NATIONAL TRANSPORTATION RESEARCH CENTER, INCORPORATED
University Transportation Center

U33: Impact of Distraction and Health on Commercial Driving Performance
Final Report

This project was funded by the NTRCI University Transportation Center under a grant from the U.S. Department of Transportation Research and Innovative Technology Administration (#DTRT-06-G-0043)

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February 2012

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
4. Title and Subtitle **U33: Impact of Distraction and Health on Commercial Driving Performance**		5. Report Date **February 2012** 6. Performing Organization Code
7. Author(s) **Philip R. (Russ) Fine, Karen Heaton, Despina Stavrinos, Richard Hanowski, Gerald McGwin, David Vance, P. Jeffrey Foster, Crystal Franklin**		8. Performing Organization Report No. **NTRCI-50-2012-029**
9. Performing Organization Name and Address **National Transportation Research Center, Inc. University Transportation Center 9125 Cross Park Drive, Suite #150 Knoxville, TN 37923**		10. Work Unit No. (TRAIS) 11. Contract or Grant No. **RITA Grant – DTRT06G-0043**
12. Sponsoring Agency Name and Address **U.S. Department of Transportation Research and Innovative Technology Administration 1200 New Jersey Avenue, SE Washington, DC 20590**		13. Type of Report and Period Covered **Final Report January 2011 – February 2012** 14. Sponsoring Agency Code

15. Supplementary Notes

Special thanks to: The University of Alabama at Birmingham and Virginia Tech Transportation Institute

16. Abstract

This study examined the interaction of the cognitive and technological aspects of distracted driving as well as physical health among commercial drivers. Participants (n=55; 5 of which were excluded from analyses) were recruited from Alabama-based trucking companies. After Informed Consent was obtained from participants, baseline health, driving, anthropometric, and demographic data were collected. Participants then completed cognitive testing, and drove an 88-mile simulated trip while engaging in one of four secondary tasks (no secondary task, cell phone conversation, texting interaction, and email interaction) in a commercial truck driving simulator. Participants had a mean age of 40.5 years, were mostly male (98.0%), and had, on average, 8.6 years of experience as a commercial truck driver. During the simulation, compared to the no secondary task condition, the emailing and texting conditions were associated with increased collisions, lane deviations, and eye glances off of the road; the cell phone condition was associated with a decreased rate of eye glances off of the road and an increased rate of riding the clutch. Driver characteristics were not associated with driving violations, although increased sleep time was associated with decreased collisions and fewer instances of speeding 15+ miles over the posted speed limit, and increased mean reaction time was associated with a slight increase in the collision rate. Findings from this study impact multiple stakeholders and will contribute to the development of future, large intervention studies targeting driver distraction and health factors in commercial drivers.

17. Key Words	18. Distribution Statement
Transportation, trucking, safety, distracted driving, distraction, health, cognition, simulation, performance, public-private partnership, commercial driver, operational efficiency	**No restrictions**

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	**Unclassified**	**97**	

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List of Abbreviations and Acronyms

Abbreviation or Acronym	Definition
ANOVA	Analysis of Variance
ATA	Alabama Trucking Association
BMI	Body Mass Index
CB	Citizens' Band (radio)
CDL	Commercial Driver's License
CI	Confidence Interval
CMV	Commercial Motor Vehicle
DBP	Diastolic Blood Pressure
ESS	Epworth Sleepiness Scale
FMCSA	Federal Motor Carrier Safety Administration
GEE	Generalized Estimating Equation
GPS	Global Positioning System
IRB	Institutional Review Board for the Protection of Human Subjects in Research
IDDM	Insulin-dependent Diabetes Mellitus
IQR	Interquartile Range
MPG	Miles per Gallon
MPH	Miles per Hour
MS	Millisecond
NIOSH	National Institute for Occupational Safety and Health
NHTSA	National Highway Traffic Safety Administration
NTRCI	National Transportation Research Center, Incorporated
OPCON	Operator's Console
OR	Odds Ratio
OSA	Obstructive Sleep Apnea
PAC	Project Advisory Committee
PI	Principal Investigator
PVT	Psychomotor Vigilance Test
RITA	Research and Innovative Technology Administration
RR	Rate Ratio
SBP	Systolic Blood Pressure
SD	Standard Deviation
TRB	Transportation Research Board
TRIP	Translational Research for Injury Prevention
UAB	University of Alabama at Birmingham
UAB SON	University of Alabama at Birmingham School of Nursing
UAB UTC	University of Alabama at Birmingham University Transportation Center
UFOV®	Useful Field of View
USBLS	United States Bureau of Labor Statistics
USDOT	United States Department of Transportation
VTTI	Virginia Tech Transportation Institute

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Units of Measurement

Unit	Meaning	Used in reference to:
kg/m^2	kilogram per square meter	body mass index
mmHg	millimeters of mercury	blood pressure
mpg	miles per gallon	operational efficiency
mph	miles per hour	driving speed
ms	Millisecond	reaction time for PVT and UFOV®

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Executive Summary

This study examined the interaction of the cognitive and technological aspects of distracted driving and physical health among Class A Commercial licensees. It is a timely investigation with important findings because combating distracted driving is a national transportation priority of the United States Department of Transportation (USDOT), and driver health and wellness are major concerns of the Transportation Research Board (TRB), Federal Motor Carrier Safety Administration (FMCSA), and the National Institute of Occupational Safety and Health (NIOSH).

Baseline health-related, driving-related, anthropometric, and demographic data were collected. Participants then completed standardized cognitive testing; and, "drove" a total of eighty-eight miles in a state-of-the-art L-3 Communications TranSim™ truck driving simulator under carefully monitored and controlled conditions. During the simulated trip, drivers were subjected to four driving scenarios, where one of four secondary tasks was presented during each drive. The secondary tasks were modeled after those to which commercial truck drivers are routinely subjected in today's professional driving environment: (1) a no task /no distraction sham condition, (2) a cell phone conversation, (3) text messaging and (4) email exchange.

The emailing and texting conditions were associated with increased collisions, lane deviations, and eye glances off of the road compared to the no secondary task condition. The cell phone condition was associated with a decreased rate of eye glances off of the road and an increased rate of riding the clutch.

Driver characteristics were not associated with driving violations, although increased sleep time was associated with fewer collisions and fewer instances of speeding 15+ miles over the posted speed limit. A measurable increase in mean reaction time was associated with a slight increase in the collision rate.

Findings from this study impact multiple stakeholders and will contribute to the development of future, large intervention studies targeting driver distraction and health factors in commercial drivers.

Background – Why Did We Do This Study?

This question is far more compelling than it appears at first glance.

Consider: There are constellations of questions that legions of scientists and academicians would love to be able to pursue independently in the purest Aristotelian sense: *Knowledge for the intrinsic sake of knowledge.*

However, from a practical standpoint, sufficient resources to do this do not exist in academia; as a consequence investigative Nirvanas of the hypothetical sort described tend to be fictional, or, at best, limited to the occasional MacArthur Genius Award Recipients.

With this in mind, the three primary reasons (which range from practical avarice with its mission to acquire as much extramural funding as possible, and then publish in high impact journals or perish) to, out-and-out intellectual altruism, in the tradition of the Talmudic Scholar or the Jesuit academician.

Combating distracted driving has become a national transportation goal, as evidenced by the USDOT/RITA sponsored Distracted Driving Summits held in 2009 and 2010 in Washington, DC. Additionally, in November 2011, the USDOT's FMCSA issued a final rule prohibiting interstate truck and bus drivers from using hand held cell phones while operating commercial vehicles (USDOT, 2011).

Thus, it made sense to think that extramural research funds might become available to a credible research organization such as the UAB UTC to help the government address an issue which had morphed beyond a transportation-related problem into a legitimate and dangerous public health concern. Subsequently, we designed a study, the aims of which were consistent with the overall mission of the USDOT and the National Transportation Research Center, Inc. (NTRCI) to, "*serve the United States by ensuring a* fast*,* <u>*safe*</u>, efficient, accessible *and* convenient *transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future."*

Specifically, the aims reflect the mission and objectives of the FMCSA to *"reduce the incidence and severity of commercial motor vehicle crashes and to improve the safety of commercial vehicle operations through systematic research, innovative practices and technologies…"*

Organizations such as the UAB UTC depend on extramural research awards to survive. This NTRCI award helped us survive as a research organization by providing the financial support we required to conduct the research described herein.

Drivers are distracted when their attention is diverted towards a secondary task unrelated to driving. Suffice to say, safe, responsible driving requires concentration. While there have always been distractions on the road, a proliferation of vehicle-based technologies coupled with an ever-increasing supply of new and sophisticated electronic devices available for personal use by everyday drivers have increased the potential for vehicle operators to be even more distracted today than they have been in the past.

The extent to which driver health factors such as the operators' physical and mental health status, workload, fatigue, and age was examined in this research because these factors are critical components of the overall goal to improve the safety-related performance of commercial drivers and in doing so, making the highways safer for all drivers who share the road with heavy, commercial trucks. Despite the fact that commercial drivers must be determined to be "medically fit" prior to being granted / awarded a Commercial Drivers' License (CDL), serious medical conditions are highly prevalent among this group of workers. Previously identified medical conditions include: Obstructive sleep apnea (Talmadge, et al., 2008; Moreno, et al., 2004), hypertension (Xie, et al., 2011; Cavagioni, et al., 2009) and other cardiovascular disorders, diabetes, nicotine and other substance use, and mental health issues-anxiety and depression (Apostolopoulos et al., 2010). Along with these medical conditions, sleep deprivation related to irregular and erratic schedules, and customer and family demands is common (Belzer, 2000; Ouellet, 1994). Each one of these conditions may independently impair the cognitive processes necessary for safe driving. Additive effects on cognition are also noted. That is, more than one condition occurring simultaneously yields a greater negative effect on cognition than that of either of the conditions alone. Another serious issue that affects driving safety in this group is the use of electronic devices that distract the driver away from the demands of safe driving performance. This is an especially important issue for commercial drivers as the availability and reliance on electronic devices has increased and facilitates communication with employers, customers, family, and friends (Richtel, 2009). What is unclear at this time, is: *how health conditions known to affect cognition in other groups, affect cognition in commercial drivers; and how the combined effects of health conditions, medication use, cognition, and various types of distraction impact driving performance.*

While previous research findings have clearly defined the negative effects of some forms of distraction, poor health habits, and cognitive deficits in information processing; no other study, to our knowledge, has directly evaluated the interactions of these factors in commercial drivers. Moreover, existing data are lacking to answer the question, “What happens to commercial driver performance when all of these factors are in play during varying mental workload (i.e., while distracted) conditions?”

Brief Overview

We designed a methodology that allowed us to examine the interaction of the cognitive and technological aspects of distracted driving as well as physical health among commercial drivers. Specifically, the study evaluated the impact of visual and cognitive distraction, sleep, medication use, medical conditions, age, and cognition on driving performance.

Study objectives included:

Comparing the relative impact of cognitive aspects of secondary tasks on driving performance of commercial drivers:

1. Evaluating potentially technological aspects of commercial vehicles (on-board technical systems and personal communication/entertainment devices) on the driving performance of commercial drivers in low vs. high mental workload conditions,

2. Assessing the driver health effects of sleep quantity, sleep quality and propensity, medication use, medical conditions, and age on cognitive function as measured by Useful Field of View (UFOV®) and Psychomotor Vigilance Testing (PVT) among commercial drivers,

3. Examining the interaction between driver health (sleep quantity, sleep quality and propensity, medication use, medical conditions, and age); cognitive function (Useful Field of View [UFOV®] and the Psychomotor Vigilance Test [PVT]); distraction; and driving performance among commercial drivers in low vs. high mental workload conditions,

4. Observing the effects of commercial driver distraction on operational efficiency, more specifically, fuel consumption during the various distraction conditions.

Research Strategy

Procedures

Participants were recruited from a trucking company in the Southeast. After Informed Consent was obtained from the prospective participants, baseline health, driving, electronic use, anthropometric, and demographic data were collected.

Eligible participants then completed cognitive testing (UFOV® and PVT), and drove four simulated trips spanning approximately eighty-eight miles while engaging in a variety of secondary tasks (talking on cell phone, text messaging, emailing) in an L-3 Communications TranSim™ truck driving simulator. Upon completion of data collection, data analyses were conducted using statistical procedures appropriate to the level of measurement of the outcomes of interest.

Data Analytic Plan

To examine the relationship between driver distraction on measures of driver performance, a variety of statistical methods were used. Basic driver information, including demographic, medical history, use of electronic devices, cognitive performance, and commercial truck driving experience characteristics were described using mean and proportional distributions for continuous and categorical variables, respectively. Analysis of the association between driver distraction and measures of driver performance was based on models that account for interdependence of observations due to the fact that participants drove in the simulator on multiple occasions. For the estimation of the association between driver distraction and both driving violation rate (i.e., rate of speeding in excess of 15 mph over the posted speed limit, space management violations, collisions, and lane deviations) and driving performance (i.e., lane changes, eye glances off the road, engine stalls, instances of hard braking, and riding the clutch), a Generalized Estimating Equation (GEE) Poisson model was used to calculate rate ratios (RRs) and associated 95% confidence intervals (CIs). GEE Poisson regression models were also used to estimate the association between violation rate and selected demographic and health characteristics.

A GEE logistic model was used to estimate odds ratios (ORs) and 95% confidence intervals (CIs) for the association between driver distraction and startup procedure violations (i.e., not fastening the seat belt, not setting the parking brake, or putting the truck in motion when the brake pressure was low). A repeated measures analysis of variance (ANOVA) was used to estimate the association between driver distraction and both average driving speed and miles per gallon during the simulation segment. Finally, a general linear model, adjusted for self-reported snoring, was used to examine whether driver characteristics (i.e., age, medication and caffeine use, sleep time, and ESS score) were associated with measures of cognition (i.e., UFOV®, mean reaction time, and number of reaction lapses). For all analyses, p-values <0.05 were considered significant.

Results

The average age of the 50 participants was 40.5 years (Table 4-1). A large proportion of participants were white (56.0%) or African American (36.0%), male (98.0%), and married (72.0%). The average experience as a commercial truck driver was 8.6 years, with an average 7.8 years with a Class A Commercial Driver's License. Participants were most employed as a company driver (86.0%), and all were drivers of single-trailer vehicles. The average haul was 874.8 miles, and the average time worked per week was 65.3 hours. Regarding electronic device use, participants most often reported using a cell phone to call, with an average use of 9 times-per-day (Table 4-2). The mean BMI of the participants was 32.8 kg/m^2, and the mean Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) were 125.6 and 81.8mmHg, respectively (Table 4-4). The most prevalent co-morbidity reported was high blood pressure (16.0%), followed by emotional or psychiatric problem (6.0%), kidney problems (6.0%), and diabetes (6.0%).

Compared to the condition with no secondary task, there was a nearly two-fold increase in violations overall for the emailing (RR 1.97, 95% CI 1.76-2.19) and texting (RR 1.90, 95% CI 1.68-2.14) conditions (Table 4-6). The observed increase was limited to collisions and lane deviations, with a 5.5-fold increase in the collision rate (RR 5.48, 95% CI 1.45-20.68) and 3-fold increase in the lane deviation rate (RR 2.89, 95% CI 2.39-3.49) for the emailing condition, and a near 3-fold increase (RR 2.71, 95% CI 2.22-3.30) in the lane deviation rate during the texting condition. Regarding driving performance, again compared to the no secondary task condition, the cell phone condition was least associated with any performance measure; however, a statistically significant 42% reduction in the rate of eye glances off the road was observed (RR 0.58, 95% CI 0.42-0.78).

The emailing and texting conditions were associated with an increase rate of lane changes (RR 1.30, 95% CI 1.14-1.48 and RR 1.21, 95% CI 1.06-1.38, respectively) and eye glances off the road (RR 12.88, 95% CI 10.45-15.86 and RR 20.17, 95% CI 16.38-24.82, respectively). Interestingly, a 35% decrease in the rate of drivers riding the clutch was observed during the texting condition (RR 0.65, 95% CI 0.45-0.94). Related to driving performance, there was no difference in the fuel efficiency obtained during the varying secondary tasks, but a significant decrease in the driving speed for the cell phone compared to the no secondary task condition was observed (54.97 vs. 56.65mph, p=0.0398) (Table 4-8). There was no association between the type of secondary task and startup procedures (Table 4-7).

In general, there was no association between driver characteristics and the cognition measures of interest (Table 9). A statistically significant effect for ESS score was observed with UFOV®, with a 1-unit increase in ESS score associated with a 4.53-unit decrease in UFOV® (p=0.0458).

While driver characteristics were not associated with driving violations as a whole, there were associations of note. Specifically, a one-hour increase in usual sleep time was associated with a 24% reduction in the rate of speeding in excess of 15mph of the posted speed limit (RR 0.76, 95% CI 0.76, 0.59-0.99) and a 34% decrease in the collision rate (RR 0.66, 95% CI 0.48-0.91) (Table 4-10). A one-unit increase in the ESS score was associated with a 3% increase in the space management violation rate (RR 1.026, 95% CI 1.001-1.051). Additionally, a 1-unit increase in the mean reaction time was associated with a 2% increase in the collision rate (RR 1.015, 95% CI 1.003-1.025).

Conclusion

The study is important at several levels: (1) Combating distracted driving is a national transportation goal of the USDOT's Secretary, Ray LaHood; (2) Commercial driver health and wellness have also been recognized as a major concern of the Transportation Research Board (TRB), the Federal Motor Carrier Safety Administration (FMCSA), and the National Institute of Occupational Safety and Health (NIOSH).

Findings from this study may ultimately influence regulations/policies, research, and practice that will positively impact commercial driver health and safety, and decrease motor vehicle crash- risk related to distraction. The association of increased sleep time with significant reductions in risky driving behaviors-space management and speeding-provides justification for the development and consistent implementation of sleep and fatigue management programs for use with current commercial drivers and commercial driver trainees. This finding also adds to the body of evidence used to influence decisions regarding hours of service regulations. While not statistically significant, the associations between use of medications for hypertension, lipid-lowering, and glycemic control and decline in cognitive performance (UFOV®) are noteworthy. More important is the statistically significant increase in driving violations associated with use of glycemic control and lipid-lowering medications in this group of participants. Because of the small sub-group of participants with hyperlipidemia and diabetes, these findings are not generalizable. However, future, large-scale studies including drivers using these types of medications should be conducted to determine whether or not the current guidelines for medical certification promulgated by FMCSA are adequate to promote the highest level of safe driving performance among commercial drivers.

While all secondary tasks were found to impact driving performance, not all tasks were detrimental to the same extent. In light of the recent ban on commercial motor vehicle hand held cell phone use while driving (USDOT, 2011), the findings from the present study suggest the need for additional restrictions to include restricting the use of on-board communication devices while the commercial vehicle is in motion. Note that the ban on cell phones does not include hands-free configurations. The research regarding the differences between the effect of hands-free and hand-held devices on commercial driving performance is mixed, (Olson et al., 2009; Strayer & Johnston, 2001) and further consideration is warranted.

In sum, the aims of the study were/are consistent with the overall missions of the USDOT, UAB UTC, NTRCI, and FMCSA which strive to ensure safer roadways and reduce morbidity and mortality related to motor vehicle crashes.

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Chapter 1 – Introduction and Background

1.1 Background

The goal of this study was to examine the relationships among age, medication use, existing medical conditions, sleep, cognition, and driver distraction among commercial truck drivers. Given the lack of research in this area, achieving this goal would result in a significant contribution to our understanding of how health and distraction interact in commercial drivers to influence driving performance.

While previous research findings have clearly defined the negative effects of driver distraction, poor health habits, and cognitive deficits in information processing; no other study, to our knowledge, has directly evaluated the interactions of these factors in commercial drivers. Moreover, existing data are lacking to answer the question, “What happens to commercial driver performance when all of these factors are in play during varying mental workload conditions?”

The implications of the current study have both theoretical and pragmatic implications. The theoretical implications are that the interaction of the factors noted above has not previously been studied, while the pragmatic implications relate to adding to the scientific background that can be used to support policy countermeasures. The current study answered the question it set out to address, and while doing so, addressed at least one investigative priority of several federal agencies.

Combating distracted driving is a national transportation goal, as evidenced by the USDOT/RITA sponsored Distracted Driving Summits held in 2009 and 2010 in Washington, DC. Additionally, in November 2011, the United States Department of Transportation’s (USDOT) Federal Motor Carrier Safety Administration (FMCSA) issued a final ruling prohibiting interstate truck and bus drivers from using hand held cell phones while operating commercial vehicles (USDOT, 2011).

The aims of this study were consistent with the overall mission of the USDOT and the National Transportation Research Center, Inc. (NTRCI) to, “*serve the United States by ensuring a* fast, <u>*safe*</u>, efficient, accessible *and* convenient *transportation system that meets our vital national interests and enhances the quality of life of the American people, today and into the future.*” Specifically, the aims reflect the mission and objectives of the FMCSA to *“reduce the incidence and severity of commercial motor vehicle crashes and to improve the safety of commercial vehicle operations through systematic research, innovative practices and technologies…”*

1.2 Project Team

This project was conducted by an interdisciplinary team of researchers from the University of Alabama at Birmingham (UAB); additionally, consultants and other critical personnel representing the Virginia Tech Transportation Institute, NTRCI, Boyd Brother’s Transportation, Inc., an Alabama-based trucking company, and numerous state level Alabama Department of Transportation personnel participated in various aspects of the project.

1.2.1 UAB Investigators, key personnel, and students

UAB provides a robust research environment for any research project. With more than 18,000 students and 18,000 faculty and staff, UAB is on the leading edge of teaching, research, health care, and service. The interdisciplinary team represented collaboration between two UAB entities: the UAB University Transportation Center (UAB UTC) and the UAB School of Nursing (UAB SON). Additional UAB staff represented UAB's: Department of Medicine, School of Public Health, Department of Psychology, and the Center for Injury Sciences. In addition to Dr. Russ Fine, Director of the UAB UTC and the project's principal investigator, two key UAB UTC scientists, Dr. Karen Heaton and Dr. Despina Stavrinos, served as Co-PIs.

Dr. Russ Fine, Professor of Medicine and Epidemiology and Director of the UAB UTC, brought nearly four decades of extensive research experience to the project contributing to the final research design and methodology, analysis and interpretation of project data, and guidance throughout the public-private partnership collaboration.

Dr. Despina Stavrinos, Assistant Professor of Medicine and Psychology and Director of the Translational Research for Injury Prevention (TRIP) Laboratory, focused on the driving simulation and driver distraction portion of the research study. Her extensive experience in behavioral research involving distractibility, driving simulation, and analysis of driving simulator outcome measures contributed to the success of collecting data to determine how driver distraction affected performance among the commercial vehicle drivers.

Dr. Karen Heaton, Assistant Professor in the UAB SON and Director of Occupational Health Nursing in the Deep South Center for Occupational Health and Safety, focused on the unique relationships among sleep restriction, sleep apnea, and other health factors and injury in the population of long-haul truck drivers. Dr. Heaton's knowledge of the unique health and safety issues of commercial drivers enhanced this research effort to understand how health factors are related to commercial driver distraction and driving performance.

Data analysis and interpretation was led by Dr. Gerald McGwin and Dr. Russell Griffin (who started on the project as student of Epidemiology, though he completed his PhD in August 2011). Drs. McGwin and Griffin used state-of-the-art statistical methods described in Dr. McGwin's chapter *Independent Variables: The Role of Confounding and Effect Modification* that appears in the Handbook of Driving Simulation for Engineering, Medicine and Psychology (McGwin, 2011). Additionally, Dr. David Vance from UAB's School of Nursing played an important role in the project, supervising and overseeing the use and analysis of the Useful Field of View (UFOV®).

The UAB UTC provided two support staff, Jeffrey Foster (Masters of Public Health) and Crystal Franklin (Masters of Public Health), who jointly managed project-related activities and interacted with NTRCI staff on an on-going basis to provide financial and general project updates.

Direct student involvement in this project was emphasized. Twenty graduate and undergraduate students worked on this project (as detailed below). Some of the students were NTRCI-funded, and some were research assistants assigned to the project from Dr. Stavrinos' TRIP Laboratory (See below):

NTRCI-funded students

Six students were funded by the NTRCI. Benjamin McManus played a very important role throughout the entire research project. Ben was trained in the use of the L-3 Communications TranSim™ truck simulator by the Boyd Brother's Simulator Technician Jason Bagley, and became the sole research assistant responsible for running participants through the driving simulator portion of the study.

Along with Emergency Medical Technician, Jonathan Harris, three nursing students played an active role in recruiting participants, collecting the health-related data, and administering the questionnaire: Gary Milligan (Doctoral-level Nursing student), Rufus Lymon (Bachelor-level Nursing student), and David (Dillon) Serafini (Bachelor-level Nursing student).

Sharon Welburn who was previously affiliated with Dr. Stavrinos' lab worked on the project from its inception. Sharon created, maintained, and managed the nearly 1100 variable database for the study and trained all research assistants involved in the data entry process.

TRIP Laboratory research assistants

Fourteen TRIP Laboratory student research assistants worked on various tasks such as chart assembly, data entry, visual coding, development of secondary task conditions, and telephone recruitment. They included: Ayushi Amin, Mili Boozer, Erica Britton, J. Barnett Chenoweth, Molly Cox, M. Scott Crawford, Shannon Denny, Annie Garner, Jennifer Jones, Parul Kapoor, Abigail Martin, Madhuri Patel, Cherell Washington, and Leslie Williams.

1.2.2 Consultant

Dr. Richard Hanowski, Director of the Center for Truck and Bus Safety at The Virginia Tech Transportation Institute, served as the project's primary consultant. Dr. Hanowski advised in the development, implementation, and quality improvement of study procedures and methods, was available for troubleshooting and problem-solving, and provided input to the writing, conceptualization, and editing of this final report. Dr. Hanowski will continue to be involved in manuscript preparation for eventual publication in scientific journals and abstract and presentation preparations for dissemination of the project findings in a variety of future scientific venues such as conferences, colloquia and symposia.

1.2.3 NTRCI

Several of NTRCI's staff played important roles in helping make this project a success. Mr. Joseph Petrolino not only provided guidance and problem solving council prior to and during the entire grant process, but also served on the Project Advisory Committee, thus providing invaluable direction for the project. Mr. Tony Spezia, Mr. Wayne Brock, Ms. Connie Smith-Holbert, and Ms. Rachel Stokes also played significant roles throughout various phases of the project, including grants and contracting support, and tracking project goals and results; in addition were responsible for acquiring, reviewing, assessing and evaluation regularly scheduled submissions of research and financial reports.

1.2.4 Boyd Brothers Transportation, Inc.

Public-private partnership has the potential of enriching academic-based research projects. Suffice to say our fortuitous partnership with Boyd Brothers Transportation, Inc. was a critical factor in the successful execution and completion of this research study.

Boyd Brothers generously donated the use of their truck simulator at no cost to UAB or the NTRCI. The simulator was a *state-of-the-art* L-3 Communications TranSim™ truck simulator that is replete with Trucking Standard Software. Boyd Brothers also allowed their Simulator Technician Mr. Jason Bagley to lend his simulator expertise to the UAB UTC staff during scenario development. The truck simulator remained on site at the Boyd Brothers Birmingham, Alabama terminal. However, UAB UTC researchers had unlimited access to the simulator on nights and weekends.

1.2.5 Project Advisory Committee

A multi-site, multidisciplinary Project Advisory Committee (PAC) provided research project oversight throughout the venture. Committee members included Mr. Joe Petrolino (NTRCI), Ms. Linda Guin [Alabama Federal Highway Administration (FHWA)], Mr. Mark Bartlett (Alabama FHWA), Mr. Gene Vonderau [Alabama Trucking Association (ATA)] and Dr. R. Kent Oestenstedt (Director, UAB Deep South Center for Occupational Health and Safety).

The first formal PAC meeting occurred on May 18, 2011, in conjunction with the UAB UTC annual Advisory Board meeting. Attendees included: Russ Fine, Jeff Foster, Crystal Franklin, Linda Guin, Karen Heaton, Ben McManus, Joe Petrolino, and Despina Stavrinos. Given that the meeting occurred only a couple of weeks after the April 27th tornado devastated the Boyd Brothers Birmingham Terminal where the simulator is housed, much of the meeting consisted of strategic planning to modify the project timeline and develop action steps to ensure the quality of the project was preserved irrespective of the time delays.

The second formal PAC meeting took place on September 28, 2011. This meeting was hosted and coordinated by Ms. Linda Guin at the Alabama Division of FHWA, located in Montgomery, Alabama. Not only were PAC members present, but Ms. Guin also invited key stakeholders in the commercial driving safety arena, including: John Driggers (Alabama Department of Public Safety), Pat Stringer (Alabama Department of Transportation), Karen Brooks [Federal Motor Carrier Safety Administration (FMCSA)], Theresa Jones (FMCSA), Gene Vonderau (ATA), and Tim Frazier (ATA).

Background information about the project as well as preliminary findings from nearly half of the planned study participants was presented. Recommendations, comments, and questions were posed to Drs. Heaton and Stavrinos throughout the meeting, including topics related to commercial driver health and lifestyle (e.g., "Why was a diagnosis of sleep apnea an exclusion criterion?" and "What can we do to improve CMV driver's health and lifestyle choices?), driving safety and driver distractions (e.g., "How many trucking companies have active on-board communication systems that are operational while the vehicles are in motion?"), and research methodology (e.g., "Do video cameras in the vehicles alter driver's behaviors?" and "What time of day and type of driving environment is simulated?"). All comments made during the meeting were recorded and evaluated in the writing of this Final Report. Those in attendance expressed an interest in reconvening for a formal presentation of final findings. The follow-up meeting will be scheduled for early 2012.

1.3 Project Description

This study examined the interaction of the cognitive and technological aspects of distracted driving as well as physical health among commercial drivers. Specifically, the study evaluated the impact of driver distraction, sleep, medication use, medical conditions, age, and cognition on driving performance.

Study objectives included:

1. Examine impact of secondary tasks on driving performance of commercial drivers,

2. Evaluate potentially distracting technological aspects of commercial vehicles (on-board technical systems and personal communication/entertainment devices) on the driving performance of commercial drivers in low vs. high mental workload conditions,

3. Assess the driver health effects of sleep quantity, sleep quality and propensity, medication use, medical conditions, and age on cognitive function as measured by Useful Field of View (UFOV®) and Psychomotor Vigilance Testing (PVT) among commercial drivers,

4. Examine the interaction among driver health (sleep quantity, sleep quality and propensity, medication use, medical conditions, and age), cognitive function (Useful Field of View [UFOV®] and the Psychomotor Vigilance Test [PVT]), distraction, and driving performance among commercial drivers in low vs. high mental workload conditions,

5. Observe the effects of commercial driver distraction on operational efficiency, more specifically, fuel consumption during the various secondary task conditions.

Participants were recruited from a trucking company in the Southeast. After Informed Consent was obtained from the prospective participants, baseline health, driving, electronic use, anthropometric, and demographic data were collected.

Eligible participants then completed cognitive testing (UFOV® and PVT), and drove a series of simulated trips while engaging in a variety of potentially distracting activities (talking on cell phone, text messaging, emailing using an on-board communication device) in an L-3 Communications TranSim™ truck driving simulator. Upon completion of data collection, data analyses were conducted using statistical procedures appropriate to the level of measurement of the outcomes of interest.

1.4 Project Schedule

The originally proposed timeline of January 2011 through September 2011 was dramatically altered after a tornado ravaged the Boyd Brothers Transportation Birmingham terminal during the tornado outbreaks across the state of Alabama on April 27, 2011. Due to the extensive damage caused by the tornado, heavy construction was required to repair the terminal; consequently, UAB researchers did not have access to the simulator for nearly three months. Thus, the project timeline (Figure 1-1) reflects the modified timeline, after a no-cost extension was granted to UAB researchers by NTRCI.

	Apr 2011	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb 2012
START-UP: • IRB approval • Preparation of instruments • Hiring & training of staff • Ordering supplies • Refinement of protocol • Development of simulator scenarios • Establishment of data management plan	X										
PARTICIPANT RECRUITMENT					X	X	X	X	X		
DATA COLLECTION					X	X	X	X	X		
DATA MANAGEMENT & ANALYSIS • Simulator data cleaned & organized • Questionnaire data entered and cleaned					X	X	X	X	X	X	
DISSEMINATION • Final report to NTRCI • Plan set for papers and presentations resulting from data										X	X

Figure 1-1. Chart. Project timeline.

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Chapter 2 – Literature Review

2.1 Overview

Although commercial drivers must be deemed to be "medically fit" prior to being granted a Commercial Drivers' License (CDL), serious medical conditions are highly prevalent among this group of workers. Previously identified medical conditions include: Obstructive sleep apnea (Talmadge, et al., 2008; Moreno, et al., 2004), hypertension (Xie, et al., 2011; Cavagioni, et al., 2009) and other cardiovascular disorders, diabetes, nicotine and other substance use, and mental health issues-anxiety and depression (Apostolopoulos et al., 2010). Along with these medical conditions, sleep deprivation related to irregular and erratic schedules, and customer and family demands is common (Belzer, 2000; Ouellet, 1994). Each one of these conditions may independently impair the cognitive processes necessary for safe driving. Additive effects on cognition are also noted. That is, more than one condition occurring simultaneously yields a greater negative effect on cognition than that of either of the conditions alone. Another serious issue that affects driving safety in this group is the use of electronic devices that distract the driver away from the demands of safe driving performance. This is an especially important issue for commercial drivers as the availability and reliance on electronic devices has increased and facilitates communication with employers, customers, family, and friends (Richtel, 2009). What is unclear at this time, is: how health conditions known to affect cognition in other groups, affect cognition in commercial drivers; and how the combined effects of health conditions, medication use, cognition, and various types of secondary tasks impact driving performance.

When drivers engage in secondary tasks their attention is directed away from the primary task of driving. The result of this “driver distraction” can be potentially fatal. Clearly, there is indisputable evidence that increased driver distraction leads to an increased incidence of traffic crashes. Naturalistic “real-world” studies have shown that CMV drivers were 23 times more likely to be involved in a crash, near-crash, or crash-relevant incident while text messaging than while undistracted, nearly 6 times more likely while dialing a cell phone, and about 10 times more likely while interacting with the vehicle’s emailing device (Olson et al., 2009).

Safe, responsible driving requires concentration. While there have always been distractions on the road, a proliferation of vehicle-based technologies coupled with an ever-increasing supply of new and sophisticated electronic devices available for personal use by everyday drivers have increased the potential for vehicle operators to be even more distracted today than they have been in the past. The extent to which driver health factors such as the operators’ physical and mental health status, workload, fatigue, and age was examined in this research. These factors are critical components of the overall goal to improve the safety-related performance of commercial drivers, and in doing so, making the highways safer for all drivers who share the road with heavy, commercial trucks.

2.2 *Distracted Driving*

According to the USDOT's Federal Motor Carrier Administration (2011), in 2009, more than 3,600 people were killed and 93,000 were injured in large truck and bus-related crashes. Of the 33,808 people who died in any motor vehicle crash, nearly 10% died in a large truck-related crash. Taking into account death, injury, and property losses, large truck and bus crashes cost Americans an estimated $48 billion in 2009 (USDOT, 2011). While driver inattention was reported as the third-leading cause of large truck crashes, this accounted for only 6% of police-reported crashes.

In the present study, distracted driving is operationalized as the misallocation of attention away from driving and towards a secondary task unrelated to driving (e.g., cell phone conversation, text messaging interaction, and emailing interaction) resulting in a degradation of driving performance (Hedlund, Simpsom, & Mayhew, 2006).

Naturalistic driving studies have highlighted the need for additional research in the area of distracted driving among commercial motor vehicle drivers. One of the first naturalistic driving studies to measure the impact of driver distraction and inattention on commercial driving performance was conducted by research scientists at VTTI. Hanowski et al. (2005) examined forty-one long-haul truck drivers, reflecting approximately 140,000 miles, on crash, near-crash, and crash-relevant conflict data. Collectively terming crashes, near-crashes, and crash-relevant conflicts as "critical incidents," 2737 critical incidents were recorded, and 178 of these were attributed to "driver distraction." Analyzing the 178 critical incidents related to distraction identified 34 unique types of distraction. Results showed that a small number of long-haul drivers were involved in a disproportionate number of distraction-related critical incidents. For example, two of the drivers accounted for 43 of the 178 distraction incidents. This gave important insight into the impact that various sources of distraction and behavior have on safety. Contributing in combination to the prevalence of the critical incidents were the frequency and duration of a task combined with the visual demand of performing the task. However, it was also found that because a task may not require visual attention does not mean that long-haul drivers will not look away from the roadway. Nonetheless, visually demanding tasks clearly carry the highest degree of risk. Unfortunately with these distraction events, 43 of the events were attributed to specifically 2 of the drivers while the rest were spread out amongst the rest of the sample, resulting in 41 drivers total.

Another naturalistic study by VTTI tracked the driving performance of 203 commercial vehicle drivers while driving on a real road. Olson et al. (2009) captured 4,452 critical safety events; 81.5% of which involved some sort driver distraction. While crashes were a rare critical safety event in the study (<0.5%), driver inattention was observed in 100% of those crashes. The observation of driver inattention in 100% of the commercial driver crashes was higher than an earlier light vehicle study, known as the 100-car naturalistic study, conducted by VTTI scientists (Klauer et al., 2006). Klauer et al. (2006) observed that driver inattention was responsible for

78% of the light vehicle crashes. Olson et al. (2009) found that commercial drivers were 23.2 times more likely to be involved in a critical safety event while text messaging as compared periods of time when they were not engaged in a secondary task. Additionally, a critical safety event was 5.93 times more likely while dialing a cell phone, and 9.93 times more likely while interacting with the vehicle's dispatching device.

Naturalistic studies provide an ideal methodology for observation of realistic driving behavior; however, these types of studies are also quite costly and provide less experimental control than empirical studies including those involving driving simulation. Driving simulators provide a safe and controlled environment for examining commercial driving performance and most recently, the possibility for training (Morgan et al., 2011). An exhaustive literature search identified no other study, to our knowledge, that has used driving simulation to measure the impact of distracted driving performance of commercial drivers. The present study is among the first to examine particular in-vehicle secondary tasks frequently encountered and used by commercial drivers such as emailing through on-board communication devices and interacting with cell phones while in a safe, simulated environment.

A number of outcomes have been used by previous studies to measure degraded driving performance in CMV drivers (see Hanowski et al., 2005; Olson et al., 2009). These include: (1) driving speed, which varies during engagement in secondary tasks, (2) crashes and near-crashes with either a vehicle or object, which have been shown to be at higher risk in certain secondary task engagement, and protective and in others, (3) lane deviations, also known as failure in lane keeping, (4) space management, which has an effect on braking distance in response to a lead vehicle, and can impact crash and near-crash risk, and (5) speeding which is indicative of risky driving behavior.

Other driving variables that have also been examined include: **Driver Error** (engine stalls, hard braking, not buckling their seat belt, parking brake not removed correctly, low air pressure during start-up), and **Driver Behavior** (eye glances [Olson et al., 2009] and lane changes [Stavrinos et al., 2010]). Our study is among the first to examine two additional variables in a research setting: **Operational Efficiency** (Miles per gallon and riding the clutch).

2.3 Driver Health Factors

The evaluation of driver health variables combined with distraction in commercial drivers under driving simulator conditions makes a unique contribution to the knowledge of driving safety in the transportation industry. The specific factors examined in the study were:

2.3.1 Sleep.

Clear associations between driving performance and sleep loss have been established in both commercial and non-commercial drivers. That is, driving performance consistently fails in sleep loss conditions (Ingre et al., 2006; Moller et al., 2006; Otmani et al., 2006; Philip & Akerstedt, 2006; Philip et al., 2006). In fact, driving performance impairment in sleep deprived individuals has been shown to be comparable to that of individuals with blood alcohol levels of 0.05-0.08% (Arnedt, Wilde, Munt & MacLean, 2001; Banks, Catcheskde, & Lacks, 2004; Fairclough & Graham, 1999). Generally, the minimum sleep time associated with safe driving is seven hours (Neri, Dinges, & Rosekind, 1997). Because of the demands of the job, shipper and consignee expectations, required non-driving tasks, and irregular and erratic schedules (Belzer, 2000; Ouellet, 1994), commercial drivers are particularly at risk for chronic sleep deprivation.

A second serious sleep issue in commercial drivers is obstructive sleep apnea (OSA). Prevalence estimates of OSA in commercial drivers range from 28-78% (Pack, Dinges, & Maislin, 2002; Stoohs, Bingham, Guilliament & Dement, 1995). Although a diagnosis of obstructive sleep apnea was an exclusion criterion for the study, OSA is underdiagnosed in the general population, and perhaps more so, in this group because of federally mandated work restrictions associated with the diagnosis (Ancoli-Israel, George, Czeisler, et al., 2008). Because of the prevalence of the condition in commercial drivers, and the likelihood of significant underdiagnosis, we included OSA screening components recommended by FMCSA Expert Panel on OSA and Commercial Vehicle Driver Safety: snoring history, blood pressure measures/hypertension history, neck circumference, and body mass index (height/weight) (Ancoli-Israel, George, Czeisler, et al., 2008).

Although short sleep duration is likely more prevalent in this group than sleep apnea, the potential additive effects of both short sleep duration and OSA on driving performance degradation is an important consideration in commercial drivers (Pack et al., 2006). For those reasons, we are not only screening for common signs and symptoms associated with OSA, but are measuring self-reported sleep time, sleep propensity, and sleepiness. Using indicators of both acute short sleep duration and OSA provided us with information to determine the presence and extent of these two distinct, yet interactive sleep problems.

2.3.2 *Medical conditions and medication use.*

A number of medical conditions are identified as having possible negative influences on driving performance. Among these are cardiovascular/cerebrovascular disease, traumatic brain injury, diabetes mellitus, epilepsy, depression, and substance use/abuse (Dobbs, 2005). When considering diabetes mellitus, it is important to note that the risk for rapid drops in blood sugar and associated altered levels of consciousness found in insulin-dependent diabetes (IDDM) is the primary reason why IDDM is a medical condition that is disqualifying for holders of commercial drivers' licenses. Although changes in glycemic control and resulting cognitive effects in non-insulin-dependent diabetes are more subtle and take place over longer time frames, these changes affect cognition, and may subsequently affect driving performance. (Stork, Haeften, & Venemen, 2006). Also, commercial drivers may be taking medications for chronic conditions that affect sleep, and thus, negatively impact driving performance.

Among the prescription medications that most commonly impact sleep are those used for depression and anxiety, cardiovascular disease, inflammation, epilepsy, Parkinson's Disease, obesity, and pain. Commonly used over-the-counter cold and diet medications may contain pseudoephedrine and phenylpropanolamine. These substances are central nervous system stimulants that may be associated with insomnia and subsequent sleep loss. Therefore, it was important for us to determine the past medical history and medication/substance use history of the participants to determine the effects of the conditions and medications on sleep and subsequent driving performance among study participants.

2.4 *Driver Cognition*

Driver cognition plays a key role in the ability of the commercial driver to recognize and process information from various sources quickly. It is the intact cognitive system that allows a commercial driver to see, recognize, and respond to a hazard to avoid critical driving safety incidents.

2.4.1 *Visual processing speed.*

As humans age, they typically experience a slowing in their ability to cognitively process information and react to the information via the musculoskeletal system. Optimum processing speed of certain information, such as visual input, is essential to safe driving performance. The Useful Field of View (UFOV®) test measures the speed and efficiency of information processing within the visual field. A 40% reduction in UFOV® in older drivers doubled their risk of at-fault motor vehicle crashes over a 3-4 year time frame, compared to older drivers with intact UFOV®. Although this tool has been used extensively with non-commercial drivers, the UFOV® of commercial drivers has not yet been explored and described in the literature. This is important for two reasons: first, it may be that commercial drivers do not experience changes in visual processing in the same way or at the same rate as non-commercial drivers. It is possible that because of the amount of driving that they do, their visual processing speed remains stable. Another possible explanation may be related to specific visual scanning practices used by commercial drivers that keep their eyes moving in a sweeping motion from left to right every few seconds. Commercial drivers who have received this type of training and practice the visual scanning technique may overcome a decline in visual processing speed that would be detected by UFOV® testing. The second reason that this is an important measure and that it is critical to determine UFOV® in commercial drivers is because there is a cognitive retraining intervention than improves UFOV® in non-commercial drivers. Therefore, if UFOV® does decline in commercial drivers, there is an intervention that can be implemented to improve visual processing speed, and decrease motor vehicle crash risk.

2.4.2 *Vigilance.*

Vigilance is the ability to sustain attention to a task over time. It can wax and wane over time, requires alertness, and an ability to filter and block external, distracting stimuli. The most commonly used measure of vigilance is reaction time measured by the Psychomotor Vigilance Test (PVT). Lapses and increased reaction time measured by PVT have been previously associated with negative driving simulator outcomes such as lane departure and speed variability. Among all of the measures of cognition available, the PVT has been most often applied to the study of cognition in truck drivers (Van Dongen & Dinges, 2003; Van Dongen, Maislin, Mullington, & Dinges, 2000).

Results from many PVT studies indicate that vigilance is sensitive to sleep and fatigue, and deteriorates in a dose-response manner. That is, as sleep loss and fatigue build, the ability to be vigilant degrades. In sleep-deprived participants, errors in test performance also increased.

2.5 Operational Efficiency

There is consensus throughout the industry that operational efficiency is critical to the success of trucking operations. For example, Bob Costello, Chief Economist of the American Trucking Association, predicted that while *for-hire tonnage* had increased in early 2011, it was expected to moderate for the second half of 2011; reflecting very slow national economic growth (McNally, 2011). Moreover, the two most significant determinants of revenue per mile calculations for trucking companies are labor and fuel costs (American Trucking Association, 2008). With a current average U.S. retail price of $3.83 per gallon, a projected increase in 2012 to $3.96 per gallon (U.S. Energy Information Administration, 2011), and an average combination vehicle fuel mileage rate of seven miles per gallon, effective fuel efficiency strategies are key to successful trucking operations.

A number of factors external to the commercial driver have been identified that influence fuel efficiency. These include tires, pavement characteristics, aerodynamics, loaded weight, and terrain characteristics. Clearly, not all of these external factors are modifiable. However, there are other factors that significantly influence fuel efficiency that are determined by driver behavior and, as such, are modifiable. These are speed and shifting patterns in the manual transmission commercial vehicle.

The possibility of text messaging distraction as an influencing factor in fuel consumption was described by FMCSA in the 2010 *Final Rule Limiting Use of Wireless De*vices. FMCSA used the following assumptions to project potential fuel costs related to texting: (1) commercial drivers idle their truck engines while texting; and (2) commercial drivers may travel additional distances to reach a location that is safe for texting. Thus, it is of more than casual interest that projected fuel consumption associated with these activities was estimated at just under 389,000 gallons. At the average 2010 price of $2.92 per gallon for diesel fuel, that projection translated to an additional $1.2 million dollars.

2.6 *Summary*

This study addressed important gaps in the literature related to: (1) the intersection of health, cognition, and distraction, and their effects on driving performance in commercial drivers; and (2) distraction as a possible influencing factor on operational efficiency and cost as related to fuel mileage. Findings from the study will potentially be used to influence policy related to distracted driving, medical fitness determination, and the development of interventions to limit distraction and promote health among commercial drivers.

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Chapter 3 – Method

3.1 Setting and Sample

Participants were recruited from a trucking company in the Southeast. Data were collected using a simulator and office space located at the Boyd Brothers Trucking Company, Inc. – Birmingham, Alabama Terminal.

3.1.1 Participants

Fifty-five commercial truck drivers were recruited from the region through flyers displayed in areas prominently visible to truck drivers. Flyers were used to encourage interested individuals to contact the program administrator who engaged the potential participant in a detailed discussion of the study to determine eligibility.

Eligibility criteria included: (1) age 21 – 65, (2) possession of a valid, state-issued Commercial Driver's License, (3) long-haul drivers who slept at least three nights per week in the sleeper berths of their trucks, (4) having been deemed medically fit per USDOT standards, (5) ownership of a cell phone, and (6) being able to read, write, and speak English. Exclusion criteria included: (1) a diagnosis of sleep apnea, (2) self–reported routine and habitual use of sedating or hypnotic medications, illicit drugs, or alcohol.

Five participants who originally met inclusion criteria were later excluded from the study (2 due to simulator sickness and 3 due to data quality issues related to the simulated drives), resulting in a total of 50 participants' data that were used in the analysis.

3.1.2 Setting

The research site was at Boyd Brothers Transportation, Inc., located approximately 7 miles north of Birmingham, Alabama. Research project staff was granted access to two private areas for the conduct of the study. One room, named the "simulator room," was equipped with the truck driving simulator, and a password protected desktop computer which was used for the cognitive tasks described elsewhere in this report.

The second "health" room was a private area, either in an office or behind a privacy curtain, and was used for the consent process, and administration of paper and pencil questionnaires and acquisition of health measures.

More complete descriptions regarding the instrumentation and measures are provided in a subsequent section ("Measures").

3.1.3 Procedure

Participants meeting eligibility criteria for the study were administered an Informed Consent document approved by the University of Alabama at Birmingham Institutional Review Board for Human Use. Participants provided written consent upon arrival to the first appointment.

After informed consent was obtained, participants completed a paper and pencil instrument (as described below, “Truck Driver Survey”-Appendix A) with a research assistant. For their convenience, participants were given the option of completing questionnaires on their own (after a brief introduction) or with a research assistant (to accommodate for the possibility that a participant might have difficulty with reading).

The research team member reviewed the survey with the participant and instructed him in correct completion of the instrument. At the completion of surveys, research team members reviewed the instruments for missing data, and facilitated completion of any missing sections prior to participants moving to the next study phase.

Participants then received a brief, modified physical upper airway exam to include neck circumference, Mallampati and tonsillar scores, blood pressure, and height and weight measures as described in greater detail in Section 3.2 “Measures.” Participants were offered a short break to minimize discomfort. Participants then completed brief computerized cognitive testing (UFOV® and PVT) to measure visual attention and processing speed.

All participants were familiarized with the truck driving simulator during a brief calibration session to ensure that each driver met a minimum standard of proficiency with basic driving tasks (e.g., shifting through all ten gears, making a right turn, using the steering wheel, accelerator, clutch, and brakes). A detailed description of the L-3 Communications TranSim™ truck simulator is provided under the “Measures” subheading which appears below.

We obtained the participants’ phone numbers by recording them on a sheet of paper. Participants then engaged in four driving scenarios, each spanning approximately a 22.50-mile distance, with secondary task conditions randomly presented to participants: (a) no secondary task condition, where participants anticipate a text, phone call, or email but do not receive either any of the three secondary tasks, (b) cell phone conversation, where participants receive a cell phone call 10 seconds after beginning the scenario, quickly answer the phone, and subsequently engage in a naturalistic phone conversation with an unfamiliar research assistant for the remainder of the scenario, (c) a text message interaction, where participants receive a text message 10 seconds after beginning the scenario and engage in reading and responding to text messages from an unfamiliar research assistant for the remainder of the scenario, or (d) emailing interaction, where participants were sent an email message 10 seconds after beginning the scenario and engage in reading and responding to email messages from an unfamiliar research assistant for the remainder of the scenario. Participants were offered a short (less than 5 minute) break in between each of the four drives.

Cell phone, text messaging, and email tasks were semi-structured to imitate a typical conversation with unfamiliar individuals (i.e., research assistants); these research assistants maintained a natural conversation flow. Example conversational questions included, “What is your favorite television show?” and “How many years have you had a CDL?”

After completion of the driving task, participants were thoroughly debriefed. The debriefing included a discussion explaining topics relevant to the present work. Participants were monetarily compensated at the end of the session.

3.2 Measures

3.2.1 Truck driver survey

Participants completed a 73-item, laboratory-developed questionnaire which provided a detailed overview of demographics, driving history and experience, experience with and use of electronic devices during the work week, medical history, sleep, and perception of distracted driving risk and ability (Appendix A-Truck Driver Survey). Frequency of engagement in distracted driving and perceptions regarding distracted driving were adapted from previous versions of the Questionnaire Assessing Distracted Driving (Welburn et al., 2010, 2011) for use with commercial truck drivers.

Two validated sleep scales were used to measure sleep propensity and acute sleepiness. The first, the Epworth Sleepiness Scale (below B-ESS), was used to acquire information on sleep propensity (Johns, 1991). The 8 items on the ESS were summed to provide the Epworth Sleepiness Scale total scale score used in the analysis. Additionally, the single item Karolinska Sleepiness Scale (C-1) was used as a measure of acute sleepiness just prior to the simulator task (Akerstedt & Gillberg, 1990).

3.2.2 Health measures

Weight

Weight was recorded using a Health-O-Meter® Physician Balance Beam Scale. A nursing research team member checked the balance of the standing beam scale by placing the rider on the “zero” mark of the weight arm. If the scale was out of balance, the counter weight was adjusted to calibrate the scale to zero. The nursing research team member placed a clean paper towel on the scale platform and instructed the participant to remove his shoes and socks. The participant then stepped up onto the scale platform. The research team member slid the rider up to a mark on the weight arm 10 pounds below the participant’s estimated weight and slowly adjusted the position of the rider until the weight arm was balanced at the midpoint of the weight arm indicator. Weight was recorded as the number upon which the rider indicator rests when the weight arm was balanced.

Height

Height was recorded using the height bar from the Health-O-Meter® Physician Balance Beam Scale. After the participant’s body weight was recorded, the participant was assisted to turn on the platform so their back was parallel to the height measuring bar. The participant was instructed to face straight ahead, and hold their head erect with eyes forward and heels together.

The research team member slid the L-shaped sliding height bar until it rested on top of the participant's head. The height measurement was read from the height bar and recorded by the research team member.

Body Mass Index (BMI)

A BMI chart (National Heart Lung and Blood Institute, 2011) was posted by the scale for use by research team members. The research team member located the BMI on the chart that corresponded with the participant's weight and height and recorded it in the participant research record.

Mallampati score

Participants were instructed to sit comfortably in a specified chair. The research team member instructed the participants to open their mouth, while directing a light at the posterior pharynx, and observing the soft and hard palates, uvula, fauces, and tonsillar pillars. The research team member assigned a Mallampati score (Mallampati, 1985) based on the following guidelines: 1) soft palate, fauces, pillars, and uvula visible; 2) soft palate, fauces, and uvula visible; 3) soft palate and base of uvula visible; and 4) hard palate only is visible.

Tonsillar score

Participants were instructed to sit comfortably in a provided chair. The research team member instructed the participants to open their mouth, protrude his tongue, and "say" "ah" while directing a light at the posterior pharynx and observing the tonsils and tonsillar pillars.

The research team member assigned a tonsillar score (Bickley, 2008) based on the following guidelines: Tonsil 0: tonsils fit within tonsillar fossa; Tonsil 1+: tonsils <25% of space between pillars; Tonsil 2+: tonsils <50% of space between pillars; Tonsil 3+: tonsils <75% of space between pillars; Tonsil 4+: tonsils >75% of space between pillars; not applicable: No tonsils.

Blood pressure

Participants' blood pressures were measured manually after having been in a seated position for at least five minutes. A Sprague stethoscope and Prestige Nylon Aneroid Sphygmomanometer® were used to measure the blood pressures using the conventional techniques described in the *Lippincott Manual of Nursing Practice* (Nettina, 2008).

3.2.3 Cognitive measures

Psychomotor Vigilance Test (PVT)

PVT is a simple test of reaction time that is administered via a hand-held device. Participants respond to randomly administered visual cues administered at varying intervals. The test duration was 10 minutes, during which participants were seated comfortably, and instructed to attend to a small, rectangular display screen on the device. They were instructed to respond to a millisecond count cue on the display screen as quickly as possible. Once they responded by pressing a button, the millisecond counter stopped, and participants were able to see their reaction times in milliseconds. They were instructed to avoid pressing the button before seeing the visual cue (false start). Several measures are collected during the 10 minute PVT, including mean reaction time, false starts, reaction time variability, etc. The test has been determined to have strong test-retest reliability for both median reaction time and lapses, demonstrated convergent validity with sleep deprivation and psychoactive drug use, and has a minor learning effect. Thus, the test is suitable for repeated measures within short time frames (Dinges & Lim, 2008; Van Dongen et al., 2003).

Useful Field of View® (UFOV®)

UFOV® Test is a measure of visual speed of processing; this measure is administered on a computer monitor with touch-screen technology with four increasingly complex subtests. For each subtest, several presentations ranging from 17 - 500 milliseconds (ms) long are displayed in order to determine the speed in which visual information is processed. For subtest 1, participants are instructed to identify a central target (truck or car) presented in a fixation box. For subtest 2, participants are instructed to identify the central target and to locate a simultaneously presented peripheral target (car). For subtest 3, participants are instructed to do the same activity as in the second subtest, except that the peripheral target is now embedded in distracters; thus, the task is more difficult. For subtest 4, the central box now has two objects (truck and/or car); participants are instructed to determine whether the two objects in the central field are the same (truck, truck; car, car) or different (truck, car), as well as to locate a peripheral object (car) embedded in the surrounding clutter. For each subtest, a double staircase method is used to determine the presentation speed in which participants correctly complete the task 75% of the time. The optimal presentation speed is the score in milliseconds (ms). The optimal presentation speed for all four subtests is combined; fewer ms to correctly perceive the target reflect a faster visual speed of processing. An association coefficient between 0.74 and 0.81 indicates good test-retest reliability (Edwards et al., 2005; Vance, 2009). In previous studies of older adults, UFOV® subtest 2 has revealed a high correlation with the UFOV® total score, and is known to be the most accurate of each of the four subtests to show associations with driving performance (Owsley, Ball, McGwin et al., 1998). In the current study, subtest 2 was used in analyses evaluating driving outcomes.

3.2.4 Commercial truck driving simulator

Participants engaged in a computerized driving simulation task in an L-3 Communications TranSim™ (D.P. Associates, Inc., Alexandria, Virginia) truck driving simulator to provide a measure of driving performance under specified conditions of interest (Figure 3-1). The simulation was displayed on three plasma screens, providing a 180° field of view. Participants sat within the simulator's passenger compartment which provided a view of the roadway and dashboard instruments, including a speedometer, tachometer, trailer and brake release buttons, and a brake pressure gauge. The vehicle was controlled by moving a force-loaded steering wheel in a typical driving manner, changing gears (10-speed), and depressing accelerator, clutch, and brake pedals accordingly. The truck was programmed to carry an 80,000 pound high-tarped load. An on-board stereo sound system provided naturalistic engine sounds, external road noise, and sounds of passing traffic. The simulated daytime environment was a four-lane interstate segment, with traffic moving in a bidirectional manner, mimicking roadway conditions typically encountered on the interstate. Speed limit signs appeared throughout the scenarios and ranged from 55mph to 60mph. Drivers were encouraged to “drive as they normally would” and were not restricted to maintain a particular speed.

Figure 3-1. Photo. The L-3 Communications TranSim™ truck driving simulator.

The other simulated vehicles were programmed to interact with the participant driver, based on pre-set parameters. Several vehicles were programmed to appear behind the participant driver, while others were programmed to appear in front. Several indicators of driving performance were electronically recorded by the simulator across each of the four secondary task conditions (adapted from previous research [Hanowski et al., 2005; Olson et al., 2009]):

1. Average **driving speed** was calculated in miles per hour.

2. The total number of **vehicle collisions** was calculated for each secondary task condition. A vehicle collision was reported as an instance when the participant-driver collided with either another vehicle or object.

3. **Space management** was based on the Smith System and measured by the total number of times the participant driver was less than 10 seconds away from the lead vehicle.

4. **Speed exceedances** were calculated as the total number of times a driver went more than 1 mph over the speed limit. Three categories of violations were also created: low exceedances (1-4 mph over the recorded speed limit), medium exceedances (5-14 mph), and reckless exceedances (greater than 15 mph over the speed limit).

5. A total number of each of the following were counted as driver errors: **engine stalls**, **hard braking**, **not buckling their seat belt**, **parking brake not removed correctly**, **low air pressure during start-up**.

6. **Miles per gallon** and **riding the clutch** served as indicators for operational efficiency and were electronically recorded by the simulator.

Two video cameras were strategically mounted (one above the simulator, providing a full image of the participant driver, and another on the Operator's Console (OpCon) providing a full, unobstructed view of the driving scene. Videos were manually coded by two-trained research assistants for the following 3 additional indicators of driving performance:

7. **Lane deviations**, which were defined as center line crossings or road edge excursions, were recorded as indicators of impaired driving performance. Greater within-lane deviation indicated poorer driving precision and the measure has been shown to be a sensitive indicator of the impairing effects of many factors suspected to disturb driving performance (e.g., Shinar et al., 2005; Weafer et al., 2008).

8. **Lane change frequency** was computed as the number of instances participants exited their lane and fully entered an adjacent lane.

9. **Eye glances off road** were manually recorded as instances when the participant drivers' eyes were off of the simulator screens and fixated elsewhere.

3.3 Data Analytic Plan

The mean and frequency distribution was used for continuous and categorical variables, respectively, to describe demographic, medical history, use of electronic devices, cognitive performance, and commercial truck driving experience characteristics of the participants. To determine the effect of secondary tasks on driving violations, driving performance, and startup procedure proficiency, statistical models utilizing Generalized Estimating Equation (GEE) analysis were used. The use of GEE modeling methods allowed for the inter-dependence of the observations, as each participant engaged in four drives. Thus, these models adjust for within-person covariance (e.g., driving ability, familiarity with simulator after multiple drives).

For the estimation of the association between secondary tasks and both driving violation rate (i.e., rate of speeding in excess of 15 mph over the posted speed limit, space management violations, collisions, and lane deviations) and driving performance (i.e., lane changes, eye glances off the road, engine stalls, instances of hard braking, and riding the clutch), a GEE Poisson model was used to calculate rate ratios (RRs) and associated 95% confidence intervals (CIs). The natural log of miles driven during the simulation driving segment was used as the offset in the Poisson model in order to model the violation rate (rather than the violation count). For driving violations, five models were created, one for each violation type (i.e., all violations, speeding, space management, collisions, and lane deviations). In each model, the no secondary task condition was the referent group. For driving performance, a similar method was used, with five models created, one for each performance measure. GEE Poisson regression models were also used to estimate the association between violation rate and selected demographic and health characteristics. The rate was calculated as the number of violations divided by the length of the segment. To get the rate per 100 miles, the resulting number was multiplied by 100.

A GEE logistic model was used to estimate odds ratios (ORs) and 95% CIs for the association between secondary tasks and startup procedure violations (i.e., not fastening the seat belt, not setting the parking brake, or putting the truck in motion when the brake pressure was low). Three models were created, one for each type of violation.

A repeated measures analysis of variance (ANOVA) was used to estimate the association between secondary tasks and both average driving speed and miles per gallon during the simulation segment. Like GEE analysis, the use of a repeated measures ANOVA controls for the within-person covariance.

An additional analysis examined whether driver characteristics (i.e., age, medication and caffeine use, sleep time, and ESS score) were associated with measures of cognition (i.e., UFOV®, mean reaction time, and number of reaction lapses). For each association, a general linear model was used to calculate beta estimates (β) and *p*-values for the association between the exposures of interest and the mean of the cognition measures. All models were controlled for the presence of snoring, used as a marker of sleep apnea.

In linear regression models, the effect of certain variables on the mean of a given outcome is examined. A linear regression model can be given by the equation Y = MX + B, where Y is the outcome, M is the slope of the line, X is the variable, and B is the intercept of the line along the Y-axis (i.e., the value of Y when X is 0). A beta estimate is the measure of the slope of the line. Using the equation notation Y = MX + B, the beta estimate can be interpreted as the change in the mean of the outcome Y per 1-unit increase of the independent variable X. For example, the beta estimate for age in a regression model HEIGHT = β(AGE) + INTERCEPT will estimate the change in the mean height per 1-unit increase in age.

Statistical models attempt to examine whether an association exists between an outcome and an independent variable based on a given set of data. It is possible, however, that the associations observed in models are found in error (i.e., the model results show an association when, in reality, no association exists). Reasons for this error vary, and can range from flawed study design to random chance. *P*-values assess whether the associations are due to random chance. We consider a finding to be "statistically significant" if the *p*-value (i.e., the error rate) is less than 5% ($p < 0.05$), meaning the association is not likely to be due to random chance. For all analyses, *p*-values <0.05 were considered significant.

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Chapter 4 – Results

4.1 Driver Demographics

The average age of the 50 participants was 40.5 years (Table 4-1). A large proportion of participants were white (56.0%) or African American (36.0%), male (98.0%), and married (72.0%). The average experience as a commercial truck driver was 8.6 years, with an average 7.8 years with a Class A Commercial Driver's License. Participants were most often employed as a company driver (86.0%), and all were drivers of single-trailer vehicles. The average haul was 874.8 miles, and the average time worked per week was 65.3 hours.

Table 4-1. Participant Characteristics.

Characteristic	Mean ± SD or N (%)
Age (years)	40.5 ± 8.2
Race (%)	
White	28 (56.0)
Black	18 (36.0)
Hispanic	3 (6.0)
Other	1 (2.0)
Gender (%)	
Male	49 (98.0)
Female	1 (2.0)
Highest education (%)	
< 12th grade	7 (14.0)
High school	18 (36.0)
Some college	24 (48.0)
College graduate	1 (2.0)
Marital status (%)	
Married	36 (72.0)
Single	9 (18.0)
Divorced	3 (6.0)
Separated	2 (4.0)
Years with Class A commercial driver's license	7.8 ± 6.5
Length of typical haul (miles)	874.8 ± 692.7
Experience as commercial truck driver (years)	8.6 ± 7.3
Current employment status (%)	
Company driver	43 (86.0)
Independent owner/operator	2 (4.0)
Owner/Operator leased to company	5 (10.0)
Type of vehicle currently driven (%)	
Single unit	2 (4.0)
Single-trailer	48 (96.0)
Hours worked per week as a long-haul trucker	65.3 ± 14.4
Days per week caffeine product consumed	5.8 ± 2.2
Days per week alcoholic beverage consumed	0.5 ± 1.0
Days per week recreational drugs used	0
Medication use (%)	
Anti-hypertensive	7 (14.0)
Lipid lowering	1 (2.0)
Diabetic	1 (2.0)

4.2 *Electronic Device Use During the Work Week*

By the number of days per week a device is used, participants reported using cell phones most often, with an average usage of a hands-free cell phone 4 days during a work week and a hand-held cell phone 2 days a week (Table 4-2). Participants used a CB radio nearly 4 days a week and had similar frequencies of sending at least one text message from a cell phone (mean 2.1 days) and using on-board communication devices for emailing (mean 2.0 days). A similar pattern was observed when frequencies were reported by number of times per day, with the CB radio (mean 8.8 times per day) and talking on a hands-free cell phone (mean 7.2 times per day) the most often reported device usage. Of note, participants reported sending a text nearly 5 times per day and emailed using an on-board communication device on average 2.5 times per day.

Table 4-2. Electronic Device Use Among Participants.

Type of Use	Mean ± SD	Median (IQR)
Days per week (while driving):		
Talk on “hands-free” cell phone	4.1 ± 2.6	5 (0-6)
Talk on “hand-held” cell phone	2.3 ± 2.7	2 (0-5)
Send a text on a cell phone	2.1 ± 2.8	0 (0-5)
Write and send email on a cell phone	0.6 ± 1.7	0 (0-0)
Access the internet on a cell phone	1.2 ± 2.4	0 (0-0)
Use a CB radio	3.8 ± 2.7	5 (0-5)
Email	2.0 ± 2.8	0 (0-5)
Times per day (while driving):		
Talk on “hands-free” cell phone	7.2 ± 9.0	4 (0-10)
Talk on “hand-held” cell phone	2.2 ± 4.0	0 (0-3)
Send a text on a cell phone	4.7 ± 11.3	0 (0-3)
Write and send email on a cell phone	0.4 ± 1.4	0 (0-0)
Access the internet on a cell phone	0.8 ± 3.4	0 (0-0)
Use a CB radio	8.8 ± 19.8	3 (0-7)
Email	2.5 ± 7.7	0 (0-2)

4.3 *Driving Perception*

Unsurprisingly, nearly all (98.0%) of participants reported travelling on interstates most often compared to all other road types (i.e., local, highway, or rural roads) (Table 4-3). Combined, nearly 75% of participants felt they were very experienced (34.0%) or experienced (40.0%) as a commercial truck driver. Similarly, 80% combined felt they were very skilled (34.0%) or skilled (46.0%) as a commercial truck driver. Nearly all perceived their training for driving during dangerous road conditions to be acceptable, with 58.0% reporting the training was very adequate and 32.0% reporting the training was adequate. All felt distracted driving was a problem for the average driver (i.e., not limited to commercial drivers), with 72.0% reporting distracted driving was a very big problem, 24.0% reporting distracted driving was a big problem, and 4.0% reporting distracted driving was somewhat a big problem for the average driver. Interestingly, these perceptions varied slightly when limited to commercial drivers. When asked if distracted driving was a problem for the general population of commercial drivers, 58.0% of participants reported it was a very big problem, 26.0% reported is as a big problem, 14.0% reported it as somewhat of a big problem, and 2.0% reported it was not a problem. Related to this, 96.0% reported receiving training regarding the risks of distracted driving.

Table 4-3. Perceptions Regarding CMV Experience and Distracted Driving.

Variable	N (%)
Roads travelled most often (%)	
Interstate	49 (98.0)
Local	0 (0.0)
Highway	1 (2.0)
Rural	0 (0.0)
Perceived experience as commercial driver (%)	
Very experienced	17 (34.0)
Experienced	20 (40.0)
Somewhat experienced	12 (24.0)
Not experienced at all	1 (2.0)
Perceived skills as a commercial driver (%)	
Very skilled	17 (34.0)
Skilled	23 (46.0)
Somewhat skilled	10 (20.0)
Not skilled at all	0 (0.0)
Perceived adequacy of training for dangerous road conditions (%)	
Very adequate	29 (58.0)
Adequate	16 (32.0)
Somewhat adequate	4 (8.0)
Not adequate at all	1 (2.0)
Perception of distracted driving as a problem for average vehicle driver (%)	
Very big problem	36 (72.0)
Big problem	12 (24.0)
Somewhat big problem	2 (4.0)
Not a big problem at all	0 (0.0)
Perception of distracted driving as a problem for commercial vehicle driver (%)	
Very big problem	29 (58.0)
Big problem	13 (26.0)
Somewhat big problem	7 (14.0)
Not a big problem at all	1 (2.0)
Received training about risks of distracted driving (%)	48 (96.0)

4.4 Health Indicators, Comorbidities, and Cognitive Performance

On average, participants were 72.1 inches tall and weighed 225 pounds, resulting in a mean BMI of 32.8 kg/m^2 (Table 4-4). The average neck circumference was 20.3 inches. The mean systolic and diastolic blood pressures were 125.6 and 81.8 mmHg, respectively. The most prevalent comorbidity reported was high blood pressure (16.0%), followed by emotional or psychiatric problem (6.0%), kidney problems (6.0%), and non-insulin dependent diabetes (6.0%). Regarding cognitive performance, participants had a mean reaction time of 252.7 milliseconds, and most often had no (52.0%) or one (30.0%) reaction time lapse. The average score for the UFOV® subtest 1 was 17.1 ± 0.6, for the UFOV® subtest 2 was 40.5 ± 53.0, and for the UFOV® subtest 3 was 11.2 ± 75.4.

Table 4-4. Participant Health Indicators, Comorbidities, and Cognitive Performance

Measure	Mean ± SD or N (%)
Health indicators	
Height (inches)	72.1 ± 16.1
Weight (pounds)	224.9 ± 52.5
BMI	32.8 ± 6.2
Neck circumference	20.3 ± 21.0
Mallampati score	2.3 ± 1.1
Tonsillar score	1.3 ± 1.4
Systolic blood pressure	125.6 ± 12.1
Diastolic blood pressure	81.8 ± 7.6
Snores while sleeping	18 (36.0)
Comorbidity (%)	
High blood pressure	8 (16.0)
Emotional or psychiatric problem	3 (6.0)
Kidney problems	3 (6.0)
Diabetes	3 (6.0)
Alcoholism	1 (2.0)
Cancer (excluding skin)	1 (2.0)
Chronic pain	1 (2.0)
Concussion	1 (2.0)
Heart attack	1 (2.0)
Heart rhythm problem	1 (2.0)
Cognitive Performance	
Psychomotor Vigilance Test	
Mean reaction time (ms)	252.7 ± 26.2
Reaction time lapses (%)	
0	26 (52.0)
1	15 (30.0)
2	5 (10.0)
3	2 (4.0)
4	1 (2.0)
5	1 (2.0)
UFOV® (ms)	
Subtest 1	17.1 ± 0.6
Subtest 2	40.5 ± 53.0
Subtest 3	111.2 ± 75.4

4.5 Sleep Characteristics

The mean ESS for participants was 7.1 ± 3.6 (Table 4-5). Prior to the beginning of the driving simulation, participants on average slept 7.5 ± 1.5 hours, and more often, reported being alert (31.9%) or a little less alert (19.2%) at the beginning of the driving simulation. However, 21 % of the participants reported being sleepy just prior to the driving simulation. Additionally, their ability to structure sleep time was mixed, with 34.0% reporting having an easy time structuring sleep and 26.0% and 22.0% having a hard or neither easy nor hard time structuring sleep, respectively. A majority (86.0%) of participants reported having at least moderate control over sleep while working, with more (40.0%) reporting having control over sleep most of the time. That said, it is important to note that 14% of the participants reported that they had little to no control over their sleep while working.

Table 4-5. Participant Sleep Characteristics

Variable	Mean ± SD or N (%)
Sleep propensity	
Mean ESS (score)	7.1 ± 3.6
Sleep prior to trial	
Duration of sleep prior to trial (hours)	7.5 ± 1.5
Sleepiness at trial (%)	
Extremely Alert	3 (6.4)
Somewhat alert	4 (8.5)
Alert	15 (31.9)
A little less alert	9 (19.2)
Neither alert nor sleepy	6 (12.8)
A little less sleepy	4 (8.5)
Sleepy, but no difficulty staying awake	6 (12.8)
No response	3
Difficulty structuring sleep time	
Very hard	4 (8.0)
Hard	13 (26.0)
Neither easy nor hard	11 (22.0)
Easy	17 (34.0)
Very easy	5 (10.0)
Control over sleep while working	
No control	2 (4.0)
A little control	5 (10.0)
Moderate control	13 (26.0)
Control most of the time	20 (40.0)
Complete control	10 (20.0)

4.6 *Comparison of Driving Violations and Performance by Secondary Tasks*

Compared to the *no secondary task condition*, there was a nearly two-fold increase in violations overall for the emailing (RR 1.97, 95% CI 1.76-2.19) and texting (RR 1.90, 95% CI 1.68-2.14) conditions (Table 4-6). The observed increase was limited to collisions and lane deviations, with a 5.5-fold increase in the collision rate (RR 5.48, 95% CI 1.45-20.68) and 3-fold increase in the lane deviation rate (RR 2.89, 95% CI 2.39-3.49) for the emailing condition, and a near 3-fold increase (RR 2.71, 95% CI 2.22-3.30) in the lane deviation rate during the texting condition. Regarding driving performance, again compared to the no secondary task condition, the cell phone condition was least associated with any performance measure; however, a statistically significant 42% reduction in the rate of eye glances off the road was observed (RR 0.58, 95% CI 0.42-0.78).

Regarding driving performance, again compared to the no secondary task condition, the cell phone condition had the least deleterious effect with any performance measure; however, a statistically significant 42% *decrease* in the rate of eye glances off the road was observed (RR 0.58, 95% CI 0.42-0.78). The emailing and texting conditions were associated with an increased rate of lane changes (RR 1.30, 95% CI 1.14-1.48 and RR 1.21, 95% CI 1.06-1.38, respectively) and eye glances off the road (RR 12.88, 95% CI 10.45-15.86 and RR 20.17, 95% CI 16.38-24.82, respectively). Interestingly, a 35% decrease in the rate of drivers riding the clutch was observed during the texting condition (RR 0.65, 95% CI 0.45-0.94).

Table 4-6. Association Between Secondary Tasks and Driving Violations

	No Task		Cell phone		Emailing		Texting	
Outcome	Mean	RR (95% CI)	Mean	RR (95% CI)	Mean	RR (95% CI)	Mean	RR (95% CI)
All violations† (per 100 miles)	126.4	Ref	133.0	1.03 (0.93-1.14)	250.0	1.97 (1.76-2.19)	243.4	1.90 (1.68-2.14)
Speeding (15+ mph)	2.9	Ref	3.8	1.35 (0.52-3.53)	4.3	1.56 (0.63-3.85)	4.4	1.29 (0.42-3.97)
Space management	62.6	Ref	68.2	1.09 (0.94-1.26)	65.8	1.05 (0.92-1.20)	69.0	1.11 (0.96-1.29)
Collisions	0.3	Ref	0.3	0.93 (0.15-5.75)	1.5	5.48 (1.45-20.68)	0.9	3.26 (0.63-16.96)
Lane deviations	60.8	Ref	60.7	0.95 (0.81-1.11)	178.4	2.89 (2.39-3.49)	169.1	2.71 (2.22-3.30)
Driving performance								
Lane changes (per 100 miles)	42.1	Ref	39.4	0.94 (0.82-1.08)	54.5	1.30 (1.14-1.48)	50.9	1.21 (1.06-1.38)
Eye glances off the road (per mile)	0.7	Ref	0.4	0.58 (0.42-0.78)	8.5	12.88 (10.45-15.86)	13.2	20.17 (16.38-24.82)
Engine stalls (per 100 miles)	0.6	Ref	0.6	1.12 (0.48-2.63)	1.1	1.94 (0.84-4.51)	1.0	1.78 (0.69-4.58)
Instances of hard braking (per 100 miles)	2.4	Ref	3.5	1.50 (0.87-2.60)	2.8	1.13 (0.63-2.04)	3.7	1.48 (0.76-2.88)
Riding the clutch (per 100 miles)	6.1	Ref	9.5	1.60 (1.01-2.54)	6.9	1.13 (0.70-1.84)	3.8	0.65 (0.45-0.94)

*Note.**Estimated from GEE analysis using a Poisson distribution with the natural log of miles driven as the offset; † Includes speeding (15+ mph), space management, collisions, and lane deviations

4.7 Association Between Secondary Tasks and Startup Procedure Violations

While there was no association between type of secondary task and startup procedures, several noteworthy findings related to safety emerged. For example, 22.2% did not wear their seat belt across all drives, with the cell phone condition having the highest proportion of occupants not wearing a seat belt (28.0%) (Table 4-7). This behavior occurred despite having been shown the location of the seat belt prior to the calibration drive. Additionally, slightly over one-third (35.3%) of participants did not have the parking brake set, with a high of 36% observed for the cell phone, emailing, and texting conditions.

Table 4-7. Association Between Secondary Task Conditions and Startup Procedure Violations

	No Task		Cell phone		Emailing		Texting	
Outcome	%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)	%	OR (95% CI)
Seat belt not fastened	22.9	Ref	28.0	1.19 (0.72-1.96)	20.0	0.82 (0.43-1.56)	18.0	0.72 (0.37-1.38)
Parking brake not set	33.3	Ref	36.0	1.20 (0.67-2.16)	36.0	1.17 (0.66-2.06)	36.0	1.17 (0.66-2.05)
Motion started when brake pressure was low	2.1	Ref	2.0	Undefined	4.0	Undefined	0.0	Undefined

*Note.** Estimated from GEE analysis using a logit distribution

4.8 Operational Efficiency by Secondary Tasks

Related to driving performance, there was no statistical difference in the miles per gallon (MPG) of fuel efficiency obtained during the presentation of secondary tasks, though fuel efficiency was slightly higher during the texting (mean 5.53 MPG) and emailing (mean 5.50 MPG) conditions as compared to the no secondary task (mean 5.43 MPG) and cell phone (mean 5.41 MPG) conditions. A significant decrease in the driving speed for the cell phone compared to the no secondary task condition was observed (54.97 vs. 56.65mph, p=0.0398) (Table 4-8).

Table 4-8. Comparison of Measures of Operational Efficiency by Secondary Task Conditions*

	No Task		Cell phone		Emailing		Texting	
Outcome	Mean	*p*-value	Mean	*p*-value	Mean	*p*-value	Mean	*p*-value
Driving speed (mph)	56.65	Ref	53.97	0.0398	54.84	0.1647	54.56	0.1069
Miles per gallon	5.43	Ref	5.41	0.8790	5.50	0.5980	5.53	0.4509

*Note.** Estimated from repeated measures ANOVA; Posted speed limit ranged from 55mph to 60mph.

4.9 *Association Between Driver Characteristics and Cognitive Performance*

In general, there was no association between driver characteristics and the cognition measures of interest (Table 4-9). A statistically significant effect for ESS score was observed with UFOV® subtest 2, with a 1-unit increase in ESS score associated with a 4.53-unit decrease in UFOV® subtest 2 (p = 0.0458). Of note, increasing days with caffeine consumption was associated, though not significantly, with decreased UFOV® subtest 2 (β = -0.455, p = 0.1797) and reaction time (β = -2.71, p = 0.1040). Additionally, medication use had particularly strong associations with UFOV® subtest 2 and reaction time, though, again, not statistically significant due to low numbers of participants reporting medication use. Of particular interest, mean reaction time increased with reported use of anti-hypertensive (β = 16.08, p = 0.1291) and lipid lowering medication (β = 29.91, p = 0.2654) and decreased with reported use of diabetic medication (β = -9.29, p = 0.7310). Adjusted for self-reporting snoring, all medications had an increased association with UFOV® subtest 2, with the strongest association observed for diabetic medications (β = 57.59, p = 0.2897).

Table 4-9. Association Between Health Indicators and Cognitive Measures.

	UFOV® subtest 2			Mean reaction time			Lapses		
Variable	Crude β estimate	Adjusted β estimate*	*p*-value*	Crude β estimate	Adjusted β estimate*	*p*-value*	Crude β estimate	Adjusted β estimate*	*p*-value*
Age (years)	0.29	1.30	0.2210	-0.41	-0.09	0.8697	0.02	0.02	0.4325
Medication use									
Anti-hypertensive	4.02	5.90	0.7856	15.09	16.08	0.1291	-0.10	-0.12	0.8013
Lipid lowering	-10.76	4.65	0.9323	21.14	29.91	0.2654	1.22	1.12	0.3422
Diabetic	40.27	57.59	0.2897	-16.63	-9.29	0.7310	0.20	0.06	0.9603
Days with caffeine consumption	-3.91	-4.55	0.1797	-2.38	-2.71	0.1040	-0.02	-0.02	0.8298
Sleep time (per hour)	-0.82	0.18	0.9680	-1.60	-1.02	0.6907	-0.02	-0.04	0.7254
ESS (total score)	-5.09†	-4.53	0.0458	-0.98	-0.43	0.7050	0.01	-0.01	0.8998

*Note.** Adjusted for presence of snoring; † Crude *p*-value <0.05

4.10 *Association Between Driver Health, Age, and Cognition, and Driving Violations*

While driver characteristics were not associated with driving violations as a whole, there were associations of note. Specifically, a one-hour increase in usual sleep time was associated with a 24% reduction in the rate of speeding in excess of 15 mph of the posted speed limit (RR 0.76, 95% CI 0.76, 0.59-0.99) and a 34% *decrease* in the collision rate (RR 0.66, 95% CI 0.48-0.91) (Table 4-10). A one-unit increase in the ESS score was associated with a 3% increase in the space management violation rate (RR 1.03, 95% CI 1.00-1.05). Additionally, a 1-unit increase in the mean reaction time was associated with a 2% increase in the collision rate (RR 1.02, 95% CI 1.00-1.03).

Table 4-10. Association Between Driver Health, Age, and Cognition, and Driving Violations.

	All violations†	Speeding (15+ mph)	Space management	Collisions	Eye glances
Variable	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
Age (years)	1.01 (0.99-1.03)	0.96 (0.89-1.03)	1.00 (0.99-1.01)	1.01 (0.94-1.09)	1.00 (0.99-1.01)
Medication use (frequency)					
Anti-hypertensive	1.26 (0.93-1.69)	2.57 (0.59-11.29)	1.14 (0.95-1.36)	1.75 (0.42-7.23)	0.98 (0.79-1.21)
Lipid lowering	1.10 (0.99-1.23)	Undefined	1.43 (1.32-1.55)	Undefined	0.70 (0.66-0.74)
Diabetic	1.19 (1.07-1.33)	Undefined	1.09 (1.01-1.19)	Undefined	1.26 (1.19-1.35)
Days with caffeine consumption	1.01 (0.97-1.06)	0.99 (0.86-1.13)	1.00 (0.96-1.04)	0.96 (0.81-1.14)	0.98 (0.96-1.01)
Sleep time (hours)	0.94 (0.88-1.00)	0.76 (0.59-0.99)	0.97 (0.93-1.01)	0.66 (0.48-0.91)	1.01 (0.97-1.05)
ESS (total score)	1.029 (1.002-1.056)	1.070 (0.940-1.219)	1.026 (1.001-1.051)	1.064 (0.944-1.198)	1.006 (0.990-1.022)
UFOV® subtest 2 (ms)	0.998 (0.996-0.999)	0.982 (0.964-1.001)	0.998 (0.997-1.000)	0.997 (0.988-1.006)	1.001 (0.999-1.002)
Mean reaction time (ms)	1.003 (0.999-1.007)	1.013 (0.997-1.029)	0.999 (0.997-1.001)	1.015 (1.003-1.025)	0.999 (0.997-1.002)
Lapses (number)	1.066 (0.986-1.153)	1.014 (0.809-1.271)	1.013 (0.955-1.075)	0.885 (0.568-1.377)	1.013 (0.960-1.068)

*Note.** Estimated from GEE analysis using a Poisson distribution with the natural log of miles driven as the offset; † Includes speeding (15+ mph), space management, collisions, and lane deviations

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Chapter 5 – Further Research

5.1 Overview

Findings from this study, supported by a public-private partnership, have made a unique contribution to the scientific literature. We focused on how important health factors interact with secondary tasks to affect commercial driver performance.

Combating distracted driving is a national transportation goal, as evidenced by the Federal Motor Carrier Safety Administration’s final ruling prohibiting interstate truck and bus drivers from using hand held cell phones while operating commercial motor vehicles (USDOT, 2011). While there have always been distractions on the road, a proliferation of on-board communication technologies coupled with an ever-increasing supply of new and sophisticated electronic devices available for personal use has increased the potential for vehicle operators to be even more distracted today than they have been in the past. Communication between company dispatchers and drivers is essential, and onboard communication devices have provided solutions a practical solution for keeping drivers and dispatch connected. However, the results from this study should urge drivers to communicate with dispatch only while the vehicle is not in motion, to prevent potentially dangerous driving outcomes. It is also interesting to note that while drivers may be able to control their initiation of communication with dispatch, they cannot control dispatch’s communication with them. Educational campaigns directed towards dispatchers regarding the negative impact of distraction might also be a useful countermeasure to consider. Company policies and procedures might also consider modifications to minimize the amount of interaction between dispatcher and driver during periods of time when the vehicle is in motion.

Findings suggest that while all secondary tasks impact driving performance, not all tasks are equally deleterious. For example, similar to previous research, findings suggested that hand held cell phones had the least deleterious effect with any driving performance outcome (Olson et al., 2009). On the other hand, the more visually demanding secondary tasks (emailing and texting) degraded driving performance to a greater degree, as evidenced by increases in driving violations, collisions, and lane deviations during these conditions. In light of the recent ban on hand held cell phones (USDOT, 2011), the findings from the present study suggest the need for additional restrictions to include restricting the use of on-board communication devices while the commercial vehicle is in motion. Note that the ban on cell phones does not include hands-free configurations. Clearly, the research regarding the differences between the effect of hands-free and hand-held devices on commercial driving performance is mixed, (Olson et al., 2009; Strayer & Johnston, 2001) and further consideration is warranted.

Visual attention while driving is a critical component for safety. The farther away from road center a driver looks, the less able drivers are to detect roadway events and remain in their lane (Victor et al., 2009), indicating glances away from the road affect a driver’s ability to visually detect and process relevant driving safety information. Consistent with our findings regarding eye glance behavior during engagement in certain secondary tasks (e.g., text messaging and emailing) in CMV drivers, Hosking et al. (2006) found that light vehicle drivers' eyes focused significantly less on the road while text messaging in a high-fidelity driving simulator. However, it is particularly noteworthy, that eye glance behavior varies by type of secondary task. Another study spanning a 6-week time period with a sample of 10 drivers found an association between cell phone conversation and frequency of long-eye fixations on the roadway ahead (Mazzae et al., 2004). That is, as the length of the cell phone conversation increased, the time spent fixating forward on the roadway increased. A similar pattern of results was found in the present study; a significant reduction in off road eye glances during the cell phone condition. Given that visual attention to the roadway results in decreased crash risk (Hanowski, 2009; Olson et al., 2009) then talking on a cell phone may act as a *protective measure* in CMV drivers by indirectly causing them to increase their visual attention on the road center while conversing.

Along with the findings related to the use of electronic devices as secondary tasks, the study yielded interesting findings related to sleep, health, and cognition. Aside from Mallampati and tonsillar scoring, biometric and demographic markers, findings are consistent with those previously described in earlier studies. That is, participants were predominantly white, male, company drivers, were generally obese, and experienced health issues previously attributed to this group: hypertension, mental health concerns, and diabetes. For the most part, drivers reported sleep time that is considered adequate for driving safety. Although drivers didn't report scores on ESS that would indicate increased sleep propensity, 21% of them reported being sleepy at the time of the trial. The primary disturbance to sleep cited by participant was heat. Although 96% of participants reported having control over their sleep while working, 34% acknowledged that it was hard – very hard to structure sleep time while working. Given the prevalence of obesity in this group, it was surprising that participants did not have higher Mallampati and tonsillar scores. We also used diagnosis of OSA as an exclusion criterion for the study. Again, given the prevalence of obesity, snoring, and hypertension in the group, we suspect that there are likely participants who have undiagnosed OSA.

Our findings support those of past studies, in which driving performance was related to sleep time in a dose-response manner. In other words, increasing sleep time was associated with decreased speeding, and collision risk, Increasing sleep propensity was also shown to be associated with increased space management violations e.g. "tailgating". These findings suggest that sleep deprivation and increased sleep propensity influence judgment and risk-taking behavior in commercial drivers, as has been posited in a recent study of sleep-deprived healthy adults performing a non-driving task (Killgore, Kamimori, & Balkin, 2011). Moving forward, it will be important to continue to investigate the relationships between sleep deprivation and risk-taking, to determine the extent of the relationships, and potential mitigating countermeasures.

After controlling for snoring, the most common sign of OSA, we found a significant relationship between sleep propensity, measured by ESS, and visual processing speed, measured by UFOV®.

That is, decreasing ESS was associated with decreasing UFOV®. In other words, as sleep propensity, or the likelihood of dozing in certain circumstances, decreased, visual processing speed increased.

The age of participants was perhaps lower than the general truck driving population last reported by USBLS (44 years old). Although none of the participants physically unloaded the freight they transported, they were all involved in physical activities at work. For example, all of the participants performed at least some physical activities during the course of their workday. Examples of these activities included: climbing on and off the trailers, tarping, chaining, and strapping loads. Because of the level and nature of physical activity involved, drivers may have self-selected. In other words, a younger, more physically fit group of commercial drivers may have comprised our sample, compared to the sample that we would have recruited had we involved drivers who did not engage in these highly physical activities (dry van drivers, for example). This may partially, at least, account for the younger age of our participants, and may have affected associated health issues. In other words, the younger group of drivers may not have experienced some of the health issues at the same frequency or in the same way as an older group of drivers would have.

5.2 Impact

Overall, we posit the results of this research effort are informative and important enough to have a major impact on transportation research, legislation as well as driver / roadway safety.

We have already begun to see the impact of our research findings on policy in the private sector. During the course of our study we were made aware that some of our research participants approached their company to tell them about the errors they made while driving in the simulator and emailing using an on-board communication system. Their companies subsequently made policy changes that rendered the on-board communication system inoperable at speeds greater than 5mph. Given the size of the companies involved, this policy change and unexpected benefit could impact over a thousand commercial truck drivers, in addition to the countless number of drivers who share America's roadways.

Findings from our study may influence future policies and regulations related to the use of communication devices, hours of service, and medical certification of commercial drivers. It is evident that commercial drivers need to have the ability to communicate with their employers, customers, and important others. The question is, "What is the safest communication device, and when should it be used?" Recently, FMCSA instituted a ban on hand-held cell phones for use by commercial drivers. The findings from our study indicated that use of the hand-held cell phone was associated with fewer eye glances off the "road" and fewer driving errors, compared to text messaging and use of an on-board communication device for email. Therefore, our findings could be used to influence the modification of this ban. Also, our findings should be used to influence manufacturers of on-board communications devices to install restrictions on the devices that disable it when the commercial vehicle is moving, and that cannot be over-ridden. This would not only enhance commercial driver safety, but could potentially decrease the liability of device manufacturers in the event of crashes that are associated with property loss and fatal/non-fatal injuries.

This group of participants reported mean sleep times that have historically been associated with safe driving performance (7.5 hours), and they did not reach the threshold for excessive daytime sleepiness measures by the ESS-a score of 10 or higher. However, it is important to note that increased sleep time was associated with decreased driving risk-measured by space management violations and speeding greater than 15 mph over the speed limit. Therefore, our findings will support ongoing efforts to identify the optimum amount of sleep time necessary for peak commercial driver performance and evidence-based hours of service policy and regulations.

The associations between use of certain medications and cognitive decline are of critical interest to health care providers and also to the medical certification arm of FMCSA. Our findings may serve as a catalyst for future, larger studies of medication use, cognition, and driving performance that could change current medical certification guidelines for commercial drivers with medical conditions associated with cardiometabolic dysfunction: diabetes, hypertension, and hyperlipidemia.

5.3 Limitations

During the course of the study, we identified limitations that might have affected our results. In spite of these limitations, this study made an important contribution to our knowledge of commercial drivers' health and cognition and how those factors affect driving performance. We acknowledge that the sample size of 50 participants limits the generalizability of our findings. This study was likely underpowered to detect significant relationships among particular outcomes of interest.

While the use of simulators is useful for ethical and safe data collection, it is difficult to ascertain whether driver behavior in the controlled laboratory setting would exactly mirror that of on-the-road driving behavior. Recent studies have validated simulator performance with real-world driving (Morgan et al., 2011), suggesting the use of this type of equipment may prove to be useful tools for research and training purposes with CMV drivers. Future research is needed to validate the L-3 Communications TranSim™ truck driving simulator.

Because we were limited to truck simulator use only in the evenings, all data were collected at night, usually after participants had completed a work assignment or while waiting for their next assignment. While the data did not show overall sleep deprivation, potential circadian effects of nighttime data collection should be considered and evaluated in future studies. An alternate approach might be to collect data at different times during the circadian cycles to offset any inherent bias by focusing on only one circadian phase.

Recall bias may have been an issue for some key independent variables (e.g. sleep time, frequency of distracted driving) that were self-reported. The team originally proposed to collect an objective proxy measure of sleep time using actigraphy, but was refused because of liability concerns. Alternate methods (e.g., in-vehicle monitoring devices) for collecting information regarding frequency of distracted driving were not feasible nor cost-effective. Self-report was also used to acquire information regarding drivers experience with electronic devices. Future research may consider whether drivers use electronic devices for personal or business reasons.

It is possible that participants did not perform in the simulated drives in the same manner they would have in naturalistic driving conditions, a phenomenon known as the Hawthorne Effect. In this experimental design, participants were encouraged to engage in secondary tasks while driving (cell phone, emailing, texting). If participants did not routinely perform these tasks in their day-to-day driving, their driving performance in the simulator may have shown degradation due to lack of regular engagement in the activity.

Many participants engaged in activities between the drives that could have been stimulating such as walking around the terminal, and using nicotine and/or caffeine. These activities and substances may have altered the performance of participants in subsequent drives. That is, driving performance degradation may have been masked. The investigators considered modifying study procedures early on to prevent participants from engaging in these sorts of activities. However, the decision was made to continue on the original protocol for the sake of participant comfort and to mimic a “real” drive, knowing that many participants smoke and consume caffeine while driving. Future considerations may include documenting the qualitative observations of caffeine consumption, nicotine use, and physical activity and their impact on driving performance.

5.4 Implications for Future Research and Partnerships

This study is among the first of its kind to investigate the intersection of health, cognition, and distraction among commercial truck drivers. The findings warrant further examination in several areas. For example, findings suggest there is a critical need to examine the ergonomic issues related to the placement of on-board communication devices in the cab of the truck. It is unknown whether the physical placement of such equipment could markedly improve the driver’s ability to keep their eyes on the road. With regard to placement, ergonomists might also inspect the effects of the use of on-board communication devices on body and head movements, the ability to keep eyes on road, vehicle control, and critical events.

There are also important driver-vehicle interface implications. Results might influence the design of in-vehicle technologies. Findings suggest that a cell phone conversation degraded performance to the lowest degree as compared to other secondary tasks (texting and emailing) which required more manual manipulation. Therefore “talk to text/email” device configurations (“hands-free”) might prove to be less taxing for truck drivers, who have a dire need to communicate for fleet and route information while on the job, but who also must keep safety a priority given the extremely high costs associated with crashes in this sector. However, we also acknowledge previous research studies which have found cognitive distraction to be a prominent factor, making "hands-free" configurations just as risky as "hands-held" in some cases (Strayer & Johnston, 2001).

In this group of participants, age did not have a significant effect on cognition and driving performance. However, these participants were younger than the mean age of U.S. commercial drivers overall. Therefore, they might not have exhibited expected cognitive changes and resulting driving impairment related to aging in the same way that an older group of commercial drivers would have. Given the current U.S. economic downturn, new entrants into the trucking industry may be older, and drivers who are aging may stay in the workforce longer because of financial concerns. Therefore, the issue of older commercial driver cognition and driving performance is an issue that merits future research using a larger sample size, and a sample more representative of the overall commercial driver age demographic.

We found that decreased sleep propensity was associated with improved visual processing speed, measured by performance on UFOV®. Although age and cognition were not significantly associated in this study, and both visual processing speed decline and remediation are most common in older drivers, implications for future studies related to the issues of sleep and visual processing speed are suggested. Future studies of cognitive remediation in drivers who have increased sleep propensity may show that the intervention can mediate cognitive decline associated with sleep problems. This is an extremely important future study, especially since the intervention is already commercially available, is easy to administer, and has shown sustained effects in studies of non-commercial drivers (Vance, 2009).

The associations of medication use and cognition, although not statistically significant, are worth noting. The use of anti-hypertensives, lipid-lowering, and glycemic-control medications was associated with worsening cognitive performance-measured by UFOV®, but not with number of lapses measured with PVT. The greatest magnitude of decline in UFOV® was noted with the use of glycemic-control medications. However, there were only three non-insulin dependent diabetic participants. Given the prevalence of obesity and associated non-insulin dependent diabetes mellitus, hypertension, and hyperlipidemia, these associations should be investigated in a larger sample size in order to have the statistical power to detect differences in cognitive performance that might not have been detected in this study.

As previously mentioned, our research had an unexpected benefit, evidenced by companies implementing a policy for use of on-board communication devices (lock out over 5 mph). Not only can these findings have a major impact on policy, but it is also important to consider that behavior modification strategies might be employed using simulator training. For example, new drivers might be given an opportunity to experience the deleterious effects of certain secondary tasks in a safe, simulated environment. Additional research could determine whether simulator training can have transfer to real-world decision making.

5.5 Conclusion

Findings from this study have the potential to impact multiple stakeholders; the research results hold great promise for making a major impact on transportation research, legislation and most importantly driver/roadway safety. The findings from this study may lead to implementation of interventions such as “hands-free” communication devices inducing only a minimal level of cognitive workload in the short term that will maintain a safe level of driving performance for commercial drivers. Another important intervention that may emerge from this study is the development, and consistent implementation of a sleep and fatigue management program for active commercial drivers and commercial driver trainees. It may also be that findings from the study will lead to reconsideration of policy regarding age and medication use among commercial drivers. In the long term, we are hopeful and optimistic that findings from the study will help reduce the incidence of commercial vehicle crashes related to distracted driving and concomitant health factors of commercial vehicle drivers.

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Chapter 6 – References

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Appendix A – Truck Driver Survey

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Subject ID: ________________________

Truck Driver Survey

This survey asks about a number of topics related to your driving history and your health issues. Please base your answers on your current work experience or on time frames given to you in specific questions. For questions that ask for a number, your best guess is fine.

Subject ID: ________________________

DRIVING HISTORY

1. How many years have you held a Class A Commercial Driver's License?

   ______ # Years

2. What is your current employment status? *Circle one*
   - A. Company driver
   - B. Independent Owner/Operator with own operating authority
   - C. Owner/Operator leased to a company
   - D. Other *Please explain*: ________________________________

3. What is the average length of a typical trip when you drive a commercial vehicle for work? *Enter a number in both blanks*

   ______ # Total miles
   ______ # Total days

4. On average, how many days do you break between work trips? *Enter # of days*

   ______ # Days between trips

5. During an average week, how many days in a row are you on the road driving a commercial vehicle?

   ______ # Consecutive days on the road in average week

6. How many hours of your sleep time do you spend in the sleeper berth of your commercial vehicle? *Enter a number in both blanks Enter **NA** if none*

   ______ # Hours in sleeper berth
   ______ # Hours of sleep time

7. How often do you drive a commercial vehicle with a driving partner (team)? *Circle one*
   - A. Never
   - B. Rarely (less than half of the time)
   - C. Sometimes (about half the time)
   - D. Often (more than half of the time)
   - E. Always

Subject ID: ________________________

8. How often do you load or unload your own freight? *Circle one*
   - A. Never
   - B. Rarely (less than half of the time)
   - C. Sometimes (about half the time)
   - D. Often (more than half of the time)
   - E. Always

8a. If you load or unload your freight, please describe what physical activities you do. For example: use a forklift or pallet jack, tarp and chain loads, assemble and attach hoses to proper fittings, and/or turn dials and controls. *Write **NA** if you never unload freight*

____

____

____

____

9. How many crashes have you had within the past year? *Enter 0 if none*

______ # **work-related** crashes in the past year
I was at fault in_____ (#) work-related crashes in the past year.

______ # **NON work-related** crashes in the past year
I was at fault in _____ (#) NON work-related crashes in the past year.

10. How many motor vehicle crashes have you had in your lifetime? *Enter 0 if none*

______ # **work-related** motor vehicle crashes in lifetime
I was at fault in _____ (#) work-related crashes in my lifetime.

_______ # **NON work-related** crashes in my lifetime
I was at fault in _____ (#) NON work-related crashes in my lifetime.

11. How many **work-related** tickets for a moving violation (such as speeding or reckless driving) have you received in the past **12 months**? *Please do not count parking tickets*

_____ # **work-related** moving violation tickets in past **12 months**

12. How many **NON work-related** tickets for a moving violation (such as speeding or reckless driving) have you received in your **lifetime**.

_____ # **NON work-related** moving violation tickets in your **lifetime**.

13. What type of roads do you most often drive on when driving a commercial vehicle? *Circle one*
    A. Interstate
    B. Local
    C. Highway
    D. Rural

14. What type of commercial vehicle do you currently drive? *Circle one*
    A. Single unit
    B. Single trailer
    C. Multi trailer
    D. Other *Please explain*: ______________________

15. How experienced do you think you are as a commercial driver? *Circle one*
    A. Very Experienced
    B. Experienced
    C. Somewhat Experienced
    D. Not Experienced at all

16. How skilled do you think you are as a commercial driver? *Circle one*
    A. Very Skilled
    B. Skilled
    C. Somewhat Skilled
    D. Not Skilled at all

17. How well has your work-related training prepared you for dangerous road conditions while on the job? *Circle one*
    A. Very Well
    B. Well
    C. Somewhat Well
    D. Not Well at all

18. How big of a problem do you think distracted driving is for the average motor vehicle driver? *Circle one*
    A. Very Big
    B. Big
    C. Somewhat Big
    D. Not Big at all

19. How big of a problem do you think distracted driving is for other commercial vehicle drivers? *Circle one*
    A. Very Big
    B. Big
    C. Somewhat Big
    D. Not Big at all

20. Have you received training or information from your employer regarding the risks of distracted driving?
    A. Yes B. No

Subject ID: ________________________

Electronic Device Use History

21. How old were you when you started using text messaging on a cell phone?

    _____ Age

22. Does the current phone you are using have a touch screen?

    A. Yes B. No

23. What type of text messaging system are you using today? *Circle all that apply*

    A. abc: to text the word "the" you would push the buttons "8-4-4-3-3"
    B. T9 (predictive text): to text the word "the" you would push the buttons "8-4-3"
    C. keyboard: to text the word "the" you would push the buttons "t-h-e"
    D. Other *Please explain*: ____

24. How long have you been using this type of text messaging system?

    _____ # Months

25. While operating your commercial vehicle, what are the three cell phone applications you use most often?

    1. ____
    2. ____
    3. ____

26. Please imagine a typical drive where you are driving your commercial vehicle. Think about the things you do with your phone while headed to your destination. In the space provided below, describe these activities. *If more than 3, please list the 3 most common*

    For example:
    1. I call a family member while driving down the interstate.
    2. I read and respond to a text from my best friend while at a stop sign.
    3. I play Solitaire while driving through the neighborhood.

    1. ____
    2. ____
    3. ____

Subject ID: ______________________

27. During an average week, how many days per week (out of 7) do you do the following activities **WHILE** you are working? *You may respond **NA** for activities you do not do*

# work days per week	# times per workday	Activities
______	______	drive other passengers in your truck?
______	______	change songs on your mp3 player while driving?
______	______	eat while driving?
______	______	drink (non-alcoholic beverages) while driving?
______	______	talk on a "hands-free" cell phone while driving?
______	______	talk on a "hands-held" cell phone while driving?
______	______	send a text on a cell phone while driving?
______	______	receive a text on a cell phone while driving?
______	______	write and send email on a cell phone while driving?
______	______	read an email on a cell phone while driving?
______	______	access the internet on a cell phone while driving?
______	______	download/ purchase music on a cell phone while driving?
______	______	leave voice/written memos on a cell phone while driving?
______	______	use a GPS/navigation system while driving?
______	______	reach for object; not taking your eyes off the road while driving?
______	______	use applications on a cell phone while driving?
______	______	enter and log trip hours while driving?
______	______	enter and log trip expenses while driving?
______	______	use CB radio while driving?
______	______	use Qualcomm while driving?

Subject ID: ________________________

Please use the following 1-5 scale to answer the questions below: *You may write in **NA** for situations which do not apply to you*

1-------------------------2------------------------3------------------------4-------------------------5

Not at All Dangerous	Somewhat Dangerous	Very Dangerous

_____28. For someone your age and with about the same driving experience as you, how dangerous do you think it is to send texts while driving a commercial vehicle?

_____29. For someone your age and with about the same driving experience as you, how dangerous do you think it is to read texts while driving a commercial vehicle?

_____30. For someone your age and with about the same driving experience as you, how dangerous do you think it is to talk on a "hands-free" cell phone while driving a commercial vehicle?

_____31. For someone your age and with about the same driving experience as you, how dangerous do you think it is to talk on a "hand held" cell phone while driving a commercial vehicle?

_____32. For someone your age and with about the same driving experience as you, how dangerous do you think it is to read emails on a cell phone while driving a commercial vehicle?

_____33. For someone your age and with about the same driving experience as you, how dangerous do you think it is to write and send emails on a cell phone while driving a commercial vehicle?

Subject ID: ________________________

Please use the following 1-5 scale to answer the questions below: *You may write in **NA** for situations which do not apply to you*

1-------------------------2------------------------3-------------------------4-------------------------5

Not at all Distracted	Somewhat Distracted	Very Distracted

_____34. How distracted do you feel when driving alone and doing nothing else but driving?

_____35. How distracted do you feel when talking on a cell phone while driving?

_____36. How distracted do you feel when there is one (1) other passenger in the car with you?

_____37. How distracted do you feel when there are two (2) or more other passengers in the car with you?

_____38. How distracted do you feel when changing radio stations while driving?

_____39. How distracted do you feel when changing songs on your mp3 player while driving?

_____40. How distracted do you feel when eating while driving?

_____41. How distracted do you feel when using a GPS/navigation system while driving?

Subject ID: ________________________

General Medical History

42. Have you ever been diagnosed by a doctor, nurse practitioner or physician assistant with any of the following problems? *Circle all that apply*

A. High blood pressure
B. Heart attack
C. Heart failure
D. Stroke
E. Liver problems
F. Kidney problems
G. Diabetes
H. Cancer-except skin
I. Drug abuse
J. Fibromyalgia
K. Heart rate problem (too fast or too slow)
L. Concussion
M. Condition requiring brain surgery
N. Emotional or psychiatric problems such as depression, anxiety, bipolar, post-traumatic stress, schizophrenia
O. Thyroid problems
P. Seizure
Q. Alcoholism
R. Chronic fatigue syndrome
S. Chronic pain
T. Heart rhythm problem (irregular, skipped or extra beats)

Caffeine and Medication Substance Use

43. Within the past month, how many days per week (out of 7) have you consumed beverages, foods, or supplements containing caffeine? *Your best guess is fine* *Enter **NA** if none*

_____ # Days per week consumed beverages, foods, or supplements containing caffeine in last month.

44. Within the past month , what prescription medication, over-the-counter medication, herbal compound, energy drink, or dietary supplement you have used. *Please list all that apply*

____

____

____

____

45. Within the past month, how many days per week (out of 7) have you consumed alcoholic beverages? *Your best guess is fine* *Enter **NA** if none*

______ # Days per week drank alcohol in past month

46. Within the past month, how many days per week (out of 7) have you used recreational or “street” drugs? *Your best guess is fine* *Enter **NA** if none*

______ # Days per week used recreational/street drugs in past month

Subject ID: ________________________

Sleep History

47. Have you ever experienced or has your bed partner/spouse or driving partner ever told you that you have any of the following problems related to sleep? *Circle all that apply*

A. Snoring that disturbs others
B. Choking
C. Stopped breathing
D. Tightness in chest
E. Sputtering/gagging
F. Difficulty breathing
G. Irresistible urge to sleep during the day
H. Gasping
I. Morning headaches
J. Congested nose or allergy
K. Waking with coughing fits
L. Throat dry on waking
M. Forgetfulness
N. Walking
O. Sleep talking
P. Severe recurring nightmares or night terrors
Q. Grinding teeth
R. Kicking or twitching legs
S. Acting out your dreams
T. Loss of muscle tone when experiencing strong emotion (while awake)
U. Other *Please explain*: _________________
____

Subject ID: ________________________

48. The following questions relate to your most recent major sleep period (do not include naps). *Please write in the times and then circle either AM or PM for each Your best guess is fine*

A.	What time did you settle down to sleep?	_____:_____	AM / PM
B.	What time did you fall asleep?	_____:_____	AM / PM
C.	What time did you wake up?	_____:_____	AM / PM
D.	What time did you get up out of bed?	_____:_____	AM / PM

49. How deeply did you sleep? *Circle one*

A. Very light
B. Light
C. Fairly light
D. Average
E. Fairly deep
F. Deep
G. Very deep

50. How many times did you wake up? *Your best guess is fin. Enter **NA** if none*

_____ # Times woke up during last major sleep period

51. How much sleep did you get? *Enter both hours and minutes*

______ # Hours
______ # Minutes

52. How well did you sleep? *Circle one*

A. Very badly
B. Badly
C. Fairly badly
D. Neither badly nor well
E. Fairly well
F. Well
G. Very well

53. Did any of the following disturb you during your last major sleep? *Circle all that apply*

a. The heat
b. The cold/draft
c. The humidity
d. Lack of ventilation
e. Condensation
f. Light
g. Noise from the radio
h. Traffic-related stress
i. Noise from outside the truck
j. Alcohol
k. Illness
l. Breathing problems
m. Stress due to time pressure
n. Stress due to family
o. Noise from loading/unloading
p. Noise from the telephone
q. Noise from the weather
r. Noise from the computer/Qualcomm
s. Noise made by co-driver/partner
t. Customer-related stress
u. Vibration
v. Dispatcher-related stress
w. Stress due to partner's driving
x. Coffee/caffeine
y. Snoring
z. Truck motion
aa. Stress due to weather
bb. None of these bothered me
cc. Other *Please explain:* ___________________
____

54. How satisfied are you with the sleep you had?

A. Very satisfied
B. Satisfied
C. Neither satisfied nor dissatisfied
D. Dissatisfied
E. Very dissatisfied

55. While you are working as a trucker, how easy is it for you to structure your time to get the sleep you feel you need? *Circle one*

A. Very hard
B. Hard
C. Neither easy nor hard
D. Easy
E. Very easy

Subject ID: ________________________

56. How much control do you have over your sleep time while you are working? *Circle one*

A. Absolutely no control
B. A little control
C. Moderate control (about half the time)
D. Control most of the time
E. Complete control

Please use the following 1-5 scale to answer the questions below: *You may write in* ***NA*** *for situations which do not apply to you*:

1-------------------------2------------------------3-------------------------4-------------------------5

Not at all affected	Somewhat affected	Greatly affected

How much have the following issues affected the safety of your work?

_____ 57. Fatigue
_____ 58. Stress
_____ 59. Distraction by you
_____ 60. Distraction of other drivers on road
_____ 61. Electronic billboards
_____ 62. Traffic Congestion

Background Information

Please answer these last few questions so that we can better understand the profile of workers in the trucking industry. All your answers will be held in strict confidence.

63. Today's Date (Month/Day/Year): _____/_____/_____

64. Date of Birth (Month/Day/Year): _____/_____/_____

65. How old were you when you first started working as a long-haul trucker? *Your best guess is fine*

______ Age when first started long-haul trucking

66. When you are working as a long-haul trucker, how many hours per week do you work? *Your best guess is fine*

______ # Work hours per week

67. How many weeks out of the year do you work as a long-haul trucker?

______ # Work Weeks per year as long-haul trucker

68. In what year where you born?

19_____ Year born

69. What is your gender? *Circle one*

Male Female

70. What is your current marital status? *Circle one*

A. Married
B. Single
C. Divorced
D. Separated
E. Widowed
F. Other *Please explain*: ______________

71. Circle the highest level of education you have completed.

A. Less than 12th grade
B. High school diploma or GED
C. Some college
D. College graduate
E. Graduate school

72. How would you best describe yourself? *Circle all that apply*

A. Caucasian or White
B. African American or Black
C. Asian-American or Pacific Islander
D. Hispanic or Latino
E. Native American or American Indian
F. Other *Please explain:* ______________

73. Which of the following best describes your household income from all sources before taxes for the year 2010? *Circle one*

- A. $35,000 or less
- B. $35,001 to $55,000
- C. $55,001 to $75,000
- D. $75,001-$100,000
- E. $100,001 or more

Thank you for participating in this survey.

Is there anything else you would like to add about your experiences as a long-haul trucker, your sleep or health issues? *Please write any comments in the space below*

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Appendix B – Epworth Sleepiness Scale (ESS)

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EPWORTH SLEEPINESS SCALE (Johns, 1991)

Please use the following 0 -3 scale to answer the questions below.

0------------------------	1------------------------	2------------------------	3
No Chance Of dozing	Slight Chance of dozing	Moderate Chance of dozing	High Chance of dozing

For this next question, think of your usual way of life in recent times. How likely are you to doze off or fall asleep in the following situations?

_____ 1. Sitting and reading
_____ 2. Watching TV
_____ 3. Sitting, inactive in a public place (a theater or a meeting)
_____ 4. As a passenger in a car for 1 hour without a break
_____ 5. Lying down to rest when circumstances permit
_____ 6. Sitting and talking to someone
_____ 7. Sitting quietly after lunch without alcohol
_____ 8. In a car, while stopped for a few minutes

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Appendix C – Karolinksa Sleepiness Scale (KSS)

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KAROLINSKA SLEEPINESS SCALE (Akerstedt & Gillberg, 1990)

Shown below is a scale from 1 to 9 with various descriptors about how alert or sleepy you may be feeling **right now**. *Please read them carefully and circle the number that best describes how you feel right now*

1---------------2---------------3---------------4---------------5---------------6---------------7---------------8---------------9

1	3	5	7	9
Extremely Alert	Alert	Neither alert nor sleepy	Sleepy/ but no difficulty staying awake	Extremely Sleepy/ fighting sleep