kirnwood Dr	SOUTHBOUND	YES	5.1%
I 635 at New Market Rd	SOUTHBOUND	YES	4.5%
US 67 at Pleasant Run Rd	SOUTHBOUND	YES	2.8%
I 35 at Kirnwood Dr	NORTHBOUND	NO	5.0%
Dallas Tollway at Meaders Ln	NORTHBOUND	YES	8.2%
I 30 at Cockrell Hill Rd	EASTBOUND	NO	3.4%

Table 31. Proportions by Location.

Location	Proportions
US 67 at Pleasant Run Rd	3.3%
Dallas North Tollway at Meaders Ln	7.4%
I 635 at New Market Rd	3.7%
I 35 at Kirnwood Dr	5.1%
I 30 at Cockrell Hill Rd	4.0%

Table 32. Proportion by Direction of Travel.

Direction	Proportion
PEAK	5.1%
OFF-PEAK	4.5%

Table 33. Proportion Across Locations.

Location	Proportion
ALL LOCATIONS	4.9%

The highest observed proportion was 8.2 percent along the northbound Dallas North Tollway, whereas the lowest observed proportion was 2.5 percent on northbound I-635. The median observed proportions were 4.5 and 4.3 percent along southbound I-635, and northbound US 67 and westbound I-30, respectively. The highest observed proportion at a site was 7.4 percent on the Dallas North Tollway. The lowest observed proportion was 3.3 percent on US 67. The median use among the five sites was 4.3 percent on I-30.

Summary

The analysis indicates that not only do LOCATION, PEAK, OBSERVER, and TIME influence the proportions observed, but the interactions of LOCATION and PEAK, PEAK and OBSERVER, PEAK and TIME, LOCATION and TIME, and the three-way interaction of LOCATION, PEAK and TIME also influence the proportions observed. These influences create difficulties in choosing an appropriate method of estimation. Tables 30 through 33 illustrated different estimates for driver's handheld cellular telephone use.

A more accurately estimated proportion of drivers using handheld cellular telephones while on Dallas County freeways during the afternoon peak period would include multiple observations (repeated measures) of all 51 highway segments, using the same set of observers. This method would help reduce variation in the observations and provide a more accurate estimate of drivers' handheld cellular telephone use.

CONCLUSIONS

Pilot Studies

Data quality is very dependent on the observer. A number of factors influence the observers' ability to accurately collect data. These factors include heavy traffic volumes, high vehicle speeds, poor contrast within the driving compartment, drivers obscured by dark tint on the top of windshields and low-profile windshield accessories, sun glare from windshields, and mental fatigue. According to observers, vertical curves near the observation sites also interfered with accurate data collection.

Freeway Sections

Handheld cellular telephone use among drivers varies by travel lane. A higher number of users occupy the outside lane. However, because of generally higher volumes in this lane, the proportion of use is diluted and lower than other travel lanes. On multi-lane freeway sections, distribution of the number of users tends toward the outside lane. Interestingly, the middle inside lane showed more users than the lanes adjacent to it.

Highly urbanized sections exhibited higher use rates among drivers than in less urban, more rural areas. Literature has shown that other demographic factors (e.g., household income, age, and sex) are less likely to influence cellular telephone ownership. This difference might be attributed to higher population densities or more societal integration with cellular telephone technologies in more urbanized areas.

Arterial Streets

Handheld cellular telephone use by drivers on arterials, as a proportion of traffic, was similar to that of the freeway sections observed. Because only one arterial location was observed, this conclusion may be weakened when additional arterial segments are observed and handheld cellular telephone use among drivers on those roads is estimated.

Because arterial streets often fail to provide proper vantage points from which traffic in all lanes can be safely and accurately observed, handheld cellular telephone use by drivers on arterials may be estimated by recording data in the outside lane of traffic for two-lane sections. Additional research is required to determine how use on three- and four-lane sections is distributed.

Data Collection Method: Human v. Video

Video recorded and human observed data collection methods for assessing handheld cellular telephone use of drivers in moving vehicles are available. Choosing an appropriate method to produce accurate and precise measurements becomes the challenge of the investigator. Both methods have their own advantages and weaknesses.

Video data collection may be thoroughly scrutinized in an office environment. However, this dramatically increases the labor cost for data collection. At the same time, the reduction of data is limited to a small field of vision compared to that available to the human observer at the site. The opportunity to view the silhouette of each driver, when tinted glass does not diminish the contrast in the passenger compartment, carries advantages for assessing the drivers' body and hand positions.

Human observers in the field usually yield a higher degree of variability in recording positive responses. Mental workload, short duration for perception and reaction, and fatigue all affect the quality of data collected by a field observer. The ability to visually follow or track vehicles along the travel lanes is an advantage for field observers. It allows them to scrutinize each driver, their body and hand position, focusing in on details as the vehicle approaches. Because of these advantages, in-field observation by staff is the preferred method of data collection.

Data collection error might be reduced through the use of electronic monitoring devices that can detect the energy impulses of cellular telephones while in use. The equipment might be installed on any overhead structure to collect data for each travel lane. The availability and cost of such equipment are unknown.

Handheld Cellular Telephone Use on Freeways

The project achieved its objectives: to develop a data collection methodology and to estimate the proportion of handheld cellular telephone use among drivers. Both the final set of procedures and estimates are summarized below.

Data Collection Procedures

A set of data collection procedures was developed and tested. Without the aid of advanced electronic monitoring equipment, human observers were used to collect data through visual observation of drivers inside their vehicles while in motion. The recommended data collection protocol is:

- Inventory roadway segments (sections defined between freeway-freeway interchanges).
- Discard segments where safety and visual conditions do not meet minimum standards.
- Randomly select a minimum of 5 freeway segments (if collecting for both directions of travel) or 10 freeway segments (if collection for either the peak or off-peak direction of travel only) from the remaining acceptable segments.
- Randomly select the observed travel lane of the roadbed for each time interval.
- Assign two observers for the travel lane observed (repeated measures).
- Physically locate observers on overpass structure sidewalks or shoulders so they are positioned over each travel lane.
- Allow observers to laterally shift position to minimize environmental factors such as windshield glare from oncoming traffic.
- Collect a minimum of 2 hours of data.
- Schedule observers for shifts of no more than 3 hours.
- Allow observers rest periods by instructing them to record data for 12 minutes and rest for 3 minutes; resting will reduce or minimize visual and mental fatigue of the observers.

Driver Use of Handheld Cellular Telephones on Freeways

Spatial location, time of day, and travel direction influence the use of handheld cellular telephones while driving. Other unidentified factors (e.g., congested conditions or speed) may also influence handheld cellular telephone use when driving.

Observers also influence the proportion estimate. This is because they must use professional judgment with mostly subjective data with a short reaction time. The selection of capable personnel is very important. They must be able to observe, recognize, and record data for both cars and trucks with short reaction times in many cases. To minimize variance among observers, a planned experiment using analysis of variance should be conducted to identify observers with similar recording techniques.

Estimates of handheld cellular telephone use among drivers can be derived as a weighted average of all observed data. Because several factors were observed to influence the dataset, a sample dataset cannot be expanded to represent the transportation network. Additional work will be required to investigate the extent and nature of these factors, so that regional estimates of handheld cellular telephone use by drivers can be made.

Five percent of all drivers in this field assessment were observed using a handheld cellular telephone on Dallas County freeways during the afternoon peak period. This proportion ranged from 3 percent at less urbanized locations to 7 percent at highly urbanized sites. Also, the peak travel direction had significantly higher use than the off-peak travel direction.

This estimate is conservative. It does not include the use by drivers of either handheld cellular telephones with hands-free adapters, or in-vehicle, installed hands-free cellular telephone systems. Available data collection methods did not incorporate the means to record use of such equipment. Electronic monitoring devices, which can detect energy fields of cellular telephones, might be used in future research to estimate a total use of cellular telephones among drivers.

CHAPTER V. CELLULAR TELEPHONE USE AND DRIVER PERFORMANCE: THE EFFECTS OF CONVERSATION INTENSITY AND MODE OF OPERATION

INTRODUCTION

Attention Capacity

When a driver chooses to use a cellular telephone, both the driving and cellular telephone tasks demand the driver's attention. Since both tasks are time continuous, there is an overlap in the task attention demands. Therefore, the driver must attend to both tasks concurrently.

Single-Resource Attention Theory

According to the single-resource attention theory, the attention of the driver is a single, limited resource (76). If the combined attention demand is less than the attention capacity, it is possible for the driver to perform both tasks successfully. If the combined attention demand exceeds the attention capacity, performance of either task may be degraded. It follows, that as the driving task becomes increasingly difficult, the performance of either the cellular telephone task or the driving task may degrade. It is possible that the performance of both tasks is compromised.

Secondary Task Methodology

Brown and Poulton tested the validity of using a secondary task to measure the spare mental capacity or attention of a driver (77). Fifteen participants drove though both shopping and residential areas, a total distance of 2.2 miles. As each participant drove, they were given either a simple memory test or a more complex mathematical addition test. The tests were administered orally and required a verbal response. The number of correct responses was recorded as well as the pedal and steering inputs of the driver. An increase in response errors to the cognitive tests indicated that driving through the shopping area required more attention of the driver than driving through the residential area. The increase in driving difficulty was associated with a lower performance of the secondary cognitive task. These results support the notion that the secondary task is sensitive to changes in the driving task. Otherwise, the single-resource attention theory is supported. When the secondary task is the use of a cellular telephone, the expected result is degradation in driving performance or the use of the cellular telephone, or both. The concern is that the driver's control of the vehicle will significantly degrade rendering the use of the cellular telephone unsafe.

Numerous researchers exploring the effects of cellular telephone use have implored the secondary task methodology. Historically, research efforts have examined the effects of dialing the cellular telephone and engaging in either a casual conversation or some form of cognitive test. Manual dialing has been shown to be as disruptive as tuning the radio and using a manual redial function has been shown to be similar to using a voice-activated dialing function. Casual conversation has been shown to have a small negative effect on driving performance, and it is likely that a more difficult or emotional conversation could have a greater effect. The cognitive tests have been shown to have a greater effect than the casual conversation, but it is unclear as to how well the cognitive test compares to an intense conversation.

Studies of Cellular Telephone Use and Effects

Historically, speed and steering control measures have been used as indicators of driving performance. These controls have been further defined as the driver's ability to maintain a desired speed, the chosen headway of the driver, the response time to an event, and the lane position or lane position deviation of the vehicle, as well as other less common measurements. By comparing the driving performance during a base condition with that of a test condition, the impact or effect of the test condition can be examined. Such an approach has been adopted in the investigations of the effects of cellular telephones on driving performance. Tests have been conducted in a variety of settings including open course, closed course, and simulated environments. Table 34 provides a listing of such experiments along with some details of the experimental designs. Further details and a discussion of the results are included in the following sections of this report.

In addition to such structured experiments, efforts have also been made to investigate the effects of using cellular telephones by examining collision reports and trends in collision rates. A number of epidemiological studies have been prepared to estimate the increase in the risk of collision or the severity of the collision given the use of a cellular telephone.

Epidemiological Studies

To conduct an epidemiological study, existing data from a large population is gathered and through statistical methods relationships in the data are identified. To determine whether the use of cellular telephone while driving affects driving performance, collision data have been studied by a number of researchers. The following epidemiological studies were conducted to reveal whether cellular telephone use was related to an increase in the driver's risk of being involved in a collision or the if the use of the cellular telephone increased the likelihood that the severity of a collision would be fatal.

Violanti and Marshall hypothesized that the increase of a driver's use of a cellular telephone increases the risk of being involved in a traffic accident (78). Using an epidemiological method and statistical regression techniques, the relationship between the use of a cellular telephone and the increase of the risk of being involved in a collision was analyzed. For the analysis, eighteen attention factors were identified for both a test group of drivers and a control group of drivers, including the amount of time per month each driver spent talking on a cellular telephone. The results of the analysis found that talking more than fifty minutes per month on a cellular telephone while in the vehicle is associated with a 5.59 fold increase in the driver's risk of being involved in a collision.

Table 34. Study Designs of the Previous Research.

	Study Type			Number of Participants		Dial Mode		Talk Type		Performance Measure		
Study	**Closed Course**	**Simulator**	**Open Course**	**Age**	**Sex**	**Handheld**	**Hands Free**	**Casual**	**Cognitive**	**Speed**	**Response Time**	**Lane Position**
Brown (1969)	✔			24: 21-57 years	24 M				✔	✔		
Kames (1978)	✔			18: 19-65 years	12 M 6 F	✔	✔			✔	✔	✔
Drory (1985)		✔		60: 24-55 years	60 M				✔		✔	✔
Stein (1987)		✔		24: Under 25 yrs 24: 25-55 years 24: over 55 years	12 M, 12 F 12 M, 12 F 12 M, 12 F	✔	✔			✔		✔
Zwahlen (1998)	✔			10: ave. 23.6 years	10 M		✔					✔
	✔			10: ave. 20.8 years	5 M, 5 F		✔					
Brookhuis (1991)			✔	4: 23-35 years 4: 35-50 years 4: 50-65 years	10 M, 2 F	✔	✔		✔	✔		✔
McKnight (1993)		✔		45: 17-25 years 56: 29-49 years 49: 50-80 years	75 M, 75 F		✔	✔	✔		✔	
Serafin (1993)		✔		6: 20-35 years 6: over 60 years	3 M, 3 F 3 M, 3 F	✔	✔	✔	✔			✔
Alm (1994)		✔		40: 23-61 years	20 M, 20 F				✔	✔	✔	✔
Alm (1995)		✔		20: under 60 years 20: over 60 years	30 M, 10 F				✔	✔	✔	✔
Briem (1995)		✔		10: 19-26 years 10: 40-51 years	5 M, 5 F 5 M, 5 F		✔	✔	✔	✔		✔
Reed (1999)		✔	✔	6: 20-30 years 6: over 60 years	3 M, 3 F 3 M, 3 F	✔				✔		✔
Lamble (1999)			✔	19: 20-29 years	10 M, 9 F		✔		✔		✔	

Redelmeier and Tibshirani also used an epidemiological method to investigate the association of cellular telephone calls and reported vehicle collisions (*7*). The report investigated 699 vehicle collisions involving drivers who had cellular telephones. By comparing police reports and reports from eyewitnesses with cellular telephone records, the time of occurrence of 231 collisions were confirmed and of those 170 had occurred within ten minutes of the driver using a cellular telephone. The results of the analysis of these collisions suggest that the use of the cellular telephone quadruples the driver's risk of being in a collision. McClure and Mittleman analyzed the data used by Redelmeier and Tibshirani and confirmed that the risk of being involved in a traffic collision doubled within five minutes after the start of a cellular telephone call (79)(*7*).

To test the hypothesis that the severity of a traffic collision is more likely to be fatal if the driver is using a cellular telephone, Violanti analyzed data from 223,137 accidents that occurred between 1992 and 1995 (80). Using an epidemiological approach, the statistical association between cellular telephone use and fatal traffic accidents was examined. The results of the examination support the idea that cellular telephone use doubled the likelihood that the severity of the traffic collision would be fatal. This statistical relationship does not imply that cellular telephone use itself is responsible for fatal traffic collisions but only identifies the potential influence of cellular telephone use on the increased severity of the collision.

Comments about the Epidemiological Studies. Epidemiological studies are prepared using collision data typically provided on collision reports prepared by investigating police officers. Unfortunately the reliability of this collision data is subject to scrutiny, as the integrity or completeness of the reports may be questioned. The driver's use of a cellular telephone is not a standard item on police reports and even if it were, drivers are not likely to admit that their use of a cellular telephone contributed to a collision. In addition, many collisions are not reported. Collisions involving only property damage and not personal injury may not be investigated by police which means many minor collisions could have occurred where the cellular telephone was a contributing factor and have not been recorded.

The results of these epidemiological studies suggest the use of cellular telephones either increases the driver's risk of being involved in a collision or increases the likelihood that a collision will be fatal. These results are influenced by the current collision reporting system and most likely contain a large amount of variability. Nevertheless, if the use of a cellular telephone degrades the driver's control of the vehicle, an increase in the risk of being involved in a collision is an expected consequence.

Open-Course Studies

An open-course study is designed to take place on a course that is a part of the public roadway. During the experiment, non-experiment vehicles and pedestrians are not controlled and can therefore act as a distraction or interference. The driver experiences the interaction with other vehicles and the associated risks.

Brookhuis, De Vries, and De Waard investigated the effects of using handheld and hands-free cellular telephones while driving in a variety of traffic conditions (81). Ten males and two females were divided equally into three age groups of 23 to 35 years, 35 to 50 years, and 50 to 65 years. The twelve participants had no previous cellular telephone experience. On every workday during a three-week period each participant drove three routes, one with low traffic volumes, one with high traffic volumes, and one in congested city traffic. While driving each of the routes, half the participants dialed the cellular telephone using handheld mode and the other half used hands-free mode. After dialing, each participant engaged in a three-minute cognitive test with the experimenter. The lateral position, speed, and steering wheel movements were recorded. The standard deviation of the lane position significantly decreased with the addition of the telephone task. The greatest effect was observed when the participants drove on the route with the low traffic volumes, although the effect was still present when the participants drove the route with high traffic volumes. When driving the route with high traffic volumes, the drivers using the cellular telephone exhibited a slower response to the brake lights of the lead vehicle increased, although the difference of 130 msec was not significant. Furthermore, the time it took for the driver to adapt to a change in speed of the lead vehicle increased by 600 msec when the telephone task was being performed. This difference was found significant.

Lamble, Kauranun, Laasko, and Summala investigated the extent to which a secondary task impairs driving performance when the driver is in a car-following situation (82). Nineteen drivers, ten males and nine females, aged 20 to 29 years participated in the experiment. Each participant drove on a section of roadway following a lead car traveling at 80 km/h (50 mph). The lead car decelerated at a rate of 0.47 m/s^2 (1.55 f/s^2) and the time it took for the participant to respond to the change in speed of the lead vehicle was recorded. The participant repeated the control condition ten times. The first test condition required the participant to engage in a cognitive test administered by the experimenter. The participants repeated the first test condition ten times. The second test condition required the participant to dial the cellular telephone, and it was also repeated ten times. During the first test condition, the inclusion of the cognitive task was associated with an increase of 0.95 second in the time to collision threshold. During the second test condition, the inclusion of the telephone task resulted in a similar increase of 0.62 second. Both the cognitive task and the telephone task significantly increased the time to collision threshold. During the first test condition, the cognitive task resulted in a 0.50 second increase in average brake response time, which was a significant change. A similar increase of 0.48 second was attributed to the telephone task in the second test condition and was also significant. During both of the test conditions, no significant change in the standard deviation of lateral acceleration was observed. The lack of degradation in lane-keeping ability may be attributed to the fact that the drivers were following a lead car. It is possible that the interaction of vehicles, such as following a lead vehicle, could aid the driver in maintaining a constant lane position.

Reed and Green compared the effects of cellular telephone dialing on driving performance when conducted in a simulator and when conducted in an instrumented vehicle on a highway route (83). Three men and three women between the ages of 20 and 30 years, and three men and three women greater than 60 years were asked to drive an instrumented vehicle at 96 km/h (60 mph) on a highway route. As the participants drove, they periodically dialed a cellular telephone. The lane position, speed, steering wheel position, and throttle positions were recorded during the driving task and the concurrent telephone task. The lane-keeping ability of the driver was significantly affected by the inclusion of the telephone-dialing task, and the age of the driver was found to be a contributing factor when combined with the use of the cellular telephone.

Summary of Open Course Studies. Although only three open course studies were reviewed, the results can be compared to build support for the idea that the use of the cellular telephone can affect the driver's control of the vehicle. It appears that the driver's response time is negatively affected by dialing the cellular telephone or by engaging in a cognitive test. The transferability of these results to a realistic, emotional or difficult conversation is unknown.

Closed Course Studies

A closed course study is designed to take place on a route that is separated from the general traffic. For this reason, the test environment can be controlled such that the test vehicle can traverse the course without distraction or interference. Although the use of a closed course offers a safe testing environment by removing the interaction with other vehicles, it also produces an environment that is less than realistic. The controlled environment may change how the driver perceives the risk and potential consequences of making an error may thus influence the performance of the driver. Even with such drawbacks, it is possible to use a closed course to conduct a comparative study. Such an approach was used in the following closed course studies.

Brown, Tickner, and Simmonds investigated the hypothesis that talking on a cellular telephone could interfere with the judgment of the driver (*29*). Twenty-four male participants between the ages of 21 and 57 years drove an Austin A40 estate car around a 2.4 km (1.5 m) closed course. As the drivers traversed the course, they encountered pairs of obstacles set up to define a predetermined clearance size for the vehicle to maneuver through. Not all clearances were large enough for the vehicle to pass through successfully, and the driver had to decide whether to drive through the clearance area or drive around the obstacles. There were a total of 20 pairs of obstacles, evenly spaced throughout the course. The number of clearance areas successfully negotiated, the time to complete the course, the driver pedal, and steering input were recorded. The driver repeated the course while answering questions about the grammatical accuracy of a series of sentences. The numbers of correct responses and the time to respond were recorded as measurements of the performance of the cognitive task. The results of the study indicate that when the driver was answering the questions, the travel speed decreased by 6.6 percent, but the driver's control of the vehicle did not significantly change. The reduction in speed suggests there is some sensitivity between the performance of the cognitive task and the driver's control of the vehicle. Unfortunately, it is not clear how these results relate to a typical cellular telephone conversation. The attention demand of the cognitive task may not be the same; therefore, the applicability of these results is unclear.

Kames compared the task of dialing of a telephone with the task of tuning a radio and its effect on driving performance (84). Six combinations of cellular telephone architecture and mounting location were investigated. Twelve males and six females between the ages of 19 to 65 years drove a 1975 Chevrolet Impala station wagon through a 7.0 km (4.4 m) closed course at 56 km/h (35 mph). As each participant drove, they were asked to indicate when a green or amber light was illuminated either to the left or right of the steering column by verbally describing the light. The light was then extinguished by depressing a foot pedal. Five driving performance measures were recorded including lane position, rate of steering reversals and range of speed. The response time to the illumination of the light was also recorded. The driver repeated the course eighteen times, three times for each of the six combinations of cellular telephone architecture and mounting location. The time to dial the telephone was recorded.

While dialing the 76 mm x 102 mm (3" x 4") telephones of various architectures and mounting locations, the drivers exhibited no significant change in driving performance. The standard deviation of the mean speed ranged from 9.8 km/h (6.13 mph) to 10.4 km/h (6.52 mph). While dialing the 152 mm x 51 mm (6" x 2") telephone with handset architecture, a significant difference in lane position was observed. The standard deviation of the mean speed was 11.4 km/h (7.13 mph); which, while greater than that associated with the 76 mm x 102 mm (3" x 4") telephone, was not significant difference. The difference in the driver's standard deviation of mean speed and lane position observed to occur when using the different sized phones, suggests that the size of the cellular telephone may contribute to the effect of using a cellular telephone.

The larger phone may demand more of the driver's attention or perhaps the size of the phone causes dialing to be more cumbersome.

Zwahlen, Adams, and Schwartz performed two closely related studies, each looking at how dialing a cellular telephone affects the driver's lane keeping ability (85). In the first study, ten males with an average age of 23.6 years drove a 1982 Pontiac station wagon in good mechanical condition. In the second study, five males and five females an average age of 20.8 years drove a 1985 Plymouth Turismo that was also in good mechanical condition. In each study the participants were asked to drive the vehicle at 64 km/h (40 mph) and manually dial an eleven-digit number. Four test conditions were defined by the two mounting locations of the telephone and whether or not the participant was permitted to look at the roadway while dialing. The participants completed the task five times for each of the test conditions.

The test condition where the telephone was mounted low and the driver was prohibited from looking at the roadway while dialing resulted in the greatest lateral deviation of 469 mm (18.47 inches). This result is not surprising. Certainly restricting the driver from looking at the roadway affects driving performance.

The vehicles used for the experiment appeared to influence the lateral position results. The mean deviation observed when the Pontiac was driven was to the left of center and for the Plymouth it was to the right of center. Although the vehicles were in good mechanical condition, perhaps the alignment of the vehicles differed.

Summary of Closed Course Studies. The small number of studies and consequently few results do not allow for strong comparisons to be made. However, the results suggest that there is some sensitivity in the performance of the driving task to the addition of a telephone task.

Simulation Studies

A driving simulator uses video imaging to present a driving scene to the driver. The images are either presented on a computer screen(s) or projected onto a wall. The available simulators range in sophistication. An open-loop simulator provides the image but does not respond to driver input. A driving environment simulator integrates the driver input with the driving scene to provide a realistic, interactive driving experience.

Regardless of the sophistication, the simulator provides a safe, controlled testing environment. As with using closed course studies, using a simulator has its share of drawbacks. The controlled environment may change how the driver perceives the risk of making an error, thus affecting driving behavior. Even using the most sophisticated simulator, the driver may feel disconnected from the driving scene and fail to accurately evaluate speed and direction. However, the simulator provides an excellent test environment for conducting comparison or before and after studies. Such an approach was used in the following simulator studies.

Drory examined how additional rest, an additional motor task, and a voice communication task could help combat the tedium and fatigue experienced by truck drivers of a large mining firm (86). Sixty truck drivers between the ages of 24 to 55 years each drove a simulator for seven hours. Four times during every 15-minute interval, half the drivers were contacted via a speaker system and asked to read the last two digits of the odometer. The other half of the drivers performed a motor task using simple controls to extinguish lights, which had an average appearance rate of 40 seconds. All the participants were given six minute rest periods, and half were given an additional half-hour rest period after three hours. Recorded performance measures included steering wheel reversals, tracking errors, and average brake response times. The inclusion of the motor task and the voice communication task significantly improved driving performance, however the level of fatigue reported by the drivers was also higher. The extra rest mitigated the drivers feeling of fatigue associated with performing the telephone task, although the extra rest alone did not significantly improve driving performance. Drory reported that the voice communication task may have kept the drivers more alert and required more concentration thereby improving driving performance and increasing the feeling of fatigue (86).

Stein, Parseghian, and Allen reported that tuning the radio has been determined to have an acceptable, although negative, effect on driving performance (87). Their research was aimed at comparing the effect of cellular telephone use on driving performance with that of tuning the radio. Comparison was also made with the control condition of driving without an additional task. Seventy-two participants were grouped by age, such that there were 24 participants in each of the Under 25, 25 to 55, and Over 55 age groups with an equal number of males and females in each group. Each participant drove a simulator. The driving scene included 12 curves, 20 obstacles, and approximately 50 highway signs, 30 of which required the driver to respond. Lane position, lane position variability, speed control capability, and response to various road signs were recorded. Each participant drove the scenario twice. For the first scene the cellular telephone was mounted on the center console and for the second scene it was mounted on the dash. While driving, the participant initiated three calls, received three calls, and tuned the radio three times. The three incoming and three outgoing calls were conducted using handheld manual dial mode, handheld memory recall dial mode, and hands-free voice-activated mode.

While driving on a simulated straight road with no obstacles, the lane position deviations of the older age group were 152 mm (6 inches) greater than that of the younger age group. This difference in lane position deviation was attributed to the task of manually dialing the cellular telephone, having the cellular telephone mounted in a low position, the driver’s age, and task/age interaction. These results were comparable to that of tuning the radio.

In comparison to the results from the manual dialing task, the use of memory recall dialing has less effect on lane position deviation. An increase of 42 mm (1.2 inches) in lane position deviation was found to be significantly different than that occurring during the manually dialing or radio-tuning task. Voice recognition dialing produced similar lane position deviations as those of the memory recall dialing. Therefore, the hands-free operation showed no immediate benefit over handheld operation.

The increases in lane position deviations were represented in terms of the increase in probability of either hitting an obstacle or exceeding the lane boundary as compared to the control condition of driving without a secondary task. In these terms, the younger age group realized no increase in probability under any of the test conditions. However the middle age group realized three times the probability of exceeding the lane boundary when making a call using the voice-activated dialing. The older age group realized a doubling in the probability of exceeding the lane boundary when receiving a call using hands-free mode. The middle and older age groups realized anywhere from a 0.3 to 7 times increase in probability of hitting an obstacle under a variety of test conditions. Analyzing these results, it appears that the driver's age contributes to the effects of using a cellular telephone while driving. The large number of experimental conditions allowed for multiple comparisons of results to be conducted but also complicated the interpretation of the study results. The comparison of the effects of the telephone tasks to the effects of tuning a radio is misleading as it is based on the idea that the effects of tuning a radio are acceptable. The many vehicle collisions that occur while the driver is tuning the radio could be used to refute such a claim.

McKnight and McKnight investigated the change in driver response to a variety of traffic situations while using a cellular telephone (88). The subject pool consisted of 45 participants between the ages 17 and 25 years, 56 participants between the ages 29 and 49 years, and 49 participants between the ages of 50 and 80 years for a total of 150 participants. The sample was divided equally among males and females and 50 participants were experienced cellular telephone users. An open-loop simulator presented ten driving scenes, including 45 traffic situations requiring the participant to respond. The driving scenes presented by the simulator did not interact with the actions of the driver. The driver's response to the traffic situations was used as a measure of performance. The greater the distraction the more missed responses. The participants experienced the driving scenes under four test conditions; tuned the radio, manually dialed the cellular telephone using the hands-free mode, engaged in casual conversation with the experimenter, and answered problem-solving questions administered by the experimenter.

The distraction to the driver associated with tuning the radio, dialing the cellular telephone, or engaging in casual or intense conversation was significantly greater than during the control condition of driving without a secondary task. The intense conversation was found to be significantly more distracting than the casual conversation. The effect of the driver's age was significant during the dialing task and the casual conversation, but not during the intense conversation. Neither the prior cellular telephone experience nor the sex of the driver showed any significant effect. By using the number of missed responses as the measure of driving performance, if the driver chose not to respond to a traffic situation or did not understand a response was required, the resulting distraction level would be inflated. From these results, it is apparent that the additional tasks cause distraction for the driver but the implications of such distraction are not clear.

Serafin, Wen, Paelke and Green conducted three experiments (89). The third experiment addressed the input method (manual versus voice-activated dialing) and the display type (instrument panel versus head-up display) of using a cellular telephone. Six males and six females between the ages of 20 to 76 years were asked to drive a simulator in which the driving scene depicted a nighttime environment. As the participant drove, the lane position was measured.

The participants repeated the driving scene and dialed the cellular telephone using a manual dialing or a voice-activated dialing; and immediately afterward performed a listening, talking, listening, or a loose-end task. The loose-end task required the participant to identify the number of loose ends in a given alphabet character. For instance, the letter C has two loose ends. The time to dial the cellular telephone was recorded. During the dialing task, the eye glances of the driver were recorded. During the loose-end task, the number of errors was recorded.

During the control condition of driving without a secondary task, the standard deviation of lane position was 142 mm (5.6 inches), and during the conversation task, the standard deviation of lane position was 132 mm (5.2 inches). This difference in the standard deviation of lane position was found not significant. However, during the manual dialing task the standard deviation of lane position was 167 mm (6.6 inches) which when compared to the control condition was significant. The most noticeable disturbance to the driver was related to the manual dialing task, although the number of digits dialed was not a contributing factor.

The small subject pool contained a lot of variation in age and may explain some of the variability in lane position deviation. Age was found to be a contributing factor, however the analysis was based on a limited number of age groups and participants. The results can be interpreted to say that the additional task of dialing the cellular telephone or engaging in conversation is likely to affect the driver's performance and may result in a change in lane position deviation.

Alm and Nilsson investigated whether the effect of using a cellular telephone would be greater when the driving situation was more difficult (90). The driver's response time, speed, and lane position were expected to be negatively affected by the use of a cellular telephone. Twenty males and twenty females between the ages of 23 and 61 were asked to drive the simulator. During the drive, the participants were to brake when a red square appeared in the driving scene. As the participant drove the simulator, the brake response time, lateral position, and speed level were measured. Each of the participants was randomly assigned to one of four test conditions. The conditions were defined by the level of difficulty of the driving scene and the inclusion or exclusion of a telephone task. The telephone task included answering the telephone and engaging in a standard cognitive test administered by the experimenter. The number of correct responses to the cognitive test was recorded.

During the easy driving scene, participants traveled approximately 95 to 105 km/h (59 to 65 mph), and the response time increased by 0.385 seconds with the addition of the telephone task. There was no appreciable difference in lateral position, and an approximate decrease of 10 km/h (6 mph) in speed was significant. These results support the hypothesis that the use of the cellular telephone increases the driver's response time.

During the more difficult driving scene, participants traveled approximately 80 to 90 km/h (50 to 56 mph), and the lane position deviations significantly increased when the driver performed the telephone task. No significant change in response time or speed was observed. These results support the hypothesis that the use of the cellular telephone increases the lane position deviations. The results of the study are interesting in that the effects of using the cellular telephone vary depending on the difficulty of the driving scene.

Alm and Nilsson investigated the effects of cellular telephone use when driving in a car-following situation (91). Forty drivers participated in the study, twenty aged 60 years and older and twenty under the age of 60 years. Thirty of the participants were male and the remaining ten were female, and each had a minimum of five years driving experience. The participants were asked to drive the simulator at a speed of 90 km/h (56 mph). When a lead vehicle presented in the simulated driving environment braked or the right-turn signal was illuminated, the participant was to respond by braking or by turning on the left-turn indicator, respectively. The response time, headway, speed, and lateral position were recorded. Participants were randomly assigned to either the described control condition or the experimental condition, characterized by the inclusion of a telephone task. The telephone task required the participant to answer the ringing cellular telephone and engage in a standard cognitive test. When the cellular telephone was used, the response time of the driver significantly increased by 0.56 seconds for the younger (under 60) age group and by 1.46 seconds for the older (over 60) age group. Both the experimental condition and the driver's age proved to be factors significantly affecting driving performance. The experimental condition and the driver's age also had a significant effect on the minimum headway such that the younger age group decreased the minimum headway by 8 m (26.4 ft), whereas the older age group decreased the minimum headway by 6 m (19.8 ft).

The maximum headway and average headway were only affected by the driver's age. The younger drivers chose a maximum headway of 96.6 m (316 ft) and an average headway of 62.9 m (206 ft). Comparatively the older age group chose a maximum headway of 125 m (410 ft) and an average headway of 85.5 m (280 ft). There was no significant difference in the lateral position and variation in lateral position between the experimental condition and the control condition.

By comparing the speed and headway results of the two age groups, it is apparent that the driver's age is a contributing factor in the results for each experimental condition. The use of the simulator must also be considered, as it may have influenced the results of speed and chosen headway. Both driving performance measures required the driver to make judgments about the travel speed of the vehicle and of other vehicles in the driving scene. Such judgment of speed and distance is difficult in a simulator and are subject to great variation.

Briem and Hedman investigated how using a cellular telephone or a car radio can affect the driver's performance under different driving conditions (92). Twenty participants, five males and five females between the ages of 19 and 26 years and five males and five females between the ages of 40 and 51 years were asked to drive a simulator. Through the response of the simulator, dry road and slippery road conditions were presented. As the participant drove the simulator under the dry road condition participants were to maintain a speed of 70 km/h (43.75 mph). Under the slippery road condition participants were to maintain a speed of 50 km/h (31.25 mph). Under each condition, position, speed, and steering wheel movements were recorded. The participants drove the simulator under the two driving conditions with and without obstacles in the driving scene. The simulator was driven under the same conditions, and the participants were asked to answer the cellular telephone, dial the cellular telephone using hands-free mode, tune the radio, engage in casual conversation with the experimenter, or answer cognitive questions posed by the experimenter. The changes in lateral position were measured in terms of screen pixels in the simulation images. The results indicated the secondary tasks, the road surface, the traffic activity and the sex of the driver perturb lane deviations but there were no observed effects on the steering wheel movements. The telephone task, road surface and the inclusion of obstacles in the driving scene were found to significantly decrease the driving speed. The results suggest that engaging in a casual conversation will have a small negative effect on driving performance, and a more difficult conversation or a more difficult driving condition could further degrade the driver's performance.

Reed and Green investigated the effects of dialing a cellular telephone on driving performance as conducted in a simulator (83). Three males and three females between the ages of 20 and 30 years, and three males and three females greater than 60 years were asked to drive the simulator at 96 km/h (60 mph). As the participants drove the simulator, they periodically dialed a cellular telephone using handheld mode. The lane position, speed, steering wheel angle, and throttle positions were recorded during the driving task and the concurrent telephone task.

With the inclusion of the dialing task, the mean lateral speed increased from 0.137 m/s (0.45 ft/s) to 0.354 m/s (1.16 ft/s) and the standard deviation of longitudinal speed increased from 1.95 to 4.8 km/h (1.22 to 3.00 mph). The driver's age, the telephone-dialing task, and the interaction of the driver's age and the telephone-dialing task were all found to significantly affect the lane-keeping ability of the driver.

Summary of Simulation Studies. From the results of the simulator studies, there appears to be a relationship between the use of the cellular telephone and the driver's control of the vehicle. The inclusion of the telephone task may increase the driver's response time or the precision of speed and lane control. Casual conversations have been shown to be distracting to the driver, and more difficult conversations could further degrade driving performance. A greater degradation has been experienced when a cognitive test is administered. It is unclear whether the driving performance associated with the cognitive test is comparable to the driving performance expected during an emotional laden or difficult conversation.

In addition to the characteristics of the telephone conversation, the mode of dialing has been shown to influence driving performance. Manual dialing appears to be more disruptive than using a manual redial function or a voice activation function. However, the influence of the mode of operation during the conversation itself has not yet been determined.

Inferences from the Previous Research

The variety of experimental research methodologies used in the previous research makes drawing any strong conclusions from the results difficult. However, a number of inferences can be made about the effects of cellular telephone use on driver performance. The first inference relates back to the single resource theory, which predicts that performance will degrade as the attention demand on the driver exceeds their attention capacity. The results of the previous research indicate evidence of this relationship.

Certain characteristics of the driver, the vehicle and the cellular telephone have been found to contribute to this relationship. There is evidence to infer that the driver's age, level of training, and state of fatigue may influence how the use of the cellular telephone could affect the driver's control of the vehicle. The characteristics of the vehicle, or the driver's familiarity with the vehicle and even the design or mode of operation of the cellular telephone may be influential.

Although few studies investigated the effects of the driving environment, the suggestion that the driving environment can influence the relationship between the use of the cellular telephone and the driver's control of the vehicle can be supported. The interaction with other vehicles and an increase in the difficulty of the driving task both appear to contribute to the relationship between the use of the cellular telephone and the driver's control of the vehicle.

What remains unclear is how the type of conversation or the intensity of conversation can contribute to the effect of using a cellular telephone. Engaging in a casual conversation has been shown to be somewhat distracting and can lead to a decrement in driving performance. It is possible that a more difficult or emotionally laden conversation could have a greater effect as indicated by Briem and Hedman (92). This supposition is based on the evidence that a greater decrement in driving performance has been observed when drivers are engaged in a cognitive task.

EXPERIMENTAL METHODOLOGY

The current experiment was designed to compare the effects of driving performance associated with engaging in a casual and an intense conversation. It also compared handheld versus hands-free mode of operation during the conversation. Based on the results of the previous research, it was believed that the driver's control of the vehicle, as measured by lane position, steering input, accelerator input, and speed should suffer from the addition of the telephone task. The effect of the telephone task was expected to be greater for the more intense conversation than the casual conversation.

To investigate whether the intensity of the telephone conversation contributes to a decrement in driving performance, and whether the mode of operation of the telephone during the conversation is an influence, the following experiment was designed, administered, and analyzed.

Experimental Participants

Twenty females and twenty males were recruited from the staff at the Texas Transportation Institute at Texas A&M University and the surrounding community. All participants were between 24 and 57 years of age. The average age of the females was 33.7 years (sd = 8.4 years) and the average age of the males was 33.6 years (sd = 8.2 years).

Each participant possessed a valid driver's license; was reported to have 20/40 vision or corrected to 20/40 vision via contact lenses or glasses; and had no known physical or cognitive limitations that might affect their performance in this project. The level of experience of the participants in using a cellular telephone ranged from novice through to expert although all participants indicated having some prior experience with cellular telephones. Participants received no monetary compensation, class credit, or other benefit for their participation.

Experimental Apparatus

The project was conducted in a high-fidelity driving environment simulator (DESi). DESi consisted of a semi-circular aluminum structure onto which three white fabric screens were affixed. Each screen extended up from the floor and was 2280 mm (90 in) in height and 2280 mm (90 in) in width. The driving scene presented to participants was generated by three personal computers using Hyperion Technologies software and projected through three liquid crystal display projectors. The three separate images projected onto the fabric screens were aligned so they appeared as one single image subtending a 150º field of view horizontally and a 50º field of view vertically. Participants sat in the driver's seat of a full-sized 1995 Saturn SC2, positioned in the center of the DESi. Participants' performance measures were collected via a fourth personal computer connected to the vehicle's steering column, brake pedal, and gas pedal. The recorded data included the lane position, steering input, accelerator input, speed, and brake input, and was sampled at a rate of 10 times per second. The lane position was measured in meters as the distance from the center of the vehicle to the center of the occupied lane. The steering input was measured in radians as the physical movement of the steering wheel. The accelerator input was measured as the physical movement of the accelerator pedal. The measurement was then normalized to obtain a value between 0 and 1. Similarly, the brake input was measured as the physical movement of the brake pedal, and its values were normalized to obtain a value between 0 and 10.

The cellular telephone used for this experiment was a Samsung SCH-3500 with dual band. For a depiction of the cellular telephone see Figure 46. The phone had redial capability, allowing the last placed call to be redialed by pressing the talk key twice. As each participant was introduced to the cellular telephone, the experimenter recalled the appropriate number from the memory so that the participant only needed to use the redial function to initiate the telephone calls. The cellular telephone was used in two operation modes, handheld and hands-free. For the hands-free mode, the cellular telephone was outfitted with an earpiece and a microphone for the participant to wear.

Figure 46. Samsung SCH-3500 Dual Band Cellular Telephone.

Experimental Procedure

Upon reading and signing the Human Subjects Consent form, as included in Appendix C, each participant completed a Conversation Topic form to aid in identifying stressful conversations the participant was willing to discuss. The conversation topics were samples of stressful events that might occur in one's life and were compiled based on the Holmes-Rahe Social Adjustment Scale (93). The Conversation Topics form is given in Appendix D.

The participant was then lead into the driving environment simulator and seated in the Saturn. The participants were given time to adjust the seat, put on the seatbelt, and become familiar with the controls of the vehicle. Once comfortable, the participant was given instructions for a practice drive (see Appendix E). After reading the instructions, the participant was given the opportunity to ask questions or verify their task.

When the practice drive began, there was a red vehicle on the right shoulder ahead of the participant's vehicle. The red vehicle moved forward and accelerated to 56 km/h (35 mph), maintaining that speed for some time before increasing to 72 km/h (45 mph), and later to 88 km/h (55 mph). The participant was instructed to place their vehicle in 'drive' and follow the lead car. The practice drive included both straight and curved roadway sections with traffic and roadside features such as buildings, barns, fields, etc. The practice drive was seven minutes long and provided the participant ample time to become familiar with the responses of the vehicle. At the end of the practice drive, the participant approached a stop sign. The participant was instructed to stop at the stop sign, put the vehicle transmission in 'park' and turn their attention to the experimenter.

Still seated in the Saturn, the participant was given the instructions for five experiment drives (see Appendix F). Included in the instructions were directions to obey all traffic laws including the speed limit. These instructions were administered to ensure the participant understood that they were to drive in a similar fashion for each of the experiment drives. After reading the instructions, and acknowledging their readiness to begin, the participant was instructed to begin the first experiment drive. A sample schematic of the layout of an experiment drive is shown in Figure 47.

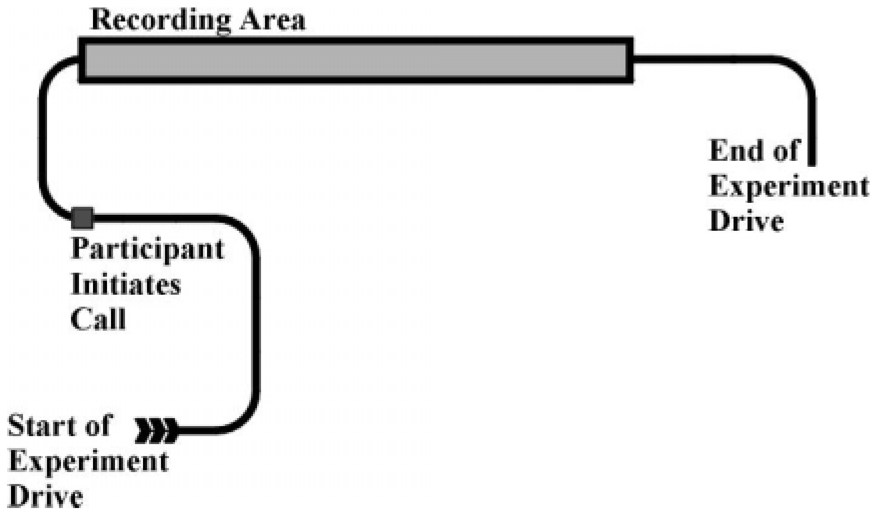


Figure 47. A Sample Schematic of the Layout of an Experiment Drive. Note the recording area was identical for each of the five experimental drives.

Each of the experiment drives had a common section where the recordings of driving performance measures were taken for an interval of two minutes. For the first experiment drive, the participant performance measures were recorded when there was no telephone call. This served as the first half of the control condition. During experiment drives 2 through 4, the driving measures were recorded while the participant was engaged in a conversation with the experimenter. For the fifth experiment drive, participant performance measures were recorded when there was no telephone call. This served as the second half of the control condition. Also during the fifth experiment drive participant performance measures were recorded while the participant was engaged in a conversation with the experimenter.

The configurations of the computer-generated experiment drives were different than that of the practice drive although the same components were used. The experiment drives included straight and curved roadway sections, roadside features, and other traffic. A sample view taken while driving through one of the recording sections is shown in Figure 48.

After the first experiment drive, the participant provided a rating to describe how hard they thought they worked to drive through the experiment drive. The ratings were determined using the Modified Cooper-Harper Scale for workload assessment as prescribed by the Modified Cooper-Harper Chart included in Appendix G. Upon recording a workload rating, the participant received further instructions for experiment drives 2 through 5. The participant was then introduced to the Sprint PCS cellular telephone and was shown how to use the manual redial function. Prior to beginning each of the remaining experiment drives, the participant was told whether to use handheld or hands-free mode. Participants were told that when they pass a red vehicle parked on the left side of the roadway that they were to initiate the cellular telephone call.

Figure 48. A Sample Portion of the Recording Area.

Upon acknowledgement from the participant that they were ready to continue, the next experiment drive was started. Once the participant saw the red car parked on the left side of the roadway, they initiated the cellular telephone call and engaged in a conversation with the experimenter. The conversation was either a casual/low-intensity or emotional/high-intensity conversation, as controlled by the questions asked by the experimenter. If the experimenter was trying to achieve a high-intensity conversation, the experimenter began the conversation by asking a question related to one of the conversation topics previously selected by the participant. For instance, if the participant had identified that they had recently experienced some trouble with their boss, the experimenter would ask questions to find out what had occurred and how the participant felt about the boss or about the experienced trouble. If the experimenter was trying to achieve a low-intensity conversation, the experimenter began with questions about where the participant worked, where they grew up or if they had any special interests or hobbies. Each conversation lasted for at least three minutes to ensure the conversation was occurring during the recording of the driving performance measurements. At the end of the experiment drive, the participant was given time to provide a workload rating that described how much effort it took the participant to talk on the cellular telephone while driving. This procedure was repeated three times, one cellular telephone call for each of the remaining experiment drives. The last experiment drive included two recording areas. The first was a control condition where no cellular telephone call was made but the driving performance measures were recorded. The second recording area recorded the driving performance measures when the participant was engaged in conversation.

The intensity of the conversation and the mode of operation of the cellular telephone were combined such that each participant engaged in two low-intensity and two high-intensity conversations, and hands-free and handheld operation were used for each type of conversation. The order of the conversation-mode combinations was counterbalanced to avoid potential order effects.

At the end of the last cellular telephone conversation, a white delivery truck spontaneously appeared on the roadway directly in front of the participant's vehicle that required the participant to swerve or apply the brakes to avoid a collision. When the truck appeared, the time to collision of the participant's vehicle and the truck was approximately 2.6 seconds. The response time, taken from the appearance of the truck to the initiation of the brake, was recorded.
Upon completion of the last experiment drive, the participant was escorted to a reception room. The participant was given two surveys to complete; one regarding simulator induced discomfort and one regarding general demographics and driver characteristics. Both surveys are included in Appendix H. Before leaving, each participant received a debriefing packet outlining the background, purpose, and hypotheses of the project. The debriefing packet is included in Appendix I.

Experimental Design

This experiment was designed to investigate the effects of conversation intensity and mode of operation of the cellular telephone on driving performance. A fixed effect model was used with the factors and factor levels shown in Table 35.

Table 35. Factors and Factor Levels for the Analysis of Performance Measures.

Factor	Levels
Sex	female, male
Mode	control, handheld, hands-free
Conversation	high, low, none

The participant performance measure recorded during five experimental drives were the means and standard deviations of lane position, steering input, accelerator input, and speed. The mean lane position described the average position of the vehicle in the lane and the standard deviation of lane position described the driver's ability to maintain a constant lane position. Measurements were taken from the center of the vehicle to the center of the traveled lane. The mean steering input described the average position of the steering wheel and the standard deviation of the steering input described how the driver made corrections to the vehicle's direction of travel. Small deviations occurred when the driver made small steering corrections while large deviations occurred when the steering corrections were large. Similarly, the mean accelerator input described the average position of the accelerator pedal and the standard deviation of the accelerator input described how the driver used the accelerator to make corrections to the vehicle's speed. Small deviations of accelerator input occurred when the corrections were small while large deviations occurred when the corrective inputs were large. The mean speed was the average speed traveled, and the standard deviation of the speed reflected the ability of the driver to maintain a constant speed. The analyses of the performance measures were carried out using the ANOVA procedure at a 0.05 level of significance.

Response Time

During the fifth experimental drive, the response time as measured from the appearance of the white delivery truck to the participants' engagement of the brake pedal was recorded. There was no control condition for this response. The fixed effects model for the response variable included the sex, mode and conversation factors, but the mode factor was restricted to the levels of handheld and hands-free, and the conversation factor was restricted to the high and low levels. The analysis of the response times also used the ANOVA procedure at a 0.05 level of significance.

Workload

After each experiment drive the participant used the Modified Cooper-Harper chart to provide a rating of their workload. The rating described the amount of effort the participant gave and the level of performance thought to have been achieved. These ratings were analyzed using multiple median comparisons for nonparametric data, carried out at a 0.05 level of significance.

EXPERIMENTAL RESULTS

Each of the forty participants drove through six recording areas where each of the eight performance measures were sampled at a rate of ten per second for a duration of two minutes. The speed profiles for each participant were plotted and a general decrease in speed was noted in the first 40 seconds of the data. This trend may be attributed to the roadway alignment prior to five of the recording sections and the location of a speed limit sign approximately 500 m (1190 ft) into each of the recording sections. The combination of the curve and the reminder of the speed limit may have contributed to the decrease in speed at the beginning of the recording sections. The speed profiles for the one recording section that was not preceded by a curve in the road did not exhibit the same disturbance. To ensure the curve and the location of the speed limit sign did not influence the analysis of the effect of the cellular telephone call, the first 40 seconds of data were discarded.

Some of the conversations took time to develop and the elimination of the first 40 seconds of data provided some assurance that the data being used in the analysis reflected the time when the participants were fully engaged in conversation. Since the intensity of some of the conversations lessened prior to the end of the recording area the last 20 seconds of the data was also truncated. The remaining minute of data for each of the performance measures was reduced and the means and standard deviations were calculated. The reduced data is included in Appendix H. The distribution and variance for the means and standard deviations of each of the performance measures were examined and determined to be normal and not to violate equal variance assumptions.

Sex

The main effect of the sex factor was significant for the mean lane position, mean steering input, mean accelerator input, and mean speed at a 0.05 level of significance. The p-values from the ANOVA tables for the analyses of the eight participant performance measures are in Table 36.

Table 36. Main Effect of Factor Sex.

Performance Measure	P-Value
mean lane position	0.0246
standard deviation of lane position	0.2269
mean steering input	0.0001
standard deviation of steering input	0.0594
mean accelerator input	0.0079
standard deviation of accelerator input	0.0618
mean speed	0.0002
standard deviation of speed	0.5734

Mode

The main effect of factor mode was significant in the analysis of the standard deviation of steering input (p=0.0417). In the analyses of the remaining seven participant performance measures the factor mode was not significant. The p-values from the ANOVA tables for the analyses of all the eight performance measures are in Table 37.

Table 37. Main Effect of Factor Mode.

Performance Measure	P-Value
mean lane position	0.5704
standard deviation of lane position	0.0951
mean steering input	0.7310
standard deviation of steering input	0.0417
mean accelerator input	0.9887
standard deviation of accelerator input	0.2540
mean speed	0.5918
standard deviation of speed	0.4292

Conversation

In the analyses for each of the eight participant performance measures, the effect of the factor conversation was not significant. Table 38 presents the p-values from the corresponding ANOVA tables.

Table 38. Main Effect of Factor Conversation.

Performance Measure	P-Value
mean lane position	0.6415
standard deviation of lane position	0.4968
mean steering input	0.7800
standard deviation of steering input	0.3454
mean accelerator input	0.1840
standard deviation of accelerator input	0.3763
mean speed	0.3788
standard deviation of speed	0.8611

Response Time

The response times were measured from the time the white delivery truck spontaneously appeared to the time the participant engaged the brake or made an evasive steering input. The response time was always measured when the participant was engaged in a conversation with the experimenter. No base measurement response time was recorded. The response times were analyzed at a 0.05 level of significance. The factor sex was significant and the factors mode and conversation were not significant. The p-values from the ANOVA table for the factors sex, mode and conversation are shown in Table 39.

Table 39. Analysis of Response Time.

Factor	P-Value
Sex	0.0053
Mode	0.1722
Conversation	0.2401

Modified Cooper-Harper Ratings

After each experimental drive the participant provided a rating to describe how much effort was given to the task and the performance that was achieved. Using multiple median comparisons for nonparametric data at a 0.05 level of significance, there were several differences. The median of the workload ratings given after the driving task without a cellular telephone conversation in the first experimental drive was lower than the medians of the workload ratings given after the task of driving while talking on the cellular telephone for each of the other four experimental drives. Otherwise, the participants felt that using the cellular telephone while driving required more effort than simply driving. The median of the workload ratings for the task of driving while engaged in a high-intensity conversation using a handheld mode was greater than the median of the workload ratings for the task of driving while engaged in a low-intensity conversation using a hands-free mode. No difference in medians was found between males and females.

DISCUSSION

The purpose of this project was to investigate whether the intensity of the telephone conversation or the mode of use contributes to a decrement in driving performance. Based on the results of the previous research, the driver's control of the vehicle, as measured by lane position, steering input, accelerator input, and speed was expected to suffer from the addition of the telephone task. The loss of control was expected to be greater when the driver is engaged in an intense conversation as opposed to a casual conversation. The use of the hands-free mode allows the driver to keep both hands on the steering wheel and was therefore expected that the driver would maintain better control of the vehicle than when using the handheld mode.

Sex

The main effect of the sex factor was significant for the mean lane position, mean steering input, mean accelerator input, and mean speed at a 0.05 level of significance. The mean values for males and females for each of these performance measures are shown in Table 40. In this current project the male participants traveled at a slightly greater mean speed and therefore had slightly greater mean accelerator input.

Table 40. Mean Performance Measure Values for Males and Females.

Performance Measure	Mean Values for Males	Mean Value for Females
mean lane position	-0.135 meters	-0.196 meters
mean steering input	-0.109 radians	-0.096 radians
mean accelerator input	0.102	0.097
mean speed	21.60 meters/second	20.78 meters/second

Mode of Operation

The main effect of the mode of use of the cellular telephone was significant in the analysis of the standard deviation of steering input at a 0.05 level of significance. The mean values of the standard deviation of steering input for the control conditions of the first and fifth experiment drives and the hands-free and handheld cellular telephone conditions are in Table 41.

Table 41. Mean Values of the Standard Deviation of Steering Input.

Mode of Operation	Mean Standard Deviation of Steering Input
control condition from first experimental drive	0.069 radians
control condition from fifth experimental drive	0.047 radians
hands-free conditions	0.085 radians
handheld conditions	0.090 radians

Although the mode was expected to be a significant factor in the analyses of the other participant performance measures, the data does not support this hypothesis. However, these results do lend support to the statement that hands-free operation shows no immediate benefit over handheld operation as previously claimed by Stein et al.(87).

Conversation Intensity

The main effect of conversation intensity was not significant in the analyses of any of the eight participant performance measures. This result does not support the hypothesis that an intense conversation would lead to a greater decrement in driving performance than a casual conversation. Notably, this result is in contrast to the research by McKnight and McKnight, who found a cognitively engaging conversation more distracting than a casual conversation (88). One potential reason that may be used to explain why no differences in driving performance was found between the low-intensity and high-intensity conversations is the inability of the experimenter to engage each participant in both types of conversations. This inability may stem from a hesitation of the participant to discuss sensitive issues or a hesitation of the experimenter to ask questions about sensitive issues identified by the participant. Since participants selected topics that they were willing to talk about, they had the opportunity to censor what was discussed. If the experimenter felt that a selected topic was too much of a sensitive issue, it may have been avoided. The inability to achieve both high-intensity conversation and low-intensity conversations with each participant may be the result of the unexpected responses to the questions posed by the experimenter. Unless there was prior knowledge about the participant, several probing questions may be required to elicit the desired response. The experimenter then had to be creative in asking follow-up questions to further probe that area of questioning to try to maintain the intensity of the conversation. Although some difficulty in achieving a high-intensity conversation was anticipated, problems maintaining a low-intensity conversation were also experienced. By asking a relatively unemotional question, the experimenter could touch upon a topic that evoked an unexpected emotional response from the participant. Such situations had to be quickly extinguished by either changing topics or redirecting the line of questioning.

Response Time

Previous research has supported the contention that there is an increase in response time when a driver is engaged in a cellular telephone task such as dialing or engaging in a conversation as opposed to no cellular telephone task (90)(91)(82). While the current project did not compare response times for the cellular telephone condition to a control condition, it did attempt to address the question of whether the mode of cellular telephone operation and the intensity of the conversation affect driver response times. In the analysis of the response times, the main effects of mode of operation and intensity of conversation were not significant at the 0.05 level of significance. Therefore, no performance gain was realized for responses to sudden occurrences that require an evasive maneuver regardless of the intensity of the cellular telephone conversation or mode of use of the cellular telephone. The main effect of sex was significant. The response time of the female participants was significantly greater than that of the male participants. Female participants exhibited a means response time of 0.66 seconds whereas male participants exhibited a mean response time of 0.81 seconds.

Mental Workload

The modified Cooper-Harper workload ratings given by participants are an indication of how difficult a task was perceived and the acceptance of the performance of that task. By comparing the median rating for the control condition with that of each cellular telephone conversation condition, it is concluded that the participants found engaging in a telephone conversation added to the workload of driving. Paired comparisons of the rating medians for each telephone conversation condition show the handheld, high-intensity conversation was significantly different than the hands-free, low-intensity conversation. No other significant differences in the rating medians were found at the 0.05 level of significance.

Previous research into the effect of using a cellular telephone while driving have been used to support the hypothesis that the performance of the driving task suffers from the additional task of using the cellular telephone. The results of the current project cannot be used to support this hypothesis but the inconsistency may be explained by the single resource attention theory (76). If the attention demand of the experimental drives used in this project were not great enough, it is possible that the additional task of using the telephone did not exceed the attention capacity of the driver. The workload ratings given by the participants were low and lead one to believe that the additional task of using the telephone could be performed without affecting driving performance.

RECOMMENDATIONS

In the fields of psychological research and transportation engineering it is important to examine the relationship between the results of research and their potential impact in real-world situations. Previous studies have found that cellular telephone use can negatively impact driver performance. The hypothesis that the intensity of cellular telephone conversation or the modes of use influences the effect of using a cellular telephone is not supported by the current research. Achieving and maintaining both low intensity and high intensity conversations was essential to the success of this study. Difficulties were experienced and likely inhibited the significance of the results. One important finding is the significant change in the standard deviation of steering input between the control conditions when no cellular telephone call was made and the cellular telephone conditions. Perhaps the variation in steering input is the first indication that the driving performance is being affected when the cellular telephone is being used. Under more demanding driving conditions, the driving task may require more attention from the driver. The use of the cellular telephone may then cause greater degradations in driving performance and become apparent in other performance measures. This proposition is limited at best because it is neither supported nor refuted by the results of previous research.

Drivers, researchers, device manufacturers, and automobile manufacturers are encouraged not to be cognitively myopic and think a decrement in driving performance only occurs when a cellular telephone is used. Many other in-vehicle devices/entities afford the opportunity to arrest a significant portion of a driver’s cognitive resources. These may include the activities of the passengers and the use of radios, HVAC systems, in-vehicle guidance systems, and devices such as web page displays and email systems, sure to be included in newly designed vehicles. Failure to recognize and accept the notion that many distractions exist in vehicles and that these distractions can have a significant and determinable negative impact on driver performance will result in unnecessary motor-vehicle crashes, injuries, and deaths.

CHAPTER VI. CONCLUSIONS

THE PROBLEM IS REAL

From meetings to restaurants to movie theatres to our vehicles, we are increasingly becoming both distracted and annoyed by the use of cellular telephones. A personalized telephone ring can snap the attention of a quiet meeting room or drivers miss traffic signs and signals when engrossed in conversation. Even syndicated newspaper columnists and others are asked what is the proper etiquette. Reminders to turn off the cellular telephone are becoming increasingly common whether at the restaurant, movie theatre, or doctor's office. Some people disturbed by 'inappropriate' cellular telephone use confront their use while others murmur under their breaths.

Society is growing increasingly dependent on the convenience of personal communication devices. The most commonly available and used device is the cellular telephone. Once a convenience for the wealthy or business people, the cellular telephone is now affordable and ownership is increasing at rates beyond the expectations of the market five years ago.

Other personal communication devices are now available and more will be dreamed and produced in the future, each a technological advancement. Society's widespread adoption of web-enabled and other two-way devices, currently available, is looming on the technological horizon. These enhanced devices offer the potential to increase productivity and information access at any time from any location, including our automobiles. In fact, the automotive industry is increasingly integrating the communication devices with the vehicle.

Cellular telephones do provide a wealth of safety benefits. Calls to emergency dispatchers are often cited as a beneficiary. The transportation industry is also benefiting from these devices as traffic probes in metropolitan areas to monitor congestion and travel times. But the responsible use of these conveniences is of concern among safety specialists.

Though current accident record systems in a majority of states do not adequately reflect the contribution of cellular telephones to vehicular accidents, recent changes to collect this type of information in a few states shows that it is becoming a relevant statistic. This interest should increase among both law enforcement and researchers as the debate to regulate continues.

Lawmakers are becoming increasingly interested in this problem as a result of public pressure, personal experiences, or tragic and fatal cases where innocent lives were lost. Strong industry lobbyists protecting their industry's interests often confront the lawmakers, typically stalling or killing pending legislation. Only recently has a breakdown within the industry ranks begun. Verizon Communications has publicly stated support for laws banning the use of handheld cellular telephones when driving.

A HIGHLY DEBATED SUBJECT

Whether the issue for laws banning cellular telephone use in the automobile is enforceability or privacy, regulating the use of these devices while driving is debated among law enforcement and lawmakers. Some will cite that existing regulations for operating vehicles could be used to penalize reckless and irresponsible drivers on their cellular telephones. However, there is a strong interest in adopting specific regulations for cellular telephones. These specific regulations place an increased emphasis on the risks of using cellular telephones while driving.

The debate has also focused on the 3 E's: engineering, education, and enforcement. Law enforcement cite a need for additional officers to enforce the new laws, if adopted. Some within law enforcement suggest that increased education would provide a more suitable alternative to legislation. The wireless industry does promote education, and some large corporations and non-profit groups are becoming more pro-active in educating cellular telephone owners of the hazards and risks present when driving and talking on the telephone.

AN ESTIMATE OF HANDHELD CELLULAR TELEPHONE USE AMONG DRIVERS ON FREEWAYS

Previous research has focused on the driving effects of cellular telephone use in the vehicle. In fact, researchers have shown that accident risk increases greatly. When problems like this are identified, it is often important to determine their extent.

An estimate of the percentage of drivers using a handheld cellular telephone was made through visual observation of freeway traffic in Dallas, Texas. As a result, 5 percent of drivers on Dallas County freeways were observed using a handheld cellular telephone while operating their vehicles. This is a conservative estimate of total cellular telephone use by drivers because technologies allowing hands-free operation of cellular telephones (e.g., ear-microphone pieces, professionally installed accessories, and other manufacturer accessories) were not included in this field assessment. Assessing total cellular telephone use might be accomplished through electronic devices positioned over travel lanes to monitor energy fluctuations resulting from in-use cellular telephones.

EXPERIMENTAL RESULTS OF CONVERSATION INTENSITY AND MODE OF CELLULAR TELEPHONE OPERATION

The participants' sex was a significant factor for mean lane position, mean steering input, mean accelerator input, and mean speed. Though expected to be a significant factor, cellular telephone use mode (handheld v. hands-free) was not significant. The hands-free mode showed no immediate benefit over the handheld mode.

Conversation intensity was also not significant from the simulator results. The experimenter's inability to engage each participant in the two conversation intensities may explain why differences were not found. Also, participants were able to select or censor topics they were willing to discuss for high-intensity conversations. Female response times were significantly greater than male participants.

Engaging in a telephone conversation did add to the driver's workload. Handheld, high-intensity conversations were significantly different than hands-free, low-intensity conversations. The lack of statistical significance may be explained by Wickens single resource attention theory. Because participants rated their workload (driving and cellular telephone use), the experimental drives may have been less attention demanding than anticipated and the additional task of using the telephone was performed without affecting driving performance.

ADDITIONAL RESEARCH NEEDS

From this research, several areas of additional research were identified. Answers to the questions these topics pose may help researchers and lawmakers better understand the nature and relationship between cellular telephones and vehicular accidents.

Investigation of Influencing Factors for Cellular Telephone Use when Driving – Many of the influencing factors identified (spatial location, time of day, and travel direction) and those not identified require additional investigation. Increased understanding of these factors will impact recommendations for the data collection protocol.

Improving the Field Measurement Process for Estimating Drivers' Cellular Telephone Use –An investigation of currently available technologies to detect and monitor cellular telephone energy fluctuations on travel lanes should be conducted. Use of these types of devices will provide researchers a more accurate and more precise estimate of cellular telephone use among vehicle operators.

Estimating Drivers' Cellular Telephone Use on Arterial Streets – Handheld cellular telephone use by drivers should be assessed on arterial streets. Though freeway sections were the focus of this study, only a very limited investigation was conducted for arterial streets. Arterial streets may have a potential for lower speed, rear-end collisions within travel lanes or high-speed, side impact collisions at intersections. Because drivers operate their vehicles at shorter headways and more environmental factors are present, accident risk may be higher for these facilities.

Linking Accidents to Drivers' Cellular Telephone Use – Additional research should be conducted to further investigate the causal relationship between the amount of handheld cellular telephone use by drivers on a roadway and accidents caused by driver inattention or related factor. Intensive study along a corridor through monitoring nets and cooperation with law enforcement, may provide insight on the relationship between distracted driving and vehicle collisions.

Continue Investigating the Effects of Conversation Intensity from Cellular Telephones on Driving Performance – An improved protocol for engaging participants in high-intensity conversations should be developed to reduce participant censorship of topics and allow the experimenter to elevate the emotional level of the participant to measurable levels. The protocol is the basis for accurately assessing effects from highly emotional conversations which are hypothesized to require greater attention resources, reducing the amount available for the driving task.

Assess Mental Workload of In-Vehicle Distractions – Cellular telephones are one of many in-vehicle distractions for drivers. Future investigations should focus on the incremental attention resource demand each distraction places on the driver for increasingly required attention to safe vehicle operations. Random ordering of these distractions may yield insight to the amount of attention removed from the driving task.

Evaluate Driver Response Times for Modes of Cellular Telephone Use when Driving – Further research on attention demands affecting driving response times is needed. Research should investigate drivers' reaction times to significant attention demanding events both outside and inside the vehicle while using a cellular telephone.

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APPENDIX A.
DATA COLLECTION INSTRUCTION SHEET

Instructions
Cell Phone Data Collection

COUNTING DIRECTIONS

1. Begin counting starting both 12-min and 15-min timers
2. Count for 12 minutes
3. After the 12-min timer alarms
4. Record data, reset counter board, reset 12-min timer, review datasheet and change lanes within 3 minutes
5. After the 15-min timer alarms, start the 12-min timer and
6. Begin counting traffic for next period

REPEAT

OTHER

- Use ink pen to record traffic for each period
- Rules for Classifying Use for Drivers Only

NO	Observe neither hand on NOR near their head Observe hands on OR near steering wheel Observe hands or arms at or below steering wheel level
YES	Observe handheld phone OR phone antenna at or near head Observe coiled phone cord stretching to head Observe the driver turn their head with hand to head Observe talking alone in car with hand at or near head
UNKNOWN	Observe hand to head AND no distinct phone or coiled phone cord

APPENDIX B.
DRIVER'S HANDHELD CELLULAR TELEPHONE USE FREEWAY FIELD ASSESSMENT DATA

Table B-1. Northbound Lanes of US 67 at Pleasant Run Road on August 28, 2000.

Time Interval (PM)	Lane	Observer 1 Cars Y	Observer 1 Cars N	Observer 1 Cars U	Observer 1 Trucks Y	Observer 1 Trucks N	Observer 1 Trucks U	Observer 2 Cars Y	Observer 2 Cars N	Observer 2 Cars U	Observer 2 Trucks Y	Observer 2 Trucks N	Observer 2 Trucks U
4:00 - 4:15	OUT	3	128	1	1	15	1	7	122	2	1	14	2
4:15 - 4:30	IN	5	65	0	0	9	0	4	67	0	0	9	0
4:30 - 4:45	IN	4	98	0	0	2	0	6	98	1	0	3	0
4:45 - 5:00	OUT	3	124	3	0	11	0	3	125	2	0	11	0
5:00 - 5:15	IN	4	97	0	0	11	0	5	96	0	0	11	0
5:15 - 5:30	IN	6	70	1	0	3	0	7	70	0	0	3	0
5:30 - 5:45	OUT	8	139	0	0	8	0	7	135	1	0	8	0
5:45 - 6:00	OUT	4	123	0	0	10	0	4	123	0	0	10	0

Notes: Y – Yes, N – No, U – Unknown

Table B-2. Southbound Lanes of North Dallas Tollway at Meaders Lane on August 31, 2000.

Time Interval (PM)	Lane	Observer 1 Cars Y	Observer 1 Cars N	Observer 1 Cars U	Observer 1 Trucks Y	Observer 1 Trucks N	Observer 1 Trucks U	Observer 2 Cars Y	Observer 2 Cars N	Observer 2 Cars U	Observer 2 Trucks Y	Observer 2 Trucks N	Observer 2 Trucks U
4:00 - 4:15	MID	15	316	2	0	8	0	16	313	5	0	3	0
4:15 - 4:30	OUT	17	201	1	0	8	0	16	198	4	0	8	0
4:30 - 4:45	OUT	5	241	1	1	2	0	8	236	4	1	3	0
4:45 - 5:00	IN	28	376	0	0	6	0	36	367	1	0	7	0
5:00 - 5:15	MID	28	305	0	0	11	0	23	303	3	0	12	0
5:15 - 5:30	IN	54	442	0	0	3	0	42	445	6	0	3	0
5:30 - 5:45	MID	10	314	0	0	6	0	18	304	1	0	6	0
5:45 - 6:00	OUT	12	235	1	1	2	0	11	235	3	1	1	0

Notes: Y – Yes, N – No, U – Unknown

Table B-3. Northbound Lanes of I-635 at New Market Road on September 5, 2000.

Time Interval (PM)	Lane	Observer 1 Cars Y	Observer 1 Cars N	Observer 1 Cars U	Observer 1 Trucks Y	Observer 1 Trucks N	Observer 1 Trucks U	Observer 2 Cars Y	Observer 2 Cars N	Observer 2 Cars U	Observer 2 Trucks Y	Observer 2 Trucks N	Observer 2 Trucks U
4:00 - 4:15	OUT	7	202	1	0	15	1	9	200	1	0	15	1
4:15 - 4:30	MID OUT	4	177	1	0	42	1	4	175	0	0	42	1
4:30 - 4:45	IN	0	117	0	1	2	0	3	114	1	0	3	0
4:45 - 5:00	MID IN	5	188	0	0	16	0	5	185	2	0	15	0
5:00 - 5:15	IN	4	140	0	1	2	0	4	140	1	1	2	0
5:15 - 5:30	MID IN	11	193	0	1	14	0	12	192	0	0	14	1
5:30 - 5:45	MID OUT	4	208	1	0	17	0	3	207	1	0	20	0
5:45 - 6:00	OUT	2	233	0	0	5	0	3	229	2	0	6	0

Notes: Y – Yes, N – No, U – Unknown

Table B-4. Westbound Lanes of I-30 at Cockrell Hill Road on September 6, 2000.

Time Interval (PM)	Lane	Observer 1 Cars Y	N	U	Observer 1 Trucks Y	N	U	Observer 3 Cars Y	N	U	Observer 3 Trucks Y	N	U
4:00 - 4:15	IN	9	354	1	0	8	0	13	347	0	0	6	0
4:15 - 4:30	MID	15	313	0	0	26	0	21	303	1	0	25	0
4:30 - 4:45	OUT	7	306	0	1	31	0	23	285	0	2	30	0
4:45 - 5:00	OUT	11	260	1	0	19	0	16	255	0	0	21	0
5:00 - 5:15	OUT	12	330	0	0	14	0	19	318	0	0	15	1
5:15 - 5:30	MID	18	351	0	0	23	0	19	349	0	0	23	0
5:30 - 5:45	IN	16	471	0	0	7	0	15	461	0	0	9	0
5:45 - 6:00	IN	21	380	0	0	12	0	23	378	0	0	12	0

Notes: Y – Yes, N – No, U – Unknown

Table B-5. Southbound Lanes of I-35E at Kirnwood Drive on September 7, 2000.

Time Interval (PM)	Lane	Observer 1 Cars Y	N	U	Observer 1 Trucks Y	N	U	Observer 3 Cars Y	N	U	Observer 3 Trucks Y	N	U
4:00 - 4:15	OUT	3	134	0	0	14	0	9	131	0	0	13	0
4:15 - 4:30	MID	12	177	1	0	21	0	9	177	1	0	22	0
4:30 - 4:45	OUT	4	162	0	1	12	0	3	163	1	2	10	0
4:45 - 5:00	MID	17	214	0	1	12	0	19	211	0	1	12	0
5:00 - 5:15	IN	14	225	0	0	3	0	13	223	0	0	3	0
5:15 - 5:30	MID	14	212	0	1	8	0	16	209	0	1	10	0
5:30 - 5:45	IN	15	240	0	0	4	0	10	240	1	0	4	0
5:45 - 6:00	OUT	6	207	0	0	13	0	8	204	0	0	13	0

Notes: Y – Yes, N – No, U – Unknown

Table B-6. Southbound Lanes of I-635 at New Market Road on September 11, 2000.

Time Interval (PM)	Lane	Observer 1 Cars Y	N	U	Observer 1 Trucks Y	N	U	Observer 3 Cars Y	N	U	Observer 3 Trucks Y	N	U
4:00 - 4:15	IN	12	229	1	0	7	1	16	216	2	1	9	0
4:15 - 4:30	OUT	12	284	1	0	14	0	20	276	1	0	13	0
4:30 - 4:45	MID IN	10	248	1	0	23	1	12	241	0	0	23	1
4:45 - 5:00	MID IN	7	229	0	1	35	0	14	220	0	2	35	0
5:00 - 5:15	MID OUT	6	249	0	0	20	0	8	247	3	0	20	0
5:15 - 5:30	IN	23	309	2	0	6	0	24	307	0	0	6	0
5:30 - 5:45	OUT	11	311	0	0	9	0	9	308	0	0	9	0
5:45 - 6:00	MID OUT	10	247	0	2	18	2	7	238	0	1	19	2

Notes: Y – Yes, N – No, U – Unknown

Table B-7. Southbound Lanes of US 67 at Pleasant Run Road on September 12, 2000.

		Observer 1						Observer 2					
Time Interval		Cars			Trucks			Cars			Trucks		
(PM)	Lane	Y	N	U	Y	N	U	Y	N	U	Y	N	U
4:00 - 4:15	IN	8	132	0	1	8	0	10	129	2	0	8	0
4:15 - 4:30	IN	7	184	0	0	3	0	7	178	5	0	3	0
4:30 - 4:45	OUT	6	217	0	0	15	0	6	212	5	0	14	0
4:45 - 5:00	OUT	7	239	0	0	12	1	5	240	1	0	12	1
5:00 - 5:15	OUT	4	259	0	1	9	0	3	256	3	1	9	0
5:15 - 5:30	IN	9	272	0	0	3	0	8	269	3	0	3	0
5:30 - 5:45	OUT	7	255	0	1	5	0	5	257	0	1	5	0
5:45 - 6:00	IN	6	239	0	0	2	0	4	239	1	0	2	0

Notes: Y – Yes, N – No, U – Unknown

Table B-8. Northbound Lanes of I-35E at Kirnwood Drive on September 13, 2000.

		Observer 1						Observer 3					
Time Interval		Cars			Trucks			Cars			Trucks		
(PM)	Lane	Y	N	U	Y	N	U	Y	N	U	Y	N	U
4:00 - 4:15	MID	4	124	1	1	14	0	11	117	1	1	14	0
4:15 - 4:30	MID	1	138	0	1	8	0	5	132	0	1	8	0
4:30 - 4:45	MID	8	138	0	0	19	0	9	134	2	1	18	0
4:45 - 5:00	OUT	4	114	0	0	6	0	7	109	4	0	5	0
5:00 - 5:15	OUT	5	108	0	0	12	0	5	106	0	0	12	0
5:15 - 5:30	IN	4	88	0	0	4	0	5	87	0	0	4	0
5:30 - 5:45	IN	8	79	0	0	6	0	9	77	0	0	6	0
5:45 - 6:00	IN	3	89	0	0	3	0	5	86	0	0	3	0

Notes: Y – Yes, N – No, U – Unknown

Table B-9. Northbound Lanes of North Dallas Tollway at Meaders Lane on September 14, 2000.

		Observer 1						Observer 3					
Time Interval		Cars			Trucks			Cars			Trucks		
(PM)	Lane	Y	N	U	Y	N	U	Y	N	U	Y	N	U
4:00 – 4:15	MID	18	323	0	0	4	0	20	318	0	0	4	0
4:15 - 4:30	IN	31	392	0	0	1	0	22	398	0	0	1	0
4:30 - 4:45	OUT	23	249	0	1	5	0	20	251	0	0	6	0
4:45 - 5:00	OUT	32	301	0	0	2	0	29	294	1	0	3	0
5:00 - 5:15	MID	27	318	0	0	4	0	18	322	0	0	4	0
5:15 - 5:30	OUT	28	321	0	0	2	0	21	325	0	0	2	0
5:30 - 5:45	IN	40	279	0	0	0	0	33	283	1	0	0	0
5:45 - 6:00	IN	46	248	0	0	0	0	32	263	0	0	0	0

Notes: Y – Yes, N – No, U – Unknown

Table B-10. Eastbound Lanes of I-30 at Cockrell Hill on September 18, 2000

Time Interval (PM)	Lane	Observer 1						Observer 3					
		Cars			Trucks			Cars			Trucks		
		Y	N	U	Y	N	U	Y	N	U	Y	N	U
4:00 - 4:15	MID	6	225	0	1	27	0	11	217	3	1	27	0
4:15 - 4:30	IN	5	222	0	0	8	1	14	218	1	0	9	0
4:30 - 4:45	IN	11	250	0	0	1	0	14	245	3	0	1	0
4:45 - 5:00	OUT	3	137	0	0	19	0	7	128	1	0	23	0
5:00 - 5:15	IN	6	237	0	0	6	0	11	233	0	0	6	0
5:15 - 5:30	MID	6	221	0	0	18	0	9	217	1	0	18	0
5:30 - 5:45	MID	5	206	0	0	27	0	7	203	1	1	27	0
5:45 - 6:00	OUT	2	121	0	0	13	0	3	119	0	0	15	0

Notes: Y – Yes, N – No, U – Unknown

APPENDIX C.
HUMAN SUBJECTS CONSENT FORMS

CONSENT FORM

I have been invited to participate in a research study investigating the effects of cellular telephone use on driver performance. The experiment is to take place in a driving environment simulator. I am being selected as a possible participant because I have normal or corrected to normal vision (with contact lenses or glasses), I am between the ages of 25 and 54, and I possess a valid driver's license. I have experience using a cellular telephone and have no apparent limitations impeding my ability to drive or engage in a cellular telephone conversation. I have been instructed to read this form and ask any questions I may have before agreeing to participate in the study.

The Cellular Telephone Study is being conducted by Jacqueline Jenkins under the supervision of Michael P. Manser, and is funded by the Texas Transportation Institute.

Background Information: The purpose of this study is to investigate the differences in driver performance that occur when drivers are engaged in cellular telephone conversations. Handheld and hands-free cellular telephone systems will be employed.

Procedures: If I agree to be in this study, I will be asked to test drive the driving environment simulator (DESi), and participate in five experiment scenarios. After completing the experiment scenarios, I will be asked to complete a standard demographic survey and a survey about Simulator Induced Discomfort.

To begin the test drive, I will be seated in the simulator and will be provided instructions. When I have acknowledged that I am ready to proceed, the simulation will begin. My vehicle will be stopped on the side of the road with another vehicle stopped ahead of me on the right shoulder of the road. The other vehicle will begin to move forward. I will be asked to place my vehicle in "drive" and follow the lead vehicle. At the end of the test drive, the lead vehicle will come to a stop. I will stop my vehicle, place it in park, and direct my attention to the experimenter.

Still seated in the simulator, I will be provided an explanation of the five experiment scenarios. When I acknowledge that I am ready to proceed, I will be asked to put the vehicle in 'drive', and drive the vehicle down the road in a normal fashion, obeying all traffic laws.

During four of the experiment scenario, I will be asked to initiate a cellular telephone call as I pass a red vehicle parked on the left shoulder of the road. As I continue to traverse through the scenario, I will engage in a conversation with the experimenter. I understand that I have the right to withdraw from any conversation and that I may request the experiment be stopped at any time without repercussion.

At the end of each experiment scenario, there will be an intersection with a stop sign. I must come to a stop, and I will place the vehicle in 'park'. At that time, I will be asked to answer several questions about driving the scenario or driving while talking on the cellular telephone. Once I have answered the set of questions, and I have acknowledged that I am ready to proceed, the next experiment scenario will begin.

I understand that the only risk associated with this study is a temporary condition named ‘Simulator Induced Discomfort’ and that it is characterized by feelings of dizziness and increased body temperature. I understand that I am to indicate to the investigator if I experience any of these symptoms, and that the study will be stopped to prevent any further discomfort to me. I understand that it is my right to stop the study at any time for any reason and there will be no repercussions.

Confidentiality: I understand the records of this study will be kept private. In any sort of report that might be published, no information will be included which may make it possible to identify me. I understand the research records will be kept in a locked file, accessible only to the investigator.

Voluntary Nature of the Study: My decision whether or not to participate will not affect my current or future relations with the Texas Transportation Institute, Texas A&M University, or the Texas A&M University System. If I decide to participate, I am free to withdraw at any time without affecting those relationships.

Contacts and Questions: The researcher conducting this study is Michael P. Manser. If I have questions now or later, I may contact Michael P. Manser at the Texas Transportation Institute, Texas A&M University, College Station, TX 77843-3135, 409.862.3311.

I will be given a copy of this form for my records.
A copy of this form will be given to me prior to my proceeding with the experiment.

This research study has been reviewed and approved by the Institutional Review Board - Human Subjects in Research, Texas A&M University. For research-related problems or questions regarding subjects’ rights, the Institutional Review Board may be contacted through Dr. Richard E. Miller, IRB Coordinator, Office of Vice President for Research and Associate Provost for graduate Studies at (409) 845-1811.

Statement of Consent: *I have read and understand the explanation provided me. I have had all my questions answered to my satisfaction, and I voluntarily agree to participate in this study. I have been provided a copy of this consent form.*

_______________________________ ___________
Signature of Research Participant Date

_______________________________ ___________
Signature of Principal Investigator Date

APPENDIX D.
CONVERSATION TOPIC FORM

Check those events that have recently occurred and indicate whether or not you are willing to discuss such events.

Occurred Recently (Y)	Event	Will Discuss (Y, N)	Detail of Event
	Death of Spouse		
	Divorce		
	Marital Separation		
	Jail Term		
	Death of a close family member		
	Personal injury or illness		
	Marriage		
	Dismissal from work		
	Marital reconciliation		
	Retirement		
	Change in health of family member		
	Pregnancy		
	Gain of new family member		
	Business readjustment		
	Change in financial state		
	Death of a close friend		
	Change to different line of work		
	Change in number of arguments with spouse		
	Major mortgage		
	Foreclosure of mortgage or loan		
	Change in responsibility at work		
	Son or daughter leaving home		
	Trouble with in-laws		
	Outstanding personal achievement		
	Partner begins or stops work		
	Begin or end of school		
	Change in living conditions		
	Revision of personal habits		
	Trouble with boss		
	Change in work hours or conditions		
	Change in social activities		
	Small mortgage or loan		
	Change in sleeping/eating habits		
	Change in number of family get-togethers		
	Vacation		
	Minor violations of the law		

APPENDIX E.
PRACTICE DRIVE INSTRUCTIONS TO PARTICIPANTS

Test Drive
Your test drive of the simulator will begin when you acknowledge that you are ready.

Your vehicle will be stopped on the road and another vehicle will be stopped ahead of you on the side of the road. The other vehicle will begin to move forward. Put your vehicle into 'drive' and follow the other vehicle.

The lead vehicle starts off travelling at 35 mph. It will speed up to 45 mph and later to 55 mph. Please try to stay with the lead vehicle.

The lead vehicle will stop at an intersection and then turn left. When you arrive at this intersection, you are at the end of your test drive. Please pull up to the stop line, bring your vehicle to a complete stop, place it in 'park', and direct your attention to the investigator.

If you have any questions regarding the test drive please feel free to ask the experimenter. If you have no questions, please let the experimenter know you are ready to proceed by saying 'READY'.

APPENDIX F.
EXPERIMENTAL DRIVES INSTRUCTIONS TO PARTICIPANTS

Experiment
Similar to the practice scenario, each experiment scenario will begin after you acknowledge that you are ready. There are a total of five experiment scenarios to drive.

Each experiment scenario begins with your vehicle stopped on the road. There is no other vehicle to follow. Put your vehicle into 'drive' and proceed down the road, as you would normally operate your car on the roadway. Please obey all traffic laws including the speed limits. At the end of each experiment scenario there will be an intersection where you must stop. Please place your vehicle in 'park'.

After each experiment scenario you are asked to provide a rating that describes how hard you thought you worked to either drive the vehicle or talk on a cellular telephone while driving the vehicle. You will use the decision tree on the reverse side of this sheet to identify which rating best describes you feeling of workload.

The approximate time to complete all experiment scenarios is 40 minutes. If you have any questions about the experiment scenarios or providing a rating of your mental workload please ask the experimenter. If there are no questions, please let the experimenter know you are ready to proceed with the first/next experiment scenario by saying **'READY'**.

Experiment Scenario 1
There is no cellular telephone call to be made. Please drive through the scenario obeying all traffic laws. Upon completion of this scenario, please circle the rating below which describes how hard you thought you worked to accomplish the driving task. Use the rating chart on the reverse side of the sheet.

Rating 1 2 3 4 5 6 7 8 9 10

Experiment Scenario 2 - 5
For the remaining four experiment scenarios, you are asked to initiate a cellular telephone call and engage in a conversation. The call is to be initiated when you pass by a red vehicle parked on the left side on the road. The call is initiated by pressing the "talk" key on the cellular telephone *twice*.

Experiment Scenario 2
After completing experiment scenario 2, please circle the rating below which describes how hard you thought you worked to accomplish the simultaneous tasks of talking on the cellular telephone while driving. Use the rating chart on the reverse side of the sheet.

Rating 1 2 3 4 5 6 7 8 9 10

Experiment Scenario 3
After completing experiment scenario 3, please circle the rating below which describes how hard you thought you worked to accomplish the simultaneous tasks of talking on the cellular telephone while driving. Use the rating chart on the reverse side of the sheet.

Rating 1 2 3 4 5 6 7 8 9 10

Experiment Scenario 4

After completing experiment scenario 4, please circle the rating below which describes how hard you thought you worked to accomplish the simultaneous tasks of talking on the cellular telephone while driving. Use the rating chart on the reverse side of the sheet.

Rating 1 2 3 4 5 6 7 8 9 10

Experiment Scenario 5

After completing experiment scenario 5, please circle the rating below which describes how hard you thought you worked to accomplish the simultaneous tasks of talking on the cellular telephone while driving. Use the rating chart on the reverse side of the sheet.

Rating 1 2 3 4 5 6 7 8 9 10

APPENDIX G.
MODIFIED COOPER-HARPER WORKLOAD RATING CHART

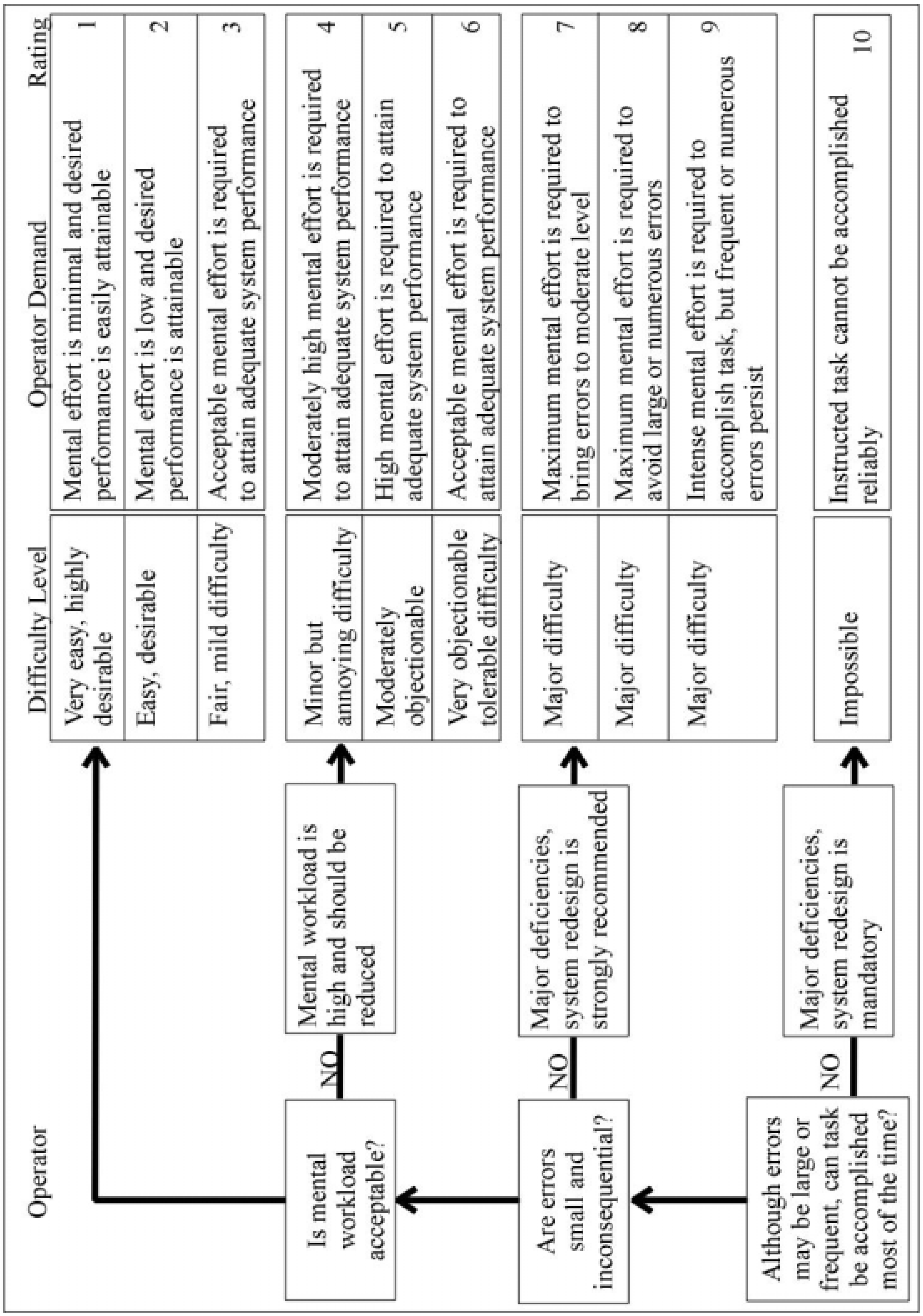

Figure G-1. Modified Cooper-Harper Workload Rating Chart.

APPENDIX H.
POST EXPERIMENT PARTICIPANT SURVEYS

SIMULATOR INDUCED DISCOMFORT

There is a small risk associated with driving in the driving environment simulator. The driver may experience feelings of dizziness and increased body temperature, which are symptoms of a temporary condition called 'Simulator Induced Discomfort' (SID).

To verify the extent of SID occurrence, we are tracking the severity of discomfort felt by those who drive in the driving environment simulator.

To provide a description of how you are feeling after having driven in the driving environment simulator, we ask that you complete the survey below.

What is your exposure to the driving environment simulator?

First time
Second time
More than two times

During this most current experience in the driving environment simulator did you experience any feelings of discomfort?

Eye Strain:	None	Slight	Moderate	Severe	
Headache:	None	Lightheaded	Slight Headache	Moderate Headache	Severe Headache
Stomach:	None	Uneasy	Slight Nausea	Moderate Nausea	Vomiting
Temperature:	None	Slight Increase	Warm and Clammy	Warm and Sweaty	Very Warm and Sweaty
Balance:	None	Unsteady	Slight Dizziness	Moderate Dizziness	Severe Dizziness

DEMOGRAPHICS

Sex:	Male	
	Female	

Age:______________

Marital Status:	Single	Married
	Divorced	Widowed

Racial Background:	White	Hispanic
	African-American	Asian or Pacific Islander
	Other	

Current Employment:	Full Time	Part Time
	Retired	Student
	Homemaker	Other

Do you live in:	City	Suburban
	Rural	

DRIVING HISTORY

How many years have you been driving?

	1-5 yrs	6-10 yrs
	11-15 yrs	16-20 yrs
	21-25 yrs	25 + yrs

How often do you drive a motor-vehicle?

	A few times a year	A few times a month
	A few times a week	Once a day
	Several times a day	

How often do you drive with other people in your vehicle?

	Almost every day	Few days a week
	Few days a month	Few days a year

What times of the day do you typically drive? (check all that apply)

6:00 - 9:00 am	9:00 am - 12:00 pm
12:00 - 3:00 pm	3:00 - 6:00 pm
6:00 - 9:00 pm	9:00 pm - 12:00 am
12:00 - 6:00 am	

What type of roads do you drive most often?

City	Suburban
Rural	About the same on each

VEHICLE INFORMATION

What kind of vehicle do you drive most often?

Car	Van or minivan
Sport utility vehicle	Pick-up truck
Motorcycle	

What is the year model of your vehicle that you drive the most?________________________

ISSUES

How often do you wear a seat belt?

Never Rarely Sometimes Most times Always

How often do you?

Drive through a light that was already red before you reached it:
Never Rarely Sometimes Most times Always

Drive 10 mph higher than the speed limit:
Never Rarely Sometimes Most times Always

Drive 20 mph higher than the speed limit:
Never Rarely Sometimes Most times Always

Enter an intersection as the light turns yellow:
Never Rarely Sometimes Most times Always

Come to a rolling stop at a stop sign:
Never Rarely Sometimes Most times Always

Drive when just under the legal alcohol limit:
Never Rarely Sometimes Most times Always

Drive when over the legal alcohol limit:
Never Rarely Sometimes Most times Always

Cross the railroad tracks when the red light is blinking:
Never Rarely Sometimes Most times Always

What is the importance of these issues?

Speeders:	None	Little	Some	A lot	No opinion
Drunk driving:	None	Little	Some	A lot	No opinion
Red light runners:	None	Little	Some	A lot	No opinion
Aggressive driving:	None	Little	Some	A lot	No opinion
Poor road signs:	None	Little	Some	A lot	No opinion
Older drivers:	None	Little	Some	A lot	No opinion
Younger drivers:	None	Little	Some	A lot	No opinion

APPENDIX I.
DEBRIEFING PACKET

DEBRIEFING PACKET

Effects of Cellular Telephone Use on Driver Performance

Michael P. Manser Ph.D.

Human Factors Program
Texas Transportation Institute
Safety and Structural Systems Division
The Texas A&M University System
College Station, TX 77843-3135
(409) 862-3311

If you would like a copy of the results of this study or have any questions concerning your participation please write or call the Human Factors Program of the Safety and Structural Division, of the Texas Transportation Institute at Texas A&M University.

Since the inception of the cellular telephone into the American consumer market, the wireless industry has flourished. As the popularity of the cellular telephone continues to grow, more people will use their cellular telephone as a part of their every day activities. One result will be the increased use of cellular telephones by automobile drivers. Concerns have been raised about the ability of drivers to maintain adequate control of their vehicle while engaged in a cellular telephone conversation and the potential for a traffic collision resulting from a decrement in driver performance.

Since 1969 when Brown and Poulton used the concept of a subsidiary task to measure the spare mental capacity of car drivers, further research has followed aimed at describing how the use of a cellular telephone while driving effects the performance of the driver. Along with the physical constraints of holding the cellular phone, the use of the cellular telephone is thought to demand attention of the driver away from the primary task of driving.

Open-road, closed-road and simulated studies have been conducted to probe the effects of using a cellular telephone while driving. Measurements of driver performance have included but are not limited to speed maintenance, headway maintenance, lane keeping, and brake response time. In addition to these performance measurements, driver workload has been measured as the response time and accuracy of response to cognitive and simple memory tests. Subjective measures of driver workload, such as participants' reports of concentration and stress levels may prove to be a useful indication of performance.

In 1989 Goodman et al prepared the report entitled "An Investigation of the Safety Implications of Wireless Communications in Vehicles" for the National Highway Traffic Safety Administration. This report includes an exhaustive literature review along with a review of the available data on user characteristics and an analysis of crash statistics. Among the conclusions drawn from the literature review, this report acknowledges that emotionally laden conversations may have a greater impact on driver performance than casual conversations.

It was the purpose of this study to determine:

- if the level of intensity of the cellular conversation effects the driver performance;
- how the use of hands-free cellular telephones compares with the use of handheld cellular telephones in conducting low-intensity and high-intensity conversations while driving; and
- whether the driving performance of male and female drivers is equally affected by the cellular telephone conversations.

Our hypotheses were that:

- driver performance as measured by the ability to maintain speed and lane position will deteriorate as the intensity of the cellular phone call increases;
- drivers will subjectively rate the workload associated with the high-intensity conversation as being greater than that of the low-intensity conversation;

- drivers will rate low-intensity conversations similar regardless of the mode of use;
- drivers will rate high-intensity conversation similar regardless of the mode of use; and
- the effect of cellular telephone use will be similar for both male and female drivers.

APPENDIX J.
SIMULATOR EXPERIMENT DATA

Table J-1. First Control Data for Females.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
01	1	19.933	0.429	-0.299	0.209	-0.084	0.037	0.086	0.011
02	2	21.157	0.828	-0.035	0.083	-0.102	0.057	0.108	0.031
03	1	20.355	0.304	0.160	0.136	-0.091	0.062	0.088	0.022
04	1	21.018	0.281	-0.385	0.085	-0.099	0.081	0.099	0.020
05	2	21.215	0.689	-0.212	0.263	-0.102	0.093	0.111	0.010
06	3	19.915	0.912	-0.021	0.102	-0.084	0.073	0.103	0.019
07	1	20.439	0.318	-0.323	0.236	-0.091	0.075	0.091	0.013
08	2	21.228	0.791	-0.099	0.270	-0.100	0.058	0.108	0.045
09	2	20.106	0.944	-0.047	0.084	-0.088	0.030	0.105	0.014
10	3	20.442	0.220	-0.308	0.134	-0.092	0.063	0.097	0.012
11	2	20.211	0.846	-0.096	0.171	-0.088	0.037	0.102	0.018
12	1	21.326	0.547	0.105	0.126	-0.102	0.085	0.110	0.006
13	1	21.062	0.093	-0.156	0.135	-0.098	0.053	0.098	0.004
14	2	20.271	0.764	-0.329	0.207	-0.090	0.050	0.082	0.032
15	2	20.240	0.572	-0.286	0.177	-0.089	0.060	0.091	0.038
16	1	19.495	0.573	-0.259	0.154	-0.082	0.053	0.083	0.041
17	2	20.906	0.313	-0.293	0.134	-0.098	0.024	0.102	0.004
18	3	22.587	1.027	-0.415	0.211	-0.123	0.158	0.113	0.058
19	2	21.040	0.554	0.177	0.103	-0.100	0.053	0.105	0.031
20	2	20.530	0.723	-0.234	0.230	-0.094	0.095	0.093	0.035

Table J-2. First Control Data for Males.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
21	2	20.649	0.617	0.196	0.142	-0.095	0.087	0.093	0.037
22	1	23.718	0.888	-0.469	0.180	-0.141	0.162	0.127	0.057
23	2	21.009	0.471	-0.388	0.132	-0.100	0.089	0.102	0.039
24	1	20.504	0.396	-0.325	0.117	-0.092	0.053	0.102	0.009
25	2	21.059	0.631	0.073	0.145	-0.099	0.030	0.109	0.016
26	2	20.523	0.320	-0.153	0.126	-0.090	0.048	0.099	0.009
27	2	21.121	0.258	-0.246	0.108	-0.100	0.046	0.101	0.013
28	2	21.013	0.247	0.046	0.148	-0.097	0.051	0.097	0.017
29	1	20.156	0.791	0.100	0.150	-0.089	0.038	0.090	0.029
30	1	22.742	1.097	-0.441	0.148	-0.124	0.069	0.100	0.033
31	2	21.307	0.804	-0.035	0.175	-0.105	0.069	0.102	0.047
32	1	18.424	0.120	-0.219	0.133	-0.069	0.059	0.079	0.005
33	1	19.688	0.254	0.045	0.104	-0.085	0.053	0.085	0.006
34	1	21.346	0.106	0.167	0.153	-0.103	0.063	0.102	0.006
35	1	19.757	0.274	-0.302	0.209	-0.084	0.148	0.086	0.022
36	1	19.776	0.295	-0.230	0.130	-0.081	0.041	0.089	0.017
37	2	20.892	1.406	-0.240	0.269	-0.098	0.046	0.117	0.027
38	1	24.143	0.235	-0.256	0.256	-0.147	0.145	0.126	0.006
39	1	21.475	0.336	-0.302	0.172	-0.106	0.064	0.102	0.031
40	2	21.817	0.390	-0.149	0.254	-0.112	0.121	0.094	0.023

Table J-3. Handheld, High-intensity Conversation Treatment Data for Females.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
01	2	20.207	0.889	-0.194	0.155	-0.089	0.061	0.083	0.026
02	2	21.702	0.350	0.077	0.107	-0.110	0.070	0.107	0.021
03	2	19.783	0.879	-0.077	0.103	-0.083	0.069	0.098	0.046
04	2	24.415	0.475	-0.319	0.098	-0.150	0.109	0.126	0.023
05	3	21.800	0.626	-0.493	0.154	-0.109	0.118	0.106	0.026
06	5	22.173	1.469	-0.198	0.133	-0.115	0.131	0.111	0.040
07	2	21.267	1.225	-0.354	0.193	-0.107	0.066	0.099	0.059
08	10	22.026	1.278	-0.485	0.269	-0.115	0.093	0.121	0.075
09	3	21.430	0.285	-0.210	0.081	-0.105	0.045	0.106	0.011
10	3	20.986	0.793	-0.313	0.140	-0.097	0.083	0.108	0.035
11	3	21.843	1.263	-0.083	0.164	-0.112	0.066	0.077	0.025
12	2	21.753	0.428	0.069	0.288	-0.110	0.104	0.113	0.005
13	2	20.193	0.222	-0.189	0.179	-0.088	0.032	0.093	0.011
14	3	19.164	0.327	-0.690	0.197	-0.077	0.095	0.084	0.016
15	3	20.227	0.825	-0.431	0.148	-0.086	0.106	0.097	0.069
16	3	19.942	0.760	-0.326	0.123	-0.088	0.068	0.091	0.054
17	6	20.339	0.344	-0.283	0.149	-0.104	0.078	0.096	0.023
18	3	21.220	0.704	-0.293	0.189	-0.101	0.100	0.109	0.065
19	3	21.218	0.307	0.168	0.110	-0.102	0.091	0.096	0.022
20	4	20.364	0.143	0.214	0.164	-0.088	0.173	0.094	0.012

Table J-4. Handheld, High-intensity Conversation Treatment Data for Males.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
21	3	22.816	0.456	0.062	0.135	-0.124	0.057	0.111	0.032
22	4	20.406	0.320	-0.077	0.147	-0.093	0.060	0.099	0.004
23	7	21.552	1.178	-0.291	0.193	-0.105	0.212	0.116	0.045
24	3	20.564	0.452	-0.484	0.247	-0.094	0.088	0.088	0.016
25	6	20.928	1.113	-0.032	0.227	-0.097	0.060	0.098	0.046
26	2	21.472	1.501	-0.173	0.156	-0.106	0.066	0.093	0.041
27	5	20.370	0.308	-0.138	0.112	-0.092	0.101	0.098	0.022
28	3	23.791	0.299	0.157	0.115	-0.141	0.071	0.121	0.028
29	3	19.648	0.078	-0.070	0.139	-0.083	0.063	0.089	0.004
30	3	23.909	0.556	-0.173	0.107	-0.143	0.088	0.120	0.025
31	4	22.204	1.273	-0.318	0.285	-0.117	0.120	0.104	0.070
32	4	18.613	0.431	-0.146	0.172	-0.072	0.088	0.075	0.003
33	1	20.856	0.375	0.069	0.099	-0.098	0.057	0.092	0.011
34	1	22.188	1.946	0.035	0.212	-0.117	0.073	0.084	0.040
35	1	19.510	0.970	-0.271	0.189	-0.085	0.125	0.086	0.041
36	3	19.898	0.279	-0.204	0.171	-0.084	0.052	0.095	0.015
37	4	20.614	0.461	-0.449	0.168	-0.096	0.086	0.097	0.018
38	1	24.280	0.271	0.054	0.165	-0.149	0.137	0.116	0.016
39	4	22.525	0.769	-0.182	0.127	-0.122	0.122	0.116	0.047
40	6	24.156	0.910	-0.196	0.166	-0.145	0.118	0.106	0.021

Table J-5. Handheld, Low-intensity Conversation Treatment Data for Females.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
01	3	19.884	1.929	-0.035	0.196	-0.087	0.141	0.077	0.062
02	2	20.081	0.851	0.111	0.134	-0.087	0.084	0.098	0.027
03	2	20.658	0.057	0.216	0.136	-0.095	0.086	0.095	0.003
04	2	21.474	0.365	-0.384	0.112	-0.105	0.113	0.100	0.020
05	4	22.230	0.846	-0.297	0.183	-0.114	0.125	0.120	0.017
06	5	19.872	0.266	-0.077	0.100	-0.085	0.107	0.087	0.009
07	2	19.482	0.701	-0.355	0.110	-0.082	0.060	0.096	0.047
08	4	23.140	1.664	-0.665	0.136	-0.132	0.082	0.115	0.066
09	3	20.061	0.270	-0.145	0.115	-0.086	0.049	0.090	0.020
10	3	20.587	0.841	-0.194	0.126	-0.095	0.094	0.096	0.051
11	2	19.887	0.381	-0.095	0.076	-0.085	0.048	0.098	0.003
12	2	21.133	1.008	0.034	0.129	-0.099	0.092	0.083	0.035
13	2	22.374	0.388	-0.006	0.229	-0.119	0.125	0.103	0.016
14	3	19.924	0.185	-0.735	0.169	-0.087	0.062	0.094	0.011
15	2	19.872	0.462	-0.449	0.089	-0.084	0.046	0.087	0.043
16	3	19.611	0.532	-0.215	0.125	-0.083	0.073	0.091	0.043
17	6	20.470	0.267	-0.010	0.125	-0.092	0.070	0.093	0.011
18	3	20.861	0.752	-0.335	0.161	-0.094	0.093	0.103	0.063
19	3	20.331	0.673	0.266	0.137	-0.088	0.096	0.087	0.025
20	2	19.705	0.961	0.140	0.167	-0.082	0.108	0.099	0.021

Table J-6. Handheld, Low-intensity Conversation Treatment Data for Males.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
21	3	22.157	0.306	0.078	0.113	-0.113	0.066	0.107	0.017
22	3	20.088	0.301	-0.154	0.162	-0.087	0.046	0.094	0.020
23	4	21.111	1.228	-0.093	0.154	-0.100	0.255	0.118	0.080
24	2	20.649	0.218	-0.368	0.184	-0.095	0.053	0.094	0.007
25	5	20.337	0.406	0.040	0.204	-0.091	0.059	0.087	0.012
26	1	20.181	0.183	-0.050	0.146	-0.086	0.071	0.090	0.016
27	5	21.286	0.573	-0.114	0.159	-0.101	0.049	0.094	0.034
28	3	22.433	0.363	0.107	0.100	-0.120	0.069	0.111	0.044
29	2	20.931	0.301	-0.102	0.134	-0.096	0.040	0.095	0.015
30	2	24.310	0.171	-0.145	0.102	-0.147	0.084	0.119	0.022
31	5	21.231	0.636	0.016	0.113	-0.101	0.067	0.097	0.057
32	4	18.657	0.286	-0.150	0.145	-0.071	0.055	0.080	0.009
33	1	19.578	0.543	0.186	0.124	-0.084	0.089	0.083	0.028
34	1	21.297	0.494	0.021	0.154	-0.103	0.054	0.110	0.014
35	1	18.956	2.040	-0.110	0.261	-0.080	0.122	0.115	0.032
36	4	26.993	0.506	-0.182	0.218	-0.199	0.069	0.157	0.003
37	4	21.952	2.274	-0.450	0.150	-0.114	0.087	0.071	0.030
38	1	24.272	0.515	-0.008	0.216	-0.153	0.182	0.118	0.028
39	4	22.975	1.475	-0.148	0.149	-0.128	0.155	0.091	0.042
40	4	22.219	0.758	-0.170	0.213	-0.116	0.141	0.101	0.026

Table J-7. Hands-free, High-intensity Conversation Treatment Data for Females.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
01	2	19.763	0.657	-0.268	0.148	-0.085	0.033	0.094	0.023
02	3	23.466	0.655	-0.167	0.153	-0.135	0.066	0.105	0.009
03	2	20.008	0.875	0.164	0.152	-0.089	0.105	0.103	0.047
04	1	21.265	0.759	-0.263	0.130	-0.103	0.168	0.094	0.051
05	4	20.690	0.608	-0.176	0.157	-0.095	0.074	0.085	0.017
06	4	19.524	0.574	-0.127	0.109	-0.081	0.078	0.086	0.021
07	2	20.165	1.318	-0.091	0.165	-0.090	0.080	0.105	0.063
08	5	19.678	0.689	-0.209	0.130	-0.080	0.087	0.102	0.075
09	3	21.414	0.690	-0.094	0.111	-0.106	0.050	0.099	0.024
10	3	20.759	0.381	-0.232	0.086	-0.096	0.066	0.103	0.026
11	2	20.059	0.464	0.035	0.207	-0.088	0.033	0.099	0.007
12	3	21.055	0.528	0.183	0.169	-0.103	0.098	0.094	0.018
13	2	21.617	0.527	-0.104	0.140	-0.107	0.103	0.103	0.029
14	2	20.227	0.637	-0.961	0.161	-0.090	0.055	0.102	0.021
15	3	20.085	0.899	-0.342	0.168	-0.090	0.130	0.108	0.066
16	2	20.451	0.143	-0.269	0.117	-0.092	0.060	0.093	0.015
17	5	23.371	0.703	-0.037	0.136	-0.013	0.037	0.113	0.038
18	3	18.959	1.255	-0.458	0.211	-0.074	0.082	0.083	0.055
19	2	21.800	0.398	0.007	0.185	-0.110	0.112	0.100	0.036
20	3	19.824	0.306	-0.188	0.102	-0.084	0.112	0.094	0.018

Table J-8. Hands-free, High-intensity Conversation Treatment Data for Males.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
21	3	21.377	0.135	0.076	0.073	-0.104	0.058	0.104	0.005
22	3	20.593	0.497	-0.174	0.143	-0.094	0.042	0.097	0.019
23	4	26.441	1.089	-0.325	0.246	-0.182	0.370	0.157	0.057
24	2	19.491	0.584	-0.459	0.124	-0.080	0.055	0.092	0.020
25	3	25.814	2.173	-0.023	0.212	-0.176	0.070	0.103	0.061
26	2	20.555	0.309	-0.221	0.102	-0.093	0.044	0.094	0.014
27	4	20.172	0.352	-0.173	0.167	-0.087	0.087	0.092	0.030
28	3	22.449	0.275	0.125	0.079	-0.118	0.057	0.112	0.013
29	4	19.555	0.276	-0.032	0.109	-0.081	0.103	0.085	0.007
30	2	25.880	0.374	-0.243	0.117	-0.177	0.074	0.140	0.015
31	5	21.260	1.106	-0.073	0.143	-0.103	0.088	0.096	0.070
32	3	19.158	0.635	-0.120	0.137	-0.080	0.091	0.074	0.006
33	2	20.749	0.128	0.104	0.124	-0.095	0.120	0.096	0.009
34	1	20.516	0.615	-0.028	0.154	-0.091	0.051	0.091	0.032
35	1	21.593	0.336	0.013	0.276	-0.109	0.139	0.095	0.015
36	3	20.806	0.752	-0.134	0.144	-0.112	0.053	0.096	0.017
37	3	19.797	0.038	-0.094	0.117	-0.082	0.118	0.082	0..011
38	1	27.744	0.215	-0.064	0.178	-0.156	0.166	0.133	0.014
39	3	23.117	0.440	-0.261	0.151	-0.128	0.097	0.123	0.015
40	3	26.036	0.194	-0.142	0.167	-0.185	0.108	0.134	0.016

Table J-9. Hands-free, Low-intensity Conversation Treatment Data for Females.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
01	2	20.585	0.565	-0.063	0.205	-0.094	0.058	0.089	0.022
02	2	19.304	1.138	0.115	0.103	-0.079	0.070	0.071	0.032
03	2	20.263	0.352	0.178	0.125	-0.091	0.067	0.087	0.013
04	2	22.138	1.114	-0.281	0.101	-0.118	0.114	0.092	0.047
05	4	20.964	0.044	-0.362	0.113	-0.098	0.044	0.100	0.003
06	3	20.179	0.642	-0.140	0.113	-0.088	0.162	0.093	0.027
07	2	19.433	0.625	-0.252	0.231	-0.081	0.073	0.077	0.009
08	8	18.881	0.882	-0.366	0.148	-0.075	0.053	0.095	0.061
09	3	22.701	0.549	-0.003	0.125	-0.123	0.036	0.099	0.036
10	3	20.700	0.671	-0.230	0.106	-0.096	0.067	0.084	0.032
11	2	20.379	0.433	-0.231	0.148	-0.092	0.040	0.087	0.005
12	2	21.027	0.985	-0.066	0.182	-0.103	0.105	0.107	0.035
13	2	22.767	2.657	-0.067	0.220	-0.129	0.110	0.071	0.027
14	2	21.113	0.300	-0.820	0.220	-0.101	0.053	0.097	0.012
15	2	20.178	0.618	-0.388	0.130	-0.087	0.070	0.088	0.045
16	2	20.202	0.500	-0.172	0.141	-0.090	0.046	0.094	0.028
17	4	23.091	0.171	-0.460	0.119	-0.131	0.044	0.115	0.008
18	3	21.214	0.636	-0.304	0.167	-0.101	0.056	0.105	0.060
19	3	20.661	0.141	0.099	0.116	-0.093	0.066	0.098	0.012
20	3	18.678	0.518	-0.214	0.108	-0.070	0.125	0.079	0.028

Table J-10. Hands-free, Low-intensity Conversation Treatment Data for Males.

	MCH Rating	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
		mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
21	3	24.065	0.279	0.109	0.127	-0.146	0.079	0.120	0.030
22	3	20.353	0.438	-0.073	0.104	-0.089	0.048	0.092	0.024
23	3	23.497	0.536	-0.404	0.181	-0.133	0.278	0.126	0.048
24	2	20.172	0.679	-0.360	0.112	-0.089	0.047	0.104	0.011
25	3	20.781	0.467	-0.043	0.257	-0.096	0.038	0.089	0.003
26	3	21.871	2.652	-0.086	0.179	-0.115	0.066	0.091	0.053
27	4	20.110	0.311	-0.147	0.140	-0.083	0.072	0.095	0.028
28	3	22.029	0.434	0.080	0.073	-0.112	0.054	0.111	0.014
29	2	19.701	0.081	-0.033	0.135	-0.085	0.093	0.088	0.007
30	3	27.506	0.609	-0.168	0.110	-0.210	0.104	0.144	0.031
31	3	21.267	0.922	-0.186	0.153	-0.101	0.081	0.086	0.064
32	2	20.887	0.210	0.018	0.142	-0.098	0.066	0.095	0.004
33	1	18.648	0.499	0.066	0.129	-0.072	0.074	0.086	0.025
34	2	21.379	0.521	0.038	0.179	-0.103	0.055	0.106	0.015
35	1	18.845	0.708	-0.400	0.170	-0.073	0.054	0.096	0.005
36	3	19.797	0.783	-0.238	0.202	-0.082	0.058	0.082	0.015
37	3	20.071	0.368	-0.220	0.097	-0.098	0.055	0.093	0.011
38	1	24.605	0.458	-0.128	0.236	-0.150	0.194	0.128	0.029
39	3	26.704	0.230	-0.203	0.182	-0.193	0.122	0.142	0.017
40	4	22.861	0.393	-0.389	0.171	-0.126	0.069	0.102	0.013

Table J-11. Second Control Data for Females.

	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
	mean	st. dev.	Mean	st. dev.	mean	st. dev.	mean	st. dev.
01	20.188	0.267	-0.301	0.189	-0.090	0.027	0.090	0.011
02	20.936	0.329	0.008	0.165	-0.098	0.066	0.092	0.006
03	20.122	0.382	0.036	0.183	-0.087	0.017	0.098	0.013
04	21.221	0.065	-0.546	0.224	-0.101	0.051	0.101	0.005
05	21.597	0.161	-0.259	0.229	-0.106	0.032	0.100	0.005
06	20.282	0.541	-0.164	0.120	-0.089	0.041	0.102	0.005
07	20.122	0.797	-0.553	0.259	-0.089	0.084	0.103	0.028
08	20.181	0.278	-0.257	0.250	-0.088	0.042	0.097	0.026
09	20.726	0.119	-0.081	0.108	-0.094	0.014	0.095	0.002
10	21.057	0.404	-0.273	0.110	-0.099	0.037	0.095	0.025
11	19.920	0.047	0.023	0.233	-0.083	0.033	0.092	0.002
12	22.805	0.223	-0.030	0.132	-0.123	0.059	0.110	0.013
13	21.297	0.309	-0.179	0.104	-0.103	0.029	0.106	0.009
14	20.929	1.068	-0.822	0.218	-0.099	0.033	0.096	0..043
15	20.711	0.587	-0.439	0.205	-0.095	0.065	0.094	0.036
16	20.314	0.339	-0.408	0.161	-0.091	0.042	0.096	0.021
17	21.466	0.113	-0.250	0.122	-0.105	0.021	0.103	0.009
18	22.522	0.536	-0.284	0.176	-0.120	0.043	0.109	0.045
19	20.669	1.117	0.032	0.273	-0.095	0.047	0.086	0.038
20	20.226	0.822	-0.192	0.155	-0.087	0.034	0.094	0.038

Table J-12. Second Control Data for Males.

	Speed (meters/second)		Lane position (meters)		Steering (radians)		Accelerator (rated 0 to 1.0)	
	mean	st. dev.	mean	st. dev.	mean	st. dev.	mean	st. dev.
21	20.986	0.231	0.045	0.107	-0.098	0.043	0.101	0.006
22	20.474	0.541	-0.216	0.170	-0.090	0.028	0.092	0.030
23	21.645	0.743	-0.390	0.130	-0.108	0.072	0.115	0.025
24	20.395	0.591	-0.503	0.268	-0.093	0.042	0.097	0.026
25	20.026	0.130	-0.044	0.346	-0.100	0.059	0.101	0.001
26	20.518	0.207	-0.282	0.203	-0.090	0.040	0.096	0.018
27	21.571	0.255	-0.349	0.234	-0.107	0.037	0.107	0.008
28	22.958	0.786	0.085	0.181	-0.127	0.064	0.103	0.016
29	20.757	0.115	-0.169	0.185	-0.096	0.057	0.099	0.001
30	24.205	1.134	0.024	0.176	-0.149	0.064	0.107	0.030
31	20.618	0.440	-0.147	0.112	-0.094	0.028	0.103	0.009
32	19.757	1.031	-0.136	0.159	-0.081	0.037	0.075	0.014
33	18.788	0.316	-0.052	0.127	-0.074	0.071	0.086	0.010
34	20.954	0.291	-0.120	0.249	-0.113	0.054	0.109	0.009
35	19.634	1.093	0.056	0.196	-0.081	0.064	0.084	0.049
36	20.648	0.545	-0.151	0.154	-0.095	0.028	0.106	0.010
37	21.357	0.022	-0.356	0.230	-0.103	0.037	0.101	0.001
38	24.331	0.643	-0.239	0.122	-0.150	0.086	0.120	0.029
39	22.725	0.440	-0.325	0.191	-0.121	0.062	0.118	0.014
40	24.712	0.594	-0.167	0.219	-0.160	0.101	0.116	0.033

Table J-13. Brake Reaction and Response Data for Females.

	Mode / Conversation	Reaction time	Response time
01	hands-free high-intensity	0.5 sec	0.7 sec
02	hands-free low-intensity	0.4 sec	0.7 sec
03	handheld high-intensity	0.4 sec	0.6 sec
04	handheld low-intensity	0.4 sec	0.7 sec
05	hands-free low-intensity	0.4 sec	0.6 sec
06	hands-free high-intensity	0.4 sec	0.6 sec
07	handheld low-intensity	0.4 sec	0.6 sec
08	handheld high-intensity	0.4 sec	0.6 sec
09	hands-free high-intensity	0.4 sec	0.7 sec
10	handheld high-intensity	0.4 sec	0.6 sec
11	hands-free low-intensity	0.4 sec	0.7 sec
12	handheld low-intensity	0.5 sec	0.9 sec
13	handheld high-intensity	0.4 sec	0.6 sec
14	hands-free high-intensity	0.4 sec	0.6 sec
15	handheld low-intensity	0.4 sec	0.6 sec
16	hands-free low-intensity	0.4 sec	0.6 sec
17	handheld high-intensity	0.5 sec	0.7 sec
18	hands-free high-intensity	0.5 sec	0.7 sec
19	hands-free low-intensity	0.4 sec	0.6 sec
20	handheld low-intensity	0.5 sec	0.7 sec

Table J-14. Brake Reaction and Response Data for Males.

	Mode / Conversation	Reaction time	Response time
21	hands-free high-intensity	0.5 sec	0.7 sec
22	hands-free low-intensity	0.4 sec	0.7 sec
23	handheld high-intensity	No data given	0.6 sec
24	handheld low-intensity	0.4 sec	0.7 sec
25	hands-free low-intensity	1.0 sec	1.2 sec
26	hands-free high-intensity	0.6 sec	0.8 sec
27	handheld low-intensity	0.5 sec	0.7 sec
28	handheld high-intensity	0.8 sec	1.0 sec
29	hands-free high-intensity	1.1 sec	1.3 sec
30	handheld high-intensity	0.5 sec	0.9 sec
31	hands-free low-intensity	0.4 sec	0.6 sec
32	handheld low-intensity	0.4 sec	0.6 sec
33	handheld high-intensity	0.5 sec	0.6 sec
34	hands-free high-intensity	0.5 sec	0.8 sec
35	handheld low-intensity	0.5 sec	0.7 sec
36	hands-free low-intensity	0.5 sec	0.7 sec
37	handheld high-intensity	0.4 sec	0.8 sec
38	hands-free high-intensity	1.1 sec	1.3 sec
39	hands-free low-intensity	0.5 sec	0.7 sec
40	handheld low-intensity	0.5 sec	0.7 sec

APPENDIX K.
POST-SIMULATOR SURVEY RESPONSES

TABLE K-1. SIMULATOR INDUCED DISCOMFORT SURVEY RESPONSES FROM FEMALES.

	Age	Exposure	Feelings of Discomfort				
			Eye strain	Headache	Stomach	Temp.	Balance
01	28	2nd time	slight	lightheaded	none	slight	none
02	31	1st time	slight	none	none	slight	unsteady
03	38	2nd time	none	lightheaded	none	none	none
04	26	1st time	none	none	none	none	none
05	57	1st time	slight	none	slight	warm	unsteady
06	49	1st time	slight	none	none	slight	slight
07	35	1st time	none	none	none	none	none
08	31	1st time	moderate	slight	uneasy	slight	slight
09	26	1st time	none	none	none	slight	slight
10	35	1st time	slight	lightheaded	none	slight	none
11	27	2nd time	none	none	uneasy	none	none
12	24	1st time	none	none	none	none	none
13	44	1st time	none	lightheaded	uneasy	none	slight
14	37	1st time	none	lightheaded	moderate	warm	moderate
15	29	2nd time	none	slight	uneasy	none	none
16	31	1st time	none	lightheaded	none	none	none
17	37	2nd time	slight	none	uneasy	none	unsteady
18	31	1st time	slight	none	slight	warm	unsteady
19	31	1st time	moderate	slight	slight	none	unsteady
20	31	1st time	none	none	none	none	slight

Table K-2. Simulator Induced Discomfort Survey Responses from Males.

	Age	Exposure	Feelings of Discomfort				
			Eye strain	Headache	Stomach	Temp.	Balance
21	55	2nd time	slight	none	none	none	none
22	30	2nd time	slight	none	uneasy	slight	slight
23	38	1st time	none	lightheaded	none	none	unsteady
24	33	1st time	slight	lightheaded	slight	slight	unsteady
25	28	> 2 times	slight	slight	uneasy	none	unsteady
26	44	2nd time	none	none	uneasy	none	unsteady
27	35	1st time	slight	lightheaded	none	slight	unsteady
28	25	2nd time	none	lightheaded	none	none	none
29	35	> 2 times	none	none	uneasy	none	none
30	40	1st time	slight	none	none	slight	unsteady
31	29	1st time	none	none	uneasy	none	unsteady
32	26	1st time	none	none	none	none	none
33	26	1st time	none	lightheaded	none	none	unsteady
34	29	2nd time	none	none	none	none	none
35	32	2nd time	none	none	none	none	none
36	25	1st time	slight	none	uneasy	slight	unsteady
37	38	2nd time	none	none	none	none	unsteady
38	32	2nd time	none	none	none	none	none
39	47	1st time	none	none	uneasy	none	unsteady
40	24	1st time	none	none	none	none	none

Table K-3. Demographic Survey Responses from Females.

	Age	Marital status	Racial background	Current employment	Habitant	Years driving
1	28	married	white	full time	rural	11-15
2	31	married	white	full time	city	11-15
3	38	married	white	full time	city	21-25
4	26	single	african american	student	rural	6-10
5	57	married	white	full time	city	25+
6	49	married	white	full time	rural	25+
7	35	divorced	white	full time	rural	16-20
8	31	divorced	hispanic	full time	city	21-25
9	26	married	white	full time	city	6-10
10	35	married	white	full time	rural	21-25
11	27	single	white	full time	rural	11-15
12	24	married	white	homemaker	city	6-10
13	44	married	white	full time	city	25+
14	37	single	white	full time	city	16-20
15	29	married	white	full time	city	11-15
16	31	married	white	full time	rural	11-15
17	37	married	white	full time	suburban	21-25
18	31	single	white	student	city	11-15
19	31	single	white	student	suburban	11-15
20	31	married	white	homemaker	city	1-5

Table K-3. Demographic Survey Responses from Females (continued).

	Drive how often?	Drive with passenger	6-9 am	9-12 pm	12-3 pm	3-6 pm	6-9 pm	9-12 pm	12-6 am
1	several/day	day	y		y	y	y		
2	several/day	week	y	y	y	y	y	y	y
3	several/day	day	y	y	y	y	y	y	
4	several/day	day	y	y	y	y	y		
5	several/day	week	y			y			
6	several/day	week	y			y	y		
7	several/day	week	y	y	y	y	y		
8	several/day	day	y		y	y	y	y	
9	several/day	day	y		y	y			
10	several/day	day	y			y	y	y	
11	several/day	week	y		y	y	y		
12	several/day	day					y		
13	several/day	day	y		y	y	y		
14	several/day	week	y			y	y		
15	several/day	day	y	y		y			
16	several/day	month	y		y	y			
17	several/day	week	y		y	y	y		
18	several/day	week	y	y	y	y	y	y	
19	few/week	month					y		
20	several/day	week	y		Y	y			

Table K-3. Demographic Survey Responses from Females (continued).

	Type of road	Type of vehicle	Year of vehicle	Seatbelt use	Enter on red	Drive 10 mph over	Drive 20 mph over
1	city	car	1994	always	rarely	sometimes	rarely
2	city	car	1998	always	never	sometimes	never
3	all	SUV	1990	always	never	rarely	never
4	rural	car	1993	always	never	sometimes	never
5	city	car	1993	always	never	rarely	never
6	rural	car	1995	always	rarely	sometimes	never
7	rural	SUV	1999	always	rarely	never	never
8	city	SUV	1994	always	never	never	never
9	city	car	1992	always	never	rarely	never
10	all	SUV	1993	always	never	never	never
11	all	pick up	1992	always	never	sometimes	never
12	city	car	1996	always	never	most times	rarely
13	city	car	1995	always	rarely	sometimes	rarely
14	city	car	1993	always	never	sometimes	never
15	city	car	1999	always	never	sometimes	never
16	rural	car	1992	always	never	sometimes	never
17	all	minivan	1993	always	rarely	sometimes	never
18	all	car	2000	always	rarely	sometimes	sometimes
19	all	car	1986	always	rarely	most times	sometimes
20	city	car	1993	always	never	rarely	never

Table K-3. Demographic Survey Responses from Females (continued).

	Enter on amber	Rolling stop	Under BAC	Over BAC	Cross rail on red
1	sometimes	sometimes	rarely	never	rarely
2	sometimes	sometimes	never	never	never
3	rarely	rarely	never	never	never
4	most times	most times	rarely	never	never
5	rarely	sometimes	never	never	never
6	rarely	rarely	rarely	never	rarely
7	sometimes	sometimes	sometimes	never	never
8	sometimes	sometimes	rarely	never	never
9	rarely	sometimes	rarely	never	never
10	rarely	rarely	never	never	never
11	sometimes	sometimes	never	never	never
12	sometimes	rarely	never	never	never
13	sometimes	rarely	never	never	never
14	rarely	sometimes	sometimes	rarely	never
15	most times	sometimes	rarely	never	never
16	most times	most times	sometimes	never	never
17	most times	sometimes	rarely	never	rarely
18	sometimes	sometimes	rarely	never	rarely
19	sometimes	rarely	sometimes	rarely	never
20	sometimes	sometimes	rarely	never	never

Table K-3. Demographic Survey Responses from Females (continued).

	Importance of Issues						
	Speeders	Drunk driving	Red-light runners	Aggressive driving	Poor road signs	Older drivers	Younger drivers
1	some	lot	lot	some	some	little	little
2	some	lot	lot	lot	some	lot	lot
3	lot	lot	lot	lot	lot	lot	lot
4	some	lot	lot	lot	lot	lot	lot
5	lot	lot	lot	some	lot	lot	little
6	lot	lot	lot	some	lot	lot	lot
7	lot	some	lot	lot	some	some	some
8	lot	lot	lot	some	some	lot	some
9	some	lot	lot	some	lot	some	some
10	lot	lot	lot	lot	some	some	lot
11	little	lot	some	some	some	little	some
12	little	lot	some	little	little	some	some
13	some	lot	some	lot	little	some	some
14	little	some	lot	lot	some	lot	little
15	some	lot	lot	lot	some	lot	lot
16	some	lot	lot	lot	some	some	some
17	some	lot	some	lot	some	some	little
18	little	lot	lot	some	some	some	some
19	some	lot	some	lot	lot	lot	some
20	some	lot	lot	lot	lot	little	little

Table K-4. Demographic Survey Responses from Males.

	Age	Marital status	Racial background	Current employment	Habitant	Years driving
21	55	married	white	full time	city	25+
22	30	married	white	full time	city	11-15
23	38	single	white	full time	city	21-25
24	33	married	white	full time	city	11-15
25	28	married	white	full time	suburban	11-15
26	44	single	white	full time	city	25+
27	35	married	white	full time	suburban	16-20
28	25	single	white	full time	city	11-15
29	35	married	white	full time	city	16-20
30	40	married	white	full time	rural	25+
31	29	married	hispanic	student	suburban	11-15
32	26	married	white	student	city	11-15
33	26	married	other	part time	rural	6-10
34	29	single	white	full time	suburban	11-15
35	32	single	asian	part time	city	1-5
36	25	single	hispanic	student	city	6-10
37	38	married	white	full time	suburban	21-25
38	37	married	white	full time	rural	21-25
39	47	divorced	white	full time	city	21-25
40	24	single	white	student	suburban	6-10

Table K-4. Demographic Survey Responses from Males (continued).

	Drive how often?	Drive with passenger	6-9 am	9-12 pm	12-3 pm	3-6 pm	6-9 pm	9-12 pm	12-6 am
21	several/day	week	Y		Y	Y	Y	Y	
22	several/day	week	Y			Y	Y		
23	several/day	day	Y		Y	Y	Y		
24	several/day	week	Y	Y	Y	Y	Y	Y	
25	several/day	week	Y	Y	Y		Y		
26	several/day	year	Y	Y		Y	Y		
27	several/day	day	Y	Y		Y	Y	Y	
28	several/day	month	Y	Y	Y	Y	Y		
29	several/day	day	Y	Y	Y	Y	Y	Y	
30	several/day	day	Y		Y		Y		
31	several/day	day	Y		Y		Y		
32	several/day	day	Y			Y	Y	Y	
33	several/day	month	Y	Y		Y	Y	Y	Y
34	several/day	week	Y			Y			
35	several/day	day		Y	Y	Y	Y	Y	
36	few/month	month					Y		Y
37	several/day	week	Y		Y		Y		
38	several/day	day	Y	Y	Y	Y	Y		
39	several/day	month	Y		Y		Y		
40	several/day	week	Y	Y		Y	Y		

Table K-4. Demographic Survey Responses from Males (continued).

	Type of road	Type of vehicle	Year of vehicle	Seatbelt use	Enter on red	Drive 10 mph over	Drive 20 mph over
21	city	car	2000	always	never	most times	never
22	city	car	1993	always	never	rarely	never
23	suburban	pick up	1990	always	never	rarely	never
24	all	pick up	1995	always	never	sometimes	rarely
25	suburban	car	1995	sometimes	rarely	sometimes	rarely
26	all	car	1995	always	never	rarely	rarely
27	suburban	car	1995	always	rarely	most times	rarely
28	city	pick up	1997	always	rarely	rarely	never
29	city	car	1990	always	never	never	never
30	all	car	1987	most times	rarely	sometimes	sometimes
31	suburban	SUV	1996	always	never	sometimes	never
32	city	car	1992	always	never	sometimes	never
33	all	car	1993	always	never	sometimes	sometimes
34	suburban	car	1995	always	never	most times	rarely
35	city	car	1985	most times	never	sometimes	rarely
36	city	car	No data given	always	never	rarely	never
37	city	car	1995	always	rarely	sometimes	rarely
38	all	SUV	1993	always	rarely	always	sometimes
39	city	car	1991	always	rarely	most times	rarely
40	All	pick up	1989	always	never	most times	rarely

Table K-4. Demographic Survey Responses from Males (continued).

	Enter on amber	Rolling stop	Under BAC	Over BAC	Cross rail on red
21	rarely	sometimes	never	never	never
22	sometimes	sometimes	never	never	never
23	sometimes	rarely	most times	sometimes	rarely
24	rarely	most times	never	never	sometimes
25	most times	most times	rarely	never	never
26	sometimes	rarely	never	never	never
27	most times	most times	rarely	never	never
28	sometimes	most times	never	never	never
29	sometimes	sometimes	never	never	never
30	sometimes	most times	most times	most times	sometimes
31	sometimes	most times	never	never	never
32	sometimes	rarely	sometimes	sometimes	never
33	rarely	sometimes	never	never	never
34	most times	sometimes	rarely	rarely	never
35	rarely	rarely	never	never	never
36	sometimes	never	sometimes	rarely	never
37	sometimes	sometimes	never	never	never
38	sometimes	always	never	rarely	rarely
39	most times	rarely	never	never	rarely
40	sometimes	rarely	never	never	rarely

Table K-4. Demographic Survey Responses from Males (continued).

	Importance of Issues						
	Speeders	Drunk driving	Red-light runners	Aggressive driving	Poor road signs	Older drivers	Younger drivers
21	lot	lot	lot	some	little	little	lot
22	some	lot	lot	lot	little	little	little
23	some	little	lot	some	some	some	some
24	some	lot	lot	lot	some	little	little
25	some	lot	lot	lot	some	some	lot
26	some	lot	lot	some	little	some	little
27	some	lot	lot	some	little	some	little
28	some	lot	some	some	some	some	some
29	lot	lot	lot	lot	some	lot	lot
30	lot	lot	lot	lot	some	lot	some
31	little	lot	some	some	none	little	little
32	some	some	lot	some	some	lot	lot
33	lot	lot	lot	some	lot	some	little
34	little	lot	lot	lot	little	some	little
35	little	lot	lot	lot	lot	no opinion	no opinion
36	some	lot	lot	lot	lot	little	little
37	some	some	lot	some	lot	little	little
38	none	lot	lot	some	some	some	lot
39	some	lot	lot	some	little	some	some
40	some	lot	some	some	little	some	little

APPENDIX L.
TEXAS TRANSPORTATION INSTITUTE EMPLOYEE WEB SURVEY AND RESPONSES TO CELLULAR TELEPHONE USE AND BEHAVIORS

CONTENTS OF THE WEB-BASED SURVEY

We are interested in gaining some insight as to how drivers use their cellular telephones. If you are 19 years of age or older please fill out the survey and at the end of the survey submit your responses. Participation is completely voluntary. We appreciate all of the responses we receive. Thank you.

DRIVER INFORMATION

Sex: Male ❑ Female ❑

Age: ________________________

Annual Household Income:	Less than $25,000	❑
	$25,000 - $44,999	❑
	$45,000 - $ 59,999	❑
	$60,000 - $74,999	❑
	$75,000 and greater	❑
Education Level	some high school	❑
	high school	❑
	some college	❑
	college	❑
Job Title	Professional	❑
	Retail/Service	❑
	Laborer	❑

WHERE IS YOUR CELLULAR TELEPHONE

Where do you keep your cellular telephone when you are driving?

Mounted on the center console	❑
Placed (not mounted) on console	❑
Mounted on the center dash	❑
Placed (not mounted) on the center dash	❑
On the driver’s dash	❑
On the passenger’s dash	❑
On the driver’s visor	❑
On the passenger’s visor	❑
On the passenger front seat	❑
On the passenger back seat	❑
On the passenger front floor	❑
On the passenger back floor	❑
In the glove compartment	❑
In the console cup holder	❑
In the driver door compartment	❑

On your belt clip ❑
In your shirt pocket ❑
In your briefcase ❑
In your purse ❑
Other: ______________________________

MAKING A CALL WHILE DRIVING

When dialing, what hand most often holds the phone?
Left ❑ Right ❑ Hands-free dialing ❑

When dialing, what hand most often presses the buttons?
Left ❑ Right ❑ Voice-activated ❑

If your phone has memory dial functionality, for what percentage of calls that you make do you use this function?
No calls ❑ Less than 50% ❑ About 50% ❑ More than 50% ❑ Every call ❑

If your phone has voice activation functionality, for what percentage of calls that you make do you use this function?
No calls ❑ Less than 50% ❑ About 50% ❑ More than 50% ❑ Every call ❑

On average, how many calls do you make while driving each day?
None ❑ Less than 1 call ❑ 1 to 2 calls ❑ 2 to 5 calls ❑ More than 5 calls ❑

What is the nature of the calls you make?
Mostly work ❑ Some work/some personal ❑ Mostly personal ❑

ANSWERING A CALL WHILE DRIVING

When answering a call, what hand most often picks up the phone?
Left ❑ Right ❑ Hands-free dialing ❑

On average, how often do you receive a call while driving each day?
None ❑ Less than 1 call ❑ 1 to 2 calls ❑ 2 to 5 calls ❑ More than 5 calls ❑

How often do you look for the phone to answer it?
Never ❑ Less than 50% ❑ About 50% ❑ More than 50% ❑ Every call ❑

How often do you look at the display before you answer the call?
Never ❑ Less than 50% ❑ About 50% ❑ More than 50% ❑ Every call ❑

What is the nature of the received calls?
Mostly work ❑ Some work/some personal ❑ Mostly personal ❑

TALKING WHILE DRIVING

When you are talking on the cellular telephone and driving your vehicle, what hand most often holds the phone? Left ❑ Right ❑ Hands-free operation ❑

Does talking on the cellular telephone:

Distract you from driving?	Never ❑	Seldom ❑	Sometimes ❑	Often ❑	Always ❑
Cause you to speed up?	Never ❑	Seldom ❑	Sometimes ❑	Often ❑	Always ❑
Cause you to slow down?	Never ❑	Seldom ❑	Sometimes ❑	Often ❑	Always ❑
Cause you to drift from or within the lane?	Never ❑	Seldom ❑	Sometimes ❑	Often ❑	Always ❑
Slow your ability to react to other drivers?	Never ❑	Seldom ❑	Sometimes ❑	Often ❑	Always ❑
Slow your ability to react to objects?	Never ❑	Seldom ❑	Sometimes ❑	Often ❑	Always ❑
Cause you to miss traffic signs or signals?	Never ❑	Seldom ❑	Sometimes ❑	Often ❑	Always ❑
Cause you to leave a greater space between yourself and the car ahead?	Never ❑	Seldom ❑	Sometimes ❑	Often ❑	Always ❑

Do you find talking on the cellular telephone is more distracting to your driving than:

the kids fussing in the backseat	Yes ❑	No ❑	N/A ❑
eating a hamburger	Yes ❑	No ❑	N/A ❑
fiddling with the radio or CD player	Yes ❑	No ❑	N/A ❑
reaching to get something	Yes ❑	No ❑	N/A ❑
using a handheld computer (PDA)	Yes ❑	No ❑	N/A ❑

Please submit your responses. Your participation in this survey will remain confidential. If you have any questions about the survey please contact:

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SUMMARY OF TABLES

Table L-1. Survey Respondent Gender.

Males	Females
52%	65%

Table L-2. Survey Respondent Age.

Males	Females
39.4	33.6

Table L-3. Annual Household Income (Question 1).

Response	Males	Females	Total
<$25,000	5	17	22
$25,000-$45,000	6	19	25
$45,000-$60,000	9	8	17
$60,000-$75,000	7	6	13
>$75,000	25	15	40
Total	52	65	117

Table L-4. Education Level (Question 2).

Response	Males	Females	Total
Some High School	1	1	2
High School	1	2	3
Some College	5	23	28
College Degree	45	39	84
Total	52	65	117

Table L-5. Employment Level (Question 3).

Response	Males	Females	Total
Professional	48	57	105
Retail	0	4	4
Laborer	4	4	8
Total	52	65	117

Table L-6. Where Cellular Telephones Are Stored (Question 4).

Response	Males	Females	Total
Belt	13	0	13
Briefcase	2	0	2
Cup Holder	11	15	26
Door Compartment	1	1	2
Driver Visor	1	1	2
Mounted on the Center Dash	2	1	3
Mounted on the Center Console	1	0	1
Other	7	2	9
Passenger Front Seat	7	14	21
Placed (not mounted) on Center Dash	1	1	2
Placed (not mounted) on Console	4	7	9
Purse	1	22	23
Shirt	1	0	1
Glove Compartment	0	1	1
Total	52	65	117

Table L-7. What Hand Most Often Holds the Phone (Question 5).

Response	Males	Females	Total
Left	18	21	39
Right	33	43	76
Hands-free	1	1	2
Total	52	65	117

Table L-8. What Hand Most Often Presses the Buttons (Question 6).

Response	Males	Females	Total
Left	15	10	25
Right	36	55	91
Hands-free, Voice-activated	1	0	1
Total	52	65	117

Table L-9. What Percentage of Calls Use This Function (Question 7).

Response	Males	Females	Total
Not Applicable	6	8	14
0	2	10	12
<50%	12	10	22
50%	3	9	12
>50%	20	23	43
100%	9	5	14
Total	52	65	117

Table L-10. What Percentage of Calls Use Voice Activation (Question 8).

Response	Males	Females	Total
Not Applicable	46	60	106
0	1	5	6
<50%	4	0	4
50%	1	0	1
Total	52	65	117

Table L-11. How Many Calls Made While Driving Each Day (Question 9).

Response	Males	Females	Total
None	1	5	6
<1 call	31	27	58
1 to 2 calls	15	20	35
2 to 5 calls	5	13	18
Total	52	65	117

Table L-12. What Is the Nature of Calls Made (Question 10).

Response	Males	Females	Total
Personal only	11	19	30
Mostly personal	21	29	50
Work & Personal	14	13	27
Mostly work	5	2	7
Work only	1	2	3
Total	52	65	117

Table L-13. What Hand Most Often Picks Up the Phone (Question 11).

Response	Males	Females	Total
Left	12	9	21
Right	38	55	93
Hands-free	2	1	3
Total	52	65	117

Table L-14. How Often Receive Call While Driving (Question 12).

Response	Males	Females	Total
None	7	8	15
<1 call	28	35	63
1 to 2 calls	15	16	31
2 to 5 calls	2	6	8
Total	52	65	117

Table L-15. How Look for the Phone While Driving (Question 13).

Response	Males	Females	Total
None	27	19	46
<50%	18	33	51
50%	4	3	7
100%	3	10	13
Total	52	65	117

Table L-16. How Often Look at Display While Driving (Question 14).

Response	Males	Females	Total
None	30	38	68
<50%	22	21	43
50%	0	6	6
Total	52	65	117

Table L-17. What Is the Nature of Calls Received While Driving (Question 15).

Response	Males	Females	Total
Personal only	14	27	41
Mostly personal	22	21	43
Work & Personal	7	8	15
Mostly work	5	3	8
Work only	4	6	10
Total	52	65	117

Table L-18. What Hand Holds Phone While Driving (Question 16).

Response	Males	Females	Total
Left	20	28	48
Right	30	35	65
Hands-free	2	2	4
Total	52	65	117

Table L-19. Talking on the Phone Distracting When Driving (Question 17).

Response	Males	Females	Total
Never	10	4	14
Seldom	21	30	51
Sometimes	18	29	47
Often	3	1	4
Always	0	1	1
Total	52	65	117

Table L-20. Speed Up While Talking on the Phone and Driving (Question 18).

Response	Males	Females	Total
Never	32	35	65
Seldom	16	26	42
Sometimes	4	4	8
Often	0	0	0
Always	0	0	0
Total	52	65	117

Table L-21. Slow Down While Talking on the Phone and Driving (Question 19).

Response	Males	Females	Total
Never	14	9	23
Seldom	10	18	28
Sometimes	25	33	58
Often	3	5	8
Always	0	0	0
Total	52	65	117

Table L-22. Drift While Talking on the Phone and Driving (Question 20).

Response	Males	Females	Total
Never	20	29	49
Seldom	18	27	45
Sometimes	14	7	21
Often	0	2	2
Always	0	0	0
Total	52	65	117

Table L-23. Slow Ability to React to Others While Driving (Question 21).

Response	Males	Females	Total
Never	11	18	29
Seldom	21	24	45
Sometimes	20	21	41
Often	0	1	1
Always	0	1	1
Total	52	65	117

Table L-24. Slow Ability to React to Objects While Driving (Question 22).

Response	Males	Females	Total
Never	17	24	41
Seldom	21	24	45
Sometimes	13	15	28
Often	1	1	2
Always	0	1	1
Total	52	65	117

Table L-25. How Often Miss Traffic Signs and Signals While Talking on the Phone (Question 23).

Response	Males	Females	Total
Never	37	44	81
Seldom	10	12	22
Sometimes	4	7	11
Often	1	1	2
Always	0	1	1
Total	52	65	117

Table L-26. Leave Greater Space Between Car While Driving and Talking on the Phone (Question 24).

Response	Males	Females	Total
Never	11	8	19
Seldom	7	10	17
Sometimes	21	29	50
Often	12	15	27
Always	1	3	4
Total	52	65	117

Table L-27. Kids Fussing More Distracting than Talking on the Phone (Question 25).

Response	Males	Females	Total
Not Applicable	25	29	54
Yes	6	6	12
No	21	30	51
Total	52	65	117

Table L-28. Eating a Hamburger More Distracting than Talking on the Phone (Question 26).

Response	Males	Females	Total
Not Applicable	2	4	6
Yes	15	11	26
No	35	50	85
Total	52	65	117

Table L-29. Fiddling with Radio More Distracting than Talking on the Phone (Question 27).

Response	Males	Females	Total
Not Applicable	0	0	0
Yes	21	26	47
No	31	39	70
Total	52	65	117

Table L-30. Reaching to Get Something More Distracting than Talking on the Phone (Question 28).

Response	Males	Females	Total
Not Applicable	0	0	0
Yes	10	11	21
No	42	54	96
Total	52	65	117

Table L-31. Using Handheld PDA More Distracting than Talking on the Phone (Question 29).

Response	Males	Females	Total
Not Applicable	27	48	75
Yes	3	3	6
No	22	14	36
Total	52	65	117

SUMMARY OF CHARTS

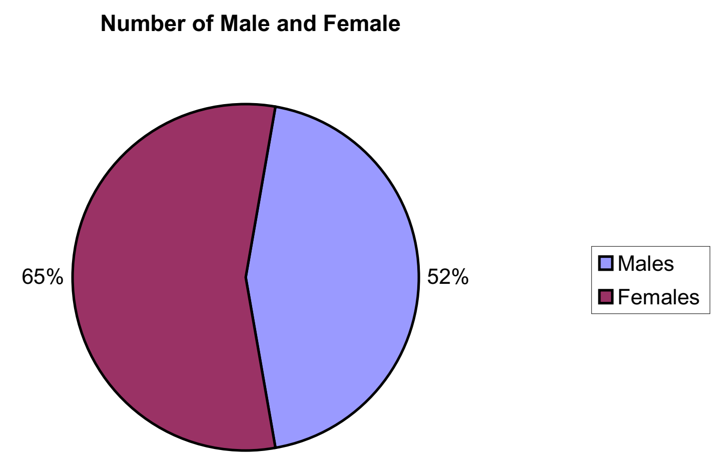


Figure L-1. Percentage of Males and Females.

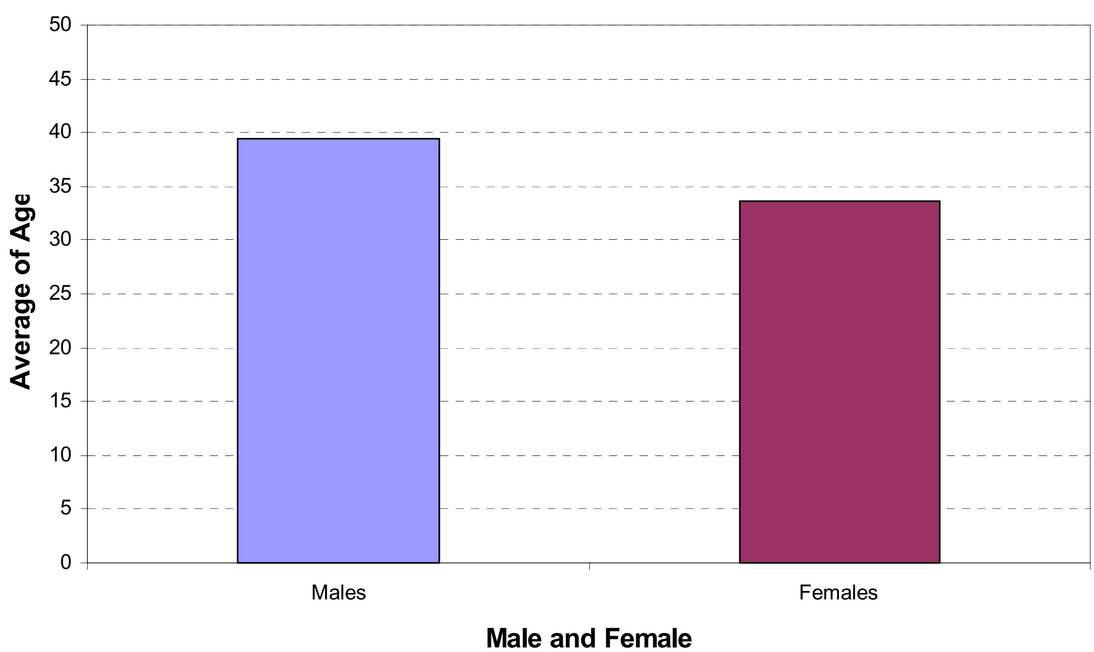


Figure L-2. Average Age of Males and Females.

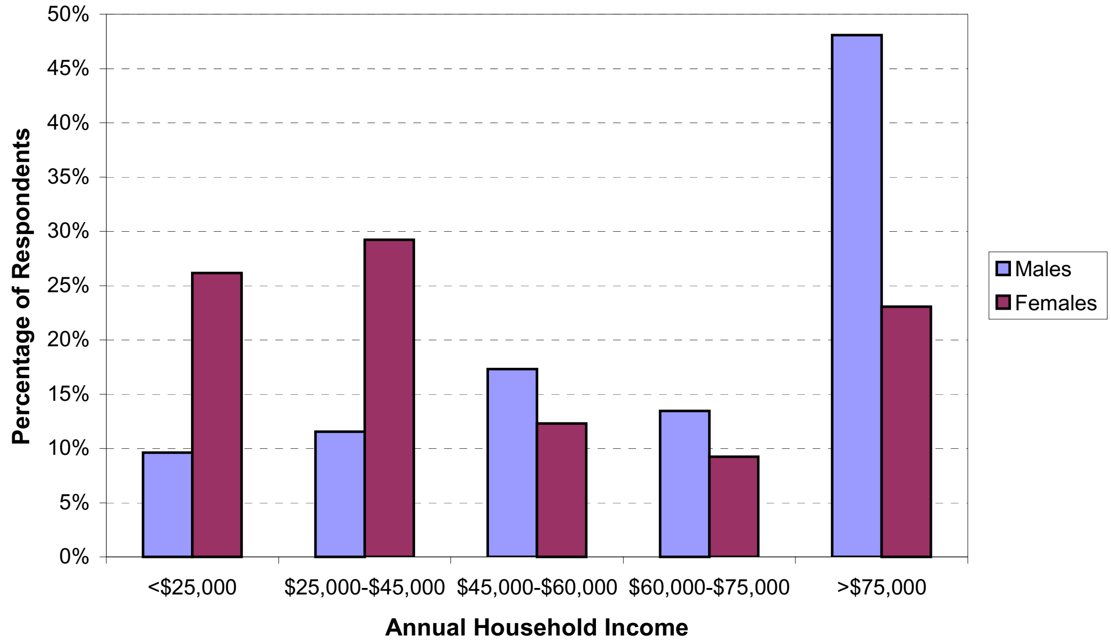


Figure L-3. Annual Household Income (Question 1).

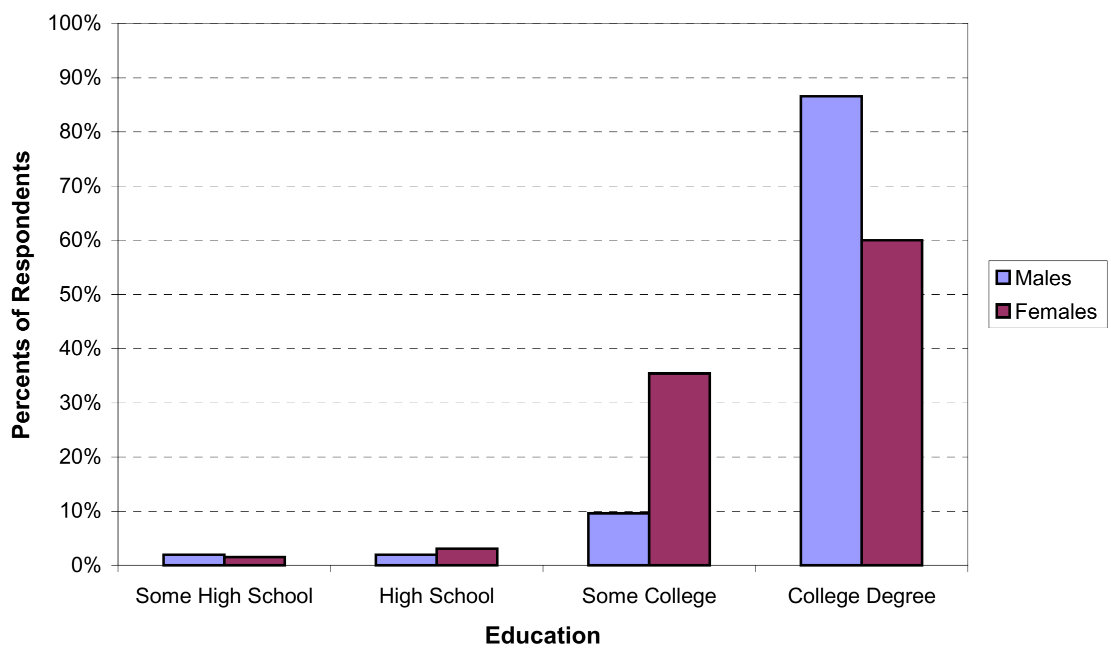


Figure L-4. Education Level (Question 2).

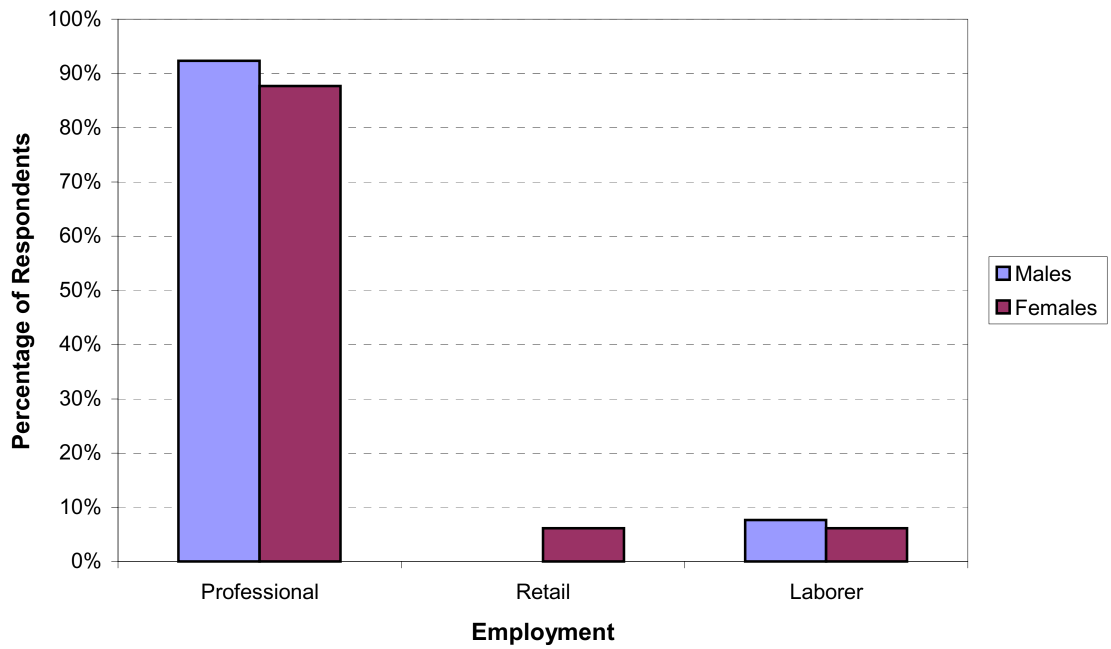


Figure L-5. Employment Level (Question 3).

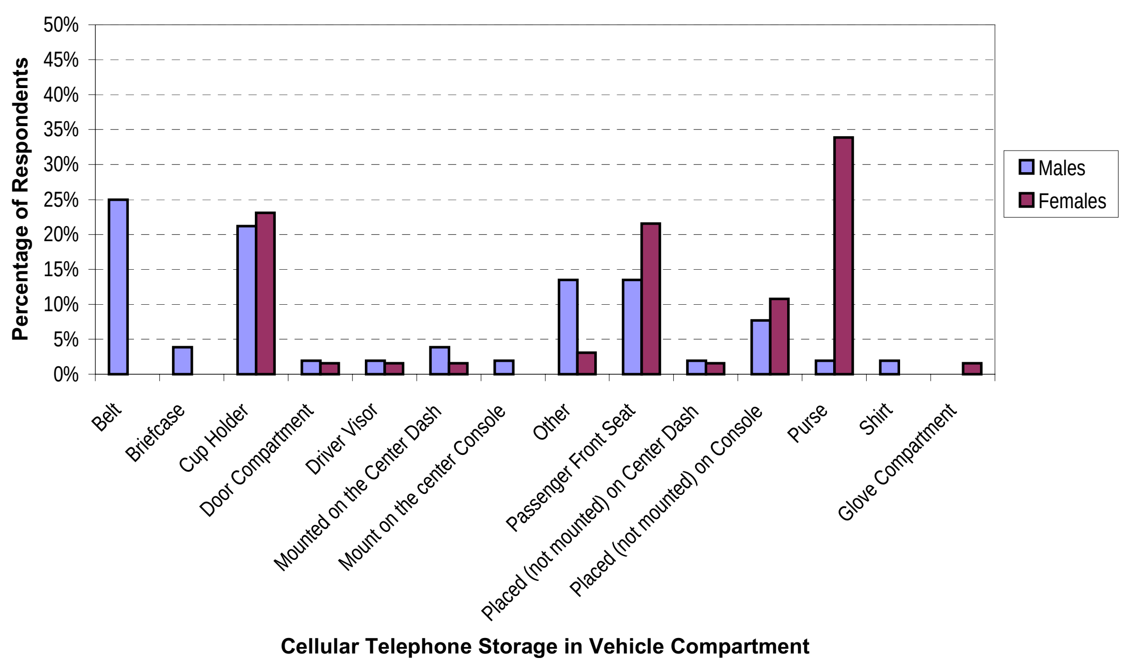


Figure L-6. Where Cellular Telephones Are Stored (Question 4).

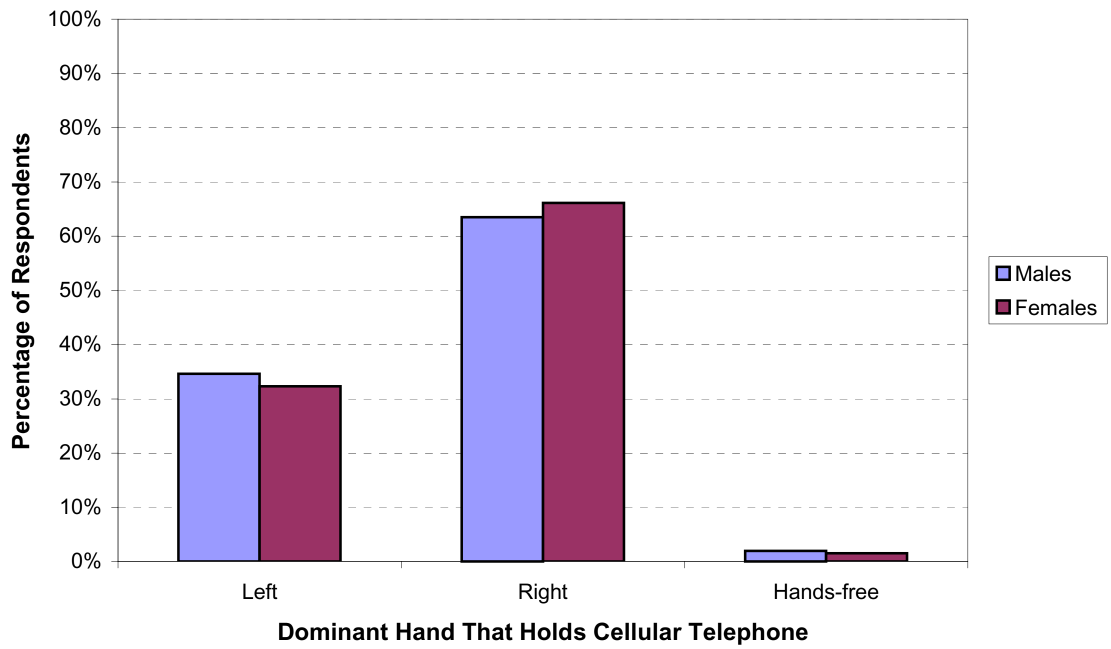
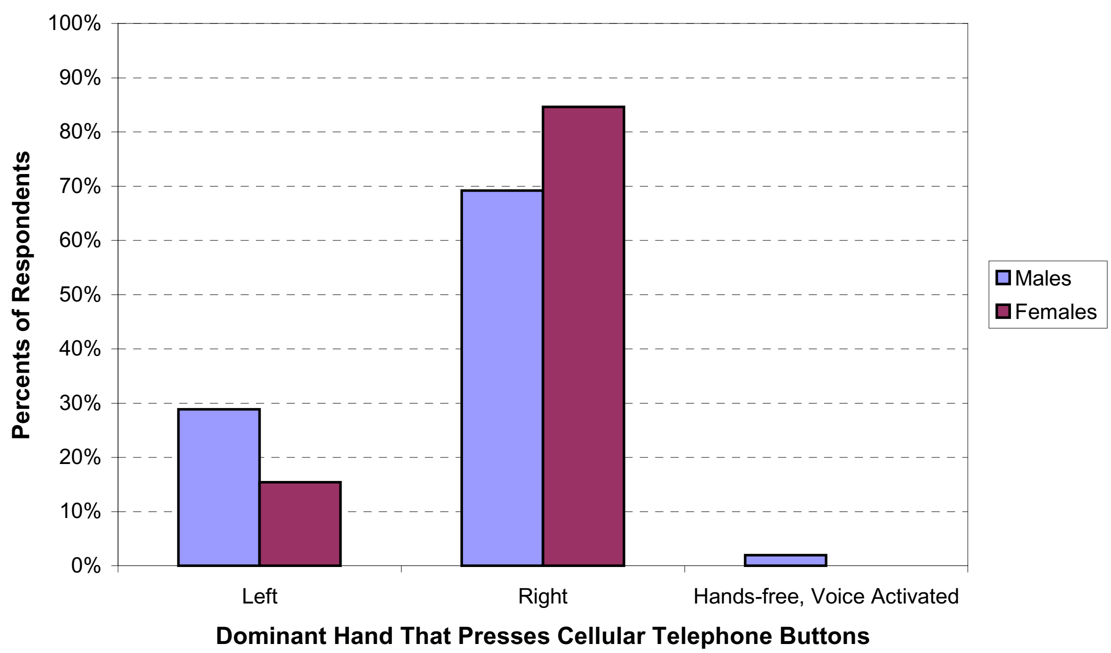


Figure L-7. What Hand Most Often Holds the Phone (Question 5).



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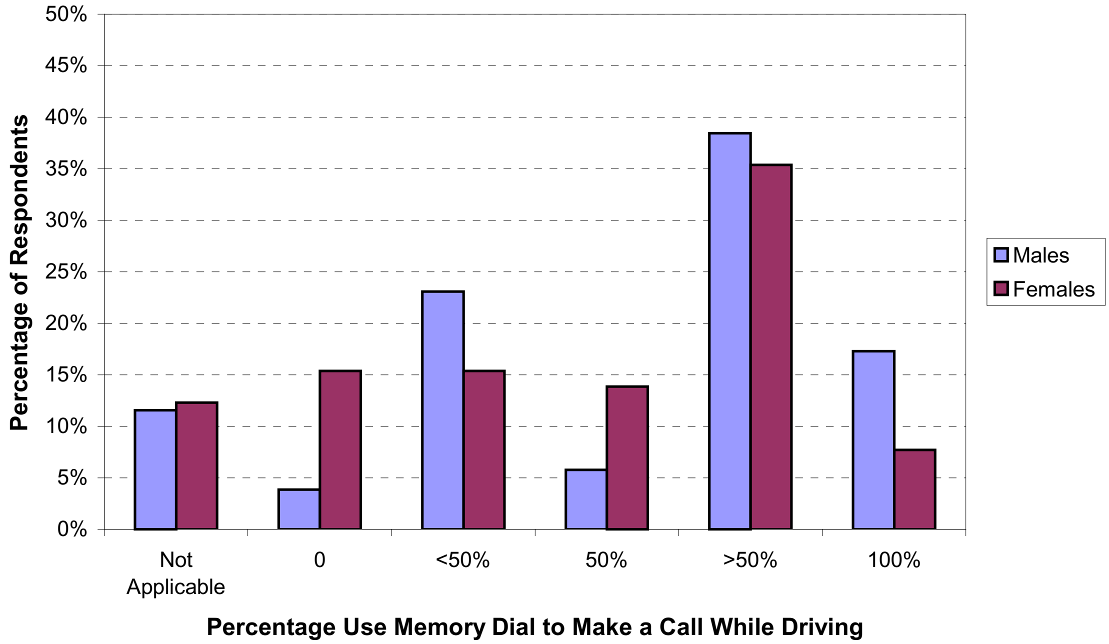

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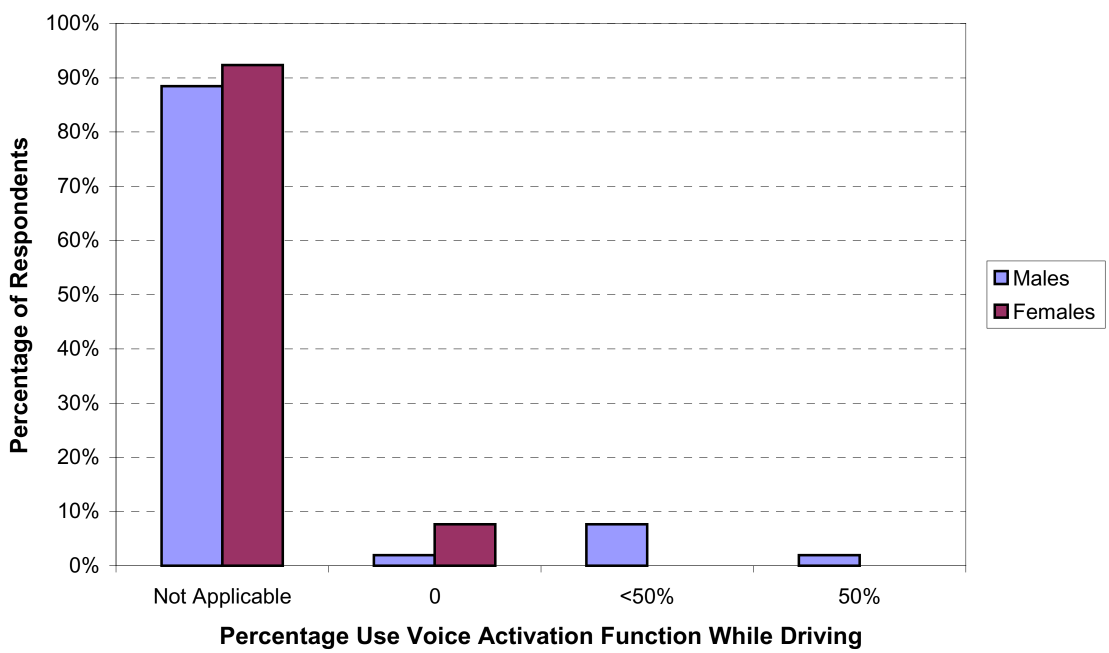
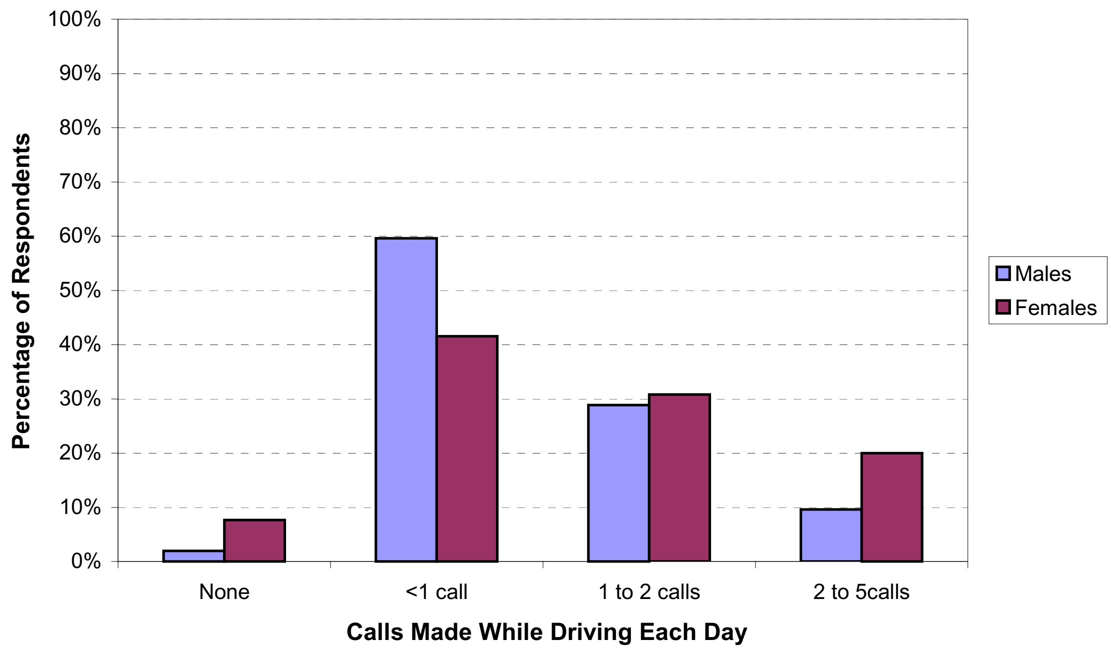


Figure L-10. What Percentage of Calls Use Voice Activation (Question 8).



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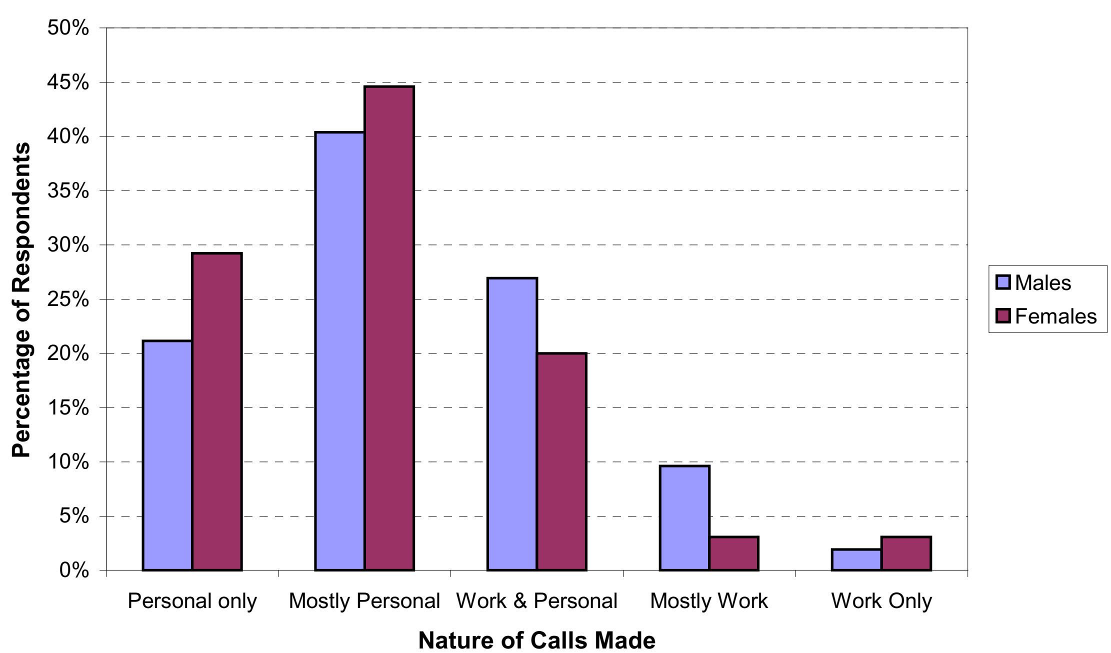

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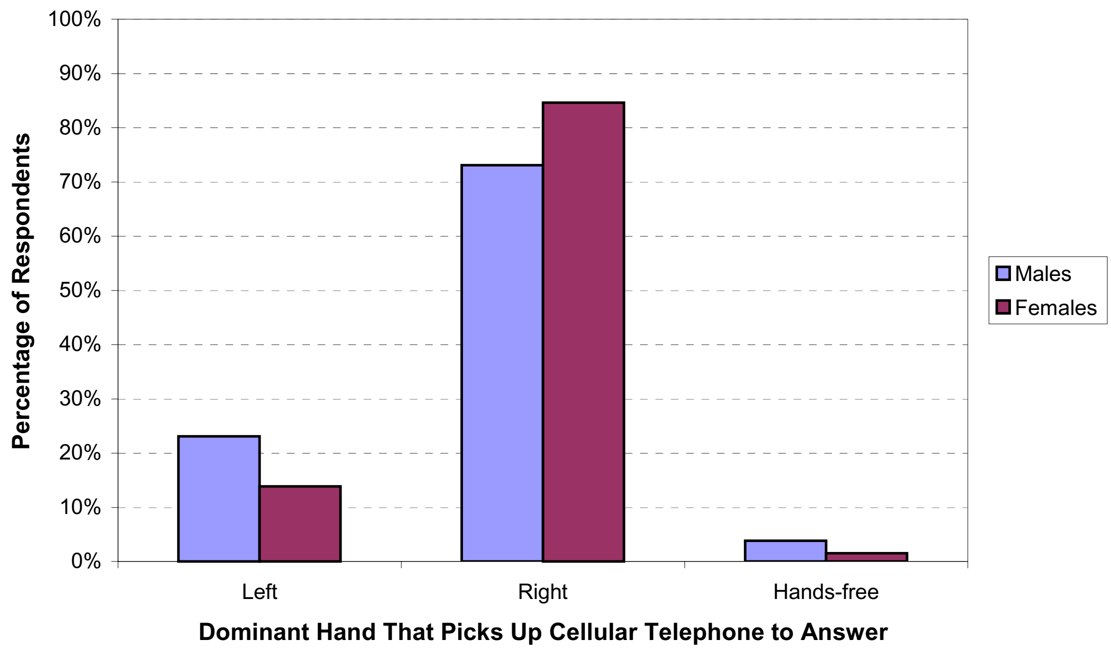

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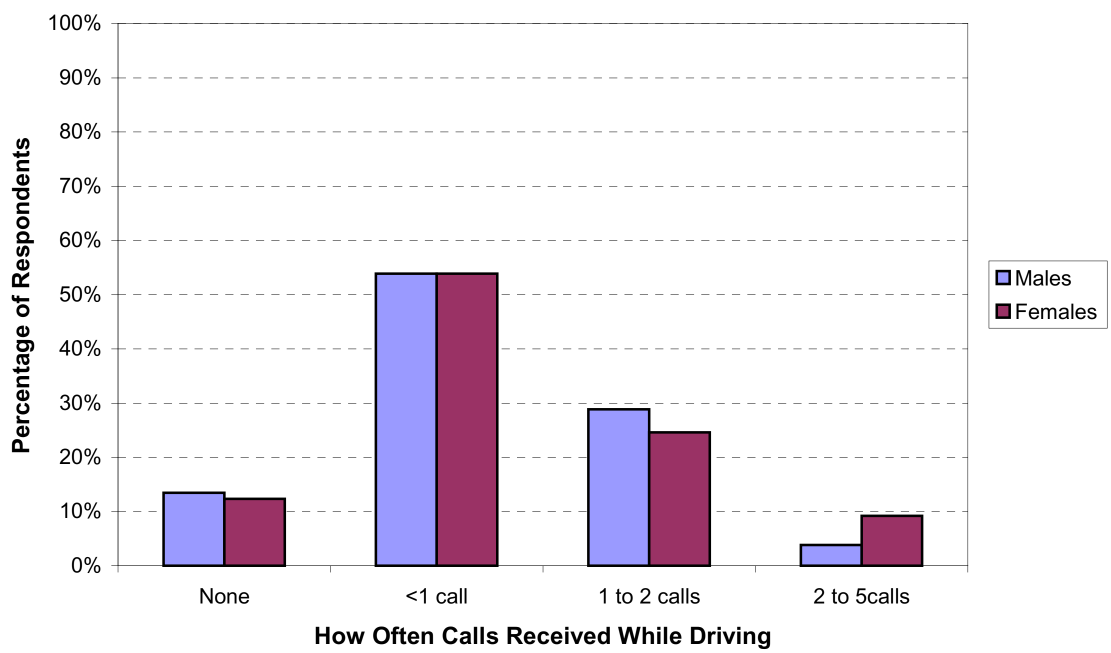
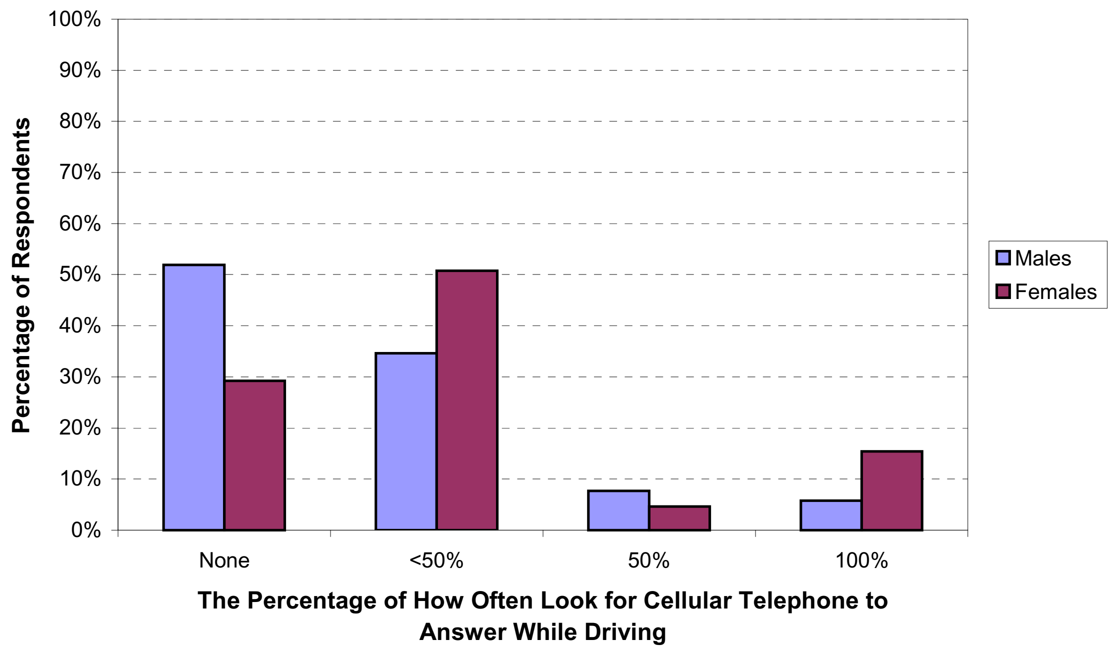


Figure L-14. How Often Receive Call While Driving (Question 12).



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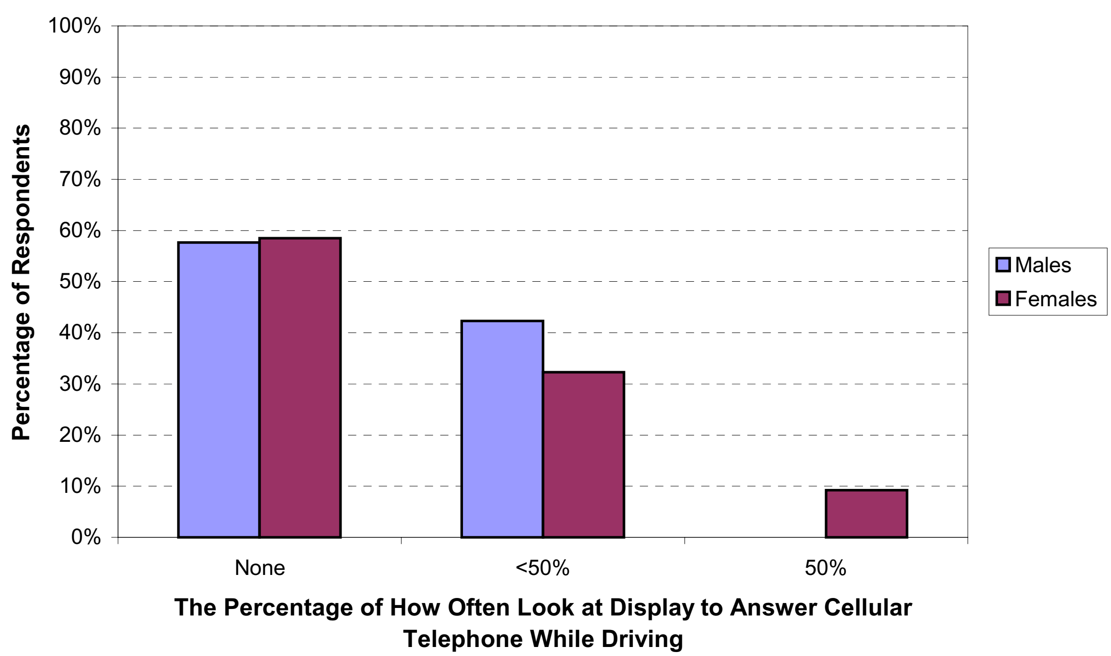
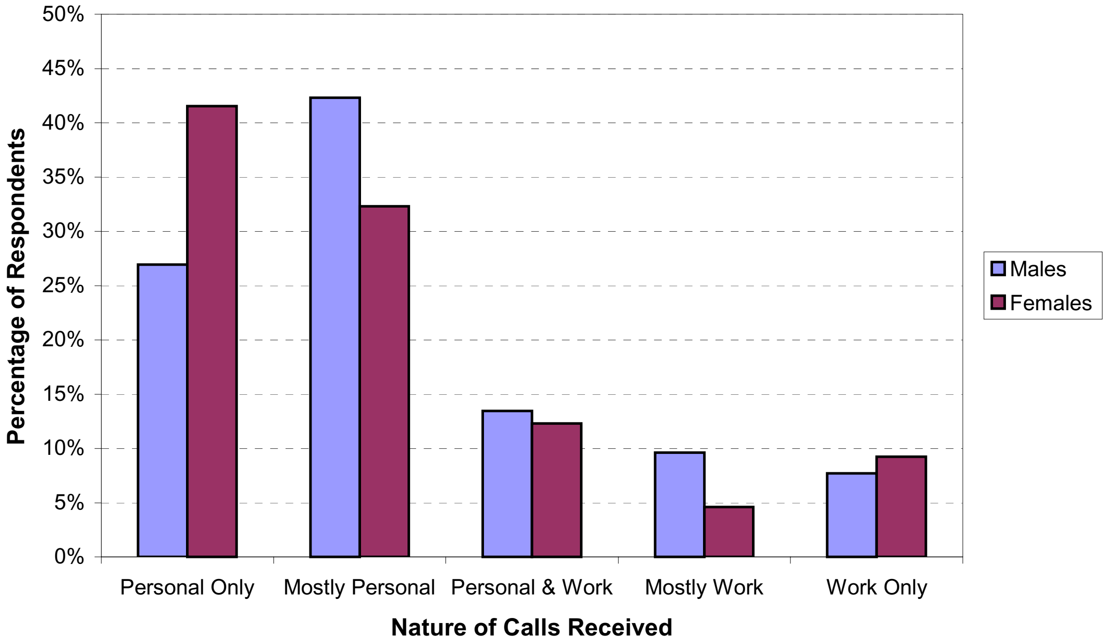


Figure L-16. How Often Look at Display While Driving (Question 14).



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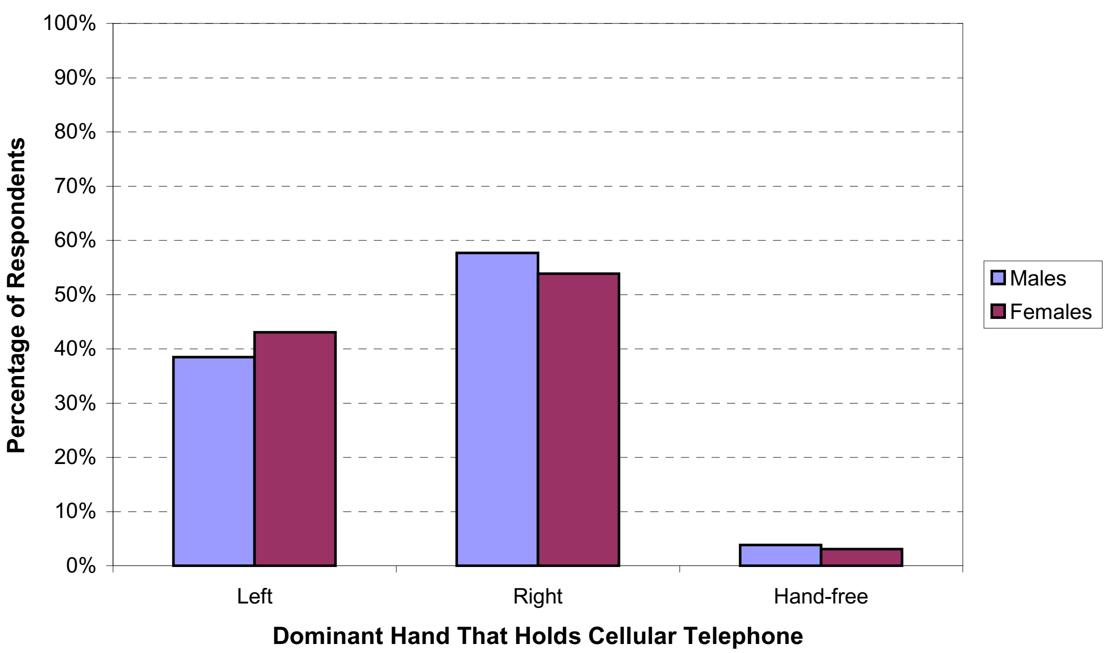

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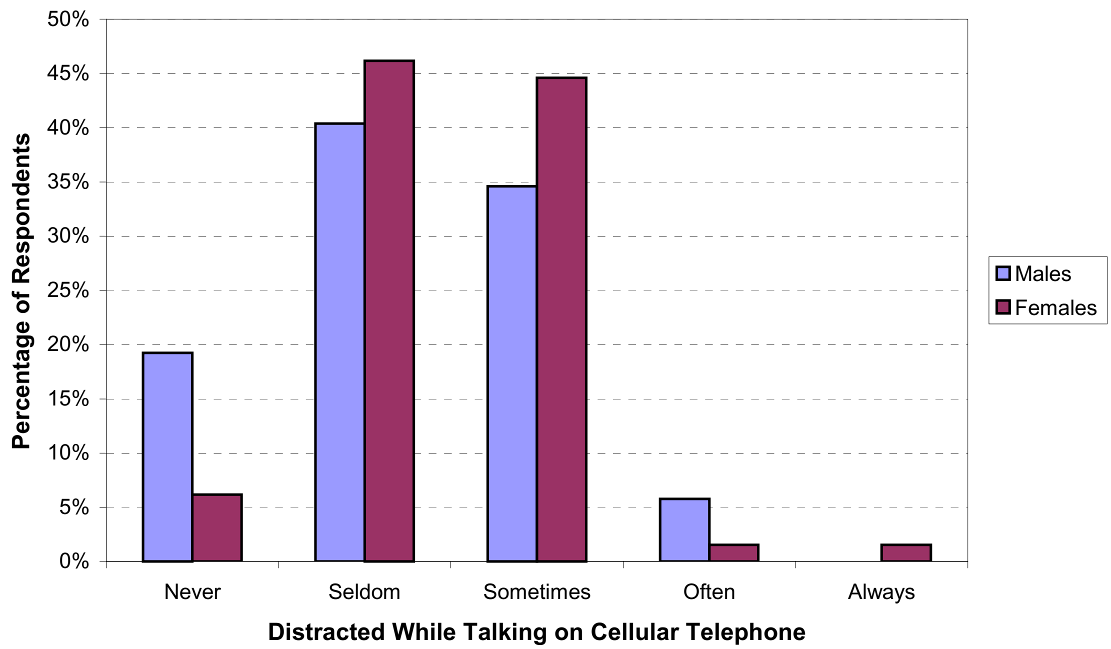
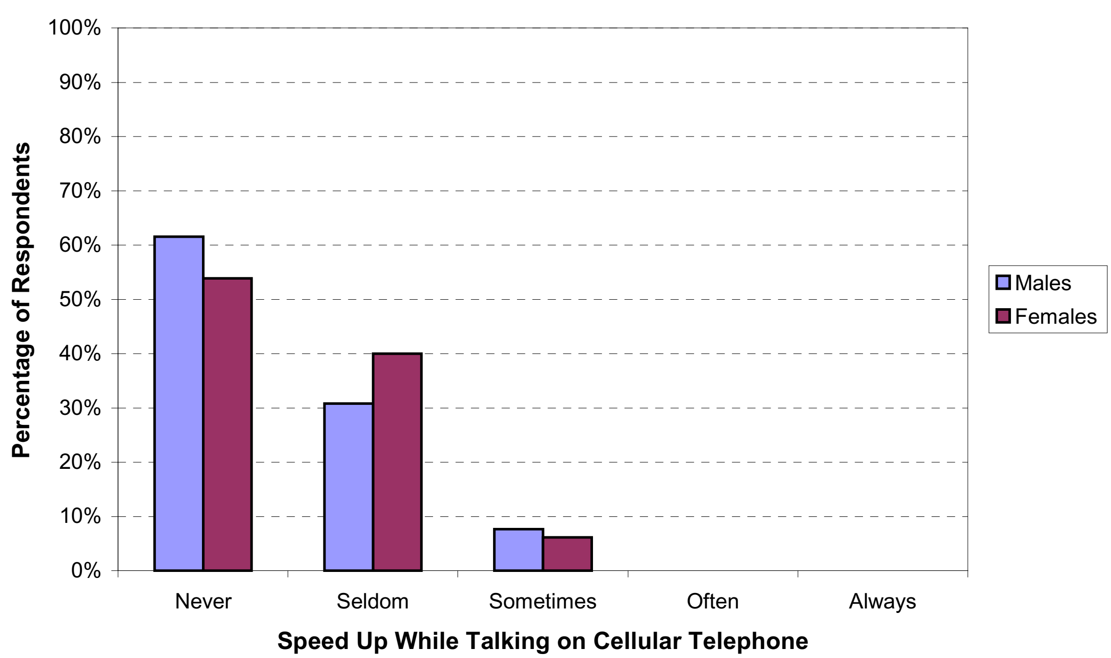


Figure L-19. Talking on the Phone Distracting When Driving (Question 17).



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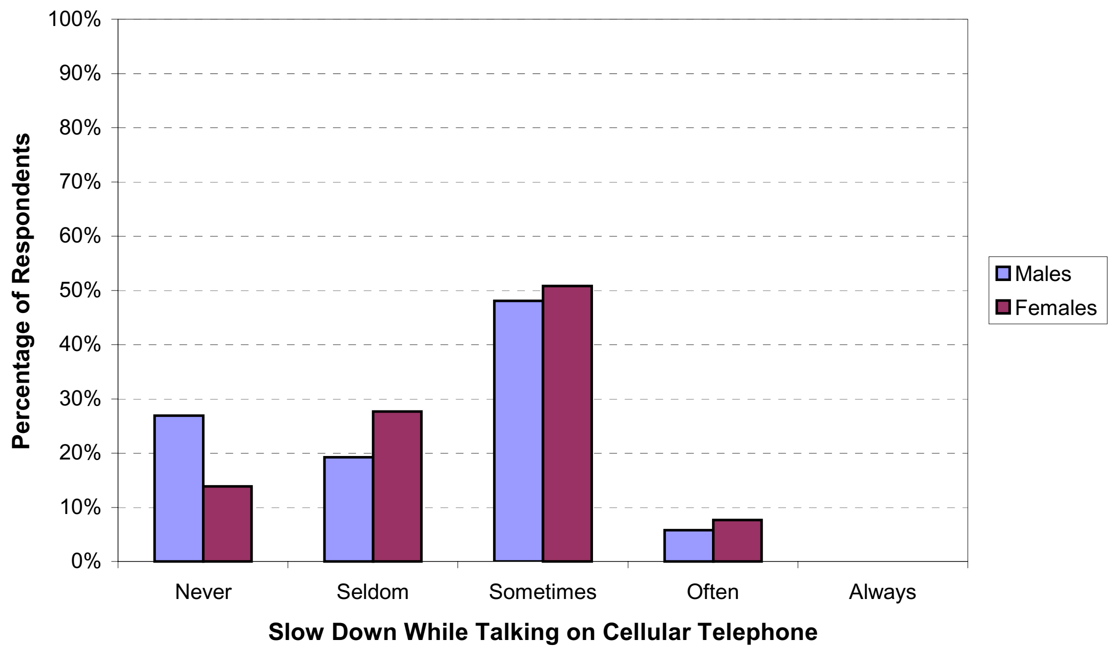


Figure L-21. Slow Down While Talking on the Phone and Driving (Question 19).

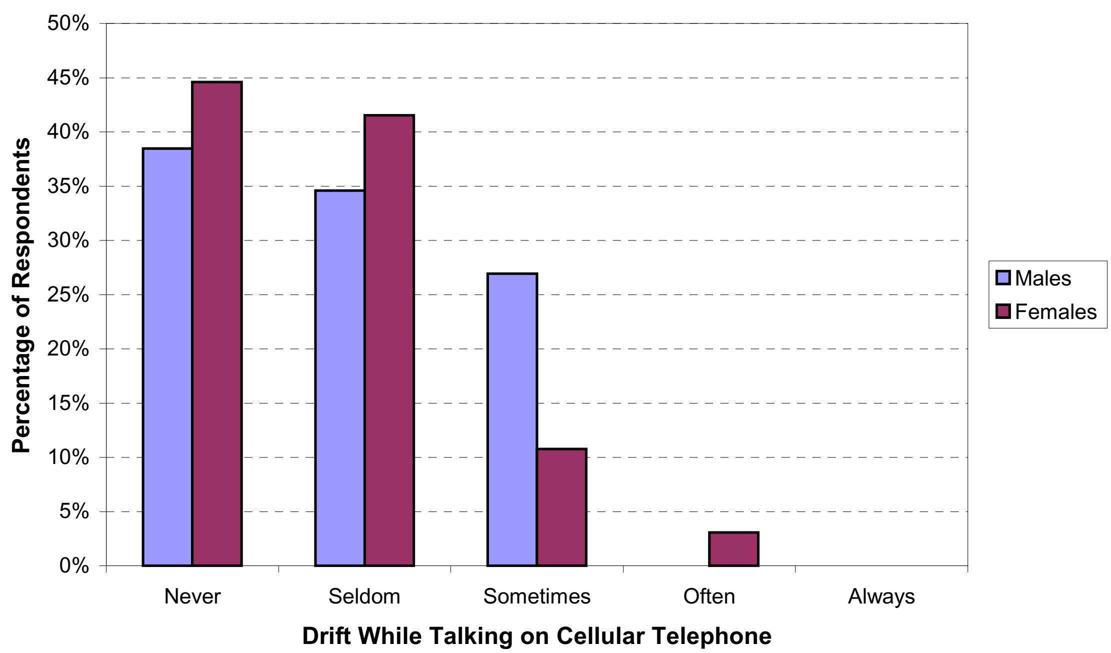
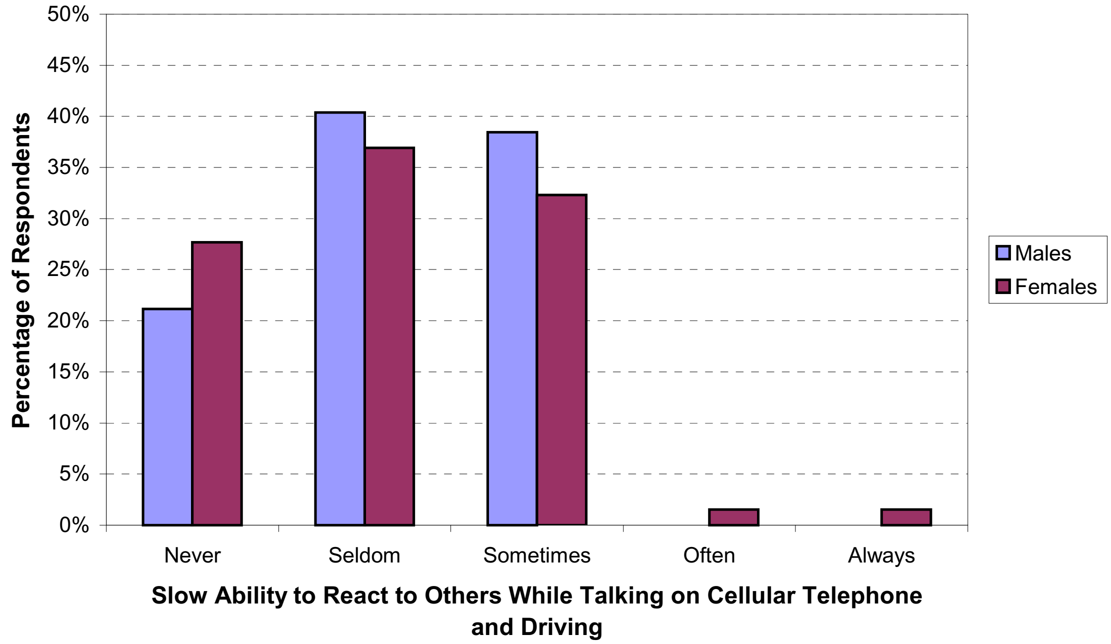


Figure L-22. Drift While Talking on the Phone and Driving (Question 20).



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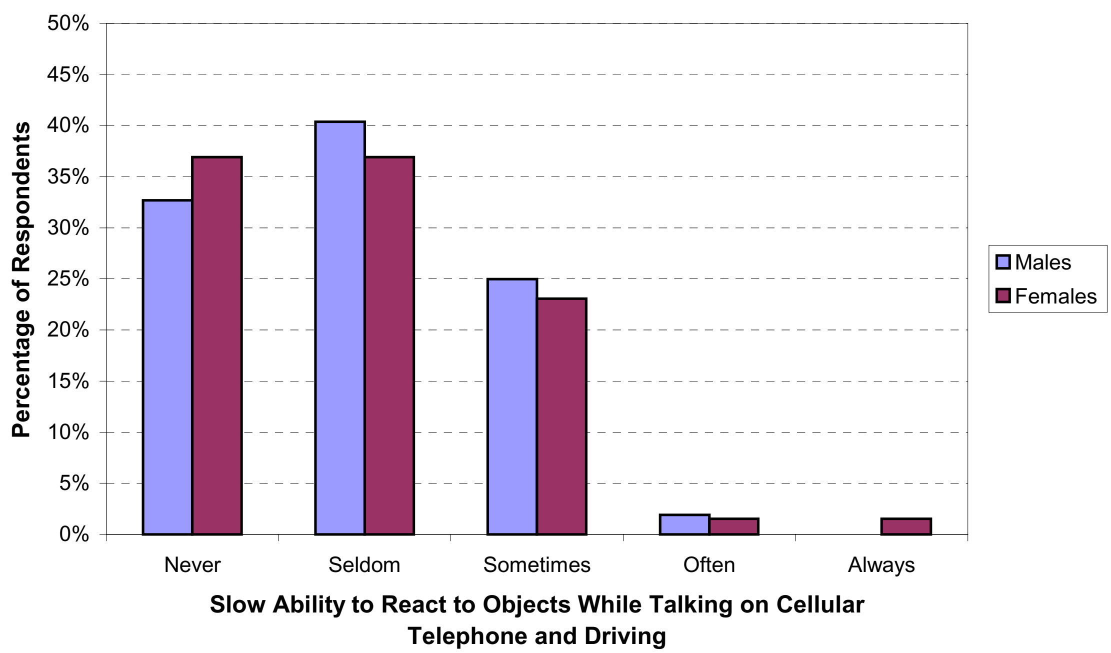

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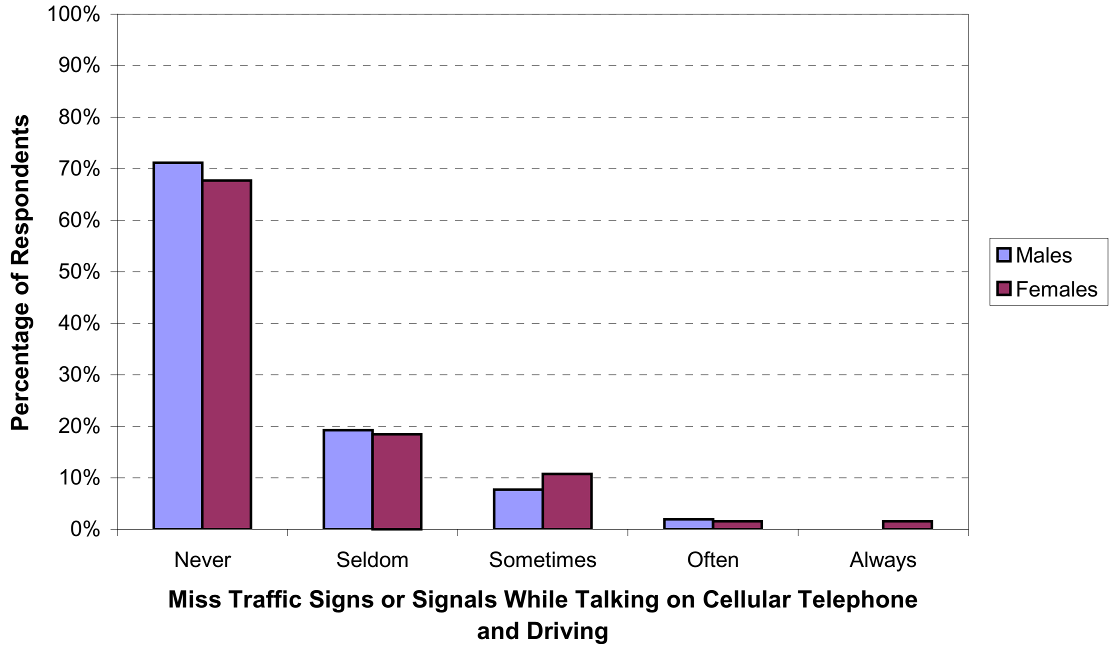

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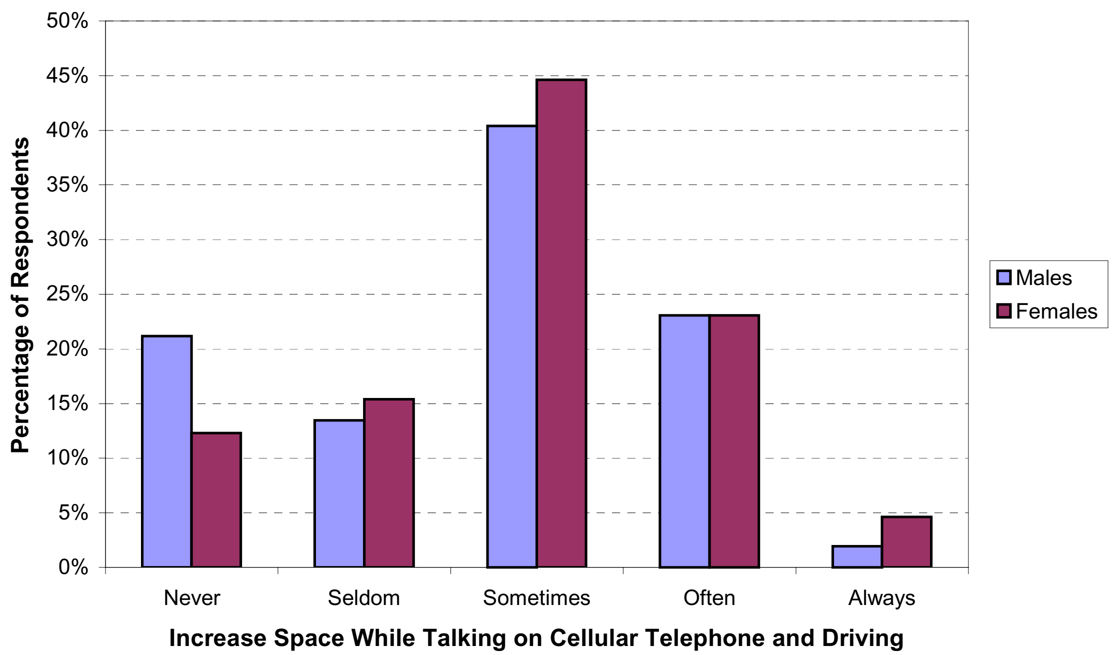
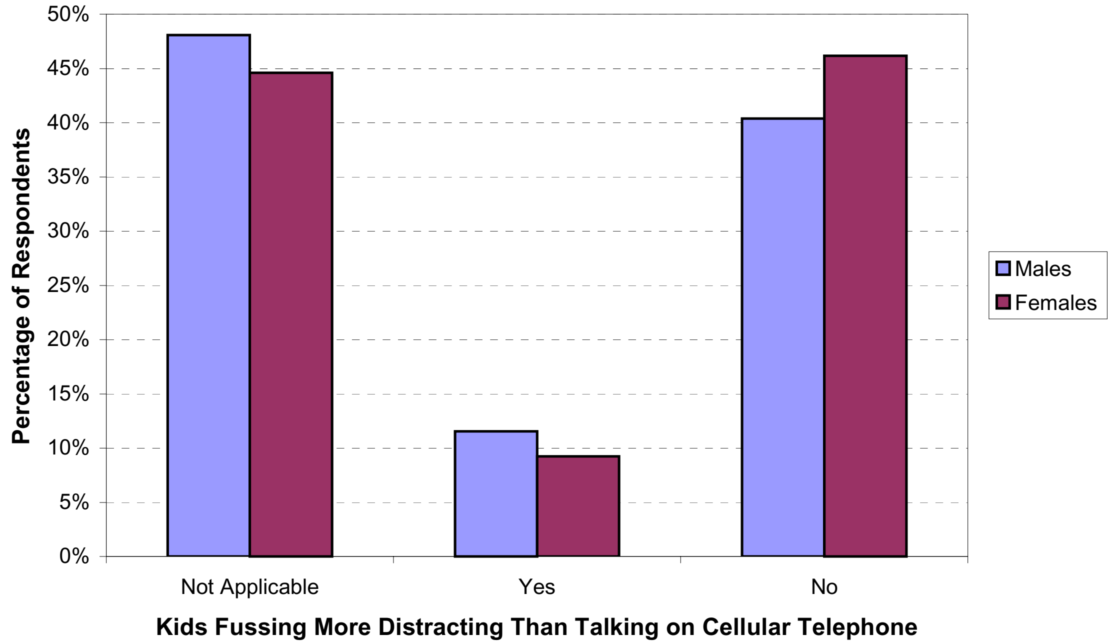


Figure L-26. Leave Greater Space Between Car While Driving and Talking on the Phone (Question 24).



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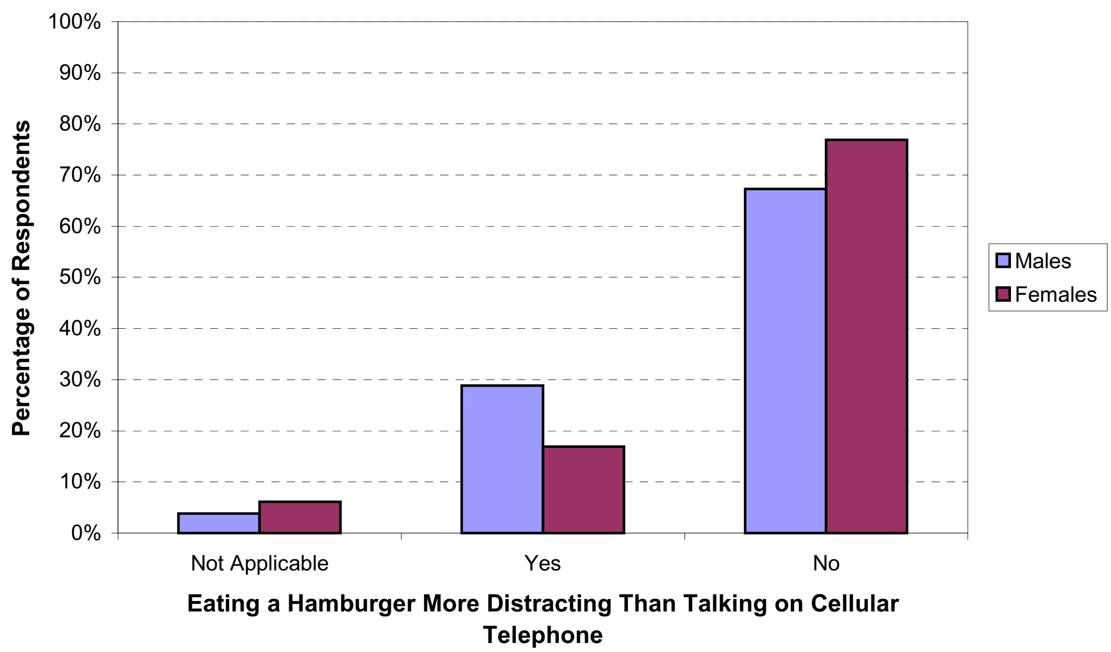

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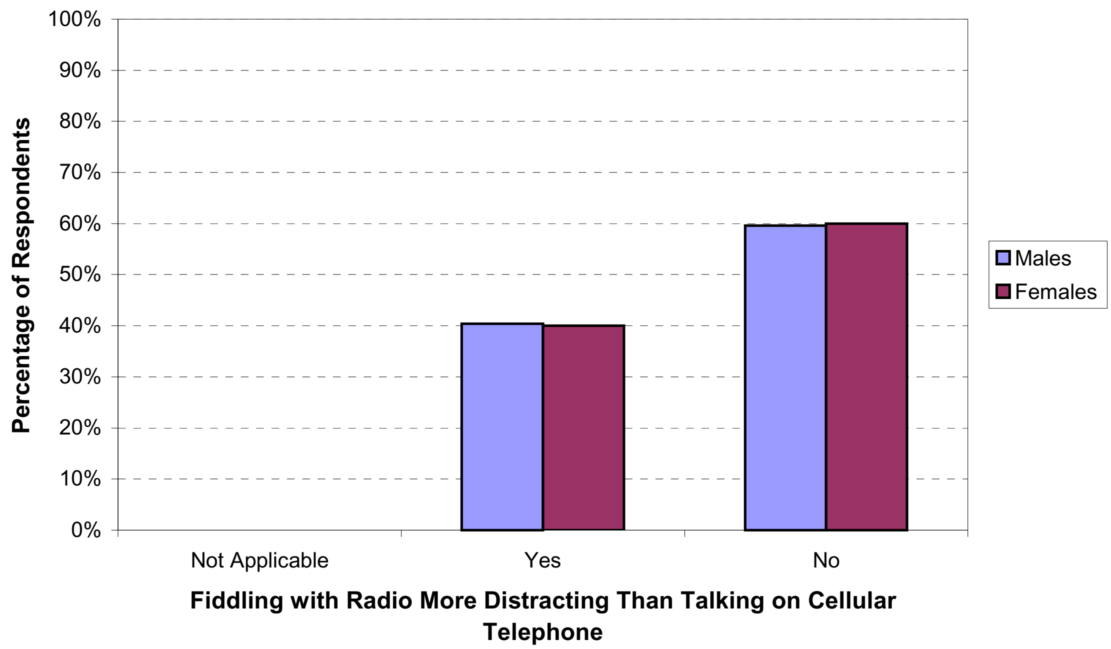

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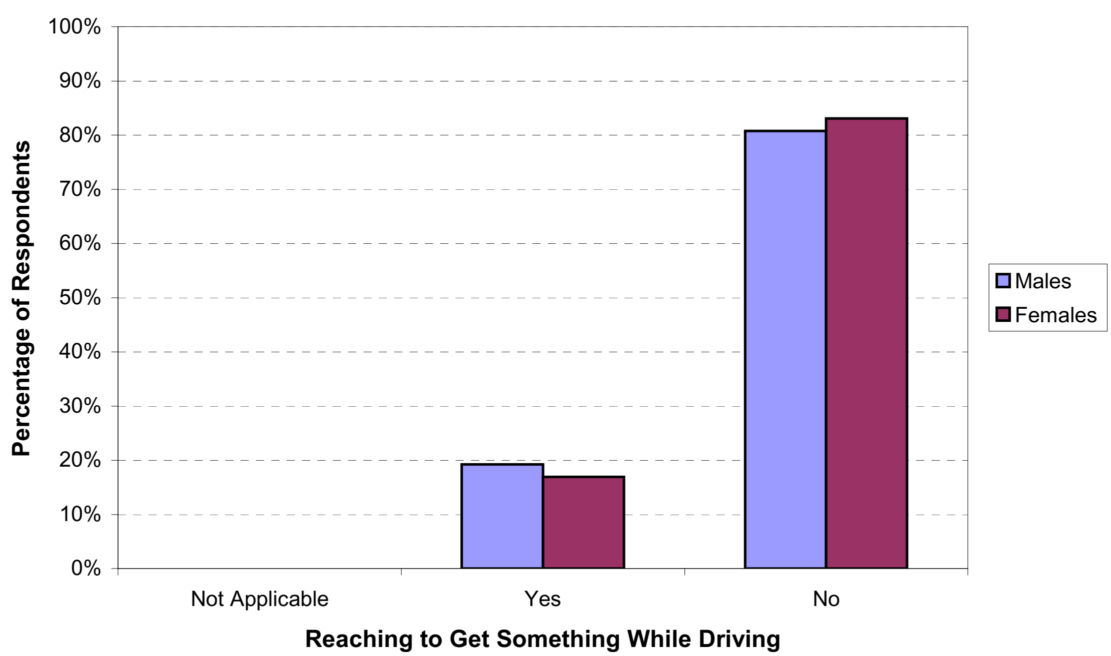

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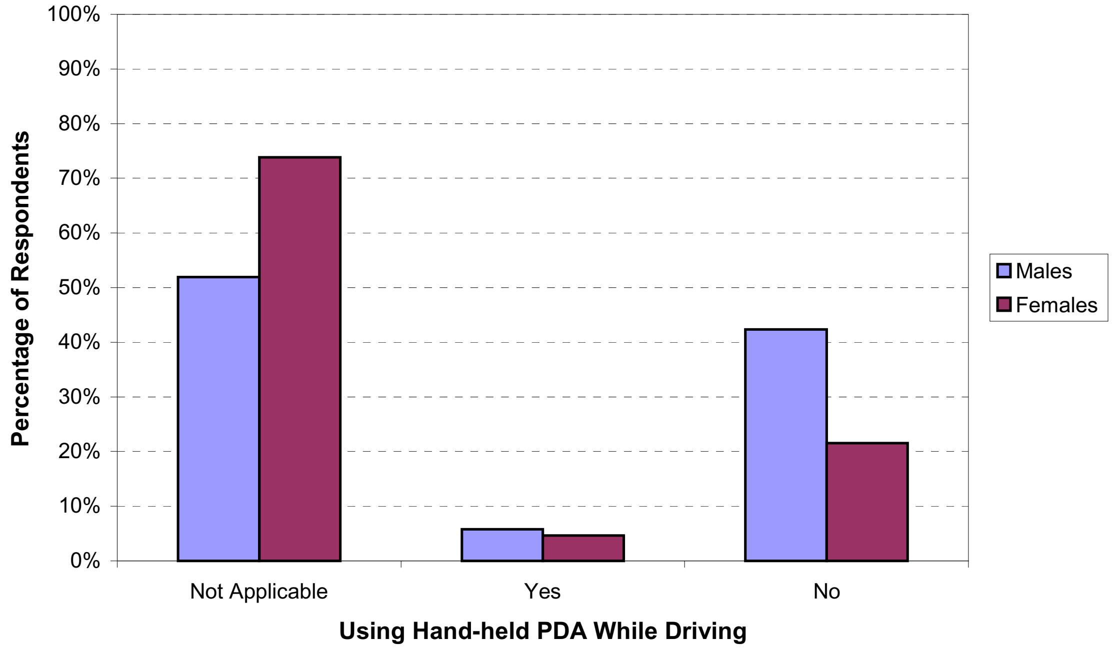

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