Newly Licensed Teenaged Drivers: A Field Study Evaluation of Eye Glance Patterns on Straight Road Segments.

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ABSTRACT

There is extensive evidence indicating that teenaged drivers are over-represented in automobile crashes. Motor vehicle crashes are the leading cause of death for 15-20 year olds, accounting for over 40% of all fatalities for this age group. Although teen drivers account for only 6.3% of the driving population, they account for 14% of all traffic fatalities (TSF, 2004). Currently there is a lack of continuous and naturalistic data in the field of teenaged driving. The purpose of this study was to obtain continuous performance data from a naturalistic setting by equipping the personal vehicles of newly licensed teenaged drivers with a data collection system for the first six months of driving. Specifically, this study examined the eye scanning patterns of newly licensed teenaged drivers and experienced parent drivers on straight road segment. This study provides insight into the development and change of eye-glance behaviors over the first six months of driving, the differences between novice teenaged drivers and experienced parent drivers, and how passenger presence affects eye scanning patterns. Results from this study found significant differences between novice teenaged drivers and experienced adult drivers. The results showed that teenaged drivers had much shorter glance durations away from the forward roadway and allocated a higher percentage of their glances to locations that were considered driving-related when compared to the experienced adult group. Results from the study also showed when one passenger was present in the vehicle teenaged drivers tended to have a higher percentage of time spent with their eyes off of the forward roadway.

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1.0 Introduction

1.1 Problem Statement

There is extensive evidence indicating that teenaged drivers are over-represented in automobile crashes. Currently motor vehicle crashes are the leading cause of death for 15-20 year olds, accounting for over 40% of all fatalities for this age group. Although teen drivers account for only 6.3% of the driving population, they account for 14% of all traffic fatalities (TSF, 2004).

Research has shown that 16-19 year old drivers are three times more likely to be involved in an accident than 25-29 year old drivers (Doherty, Andrey & MacGregor, 1996). This increase in risk is attributed to risk taking behavior, over-estimation of ability, and limitations in driver performance due to lack of experience (Gonzales, Dickinson & DiGuiseppi, 2005).

According to research, crash rates among teenaged drivers have the sharpest decline within the first six months of driving and therefore it is assumed this is where the majority of learning and development occurs (McCartt, Shabanova & Leaf, 2001). Although researchers have tried to understand the changes in driver performance that lends itself to a reduction in crash rates over the first six months of driving, it is still unclear how driving skills are changing and to what extent learning is experienced within the first six months of driving.

Research aimed at understanding this change has been conducted using several different methods. The most common methods of studying the teenaged driver problem have been by the use of epidemiology, a test-track, or a simulator. Although these methods have been insightful, these designs both have their advantages and disadvantages. For example, test track and simulator studies have the advantages of being able to choose and manipulate tasks, but the disadvantages include limitations in tasks and situations, the artificial nature of the tasks, and the use of only brief assessment periods.

Currently there is a lack of continuous and naturalistic data in the field of teenaged driving. The purpose of this study is to obtain continuous performance data from a naturalistic setting by equipping the personal vehicles of newly licensed teenaged drivers with a data collection system for the first six months of driving. Specifically, this study examines the eye scanning patterns of newly licensed teenaged drivers, giving insight into the development and change of eye-glance behaviors over the first six months of driving and the differences between novice teenaged drivers and experienced adults.

2.0 Background Literature

The following sections review the literature discussing crash risk of newly licensed teenaged drivers within the first six months of licensure. The effect of the implementation of the graduated licensing system is discussed as it pertains to these risk factors. Finally, the use and benefit of naturalistic data collection is described as it relates to providing a better understanding of these crash factors.

2.1 Teenaged Crash risk

Extensive research has been conducted that demonstrates that newly licensed teenaged drivers are at a high risk of being involved in a crash within the first few months of licensure. To better understand this crash risk, McCartt et al. (2001) conducted a longitudinal study in which teenagers from freshman to their senior year of high school were surveyed by telephone every six months. Results from the study showed that the risk of crash or citation during the first six months of licensure was substantially higher than during any other time period. The study also found that a low Grade Point Average (GPA) was associated with higher crash risk. Specifically, students with a C or D average were more likely to be involved in a crash.

A study conducted by Mayhew, Simpson, & Pak (2002) examined when experience, measured in months and miles driven, is most influential on teenaged drivers by comparing novice teenaged drivers aged 16 to 19 years with novice adult drivers aged 20 years or more. Researchers found that crash rates for novice teenaged drivers were significantly higher than those of novice adult drivers, and that crash rates declined more dramatically during the first six months of driving. The greatest decline for the novice teenaged drivers occurred after the first month of licensure.

2.1.1 Passengers

Passengers in the vehicle with a teenaged driver have been identified as one factor affecting crash risk for younger drivers. Findings from previous research have been consistent in showing that teenaged drivers carrying passengers are at a higher risk of being involved in a crash, being injured in a crash, and being involved in a fatal crash.

In an epidemiological study reviewing crash records conducted by the University of Windsor and the University of Central Florida, researchers found that drivers tended to show safer driving characteristics in the presence of adult passengers. However, results demonstrated that with younger drivers the presence of passengers increases the potential for a crash. It was concluded in this study that this increase in crash risk was because younger drivers were more distracted by the passengers, and the drivers were also more likely to exhibit risky driving behaviors (Lee & Abdel-Aty, 2007).

In another study utilizing the Fatality Analysis Reporting System (FARS), researchers assessed fatal crashes for the period of 1990 through 1995 involving teenaged drivers. Each driver was categorized as either being alone at the time of the crash or in the presence of passengers. Results from the study indicated that the presence of passengers was associated with more at-fault fatal crashes for drivers aged 24 and younger. Specifically, the risk of being involved in a fatal crash was high for teenaged drivers when traveling with two or more passengers. In addition, the authors suggest that additional research is needed to determine how the risk of passengers riding with teenaged drivers can be reduced (Preusser, Ferguson & Williams, 1997).

Research is consistent in identifying that teenaged drivers are at a higher risk of being involved in a crash, injured in a crash, and killed in a crash when passengers are present. However, there are limitations to assessment methods. Oftentimes, crash databases and surveys are incomplete, based on memory, and based on self report. The data may be somewhat inaccurate or unrepresentative of the teenaged driving population. The studies identify that the risk may be higher when passengers are present in the vehicle, but fail to identify the driving skills associated with the change in crash risk.

2.1.2 Distraction

As stated previously, distraction has been identified as a factor associated with teenagers transporting passengers (Lee & Abdel-Aty, 2007). One possible cause of distraction is emerging new technology. Devices popular to teenagers such as cellular phones with text messaging, email/internet access, and mass storage portable music players have changed the nature of driving distraction. To better understand teenaged drivers' perception of motor vehicle safety the National Highway Transportation Administration (NHTSA, 2007) facilitated discussions with groups of teenage drivers in four cities across the United States. In these focus groups it was the opinion of the teenaged drivers that driver distraction has become a serious problem among young drivers.

In a study utilizing the U.S. DOT-General Estimate System (GES), researchers at the University of Iowa examined crashes of teenage drivers (age 16-19 years) to determine what role distraction played in the severity of a crash. Results demonstrated that teenaged drivers have an increase likelihood of sustaining more severe injuries when a distraction was present (Neyens & Boyle, 2006). This method of obtaining data through crash databases is beneficial in identifying that teenaged driver distraction leads to a higher crash risk and an increase in severity. Although beneficial, it does not identify specific detriments to the driving abilities of teenaged drivers necessary in understanding, reducing and eliminating these risks.

2.1.3 Eye scanning patterns

In a study conducted by the Insurance Institute for Highway Safety and the Preusser Research Group, researchers interviewed teenagers and examined crash reports for 16 year old drivers in Connecticut with the goal of identifying the driving performance characteristics and contributing factors of crashes. Researchers found that one of the major characteristics and contributing factors was the teenaged driver's inability to detect another vehicle, or not properly looking in the ideal direction (Braitman, Kirely, McCart & Chaudhary, 2007). Results from this study give us insight into some of the performance characteristics of driving behaviors that lead to higher crash risk and to an extent suggest that an indicator of eye glance locations would prove beneficial.

Eye scanning patterns, such as glance duration, glance location and time spent with eyes off of the forward roadway (EOFR) as a metric have been used in identifying safe and unsafe driving for a variety of transportation related research studies. The 100Car Naturalistic Driving Study reported that driver inattention contributed to 78% of crashes and 65% percent of near crashes (Dingus et al., 2005).

Eye off the forward roadway (EOFR), glance location, and glance duration are currently used as safety surrogate measures that indicate awareness and attention to driving tasks. Dingus, et al. (2005) conducted the 100 Car Naturalistic Driving Study, which examined the eye scanning patterns of participants over the period of one year. The results suggested that eye-glance behavior is a complicated construct because glancing away from the forward roadway may not always be a potential hazard. Results from the study indicate that eye glances that were less than two seconds to the rear-view mirror or windows for traffic checks were safe actions and result in a reduced crash risk. The following table contains odds ratios calculated by Klauer, Dingus, Neal Sudweeks & Ramsey, (2006). Table 1 provides odds ratios for eyes off the forward roadway (EOFR) presented in incremental durations. An odds ratio greater than one indicates a possible increase in crash risk, whereas an odds ratio less than one indicates a possible reduction in crash risk. It can be seen from the table that drivers who had eyes off of the forward roadway time of greater than two seconds were twice as likely to be involved in a crash/near-crash, whereas drivers who had shorter glances were less likely to be involved in a crash/near-crash.

Table 1: Odds Ratios for Eyes Off Road Way from the 100Car Report

	Total Time of Eyes Off the Forward Roadway	Odds Ratio	Lower CL	Upper CL
1.	Less than or equal to 0.5 s	1.31	0.91	1.89
2.	Greater than 0.5 s but less than or equal to 1.0 s	0.82	0.60	1.13
3.	Greater than 1.0 s but less than or equal to 1.5 s	0.92	0.65	1.31
4.	Greater than 1.5 s but less than or equal to 2.0 s	1.26	0.89	1.79
5.	**Greater than 2.0 s**	**2.19**	**1.72**	**2.78**
6.	**OR for Eye Glance (all durations)**	**1.32**	**1.09**	**1.60**

A test-track study conducted by Olsen, Lee, & Simons-Morton (2005) examined and compared eye glance behaviors of novice teenaged drivers and experienced adult drivers. Measures used in the study included percent eyes off road time, number of glances, and mean single glance time. The results of the study show that novice teenaged drivers spent more eyes off road time looking at task displays, whereas adults used some of the eyes off road time to check mirrors and windows. The results from this study suggest that eye glance behaviors are a characteristic of driving that changes and is learned over time. Results imply that teens may lack situational awareness when compared to experienced adults.

Glance duration, glance location and time spent with EOFR may prove beneficial in determining the performance characteristics of driving that lead to an increase in crash risk for teenaged drivers. Previous research has been consistent in identifying the situations where teenaged drivers are at higher risk for crashes, injuries and fatalities. The next step is attempting to reduce and eliminate these risks through a better understanding of the driving performance characteristics, specifically eye scanning patterns under typical driving conditions.

In attempt understand the difference in eye scanning patterns between drivers who have had hazard detection training and drivers who have not, Pradhan, Fisher, &

Pollatsk (2006) developed a Risk Awareness and Perception Training Program (RAPT). The RAPT program is designed to train novice drivers on the different risky situations involved under normal driving conditions. In this study, researchers used a driving simulator to simulate normal driving conditions and an eye tracker to assess eye scanning patterns. The goal of the training programs was to introduce risky scenarios and indicate where visual attention should be directed by using an interactive PC presentation. One group of novice drivers received RAPT training and tested on the simulator. A second group (control group) was tested on the simulator without receiving the RAPT training program. The results of the study demonstrated that the group that received the training showed more awareness of potential risks and tended to fixate their gaze on areas where hidden risks could be present than the group that did not receive training. In addition, it was concluded that the group that received training also performed closer to the levels of more experienced adults when compared to previous studies.

2.2 Graduated Licensing

Over the past decade efforts have increased to reduce crash risk and provide quality training for newly licensed teenaged drivers. In a study conducted by Ferguson International and the Institute for Highway Safety, data between 1996 and 2005 on fatal crashes were collected from the Fatality Analysis Reporting System (FARS) and police reported crashes were collected from the National Automotive Sampling System/General Estimates System (GES). Researchers found that during the past decade police reported crashes declined about 40% for 16 year old drivers while only decreasing 25% for 17 year old drivers, and 15%-19% for 18+ year old drivers. According to the author, this decline demonstrates that significant progress has been made in reducing crash risk for new drivers. While this study does not provide empirical evidence, the author notes that this decline in crash rate is consistent with the implementation of Graduated Licensing Systems practices (Ferguson, Teoh, & McCartt, 2007).

Graduated Driver's licensing (GDL) is the practice of gradually introducing new drivers to the system so they may become fully licensed members of the driving community. Generally the GDL starts with a minimum hourly requirement of supervised driving (pre-licensure), followed by a period of time where the driver has obtained a license but is subject to restrictions. The Virginia graduated licensing system restricts newly licensed teenaged drivers from driving during the hours of 12am to 4am, from cellular phone usage, and limits drivers to one passenger that is a non-relative in the vehicle. Finally, once the driver reaches the appropriate age and has met all requirements, he or she becomes a full-privileged license holder; requirements vary state to state (DMV, 2006).

2.2.1. Support of GDL

There is currently research on novice teenaged drivers that supports GDL, Williams & Ferguson (2003) state that level of risk among novice teenaged drivers varies and is situational. Some high risk situations are found to be high for all drivers, whereas other high risk situations are specific to novice teenaged drivers. A few driving variables identified that are associated with elevated risk for novice drivers are presence of passengers, nighttime driving, and alcohol use. Restrictions have been applied in many GDL programs such as limiting hours available for teens to drive and limiting the number of passengers. Currently, a nationwide mandate for GDL programs does not exist and each state with an implemented GDL program is responsible for establishing its own criteria.

In an evaluation of GDL conducted by the University of Michigan Transportation Research Institute, researchers reviewed twenty-one different studies of the GDL system. Although each study was unique, researches noted that the findings among studies were consistent, and that overall GDL has reduced younger driver crash risk roughly 20% to 40% (Shope, 2007).

2.2.2 GDL Shortcomings

In a report by the National Highway Traffic Safety Administration (NHTSA, 2007), researchers facilitated discussions with groups of teenaged drivers in four cities. The topic of the focus groups was unsafe driving behaviors by teenaged drivers. The goal of the focus groups was to understand the teenagers' perspectives of motor vehicle safety risks and how these behaviors can be influenced. In the focus groups teenagers reported that graduated licensing (GDL) restrictions are not generally enforced and are frequently ignored. According to the report, the restriction that most teens dislike and ignore is the passenger restriction.

According to Foss (2007), GDL should change non-drivers into reasonably safe drivers while minimizing risks as they learn. The author also states that the benefits obtained by states adopting GDL are primarily due to reducing exposure to risk; and in order to further reduce the crash rate for newly licensed teenaged drivers it is necessary to understand the actual cause of teenaged crashes. The author also states that teenaged drivers should obtain sufficient experience, including plenty of practical experience under safe conditions.

Ferguson (2003) examines the extent to which GDL programs address risk factors specific to novice teenaged drivers. Ferguson states that nighttime and passenger restrictions keep novice teenaged drivers from experiencing elevated risk situations rather than training them to respond appropriately in the situation. Based upon literature reviews, Ferguson makes recommendations for possible improvements to current GDL programs such as an exit test and restrictions on speed and road access. The author suggests that research should continue to develop and evaluate criteria to reduce risk associated with novice teenaged drivers. Also, performance measures and effectiveness of these criteria should be established before large scale implementation of GDL takes place.

2.3 Benefit of Naturalistic Data Collection

In the past, the majority of driving safety research has been carried out using epidemiological data collection, driving simulators, and/or a test-track with an instrumented vehicle. Although these methods help to produce valuable data on driving safety, each method has limitations. The following is a description of the benefits and limitations of each.

Epidemiological research has been conducted for a vast amount of transportation research and has proved useful in identifying certain characteristics of automobile crashes, injuries and fatalities. The benefits of epidemiological data collection are: Precise knowledge of crash risks and information about important circumstances and scenarios that lead to crashes. The disadvantages are: the method is reactive, only examines circumstances and behaviors after years of crash and fatality data is compiled, crash databases are often limited due to missing data and inaccurate reports, often rely on memory, and are limited in pre-crash data minimizing the ability to identify specific driving performance characteristics that leads up to the crash.

Empirical data collection methods such as driving simulators and test-tracks have been used to create an environment where researchers can observe physical driving characteristics and behaviors. The advantages of these methods are: the research is proactive testing in-vehicle systems either prior to deployment or prior to having a system available on vast numbers of vehicles for several years to assess if driving performance decrements are apparent ; also it provides important ordinal crash risk information. The disadvantages of these methods are: it is uncertain if any measured performance decrements are related to crash risk, the artificial nature of the experiment modifies the participant’s behavior, the use of only a brief assessment period, and the lack of continuous data in a realistic setting. Specific to teenaged driving the disadvantages are that a learning curve cannot continually be assessed over time, and the artificiality of examining passenger distraction and modified physical characteristics not representative of natural driving, such as eye glance behavior.

Currently, naturalistic data collection is the most valid method of determining which driving performance characteristics influence risk of crashes and near-crashes. The following are research studies that utilized naturalistic data collection means and instrumented vehicles to capture more natural driving behaviors.

In a study conducted by Stutts et al. (2005), researchers used a naturalistic approach to examine driver's exposure to distraction in a natural driving environment. Researchers instrumented 70 vehicles, each driver for a one week period. From the data collected researchers determined how often distractions took place as well as which distractions occurred most frequently. Researchers were also able to associate driver distraction with an overall decrease in driving performance. Conclusions from the study state that "Naturalistic driving studies can provide a useful supplement to more controlled laboratory and field studies to further our understanding of the effects of all types of distractions on driving safety."

The 100-Car Naturalistic Driving Study conducted by Dingus et al. (2005) was the first successful large scale naturalistic data collection effort. Researchers collected video and kinematic data on 100 vehicles for a period of one year. Approximately 2,000,000 miles and 43,000 hours of driving data were recorded. Researchers constructed a database similar to an epidemiological crash database, which included not only crashes but also near-crashes, incidents, and baseline events with driving video and performance data appended. Information such as pre-crash data, driver distraction, and eye scanning patterns, roadway infrastructures, and driver behaviors were recorded. This method was shown to be useful in examining driver safety due to the amount of detail included in the database. Whereas much information is often excluded in epidemiological databases, the 100 Car database provides details that offer researchers the ability to mine the raw data.

Although naturalistic data collection is the most valid method of determining which driving performance characteristics influence risk of crashes and near-crashes it still has its disadvantages. Unlike empirical data collection, naturalistic data does not allow for control of the environment and does not allow for the manipulation of tasks. By using quasi- naturalistic data collection means, equipping personal vehicles with a data collection system and monitoring participants driving in their own environment, a method can be created that is more naturalistic and complete in capturing driving behaviors. Specific to teenaged drivers and eye glance behaviors this method provides the ability to: establish a learning curve within the first six months of driving, provide sound performance indicators measuring inattention, and examine what effects passengers have on the teenaged driver. Although naturalistic data collection has its disadvantages, currently naturalistic data collection is the most valid method of determining the extent of these issues for teenaged drivers.

2.4 Objectives

The objective of this study is to assess and understand the impact of eye scanning patterns on newly licensed teenaged drivers' ability to drive safely in a more natural setting. The study attempts to provide the following:

- Insight into how glance patterns of teenage drivers change across the first six months of driving and compare these glance patterns to experienced parent drivers. Specific eye glance metrics used include single glance durations and percentage of driving related glances.
- Justification and evaluation of the GDL passenger restriction by providing percent of time spent with eyes off of the forward roadway in the presence of passengers in comparison to experienced parent drivers in the presence of passengers.

2.5 Research Questions

The objectives will be delivered by answering the following questions.

2.5.1 Research Question 1.

How does the frequency of driving related glances and duration of single glances away from the forward roadway change from immediate licensure to six months post licensure for newly licensed teenaged drivers and how does it compare to experienced parent drivers?

Hypotheses:

1. As driving experience for teenaged drivers increases, single eye glance durations away from the forward roadway will decrease.

   Ho: = There will be no difference in single eye glance durations away from the forward roadway over a six month period.

   Ha: = As driving experience increases, single eye glance durations away from the forward roadway will decrease.

2. Teenaged drivers will have longer single eye glance durations away from the forward roadway compared to the experienced parent group.

   Ho: = There will be no difference in single eye glance durations away from the forward roadway between teenaged drivers and the experienced parent group.

   Ha: = Teenaged drivers' single eye glance durations away from the forward roadway will be higher than the experienced parent group.

3. As driving experience increases, the percentage of driving related glances away from the forward roadway will increase.

   Ho: = There will be no difference in the percentage of driving related glances away from the forward roadway over the first six months of driving

   Ha: = As driving experience increases, the percentage of driving related glances away from the forward roadway will increase.

4. Teenaged drivers will have a lower percentage of driving related glances away from the forward roadway than the experienced adult group.

   Ho: = There will be no difference in the percentage of driving related glances away from the forward roadway between teenaged drivers and the experienced parent group.

   Ha: = Teenaged drivers' percentage of driving related glances away from the forward roadway will be lower than the experienced parent group.

2.5.2 Research Question 2

How does the percentage of time spent with eyes off forward roadway (EOFR) change in the presence of passengers and how does this compare to experienced parent drivers?

Hypotheses:

1. In the presence of passengers, newly licensed teenager's percentage of time spent with EOFR will change significantly compared to when driving alone.

   Ho: = There will be no difference in percent time spent with EOFR when teenaged drivers are in the presence of passengers compared to when driving alone.

   Ha: = Percentage of time spent with EOFR will be higher with passengers in the vehicle when compared to driving alone.

2. Teenaged drivers compared to the experienced parent group will have a higher percentage of time spent with EOFR when in the presence of passengers.

   Ho: = In the presence of passengers there will be no difference in percentage of time spent with EOFR between teenaged drivers and the experienced adult group

Ha: = In the presence of passengers teenaged drivers will have a higher percentage of time spent with EOFR.

3.0 Method

3.1 Project Design and Overview

The study was a naturalistic field study in which teenaged drivers were observed operating their personal or their family's vehicle during normal daily driving. This was part of a larger research effort sponsored by the National Institutes of Child Health and Human Development (NICHD) that studied novice teenaged drivers and parents for a period of 18 months starting at licensure. Each participant's vehicle was equipped with cameras and a data acquisition system. Once the vehicle was equipped, participants were instructed to drive as they normally would for the next 18 months. This particular study used a subset of the data collected and spanned over the first six-month period for each driver.

Data from each participant's vehicle was offloaded onto a secure server at the Virginia Tech Transportation Institute (VTTI) and both video and kinematic data were further reduced by data reductionists. A variety of classification variables (e.g., road type, location, and month of driving) and number of passengers in the vehicle were observed and recorded.

3.2 Participants

Due to the nature of the sampling plan each research question and hypothesis had a separate and different set of participants pulled from the following pool of participants.

Participants included a sample of 42 teenaged drivers: young, novice drivers between the ages of 16 and 17 years who have held their driver's license for less than three weeks. In addition, a sample of 20 parents served as a comparison group. A parental comparison group is used for the following reasons: to show that the growth over time is specific to teenaged drivers and to serve as a comparison group to demonstrate the differences between teenaged and adult drivers under different conditions. Guidelines for eligibility to receive a license in the state of Virginia can be found in Appendix A. The tables below demonstrate the breakdown of participants for each research question and hypothesis.

Table 2: Participant Sample Research Question 1 Hypothesis 1.

Driver Type	Male	Female
Novice teen Drivers	n-=10	n=10
Adult/Parent Drivers	n=4	n=3

Table 3: Participant Sample Research Question 1 Hypothesis2.

Driver type	Male	Female
Novice teen Drivers	n-=10	n=11
Adult/Parent Drivers	n=6	n=11

Table 4: Participant Sample Research Question 2.

Driver type	Male	Female
Novice teen Drivers	n-=6	n=6
Adult/Parent Drivers	n=5	n=1

3.3 Apparatus

3.3.1 Data Acquisition System

The data acquisition system (DAS) used for this study comprised three general groups of measures: (i) DAS measures, (ii) vehicle network measures, and (iii) add-on measures.

The general design characteristics for the DAS include the following:

- Compatible with the vehicle (e.g., power obtained from vehicle battery, data from in-vehicle network).
- Unobtrusive and non-invasive:

- Not distracting.
- Does not limit driver visibility.
- No permanent modifications to the vehicle.
- Minimal space requirement (e.g., for data storage unit).
- Automatic start-up, shut-down, and continuous operation.
- No subject tasks required for operation or data downloading.

- Reliable performance in the often harsh operational environment of driving. Minimal data loss and automatic detection of failures.
- Continuous multi-camera video recording system (30 Hz) to capture driver's face, over-the-shoulder, wide-angle rearward, forward scene; a passenger camera to provide a snapshot of the vehicle's cabin, allowing researchers to determine the presence of a passenger, but filtered in order to conceal their identity.
- Ruggedness and crash survivability.

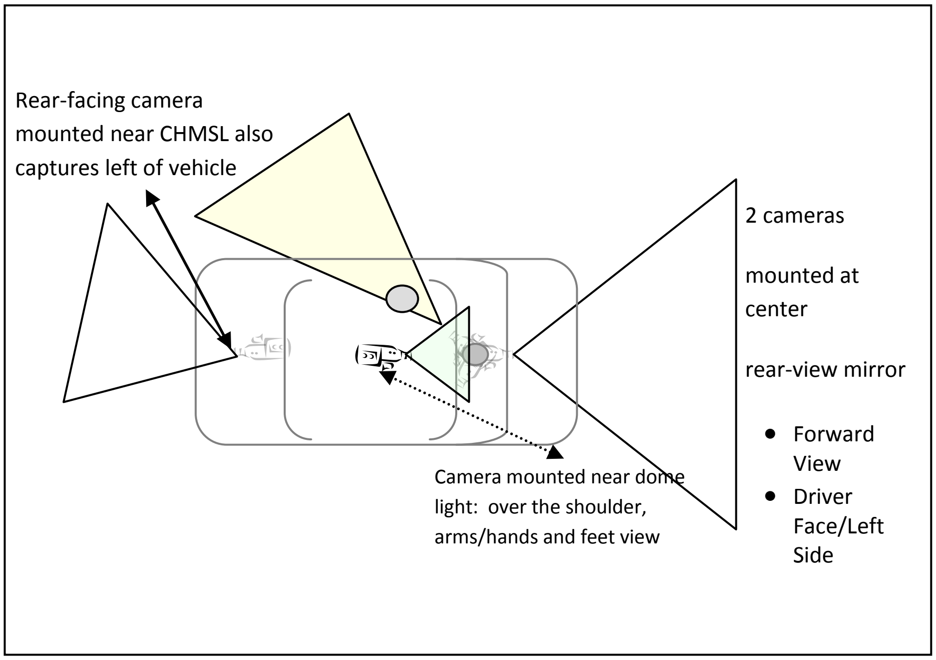
The main unit was mounted on the floor of the trunk using Velcro under the "package shelf" depicted in Figure 1.

Figure 1: Data Acquisition System mounted under the package shelf in the trunk of a vehicle

The vehicle network box is located under the front dashboard. Wiring was run though the normal wire chases on a vehicle to all the various network nodes, as well as to the cameras. The cameras were mounted unobtrusively to facilitate naturalistic driving behavior.

3.3.1.1 Video Cameras

Digital video cameras were used to record continuous video of the driver and the driving environment. Four video cameras were used and were multiplexed into a single image. The four camera views are: (1) forward roadway view, (2) driver's face camera, (3) over-the-shoulder, and (4) wide-angle rearward. The forward and rearward camera views provide good coverage of the driving environment. The face view provides coverage of the driver's face and allowed researchers to conduct eye glance analyses. A timestamp (mpeg frame number) is also included in the mpg data file but is not displayed on the screen. The frame number is used to time-synchronize the video (in mpeg format) and the vehicle/performance data (in binary format). The digital video does not contain



audio.

Figure 2. Diagram of camera angles

3.3.1.2 Snapshot Camera

A modified digital camera was used to provide a snapshot of the interior cabin of the vehicle. This digital camera was modified as to blur any identifying characteristics of the passengers while still allowing researchers to determine the number of passengers present in the vehicle, gender of the passengers, and general age of the passengers. Figure 3 shows an example of this filtered camera shot. It can be seen from this picture that there are two passengers in the vehicle. The person in the driver seat is a male adult (front right side of the snap shot) and the person in the passenger seat is an adult female (front left side of the snap shot).

Figure 3. Example of the quality of the cabin snap shot.

3.4 Protocol

3.4.1 Participant Recruitment

VTTI is located in Blacksburg, Virginia in a region known as the New River Valley, which also includes the cities of Christiansburg, Radford, Pulaski, and Dublin, as well as several smaller communities. This area achieved status as an urbanized area in the 2000 census with a combined population of over 100,000. In this area of Virginia teenagers must obtain the on-road portion of their driving education by enrolling in one of several commercial driving schools. Due to an ongoing study of teenaged driving, VTTI has established relationships with several of these driving schools in the New River Valley. Driving schools that collaborated with VTTI include:

- Blacksburg Driver Training
- Learn Right Driving School
- Wright Way
- Driving for All Ages, Inc.
- New River Valley Driving School, Inc.

VTTI researchers recruited participants by contacting the local driving schools, setting up meetings to announce the study, and providing contact information so that interested participants could discuss participation with their parents and contact VTTI. Driving instructors were sent a letter informing them of the study (Appendix B), along with information flyers that were distributed to students who were possibly eligible (Appendix C).

In addition, there were at least seven high schools located in or near the area, which were used for recruiting through driver's education classes (the classroom portion of driver's education takes place in the schools). Finally, students who might not have been reached were recruited through VTTI personnel connections with the home schooling community. In order to obtain permission to recruit within the school system a letter was sent to the superintendent, as well as the principals of the school system (Appendix D).

3.4.2 Screening

Both teenagers and parents were initially screened over the telephone by a researcher at VTTI. The screening questions were structured to identify demographics and determine eligibility (Appendix E). Questions that determined eligibility included:

- Licensure date – Eligible participants must not already have a license and must be receiving it within a specified time frame.
- Vehicle type – Eligible participants needed a personal vehicle that is no older than 1992 and cannot be a pick-up truck.

Before screening the teenagers, parental permission to screen the teenagers was obtained over the telephone with a witness present.

3.4.3 Participant Orientation

Upon arrival at VTTI each participant reviewed the information recorded on the telephone screening and demographic questionnaire for accuracy. Next, participants were asked to either review the Assent Form or, if consent/assent had not yet been received, to read and sign the Informed Assent Form (Appendix F, G, & H). Teenagers were required to have parental consent. The participant's driver's license was examined to assure that they had obtained a valid driver's license.

3.4.4 Instrumentation

Participants made appointments to drop their vehicles off at VTTI for 4 to 36 hours to have the data acquisition system and cameras installed. VTTI provided drop off and pick up services to make the process as easy as possible for the participants.

3.4.5 Instructions

Upon returning to VTTI participants were shown the instrumentation system. Staff at VTTI pointed out and reviewed the camera locations and where the main unit of the data acquisition system was located. Participants were instructed to drive as they normally would and contact VTTI if they encountered any difficulties with their vehicle that could be related to the instrumentation system, or if they noticed any maintenance issues with the system (e.g., loose or dangling camera). Due to the fact that passengers' identities were kept confidential participants were not instructed to inform passengers in the vehicle that there was a data collection system present. There was no way to enforce and insure that the participant would always inform the passenger as well. In order to keep the driving behavior as natural as possible it was also important to not to remind the participant and/or passengers the system was present.

for the following reasons: there was no way to enforce the instruction, the passengers identities were kept confidential, and to keep the driving behavior as natural as possible by not reminding the participant and/or the passengers the system was present.

3.4.6 Downloading

Researchers at VTTI were assigned to "chase vehicles." These are vehicles dedicated to downloading data from the participant's vehicle. Participants' vehicles were located based on daily schedules determined by participants' report of schedules (e.g. at work or school from 9:00AM to 5:00PM). Researchers dedicated to downloading data were required to carry proper identification during all downloads.

3.4.7 Payment

Participants were compensated $75 for each month of participation as well as $20/hour for completing questionnaires and other paperwork. Upon completion of the study participants received a $450 bonus.

3.5 Data Reduction

Video and corresponding data were viewed by twelve trained data analysts (data reductionists). Analysts viewed the selected video and data files, and recorded a battery of variables (Appendix I). Reductionists also used eye glance reduction software, developed at VTTI, to record eye scanning patterns (the software is described later in this section).

Eye glance reduction was performed by reductionists on the business/ residential straight road segments using software developed by engineers at VTTI. Reductionists reviewed the video and marked glances corresponding with the video. The glance locations used for this study are as follows along with a description of which glances were considered driving related.

- Forward (driving related)
- Left Forward (driving related)
- Right Forward (driving related)
- Left Mirror (driving related)
- Right Mirror (driving related)
- Left Window (driving related)
- Right Window (driving related)
- Rear View Mirror (driving related)
- Cellular Phone
- Instrument Panel (driving related)
- Object
- Passenger
- Center Console
- Eye Closure
- Unknown

The eye glance information window and video window are displayed simultaneously. Reductionists played the video, at ¼ speed or ½ speed, by holding down the letter corresponding to the glance selection as shown in Figure 4.

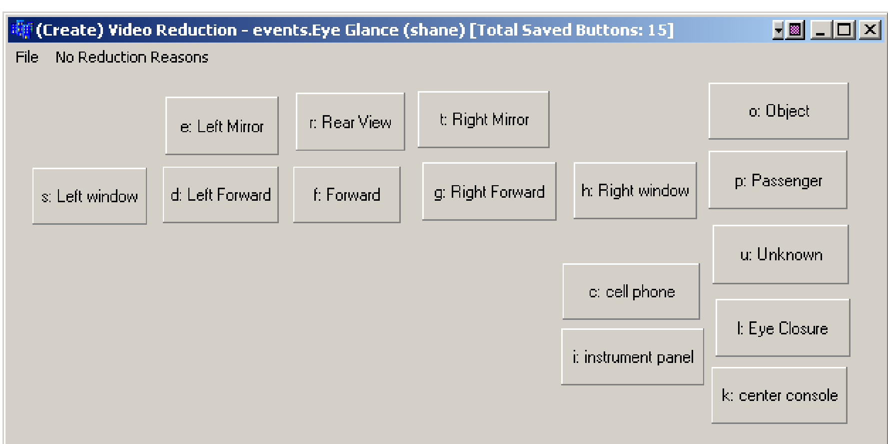


Figure 4. Eye glance software with corresponding video.

3.5.1 Data Reductionist Training

Each data reductionist completed a two-week training session that included observing an expert data reductionist, reviewing pre-reduced events, and working under the supervision of another trained data reductionist. Reductionist training ended once a consensus among supervisors had been reached.

For quality purposes reductionists worked a maximum of four hours per day and were required to take a ten minute break every hour. Inter-rater and intra-rater tests were performed to determine the reliability and consistency among data reductionists. To determine inter-rater reliability data reductionists were given a set of 20 trip files to perform reduction on; every reductionist's answers were compared to each other to determine a percentage of agreement. The inter-rater reliability for the test was 90%. In order to determine the intra-rater reliability data reductionists were given another set of trip files to perform data reduction on six months after the inter-rater test. In this new set of files four files were repeated from the initial test. Answers from test one and test two were compared to determine the consistency of a reductionist's answers over time. The intra-rater reliability was 93%.

3.5.2 Data Reduction Software

Software developed in-house by VTTI software engineers was used to view and reduce data. The software allowed reductionists to view video and necessary data from the

DAS and record the variables of interest. Figure 5 is a depiction of some of the tools available from the software.

Figure 5: Depiction of Software Tools Available

All of the variables recorded by the reductionists were stored in a SQL database format. This format allowed for easy access during the analysis phase of this project.

3.6 Analyses

3.6.1 Research Question 1

How does the percentage of driving related glances and duration of single glances away from the forward roadway change from immediate licensure to six months post licensure for newly licensed teenaged drivers and how does it compare to experienced parent drivers?

To assess this research question eye glances were measured in percentage of driving related glances, duration of single glances away from the forward roadway, and glance type (driving related glances vs. non-driving related glances).

3.6.1 .1 Hypothesis 1

As driving experience for teenaged drivers' increases, single eye glance durations away from the forward roadway will decrease.

Ho: = There will be no difference in single eye glance durations away from the forward roadway over a six month period.

Ha: = As driving experience increases, single eye glance durations away from the forward roadway will decrease.

Table 5: *Participant sample, experimental design, independent and dependant variables for research question 1 hypothesis 1.*

Research Question 1 Hypothesis 1				
Novice Teen Driver	Design	Independent Variable		Dependant Variable
n = 20	Within Subject	Teen driving experience	1. 1 -2 months	Single Glance Durations
			2. 3-4 months	
			3. 5-6months	

To address hypothesis 1 mean and mean maximum single glance durations for teenaged drivers were compared within subjects using single factor ANOVA with three levels of teenaged driving experience:

1. 1-2 months
2. 3-4 months
3. 5-6 months

Independent variable: Teenaged driving experience.

Dependant variable: Single glance duration away from the forward roadway.

3.6.1.2 Hypothesis 2

Teenaged drivers will have longer single eye glance durations away from the forward roadway compared to the experienced parent group.

Table 6: *Participant sample, experimental design, independent and dependant variables for research question 1 hypothesis 2.*

Research Question 1 Hypothesis 2					
Novice Teen Driver	Adult/Parent Driver	Design	Independent Variable		Dependant Variable
n = 20	n=7	Between Subject	Experience	1. Novice Teen Driver	Single Glance Durations
				2. Experienced Parent Driver	

Mean and mean maximum single glance durations were compared between subjects for both teenaged drivers and adult drivers using a T-test with two levels of experience:

1. Teenaged driver
2. Experienced parent driver

Independent variable: Experience.

Dependant variable: Single glance durations away from the forward roadway.

3.6.1.3 Hypothesis 3

As driving experience increases, the percentage of driving related glances away from the forward roadway will increase.

Table 7: *Participant sample, experimental design, independent and dependant variables for research question 1 hypothesis 3.*

Research Question 1 Hypothesis 3				
Novice Teen Driver	Design	Independent Variable		Dependant Variable
n = 21	Within Subject	Teen driving experience	1. 1 -2 months	% DRG
			2. 3-4 months	
			3. 5-6months	

Mean and mean minimum percentage of driving related glances for teenaged drivers were compared within subjects using a single factor ANOVA with three levels of experience:

1. 1-2 months
2. 3-4 months
3. 5-6 months

Independent variable: Teenaged driving experience.

Dependant variable: Percentage of driving related glances.

3.6.1.4 Hypothesis 4:

Teenaged drivers will have a higher percentage of driving related glances away from the forward roadway than the experienced adult group.

Table 8: *Participant sample, experimental design, independent and dependant variables for research question 1 hypothesis 4.*

Research Question 1 Hypothesis 4					
Novice Teen Driver	Adult/Parent Driver	Design	Independent Variable		Dependant Variable
n = 21	n=17	Between Subject	Experience	1. Novice Teen Driver	% DRG
				2. Experienced Parent Driver	

Mean and mean minimum percentage of driving related glances were compared between subjects for both teenaged drivers and adult drivers using a T-test with two levels of experience:

1. Teenaged driver.
2. Experienced parent driver.

Independent variable: Experience.

Dependant variable: Percentage of driving related glances.

3.6.2 Research Question 2

How does the percentage of time spent with eyes off forward roadway (EOFR) change in the presence of passengers and how does this compare to experienced parent drivers?

3.6.2.1 Hypothesis 1 & 2

Hypothesis 1: In the presence of passengers, newly licensed teenager's percentage of time spent with EOFR will change significantly compared to when driving alone.

Table 9: *Participant sample, experimental design, independent and dependant variables for research question 2 hypothesis 1.*

Research Question 2 Hypothesis 1				
Novice Teen Driver	Design	Independent Variable		Dependant Variable
n = 12	Within Subject	Numb of passengers	1. 0 passengers	% Time spent EOFR
			2. 1 passenger	
			3. 2+ passenger	

Hypothesis 2: Teenaged drivers compared to the experienced parent group will have a higher percentage of time spent with EOFR when in the presence of passengers.

Table 10: *Participant sample, experimental design, independent and dependant variables for research question 2 hypothesis 2.*

<table>
<tr><th colspan="6">Research Question 2 Hypothesis 2</th></tr>
<tr><th>Novice Teen Driver</th><th>Adult/Parent Driver</th><th>Design</th><th colspan="2">Independent Variables</th><th>Dependant Variable</th></tr>
<tr><td rowspan="5">n = 12</td><td rowspan="5">n=6</td><td rowspan="5">2 x 3 mixed design</td><td rowspan="2">Experience</td><td>1. Novice Teen Driver</td><td rowspan="5">% Time spent EOFR</td></tr>
<tr><td>2. Experienced Parent Driver</td></tr>
<tr><td rowspan="3">Numb of passengers</td><td>1. 0 passengers</td></tr>
<tr><td>2. 1 passenger</td></tr>
<tr><td>3. 2+ passenger</td></tr>
</table>

For these hypotheses mean and mean maximum percentage of time spent with EOFR were compared using a mixed design two factor ANOVA.

Factors

1. Experience (two levels), between subjects
    - Teenaged driver
    - Experienced parent driver
2. Number of passengers (three levels) within subjects
    - No passenger
    - One passenger
    - Two or more passengers

Independent variables: Experience and Number of passengers

Dependent variables: Percent of time spent with EOFR.

3.7 Sampling Plan

To capture eye glance behavior in an optimal setting a geo spatial sampling plan was used. Four straight road segment types were pre-selected: four lanes business/industrial, two lanes business/industrial, two lanes rural, and residential. Specific locations around the New River Valley that met the criteria were selected. Two GPS points for each segment were determined: Start of the segment, and the end of the segment. For the data to be useable the drivers (Teenaged and Adult) must have had to pass through both points of the segment, ensuring the whole segment had been traveled. This sampling plan resulted in over 5000 road segments for the first 6 months of driving. Due to project resources, eye glance reduction was performed on only those straight road segments where the teen driver performed a lane change or had a teenaged passenger present in the vehicle. The number of crossing for each participant can be found in Appendix J.

Figure 6: Example of a two lane road straight road segment with GPS points

3.8 Demographics

3.8.1 Research Question 1

3.8.1.1 Hypothesis 1

For this analysis participants aged ranged from 16.3 to 16.8 years of age with a mean age of 16.4. Participant GPA ranged from 3.3 to 4.1 with a mean of 3.62.

Participants resided in Blacksburg, Christiansburg, Roanoke, Salem, and Newport. The following figure is a breakdown of the participant's hometowns. It can be seen from the figure that the majority of participants were from Blacksburg.

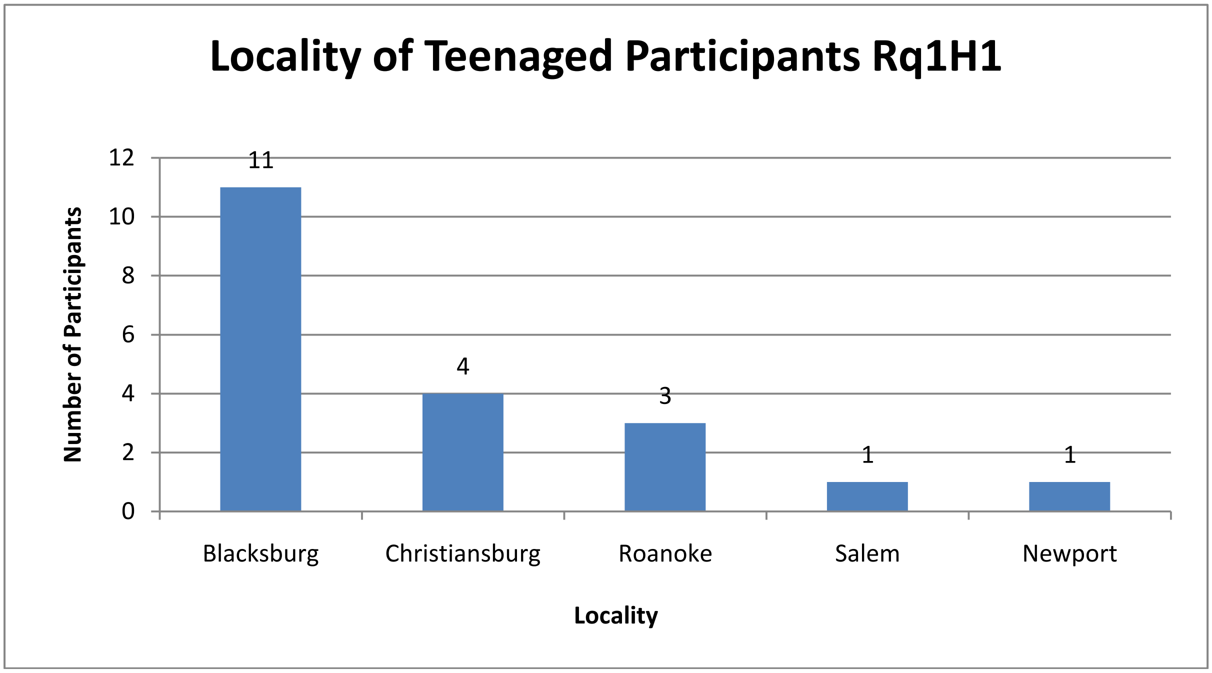


Figure 7. Distribution of participants' hometowns.

Participants' annual household incomes ranged from $40,000 to $100,000+ with a median family income of $100,000 and over. The following figure depicts the income levels for the participants. It can be seen that the majority of participants were from households with an annual income of $100,000 and over; $70,000 to $99,999 was the second largest, and $40,000 to $49,999 was the lowest.

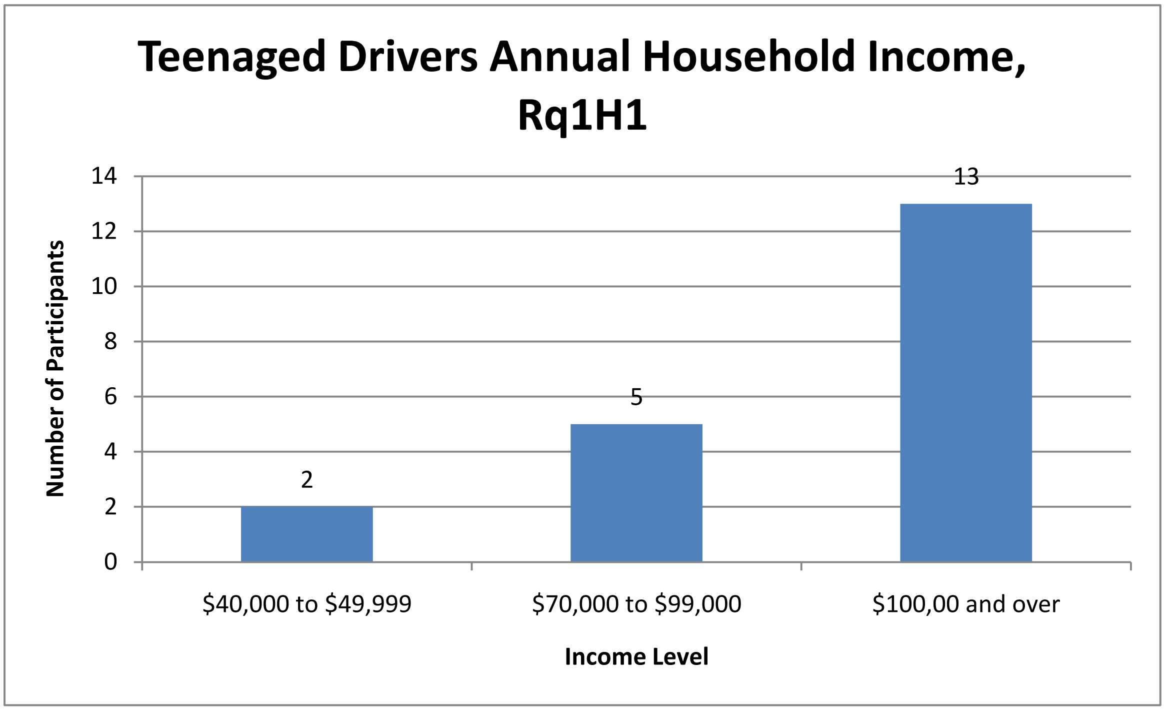


Figure 8. Income levels of participants

3.8.1.2 Hypothesis 2

For this analysis the demographics on the teenaged drivers is identical to hypothesis 1. The experienced parent group's age ranged from 44.9 to 53.1 with a mean age 48.3.

Participants resided in Blacksburg, Christiansburg, and Dublin. The following figure is a breakdown of the participant's hometowns. It can be seen that the majority of the participants' hometowns are Blacksburg.

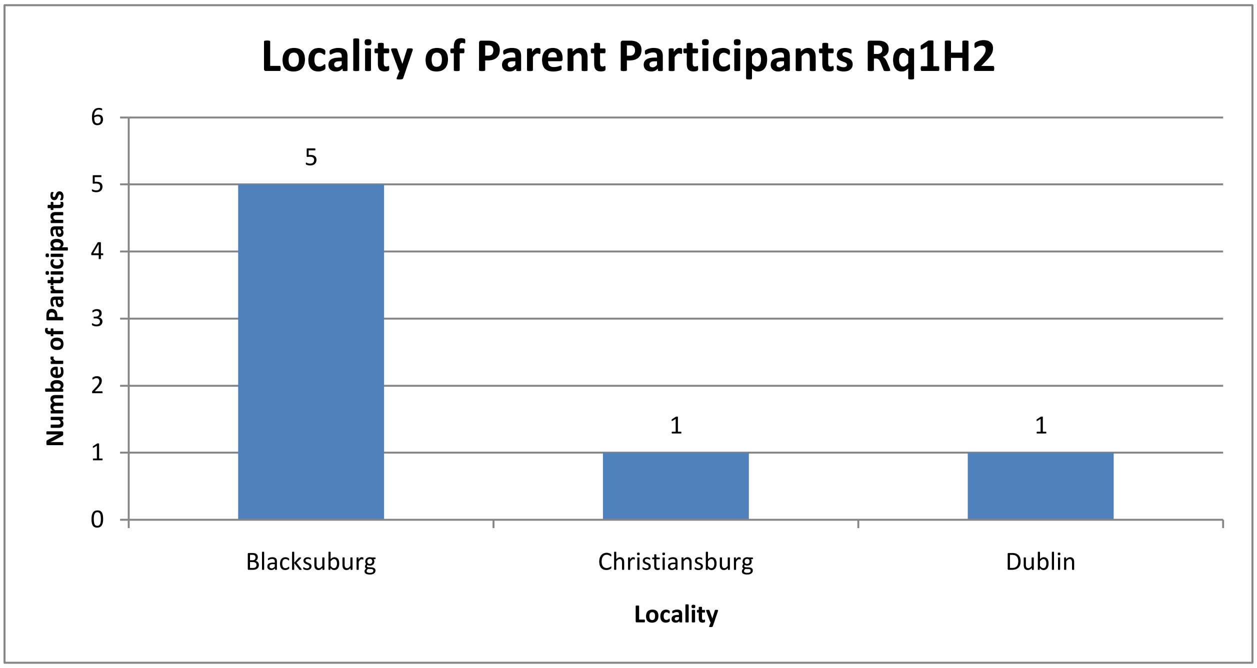


Figure 9. Distribution of participants' hometowns

Participants' annual household incomes ranged from $70,000 to $100,000+ with a median income of $100,000 and over. The following figure depicts the income levels for the participants. It can be seen that the majority of participants were from households with an annual income of $100,000 and over. Households with annual incomes of $70,000 to $99,999 were the second largest.

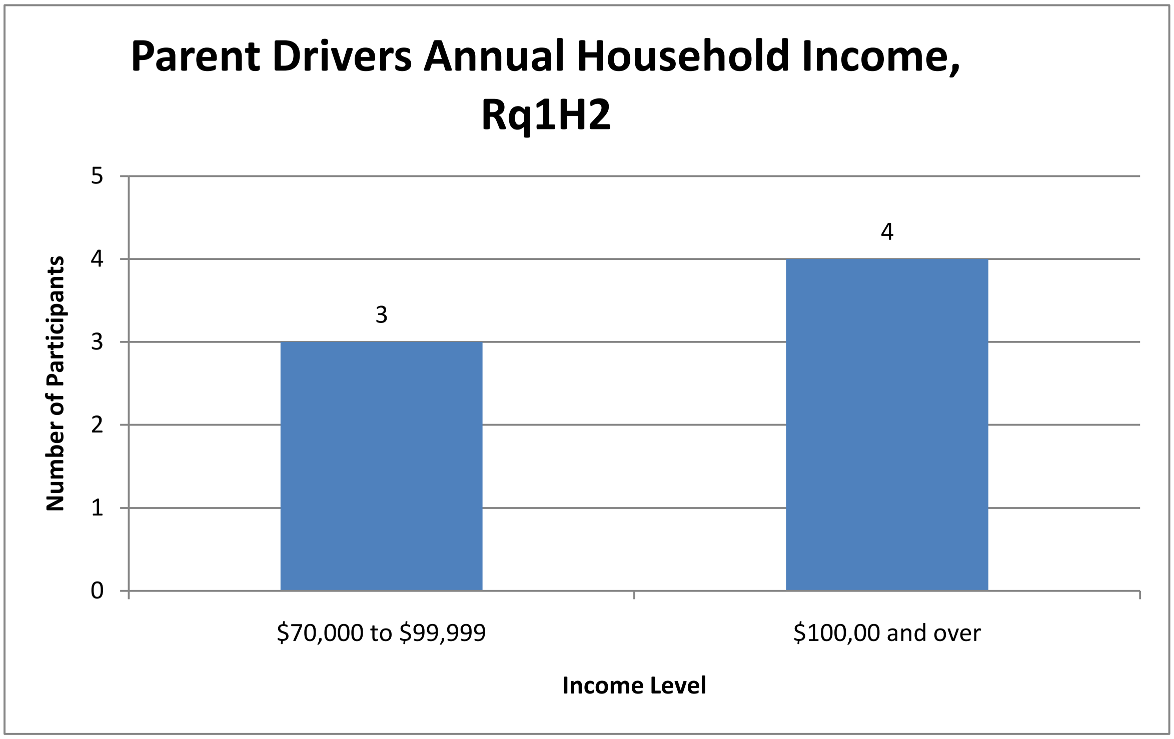


Figure 10. Income levels of participants

3.8.1.3 Hypothesis 3

For this analysis participants' ages ranged from 16.3 to 16.8 years of age with a mean age of 16.4. Participant GPA ranged from 3.3 to 4.1 with a mean of 3.6. Participants resided in Blacksburg, Christiansburg, Roanoke, Salem, Newport, and Dublin. The following figure is a breakdown of the participants' hometowns. It can be seen from the figure that the majority of participants were from Blacksburg.

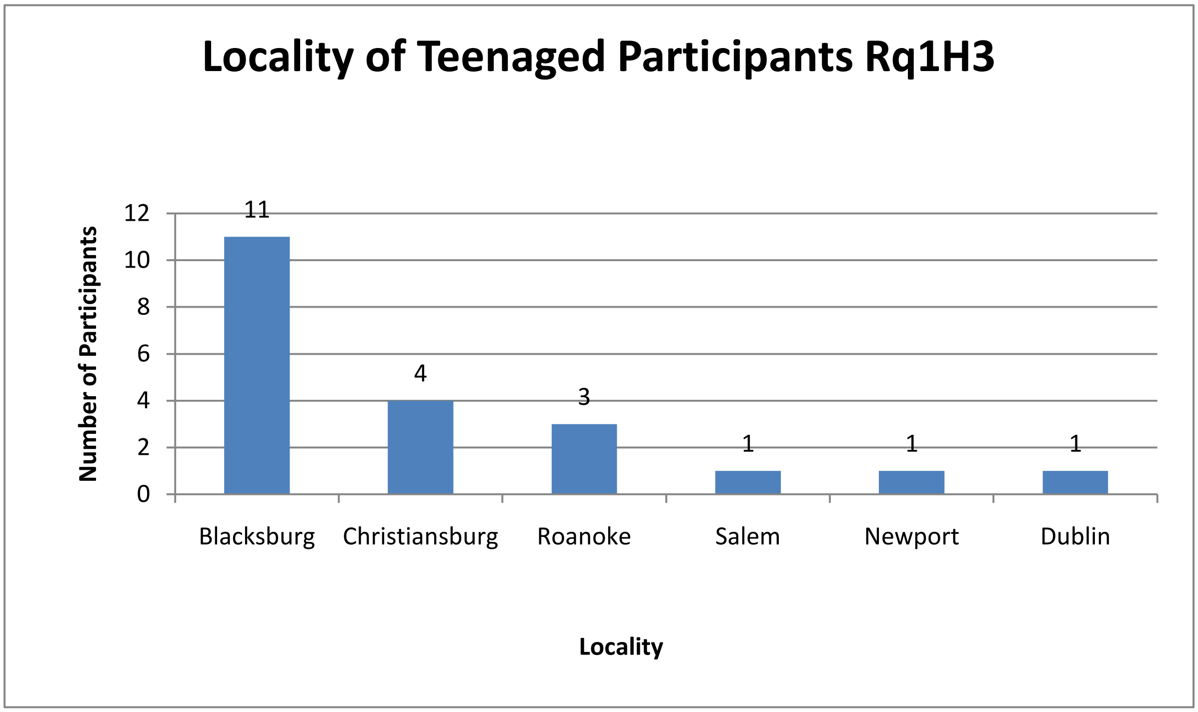


Figure 11. Distribution of participants' hometowns

Participants' annual household incomes ranged from $40,000 to $100,000+ with a median income of $100,000 and over. The following figure depicts the income levels for the participants. It can be seen that the majority of participants were from households with an annual income of $100,000 and over; $70,000 to $99,999 was the second largest, and $40,000 to $49,999 was the lowest.

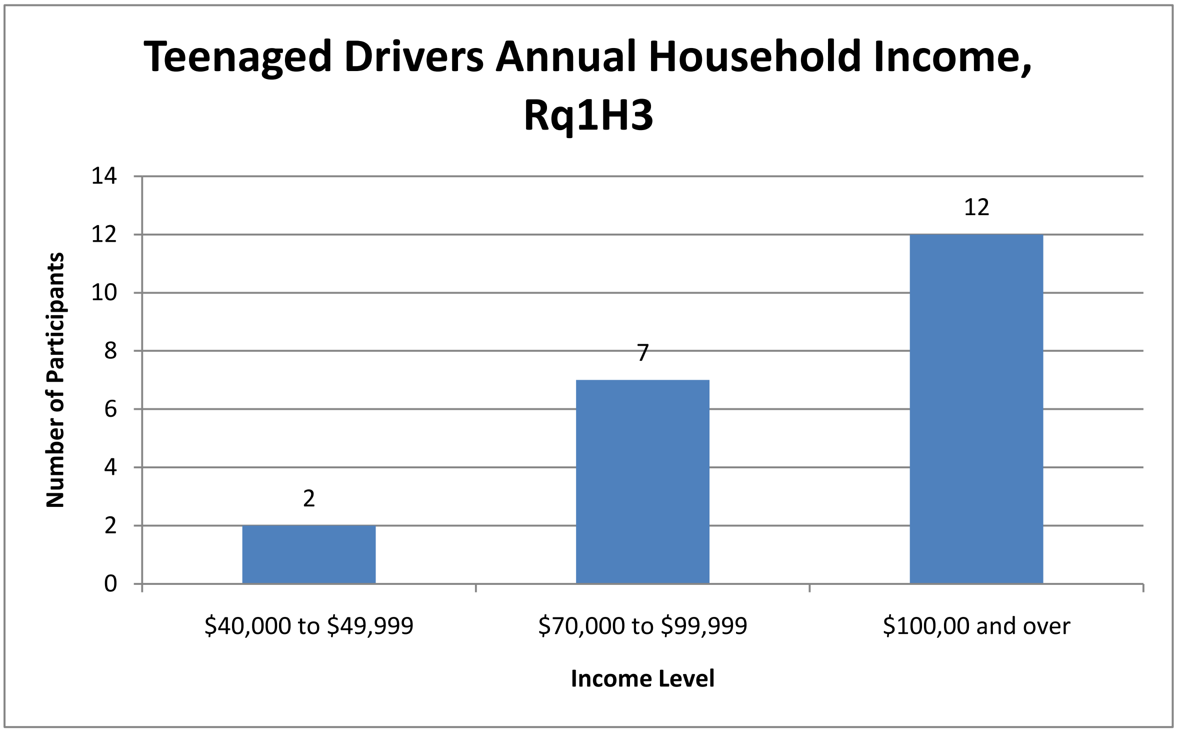


Figure 12. Income levels of participants

3.8.1.4 Hypothesis 4

For this analysis the demographics on the teenaged drivers is identical to hypothesis 3. The experienced parent group's age ranged from 43.3 to 53.1 with a mean age 47.3.

Participants resided in Blacksburg, Christiansburg, Radford, Newport and Dublin. The following figure is a breakdown of the participants' hometowns. It can be seen that the majority of the participants' hometowns are Blacksburg.

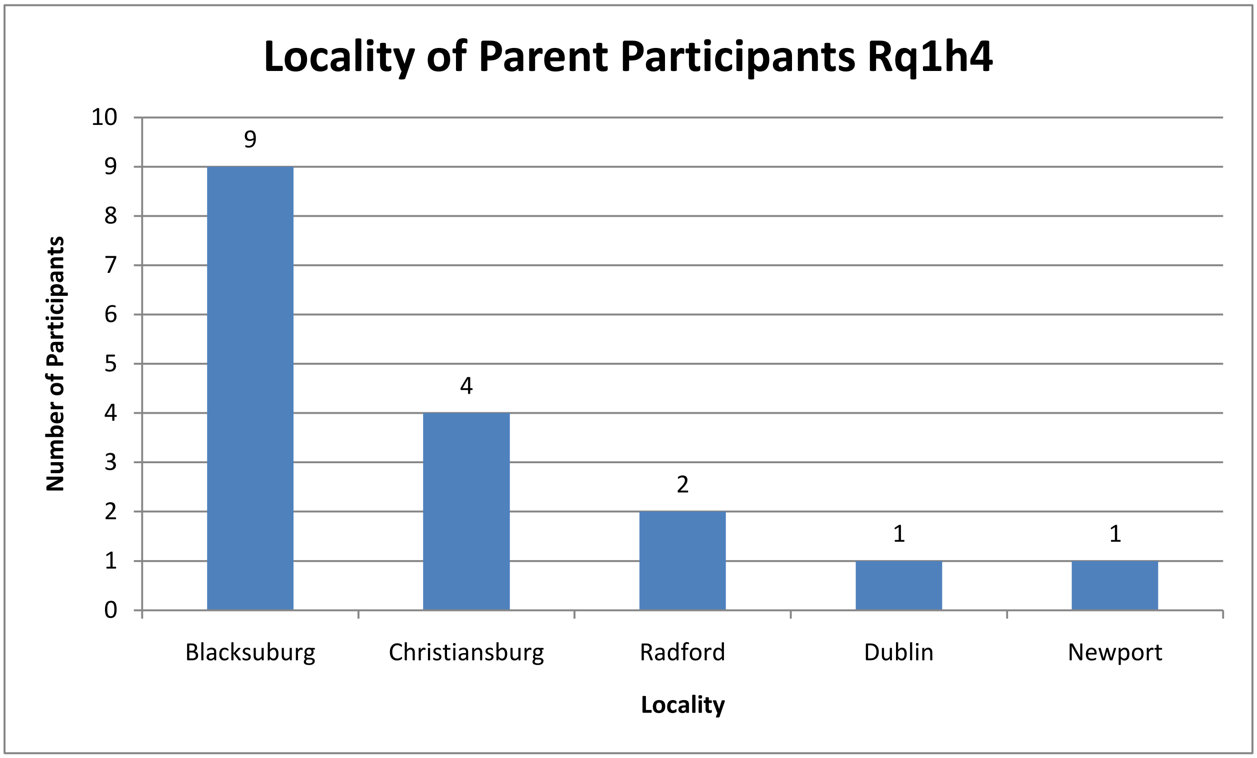


Figure 13. Distribution of participants' hometowns

Participants' annual household incomes ranged from $29,000 to $100,000+ with a median income of $100,000 and over. The following figure depicts the income levels for the participants. It can be seen that the majority of participants were from households with an annual income of $100,000 and over; $70,000 to $99,999 was the second largest, $40,000 to $49,999 was the third largest, and $29,000 was the lowest.

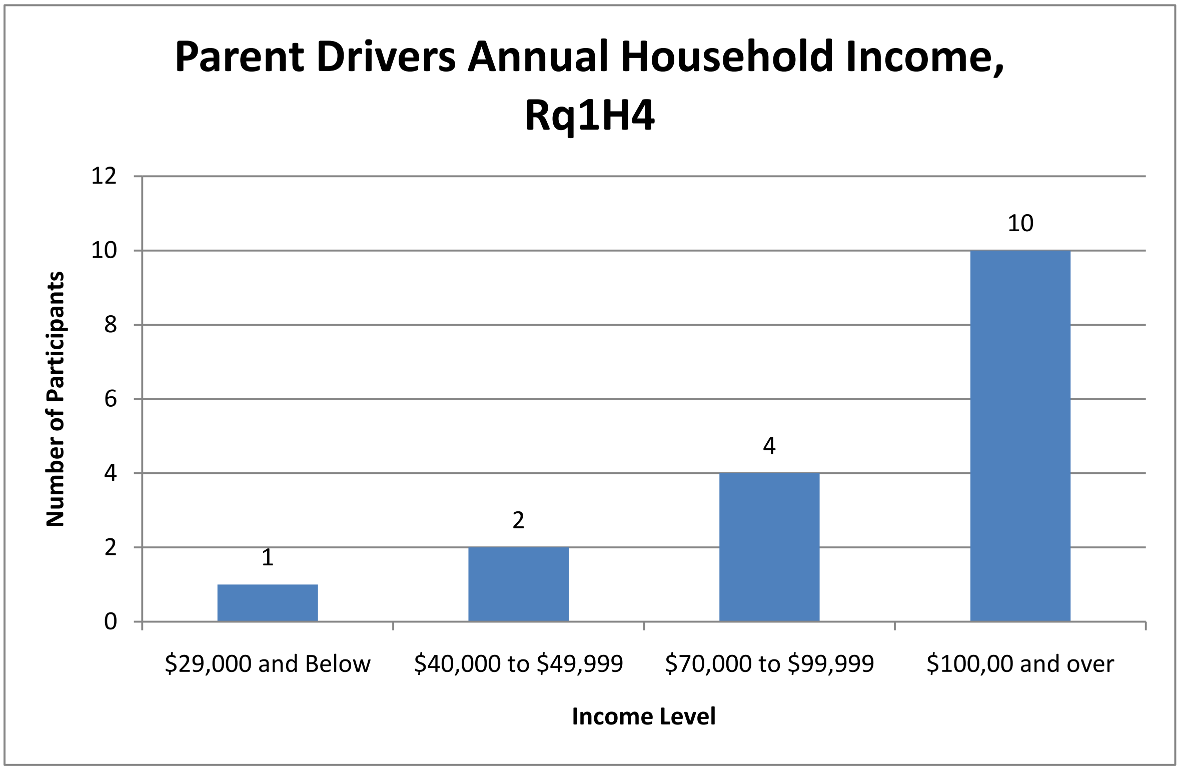


Figure 14. Income levels of participants

3.8.2 Research Question 2

3.8.2.1 Hypothesis 1

For this analysis the teenaged participants' ages range from 16.3 to 17.3 years of age with a mean of 16.5. Participant GPA ranged from 3.3 to 4.0 with a mean of 3.6.

The teenaged participants resided in Blacksburg, Christiansburg, Roanoke and Newport. The following figure is a breakdown of the participant's hometowns. It can be seen that the majority of the participants' hometowns are Blacksburg.

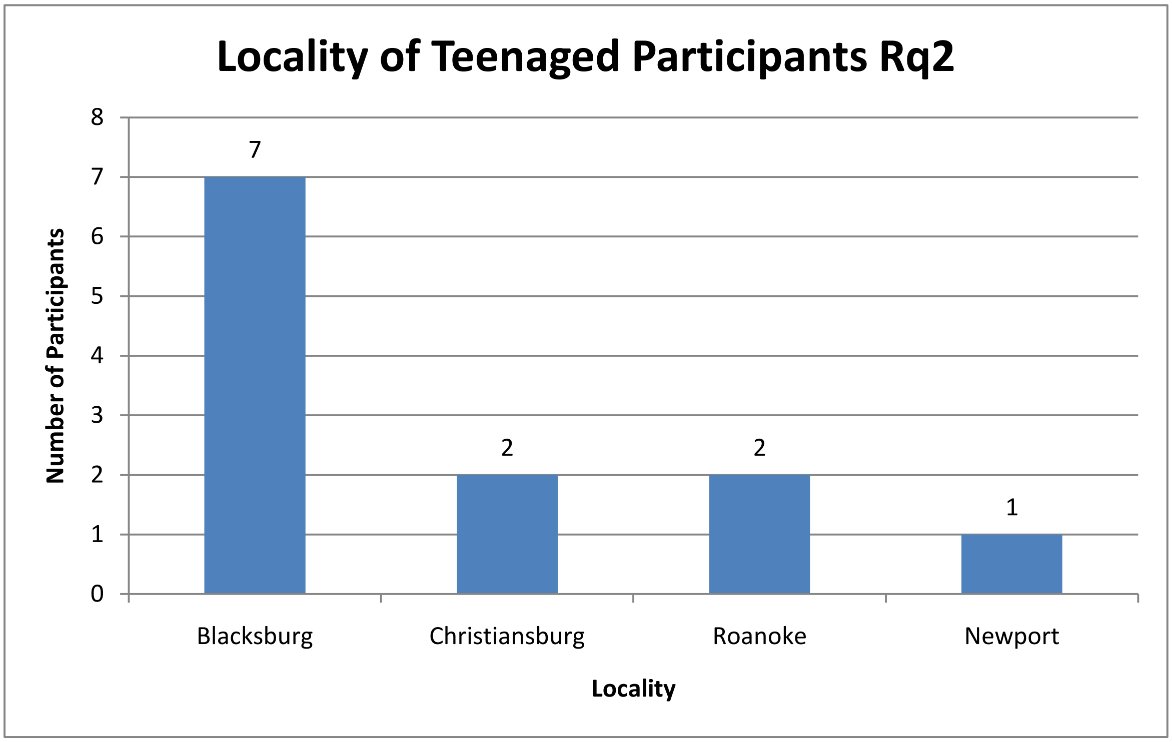


Figure 15. Distribution of participants' hometowns

Participants' annual household incomes ranged from $40,000 to $100,000+ with a median income of $100,000 and over. The following figure depicts the income levels for the participants. It can be seen that the majority of participants were from households with an annual income of $100,000 and over; $70,000 to $99,999 was the second largest, and $40,000 to $49,999 was the lowest.

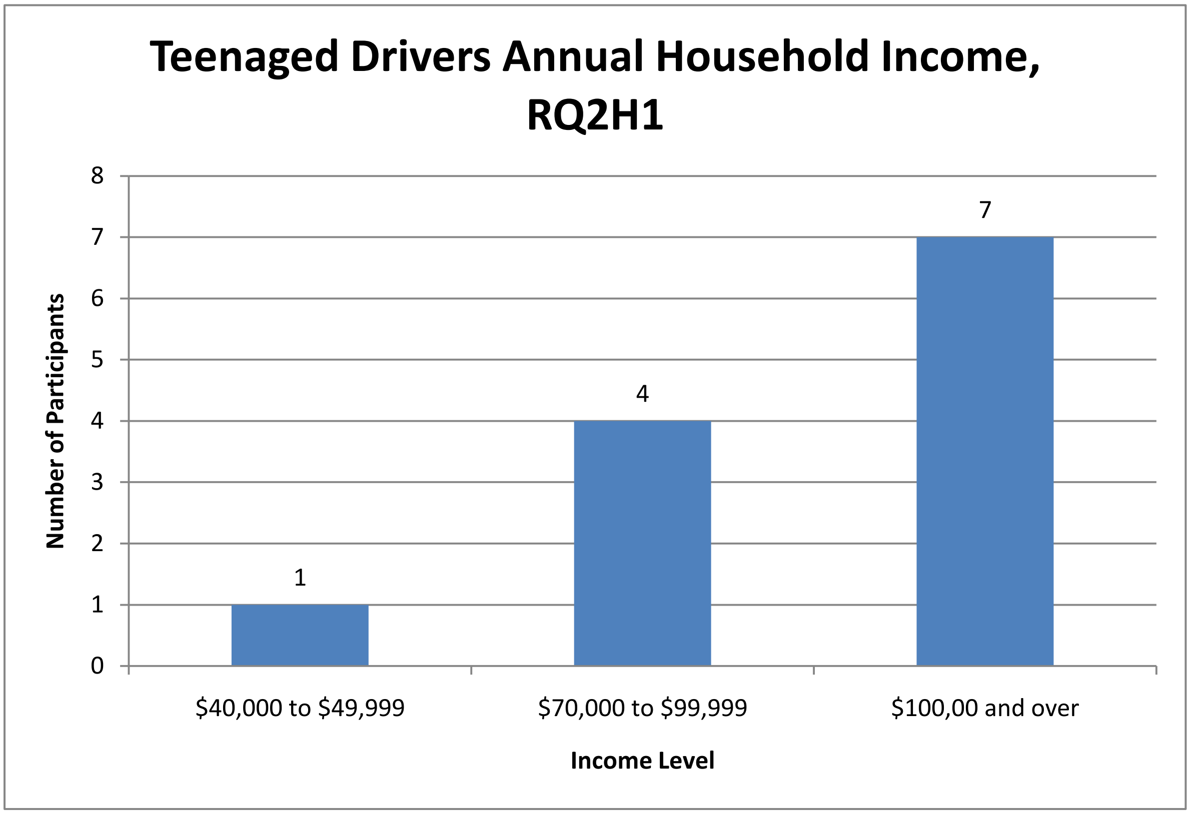


Figure 16. Income levels of participants

3.8.2.2 Hypothesis 2

For this analysis the teenaged demographic data was the same from hypothesis 1. The parent drivers' ages range from 43 to 48.3 years of age with a mean age of 45.6.

The parent driver participants resided in Blacksburg, Christiansburg, and Newport. The following figure is a breakdown of the participants' hometowns. It can be seen that the majority of the participants' hometowns are Blacksburg.

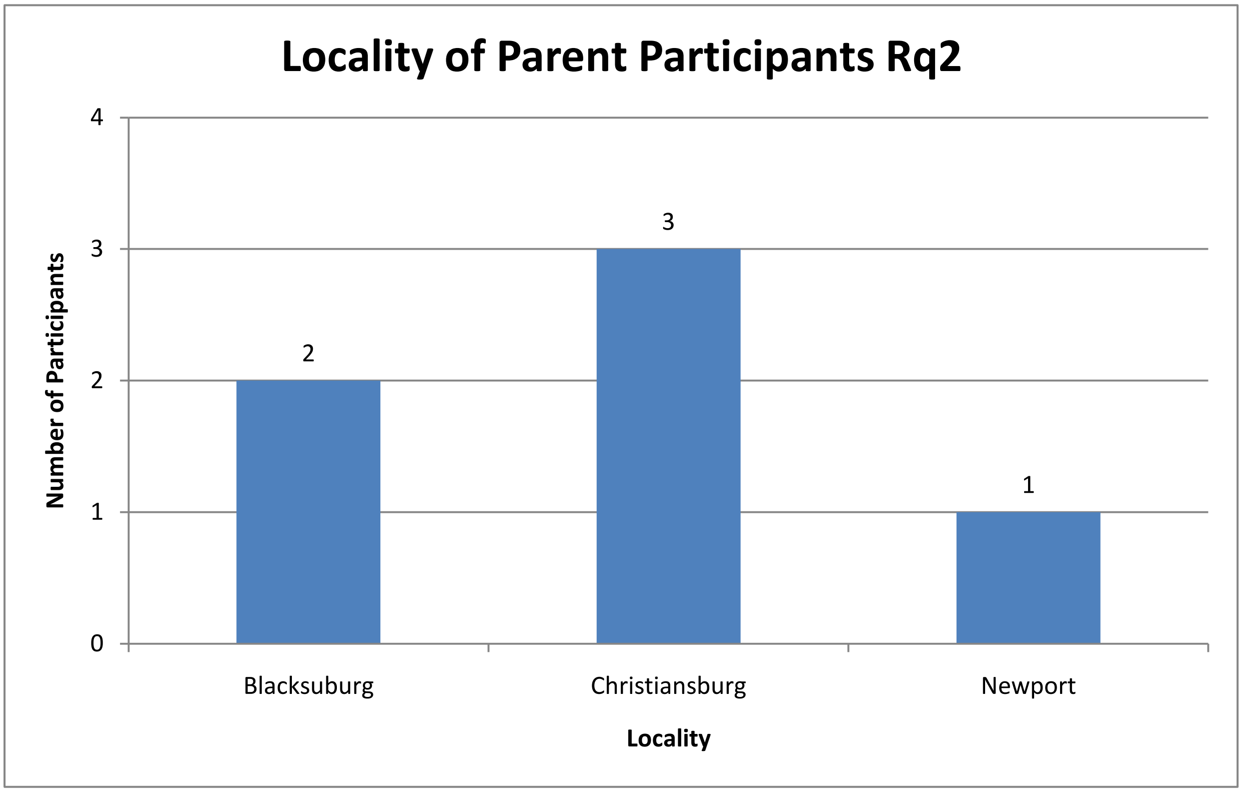


Figure 17. Distribution of participants' hometowns

Participants' annual household incomes ranged from $70,000 to $100,000+ with a median income of $100,000 and over. The following figure depicts the income levels for the participants. It can be seen that the majority of participants were from households with an annual income of $100,000 and over; $70,000 to $99,999 was the second largest.

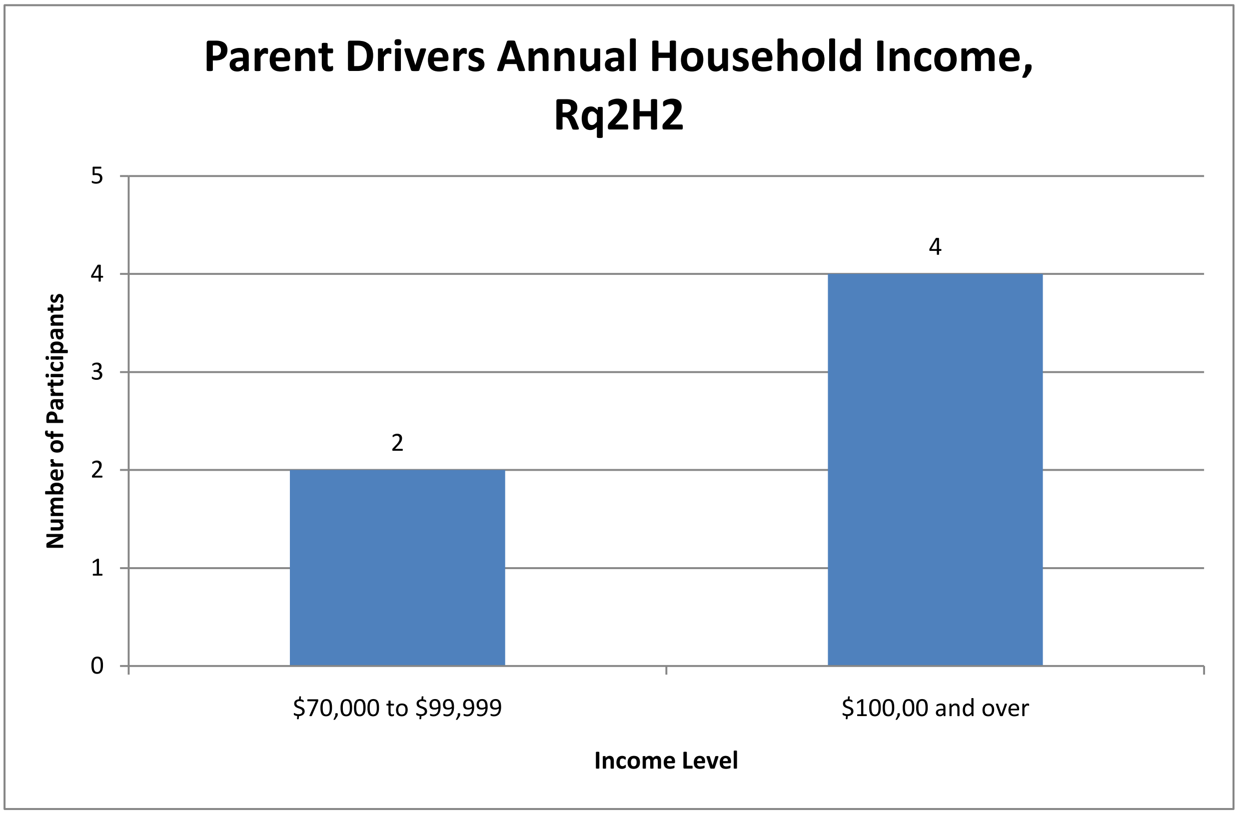


Figure 18. Income levels of participants

4.0 Results

(ANOVA tables can be found in appendix K)

4.1 Research Question 1

How does the frequency of driving related glances and duration of single glances away from the forward roadway change from immediate licensure to six months post licensure for newly licensed teenage drivers?

The Shapiro-Wilks test was used to establish that the dependant variables glance duration and percentage of driving related glances were normally distributed, $w = 0.97$, $p = 0.2$

4.1.1 Hypothesis 1

As driving experience for teenaged driver's increases, single eye glance durations away from the forward roadway will decrease.

> Ho: = There will be no difference in single eye glance durations away from the forward roadway over a six month period.
>
> Ha: = As driving experience increases, single eye glance durations away from the forward roadway will decrease.

When an ANOVA was performed comparing glance duration for each category of month (for newly licensed teenage drivers) no significance was found.

When an ANOVA was performed comparing the mean maximum glance duration for each category of month (for newly licensed teenage drivers) no significance was found.

4.1.2 Hypothesis 2

Teenaged drivers will have longer single eye glance durations away from the forward roadway compared to the experienced parent group.

> Ho: = There will be no difference in single eye glance durations away from the forward roadway between teenaged drivers and the experienced parent group.
>
> Ha: = Teenaged drivers single eye glance durations away from the forward roadway will be higher than the experienced parent group.

Due to unequal variance between the Newly Licensed teenage drivers and the parental control group a Welch's t-test was performed and found a significant difference between groups $t(6) = 3.75$, $p = 0.03$.

Below is a figure depicting the mean glance durations for newly licensed teenage drivers and the parental control group. The mean glance duration for the teenaged drivers was 0.43 seconds with a standard deviation of 0.11 seconds. The mean glance duration for the experienced parent group was 1.25 seconds with a standard deviation of 0.5 seconds. Note the longer mean glance durations for the parental control group.

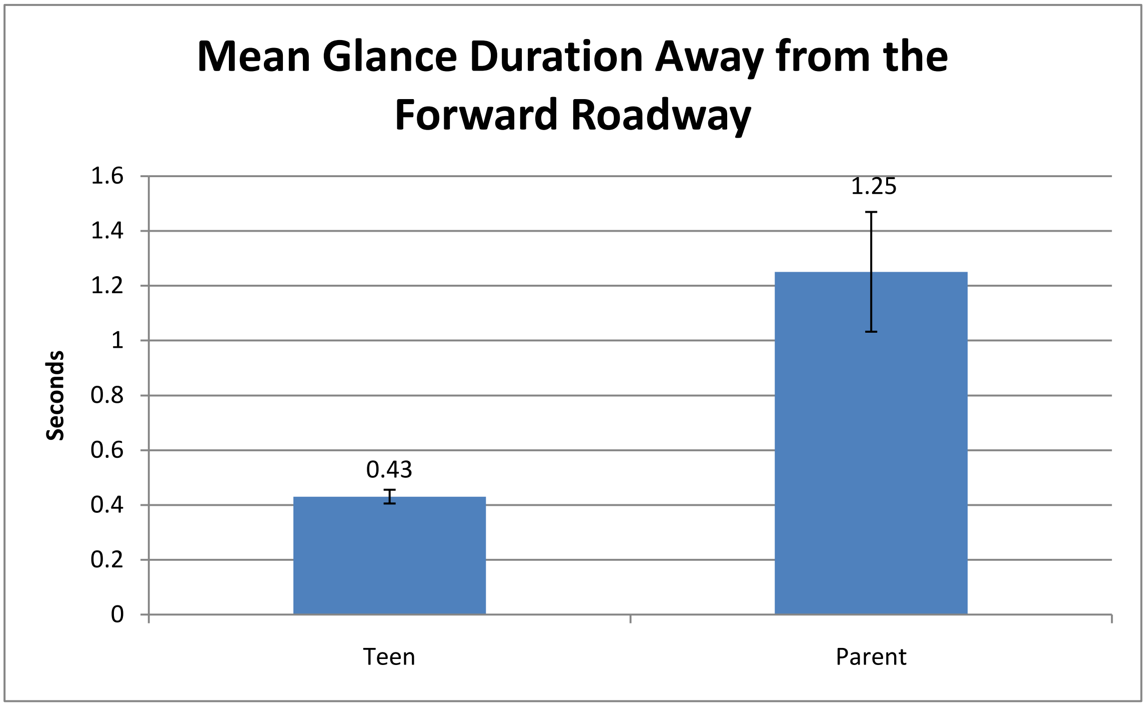


Figure 19. Mean glance duration away from the forward roadway for newly licensed teenage drivers and the parental control group.

Due to unequal variance between the newly licensed teenaged drivers and the parental control group a Welch's t-test was performed on the mean maximum glance durations and found a significant difference between groups $t(6) = 3.67$, $p < 0.01$.

Below is a figure depicting the mean maximum glance durations for newly licensed teenage drivers and the parental control group. The mean maximum glance duration for the teenaged drivers was 0.5 seconds with a standard deviation of 0.05 seconds. The mean glance duration for the experienced parent group was 1.36 seconds with a standard deviation of 0.6 seconds. Note the longer mean glance durations for the parental control group.

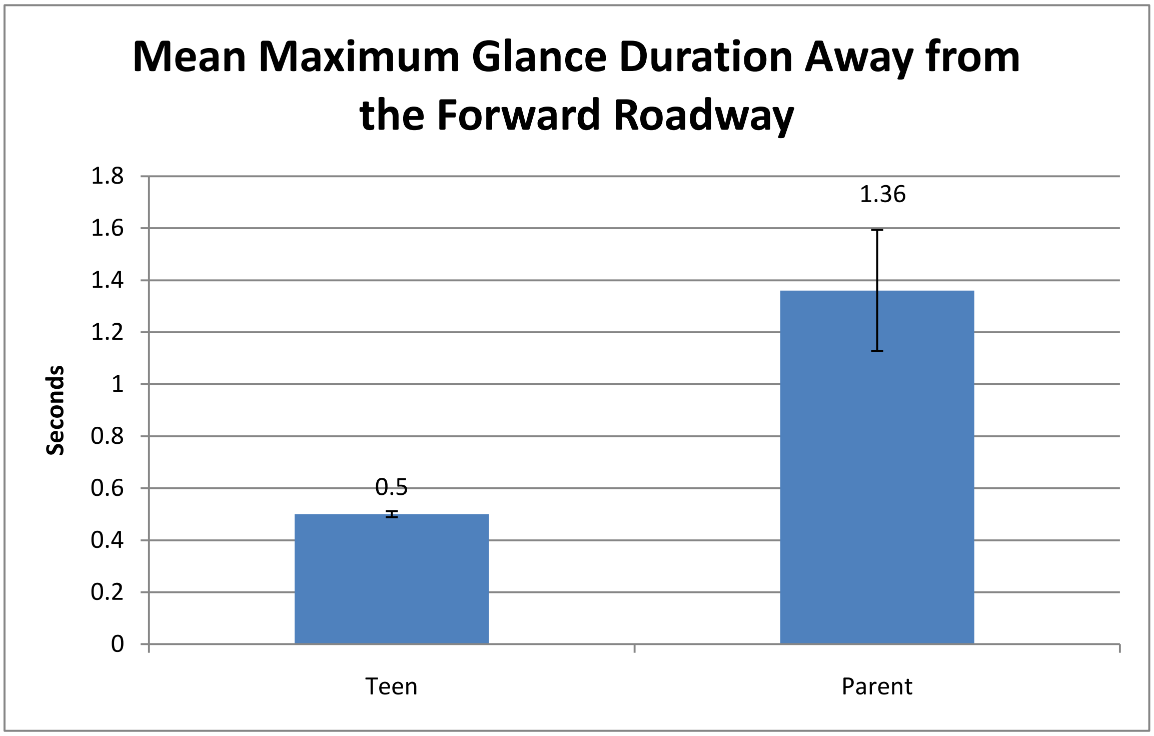


Figure 20. Mean Maximum glance duration away from the forward roadway for newly licensed teenage drivers and the parental control group.

4.1.3 Hypothesis 3

As driving experience increases, the percentage of driving related glances away from the forward roadway will increase.

> Ho: = There will be no difference in the percentage of driving related glances away from the forward roadway over the first six months of driving
>
> Ha: = As driving experience increases, the percentage of driving related glances away from the forward roadway will increase.

When an ANOVA was performed comparing percentages of driving related glances for each category of month (for newly licensed teenage drivers) no significance was found.

When an ANOVA was performed comparing the mean minimum percentage of driving related glances for each category of month (for newly licensed teenage drivers) no significance was found.

4.1.4 Hypothesis 4

Teenaged drivers will have a higher percentage of driving related glances away from the forward roadway than the experienced adult group.

Ho: = There will be no difference in the percentage of driving related glances away from the forward roadway between teenaged drivers and the experienced parent group.

Ha: = Teenaged drivers percentage of driving related glances away from the forward roadway will be lower than the experienced parent group.

A t-test was performed comparing the mean percentage of driving related glances of newly licensed teenaged drivers to the experienced parent group and found a significant difference $t(36) = 3.86$, $p < 0.01$.

Below is a figure depicting the mean percentage of driving related glances for newly licensed teenaged drivers and the experienced parent group. The mean percentage of driving related glances for teenaged drivers was 75% and 62% for the experienced parent group. Note the higher percentage of driving related glances for the parental control group.

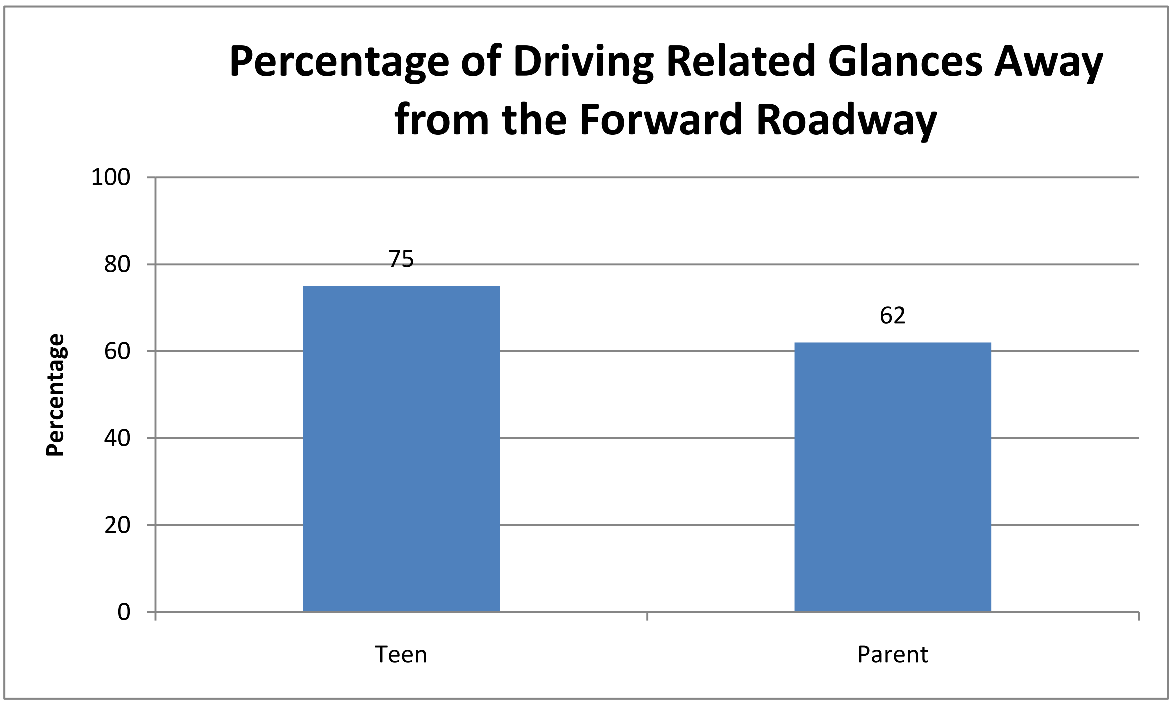


Figure 21. Percentage of driving related glances away from the forward roadway for newly licensed teenage drivers and the parental control group.

A t-test was performed comparing the mean minimum percentage of driving related glances of newly licensed teenaged drivers to the experienced parent group and did not find any significant difference.

4.2 Research Question 2

How does the percentage of time spent with eyes off forward roadway (EOFR) change in the presence of passengers and how does this compare to experienced parent drivers?

The Shapiro-Wilks test was used to establish that the dependant variables glance duration and percentage of driving related glances were normally distributed, $w = 0.97$, $p = 0.1$.

4.2.1 Hypothesis 1

In the presence of passengers, newly licensed teenager's percentage of time spent with EOFR will change significantly compared to when driving alone.

> Ho: = There will be no difference in percent time spent with EOFR when teenaged drivers are in the presence of passengers compared to when driving alone.
>
> Ha: = Percentage of time spent with EOFR will be higher with passengers in the vehicle when compared to driving alone.

When an ANOVA was performed comparing percentage of time spent with EOFR for each level of passenger no significance was found.

When an ANOVA was performed comparing the mean maximum percentage of time spent with EOFR for each level of passenger a significant difference was found, $F(2,33) = 0.12$, $p = .016$.

A Tukey multiple comparison test was performed on the mean maximum percent of time spent with EOFR for each level of passenger present, and the significant difference between zero passengers in the vehicle and one passenger in the vehicle, $F(2,33)=3.09$, $p=.015$. The following figure shows the percentage of time spent with EOFR for no passengers in the vehicle and one passenger present in the vehicle. Note that the percentage of time spent with EOFR for one passenger was over double that of no passengers present.

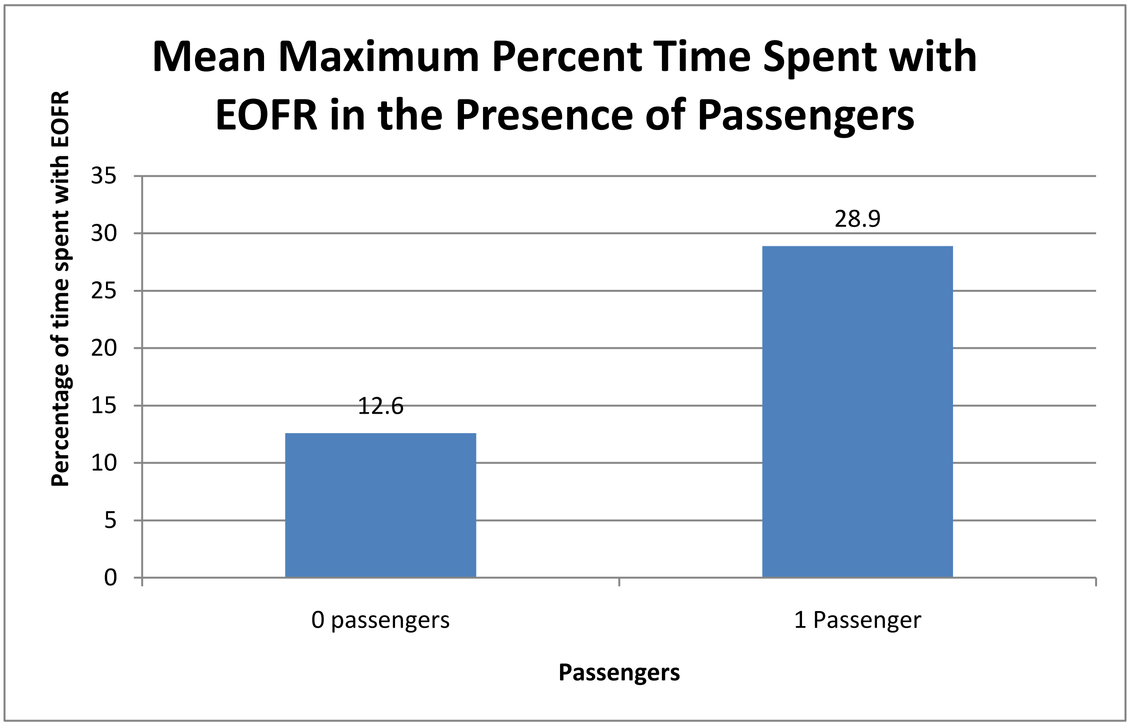


Figure 22. Mean maximum percent time spent with EOFR in the presence of passengers.

4.2.2 Hypothesis 2

In the presence of passengers, newly licensed teenager's percentage of time spent with EOFR will change significantly compared to when driving alone.

Ho: = There will be no difference in percent time spent with EOFR when teenaged drivers are in the presence of passengers compared to when driving alone.

Ha: = Percentage of time spent with EOFR will be higher with passengers in the vehicle when compared to driving alone.

When an ANOVA was performed comparing percentage of time spent with EOFR for each level of experience no significance was found.

When an ANOVA was performed comparing mean maximum percentage of time spent with EOFR for each level of experience no significance was found.

Although there was no difference found when comparing the mean maximum percent of time spent with EOFR of teenaged drivers and experienced parent drivers the data did follow a trend. The following figure shows percent time spent with EOFR in the presence of passengers for both teenaged drivers and experienced parent drivers. It can be seen from the figure that the data does follow the trend of no passengers having the lowest percent EOFR, two passengers having a higher percent EOFR and one passenger present having the highest percent EOFR.

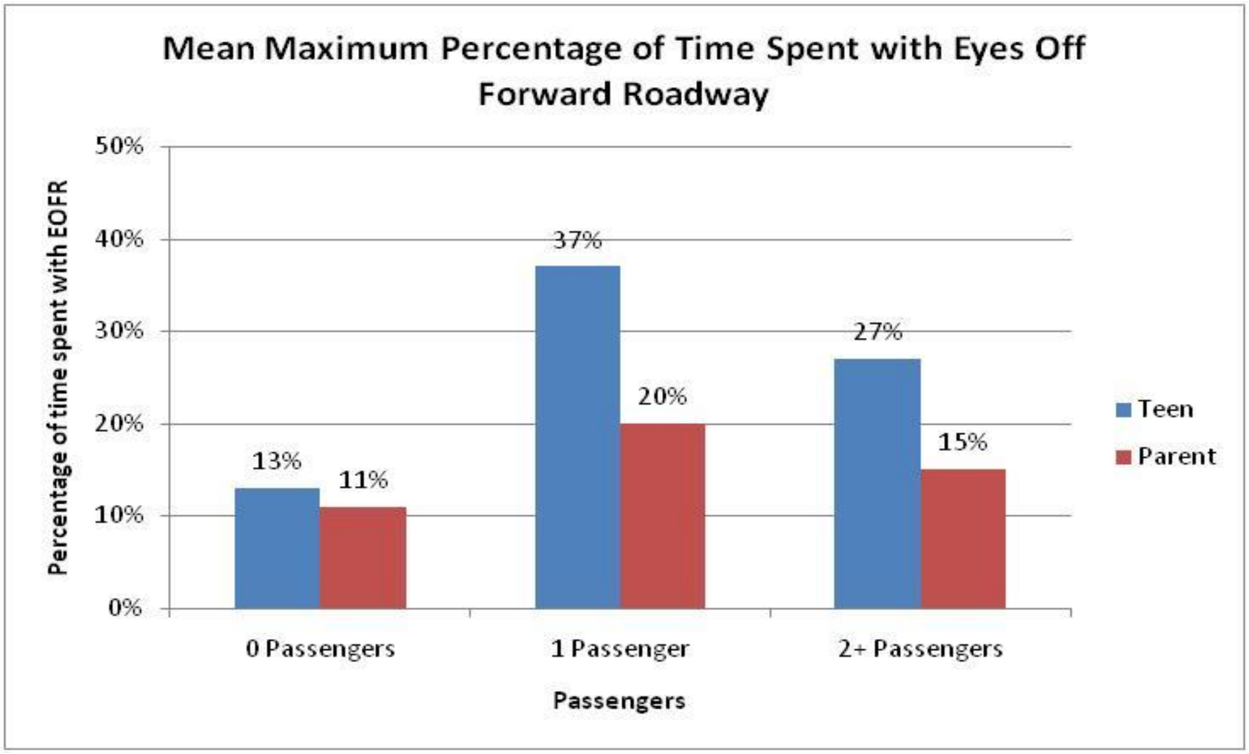


Figure 23 . Mean Maximum percentage of EOFR for newly licensed teenage drivers and the adult comparison group in the presence of passengers.

5.0 Discussion

5.1 Research Question 1

How does the frequency of driving related glances and duration of single glances away from the forward roadway change from immediate licensure to six months post licensure for newly licensed teenaged drivers, and how does it compare to experienced parent drivers?

5.1.1 Hypothesis 1

As driving experience increases, single eye glance durations away from the forward roadway will decrease.

Ho: = There will be no difference in single eye glance durations over a six month period

Ha: = As driving experience increases, single eye glance durations will decrease

The analysis failed to reject the null hypothesis; the results in the data showed that there were no significant differences in mean glance duration of teenaged drivers within the first six months of driving, with mean glance lengths ranging from 0.4 seconds to 0.5 seconds. When examining the extremes, the results indicated there were no significant differences in mean maximum glance durations of teenaged drivers within the first six months of driving, with the mean maximum glance lengths ranging from 0.49 seconds to 0.53 seconds. It is important to note that there was not a large difference between mean glance durations and mean maximum glance durations. This indicates that teenaged drivers glance durations are relatively consistent at around half a second.

This finding possibly suggests that as a youth or a beginner driver glance duration is a stable characteristic within the first six months of driving and that glance duration may not be a strong indicator of learning/growth within the first six months of driving. However, it is also important to note that glance durations were only looked at for the first six months of driving, and the glances durations were specific to straight road segments only.

5.1.2 Hypothesis 2

Teenaged drivers will have longer single eye glance durations compared to the experienced parent group.

Ho: = There will be no difference in single eye glance durations between teenaged drivers and the experienced parent group.

Ha: = Teenaged drivers' single eye glance durations will be higher than the experienced parent group.

While no significant difference in glance duration was found within six months for teenaged drivers, this does not indicate that glance durations stay consistent over a longer period of time. For this analysis the null hypothesis was rejected. When comparing both mean and mean maximum eye glance durations of teenaged drivers to experienced parent drivers, the parent drivers had significantly longer glance durations. The mean and the mean maximum glance duration for the parent drivers were almost four times higher than that of teenaged drivers.

The results demonstrate that somewhere between six months of driving experience and being and an experienced adult driver a change in the duration of glances takes place. What is unknown is exactly where and over what time frame these changes occur. It would be beneficial to examine glance durations for multiple groups of different experience level drivers to determine where and at what point do glance durations change. It could also be determined if the rate of change is rapid or if it is a slow, gradual change that takes place over a longer period of time

One possible reason for the large difference in glance durations between the experienced parent group and the teenaged driver group is that experienced drivers are more comfortable taking longer glances away from the forward roadway. This may be a result of experienced drivers knowing the appropriate times to take these longer glances. In a study that examined processing demands on visual information acquisition in drivers for experienced and novice drivers, researchers recorded eye movements using a head mounted eye tracker while participants were driving. Results from the study showed that novice teenaged drivers had longer glance durations the more complex the roadway became (Crundall & Underwood, 1998). Similar to the findings in this study, rural settings, which were considered less complex, adult drivers had longer glance durations than the teenaged drivers. For example, in this study the roadways sampled were straight road segments with no traffic lights, crossing traffic or merging traffic. The experienced parent comparison group may have recognized this situation as a more appropriate time to take a longer glance without drastically increasing their risk of a crash.

According to Lee, Olson & Simons-Morton (2006), authors suggest that teenagers may lack situational awareness when compared to experienced adults. Another possible reason for the experienced driver group having a longer mean glance time is that the experienced parent group may have more situational awareness compared to the teenaged driver group. With a higher situational awareness the experienced parent drivers may be able to take in more information with a single glance and therefore have longer glance durations while being aware of their surroundings. It could also be suggested that the experienced parent driver group's situational awareness is enhanced by the longer glance durations.   For example, an experienced driver may take a longer glance away from the forward roadway therefore taking in more information of their surroundings, as opposed to taking in less information with a shorter glance as suggested with the teenaged driving group.

In the study conducted by Lee, Olson, & Simons-Morton (2005), where researchers examined and compared eye glance behaviors of novice teenaged drivers and experienced adult driver's, the findings showed that novice teenaged drivers spent more eyes off road time looking at task displays, whereas adults used some of the eyes off road time to check mirrors and windows. Although in this study the experienced adults may have had longer glances away from the roadway, it is unclear the exact locations that the glances were targeted towards and it would be beneficial to examine this with a more in-depth study utilizing a larger data set.

In a study assessing the development of spatial attentional orienting during the school aged years, researchers used focused attention tasks and shift in attention tasks in 7 – 17 year olds and 40 adults. The study found that orienting attention and disengaging attention was faster and visual processing was more accurate as age increases (Schul, Townsend, & Sites, 2003). In comparing glance durations away from the forward roadway of teenaged drivers to experienced parent drivers, the research could suggest that the experienced parents use longer glance durations because they have the ability to disengage and orient attention back to the forward roadway faster that the younger teenaged drivers. Whereas teenaged drivers have shorter glances away from the forward roadway because it takes more time to orient attention back to the forward roadway once the glance is complete.

In Pradhan et al. (2006), using a driving simulator researchers concluded that with training novice teenaged drivers were better able to detect hazards and perform closer to the level of experienced adults when compared to novice teenaged drivers that received no training. An explanation for experienced parents having longer glance durations is that they are able to adjust their attention faster and are more aware of hazards therefore they are more comfortable with longer glance durations away from the forward roadway. Whereas, teenaged drivers do not as accurately recognize hazards as accurately as adults, therefore they need to constantly monitor the forward roadway resulting in shorter glance durations away from the forward roadway.

Another possible explanation for teenaged drivers having shorter glance durations than the experienced adult group lies in the demographic data. The average teenaged driver's GPA was 3.62, which is considered either an A- or a B+ average depending on the school system. As described in the literature review section students with higher GPA's generally demonstrate safer driving behaviors.

5.1.3 Hypothesis 3

As driving experience increases, the percentage of driving related glances will increase.

> Ho: = There will be no difference in the percentage of driving related glances over the first six months of driving
>
> Ha: = As driving experience increases, the percentage of driving related glances will increase.

This analysis failed to reject the null hypothesis; the results in the data showed that there was no significant difference in the mean percentage of driving related glances within the first six months of driving for teenaged drivers with the mean percentage of driving related glances ranging from 75% to 76%. The results do demonstrate that teenaged drivers spend about three quarters of their glances away from the forward roadway focused on glances related to the operation of the vehicle.

When examining the extremes, mean minimum percentage of driving related glances, there was also no significant difference found within the first six months of driving with the mean minimum percentage of driving related glances ranging from 20% to 30%. The results do demonstrate at the minimum teenaged drivers within the first six months consistently spend around one third of their glances related to the operation of the vehicle.

The results do suggest that the percentage of driving related glances within the first six months of driving is a stable characteristic and similar to glance durations may not be a strong indicator of learning or development within the first six months of driving for teenaged drivers. Although there were no differences within the first six months of driving, there is a large gap present between the mean and the mean minimum percentage of driving related glances. This gap doesn't suggest much when examining only teenaged drivers but does have possible implication when looking at the mean and mean minimum percentage of driving related glances when comparing teenaged drivers and the experienced parent driver group. This will be discussed in the following section.

5.1.4 Hypothesis 4

Teenaged drivers will have a higher percentage of driving related glances than the experienced adult group.

> Ho: = There will be no difference in the percentage of driving related glances between teenaged drivers and the experienced parent group.
>
> Ha: = Teenaged drivers' percentage of driving related glances will be lower than the experienced parent group.

For this analysis the null hypothesis was rejected. When comparing the mean percentage of driving related glances of teenaged drivers to the experienced parent drivers a significant difference was found. The teenaged driver group had a mean percentage of driving related glances of 75% and the experienced parent driver group had a mean percentage of 62%.   The results show that experienced parent drivers allocate less of their glances to the operation of a vehicle than the teenaged drivers do.

These results are of interest because they contradict the findings of the test-track study conducted by Lee et al. (2005). The test-track study found that during driving adults spent more of their time glancing at mirrors and other locations associated with driving than teenaged drivers. This could possibly be explained by the nature of the studies. For example, in the test-track study drivers were placed in a situation where they knew they were being tested and were more conscious of their driving habits possibly altering their driving habits.

One possible explanation of teenaged drivers having a higher mean percentage of driving related glances is that, like the suggestion with glance durations, they do not have the same level of situational awareness that the experienced parent drivers have. It could be suggested that the experienced parent drivers can take in and process more information with fewer glances than the less experienced teenaged driver group.

In a driving simulator study conducted by Land & Harwood (1995) researchers examined attentional demands on novice teenaged drivers. The study found that novice teenaged drivers had perceptual narrowing with an increase in cognitive load, therefore reducing the peripheral field of vision. It could be suggested that in this study because novice drivers are experiencing a large amount of new stimuli that they are susceptible to perceptual narrowing and reduction of the peripheral field of vision. This could in turn cause teenaged drivers to allocate a higher percentage of their glances toward driving related glances to compensate for the reduced peripheral field of view.

Teenaged drivers having a higher percentage of driving-related glances away from the forward roadway compared to the experienced parent group can also be explained by the development of visual short term memory (VSTM). In a study that examined VSTM on objects of expertise researchers found that VSTM is limited for complex objects and scenarios and as expertise increases so does VSTM (Curb & Glazek, 2009). This could be applied when comparing the percentage of driving-related glances away from the forward roadway of teenaged drivers and experienced parent drivers. Because driving is new to teenaged drivers and they are not considered experts, VSTM of their surroundings may be limited therefore causing them to utilize a higher percentage of glances. On the other hand experienced parents could be considered as having expertise with objects and driving scenarios therefore increasing their VSTM and reducing the necessity of having a higher percentage of driving-related glances away from the forward roadway.

In the study where researchers assessed spatial attentional orienting for the school-aged years as well as adults, researchers also found that visual processing becomes more accurate as age increases Schul et al. (2003). This could explain why teenaged drivers had a higher percentage of driving-related glances away from the forward roadway compared to experienced parents. Because visual processing becomes more accurate as age increases the experienced parent group may not be required to allocate a higher percentage of their glances toward glances that are driving-related; whereas teenaged drivers may need a higher percentage of driving-related glances away from the forward roadway to process their surroundings.

Though there was a significant difference when comparing the mean percentage of driving related glances of the two groups, there was no significant difference found when comparing the mean minimum percentage of driving related glances. Teenaged drivers had a mean minimum percentage of driving related glances of 23%, whereas the experienced parent driver was 25%. This finding suggests that there is a lower limit threshold of percentage of driving related glances that drivers generally do not go below.

Although results of comparing the teenaged driver group to the experienced parent driver group demonstrate that teenaged drivers have a higher mean percentage of driving related glances and there were no differences when examining the mean minimum, it is important to take notice that the average driving related glance length was not recorded. It would be of benefit to utilize a larger data set across multiple situations examining the glance length of specific situations.

As stated previously when comparing glance durations, a possible explanation for teenaged drivers having a larger percentage of driving related glances when compared to the experienced adults may be due to the demographics. The average GPA for participants in the analysis was 3.6.

5.2 Research Question 2

How does the percentage of time spent with eyes off forward roadway (EOFR) change in the presence of passengers and how does this compare to experienced parent drivers.

5.2.1 Hypothesis 1

In the presence of passengers, newly licensed teenager's percentage of time spent with EOFR will change significantly compared to when driving alone.

> Ho: = There will be no difference in percent time spent with EOFR when teenaged drivers are in the presence of passengers compared to when driving alone
>
> Ha: = Percentage of time spent with EOFR will be higher with passengers in the vehicle when compared to driving alone

For this analysis the null hypothesis was rejected; when comparing mean percent time spent with EOFR for teenaged drivers in the presence of passengers no significant difference was found. When examining the extremes for teenaged drivers, mean maximum percent time spent with EOFR, there was a significant difference between no passengers present and having one passenger present in the vehicle. When no passengers were present in the vehicle teenagers had a mean maximum percent time spent with EOFR of 12.6%; when one passenger was present the mean maximum percent time spent with EOFR was 28%.

Although there was no significant difference found when comparing no passengers and one passenger to two or more passengers, the data did follow the same trend for both teenaged drivers and the experienced parent group. Newly licensed teenage drivers had the lowest percent time spent with EOFR when no passengers were present at 13%, the second highest when two or more passengers were present at 27%, and the highest percent time spent EOFR when one passenger was present 37%. This is an interesting and important finding because currently GDL restrictions limit newly licensed teenage drivers to having no more than one passenger in the vehicle. While these restrictions may be in part due to distraction and willingness to engage in risk taking behaviors, the data shows that the percentage of time spent with their eyes off the forward roadway is actually greater with only one passenger in the vehicle than when there are two or more passengers present.

One possible explanation for this trend may be related to current GDL restrictions. Currently, GDL regulations prohibit teenaged drivers from having more than one passenger that is not related to the driver in the vehicle. Because of this restriction it could be suggested that the driver may be more reluctant to interact with passengers in the vehicle and may opt to pay more attention to the forward roadway for fear of being caught and losing his/her license.

Another explanation of this trend may be due to the concept of Diffusion of Responsibility. Diffusion of responsibility is a social phenomenon that occurs in groups above a critical size when responsibility is not explicitly assigned and when an individual's sense of responsibility is diluted in a large group setting (Latane & Darley, 1968). Specific to this study, when only one passenger is present in the vehicle the teenaged driver may feel obligated or responsible to interact with that passenger. If there are two or more passengers in the vehicle responsibility is not assigned to a specific person in the vehicle. For example, since there are more passengers in the vehicle the driver may not feel obligated or responsible for interacting with the passengers and pass the responsibility along to the other passengers to keep each other entertained; therefore enabling the driver to spend more time focused on the forward roadway.

5.2.2 Hypothesis 2

Teenaged drivers compared to the experienced parent group will have a higher percentage of time spent with EOFR when in the presence of passengers.

Ho: = In the presence of passengers there will be no difference in percentage of time spent with EOFR between teenaged drivers and the experienced adult group

Ha: = In the presence of passengers teenaged drivers will have a higher percentage of time spent with EOFR.

This analysis failed to reject the null hypothesis; although no significant differences were found when comparing mean and mean maximum percent time spent with EOFR for the experienced parent driver group, it is important to note that the data did follow the same trend as the teenaged passengers. This finding may suggest that both teenaged drivers and experienced adult drivers exhibit the same EOFR behaviors regardless of age.

Another explanation for not finding a significant difference between the teenaged drivers and the experienced parent group lies in the demographics. Teenaged drivers, the same as in question one, had an average GPA of 3.6 and as discussed earlier generally demonstrate safer driving behaviors.

6.0 Conclusion

6.1 Changes in Eye Scanning Patterns

Data from this study demonstrate that single glance durations within the first six months of driving for newly licensed teenaged drivers are a stable characteristic. When compared to the experienced parental group there was a difference, indicating that somewhere between the first six months of driving and adulthood glance durations of drivers actually increases. Below is a figure that depicts the area of interested where eye glance durations increase. The figure shows zero months of driving experience, six months of driving experience, and experienced adulthood. The area of interest where glance durations can be seen is between six months of driving experience and adulthood.

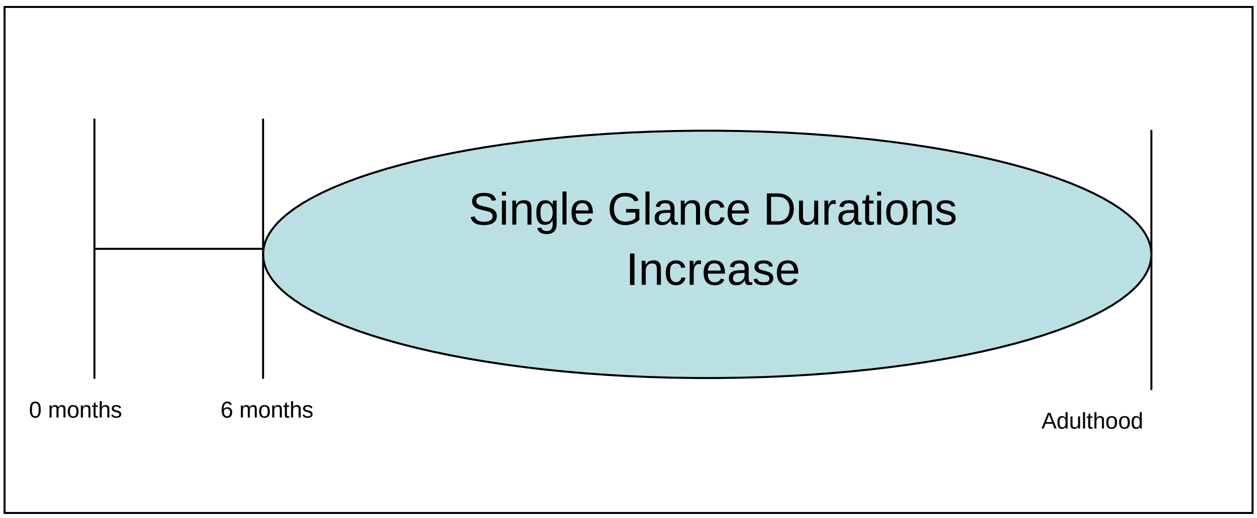


Figure 24. Area of interest where single glance durations increase.

Data from this study also demonstrates that percentage of driving related glances did not change within the first six months indicating that this is a stable characteristic. When compared to the experienced parental group there was an indication that somewhere between the first six months of driving and adulthood the percentage of driving related glances actually decreases. Below is a figure that depicts the area of interest where the percentage of driving related glances decrease. The figure shows zero months of driving experience, six months of driving experience, and experienced adulthood; the area of interest where percentage of driving related glances decreases can be seen between six months of driving experience and adulthood.

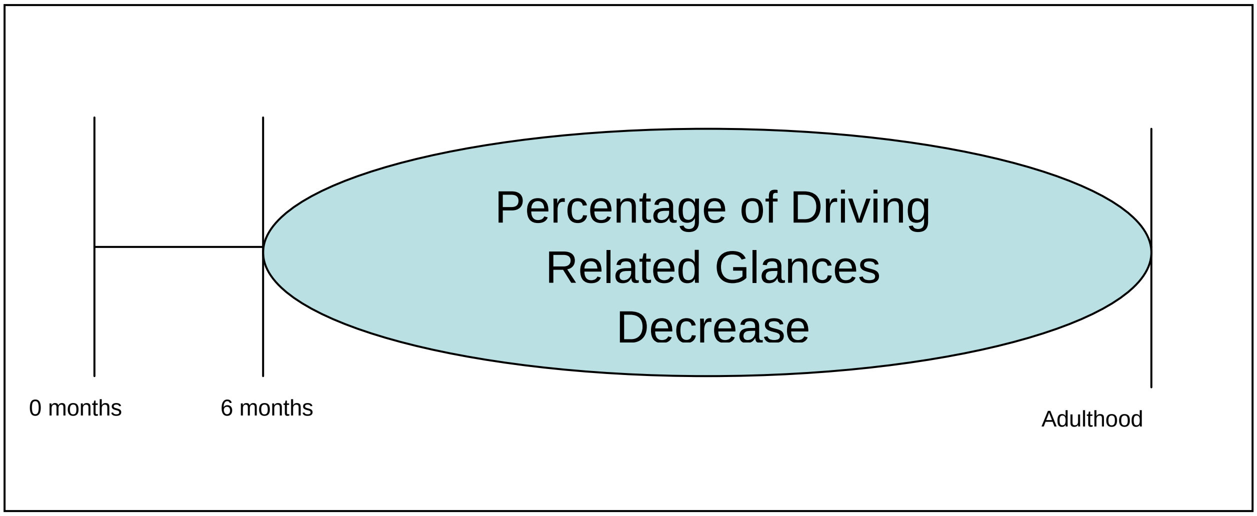


Figure 25. Area of interest where Percentage of Driving Related Glances Decrease.

6.1.1 Recommendations

In order to better understand the following findings

- Teenaged drivers' glance durations are shorter compared to that of the experienced parent group
- Teenaged drivers' percentage of driving related glances are higher than that of the experienced parent group

It is recommended that an analysis of glance durations and driving related glances be performed using the 100Car Naturalistic Driving Study (Dingus et al., 2006) and Naturalistic Teenaged Driving Study (NTDS). Both studies are similar in nature and use similar collection methods and metrics. Glance metrics on identified crashes, near-crashes, and baseline driving events for teenaged drivers could be examined in the NTDS data and the glance metrics for experienced drivers could be examined in the 100 car data. With this information the implications of these glance metrics on crash risk could be better understood. For example, teenaged drivers experience shorter glance durations than experienced parent drivers in this study. By using both the 100car and NTDS data it could be determined if these shorter glances have any impact on crash risk than the longer adult glances.

It is understood from this study that change occurs somewhere between six months and adulthood, but it is not understood where. The NTDS collected data on teenaged drivers from zero months of driving experience to eighteen months of driving experience; the 100car naturalistic driving study collected data on drivers ranging from eighteen years of age to 73. By utilizing demographic data on participants' ages from the two studies it could be determined where these changes in glance metrics occur and over what kind of time frame these glance metrics take place.

6.2 Evaluation of the Graduated Licensing System Passenger Restriction

In examining the GDL passenger restriction the data showed that when one passenger was present in the vehicle the drivers spent over twice the amount of time with their eyes off of the forward roadway. This finding gives argument that graduated licensing restrictions may need to be tighter, such as not allowing any passengers in the vehicle until the driver becomes more experienced. It is recommended that percent of time spent with EOFR in the presence of passengers should be evaluated over time to determine how long a teenaged driver should be required to drive alone.

The trend in the data did suggest that teenaged drivers may have less time spent with their eyes off of the forward roadway when two or more passengers are present. A study with a larger sample size and from a different population that is more representative to teenaged drivers as a whole would be beneficial in understanding glance behaviors in the presence of passengers.

6.3 Limitations

One limitation of the study is that by using an instrumented vehicle, driving behavior can change over time due to the knowledge of the system in the vehicle. When the instrumented vehicle is first introduced the awareness of being monitored is at its highest and the longer the system is in the vehicle the less aware the participant becomes. One example of this decreased awareness is in the use of the critical incident button. When the system is presented to the participants they are instructed to press the button when an event that they consider important occurs (such as a near-crash); when the instrumented vehicle is new to the participant critical incident buttons are more prevalent, the longer the participant is in the study the less they tend to press the critical incident button. Although this could be argued, according to Dingus et al. (2005) when comparing the behavior of driving in instrumented vehicles over the course of a year there was no appreciable change in driver behavior after the first two weeks.

Since this study is quasi-naturalistic, control is another limiting factor. Although location, experience level, and number of passengers in the vehicle were determined based upon data that had been collected, this study lacked the control of empirical research. Variables such as time of day, driving experience, in-vehicle distractions, and weather could not be controlled. Also because this study observed drivers in a natural state, without changing the behavior the driver, manipulation of tasks was not possible.

Self-selection bias is another limitation of this study. Self-selection indicates any situation in which a participant individually selects themselves to be included in part of a group or a study (Laub & Sampson, 1993). Because the participants chose to volunteer for this study this creates undesirable conditions that may cause bias in the behavior that was being observed. In this case participants who chose to volunteer for the study may have shown an interest in driving safety therefore possibly causing the sample of participants to engage in safer driving behavior than the teenaged driving population.

Grade point averages in this study were unusually high and according to the literature teenaged drivers who have higher GPA's tend to exhibit safer driving traits. This does suggest that the teenaged drivers in this study were in fact better drivers than your average newly licensed teenaged driver. As stated earlier, this could possibly explain the significant differences found between the teenaged drivers and the experienced adult drivers when looking at glance durations and percentage of driving related glances. This could also explain the lack of significance found when comparing EOFR for parents and teenaged drivers in the presence of passengers.

Income level in this study was found to be far higher than the national average. According to the U.S. Census Bureau the median annual household income level in the United States is $50,710 and $59,575 in the state of Virginia (U.S Census Bureau, 2007). The median annual income level for families in this study was $100,000 and over. Overall, the income level of participants in this study was not representative of the population as a whole and would be considered more representative if it had included a larger range of income levels including lower income drivers.

The Locality of participants in this study were from Blacksburg and the surrounding areas, and any findings from this study can only be generalized to the populations of these areas. For each research question and hypotheses the majority of the participants resided in Blacksburg, which is largely considered a University town. The locality could be considered more representative if it had included more metropolitan areas as well.

Due to limitations of recourses this study only used situations where drivers were traveling on straight road segments, which is considered only a portion of the situations that drivers are subject to. Including situations such as merging, traveling through intersections, and traveling in residential areas could give more insight into the glance behaviors of both teenaged and experienced adult drivers.

6.4 Future Research

There are several recommendations for future research. The following three methods could be used to better understand eye scanning patterns of teenaged drivers.

First, a more extensive study utilizing data from the NTDS would be beneficial. This study only examined the eye scanning patterns within the first six months of driving and only for a limited number of participants. Data are available for a full 18 months for all 40 participants. Since the data and video is continuous, to better understand where these scanning patterns change it would be beneficial to examine the full 18 months, and also examine them under different driving conditions.

Second, as stated previously, utilizing data from both the 100 Car Naturalistic Driving Study in conjunction with the NTDS could provide information on the crash implications of the scanning patterns for different ages. Utilizing both studies could also pinpoint where these changes take place and over what time period these changes occur.

Lastly, there is currently a naturalist study in the beginning phases which includes all age ranges of drivers and multiple geographic localities. This study will collect naturalistic driving data and video for one year on 2500 participant drivers. Using this data could potentially eliminate the majority of limitations present in this study. Because there are 2500 participants it is likely the distribution of GPA for the younger teenaged participants would be more evenly distributed, as would the income levels. There would also be a wider variety of localities and driving situations to sample from. The data on all age ranges would be provided as well, enabling researchers to examine specific differences in eye scanning patterns for all levels of driving experience.

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Appendix A - Processes and Guidelines for Licensure in Virginia

To be eligible for a driver's license in the state of Virginia Teens must first meet the following requirements to obtain a learner permit.

- Be a resident of the Commonwealth of Virginia
- Be at least 15 years and 6 months of age
- Parents must provide written consent
- Pass a 2 part knowledge exam
- Pass a vision test

A learner permit allows newly licensed teens to operate a motor vehicle under the condition that a licensed driver over the age of 21 is present.

Once a learner permit is obtained teenagers must then successfully complete a driver education program.   Driver education programs are available through public schools and private programs.   Each program must meet the following requirements:

- 36 class room periods
- Must provide information on alcohol safety, drug abuse awareness, aggressive driving, distracted driving, motorcycle awareness, and organ and tissue donation awareness
- 14 in vehicle instruction periods
- 7 periods of driving and 7 periods of observation (1 period is equal to 50 minutes)

Current restrictions in place for newly licensed teenage drivers in Virginia are:

- Curfew restriction – prohibits newly licensed teenage drivers under the age of 18 from driving from 12am to 4am.
- Passenger restriction – The first year of licensure teenagers may only carry one passenger under the age of 18 in the vehicle. After the first year teenagers may carry up to a maximum of three passengers until the age of 18 when the restriction is removed.

Once a teenager is 16 years and 3 months of age, and has held a learner permit for 9 months, a driver education certificate and learner permit will allow the teenage to driver without the supervision of another license driver.

Appendix B – Letter Sent to Driver Instructors

Date

Address

Dear (driving instructors Name),

We thank you for your recent support of the 2004-2005 teen driving study conducted on the Smart Road at the Virginia Tech Transportation Institute (VTTI). As you may recall, this research was sponsored by the National Institute of Child Health and Human Development (NICHD), part of the National Institutes of Health (NIH).

We are happy to announce that NICHD has awarded us with another multi-year contract to study teen drivers in more depth. We are again asking for your assistance in helping us to find potential drivers. This study will involve 2 phases: 1) a Smart Road (test-track) portion; and 2) and on-road data collection portion. The on-road data collection will involve VTTI instrumenting participants' own vehicles with cameras and other sensors, and collecting continuous driving data for an 18-month period. With your help, we will recruit at least 24 new teen drivers and their parents in the study.

We thank you in advance for your support of this important study. Enclosed are several ½ sheet flyers for distribution to potential participants. All teen participants must:

- Be new drivers, under the age of 18 (ideally, close to 16 ¼ years old)
- Have just received, or about to receive their driver's license (within 3 weeks)
- Have parental consent (parental participation is also required)
- Meet other eligibility requirements such as type and age of vehicle

For questions, please contact Charlie Klauer (cklauer@vtti.vt.edu), Dave Ramsey (dramsey@vtti.vt.edu), Suzie Lee (slee@vtti.vt.edu), or Erik Olsen (eolsen@vtti.vt.edu)or call 540-231-1500.

Sincerely,
Charlie Klauer
Senior Research Associate
Virginia Tech Transportation Institute
Cc: David Ramsey, Erik C. B. Olsen, Suzanne E. Lee

Appendix C – Recruitment Flyer

Receiving your driver's license soon?

Be part of a study on the *Smart Road*

WHO: New drivers (under 18 years old) who will receive their driver's license within the next 6 months (between May and October) to participate in a 2-part study including: 1) a test-track portion on the Smart Road, and 2) an on-road portion, in which we instrument your vehicle with cameras and sensors for 18 months.

WHAT: Participate in a study of drivers for $20 hour (approximately 4-6 hours total for 4 questionnaires and driving sessions) and $75 per month for the on-road portion, with a $450 bonus for successful completion of all requirements. There will also be a Cortisol measurement session (requiring saliva samples) lasting approximately 2 hours; this will also be compensated at $20/hour. The overall payment for those who complete all requirements is expected to be approximately $1,900.

QUALIFICATIONS: You must be healthy, have held your driver's license for 3 weeks or less, and be available during the daytime (can be after school). You will also need your parents' permission to participate, and access to a vehicle that can be instrumented (the vehicle will not be altered in any way). At least one of your parents will also have to agree to participate.

DETAILS: The Virginia Tech Transportation Institute in Blacksburg, VA is conducting a test-track study involving drivers using instrumented vehicles. Participants will drive an instrumented vehicle on a test-track under the guidance of an experimenter. This research is supported by the National Institutes for Health.

For more information contact Dave Ramsey at:
540-231-1500 (work) or email: dramsey@vtti.vt.edu

More details:

- To find out more call Dave at 231-1500 or Erik Olsen at 231-1536. We will provide more details about the study and what is required.
- Then, if you are interested and eligible, we will complete a screening and questionnaire over the telephone with both the teen and parent. Upon completion of the screening we will set-up an appointment to review and complete required paperwork, including consent and assent forms and questionnaires.

Car-instrumentation: We will then set-up a time to instrument your car (the vehicle will not be altered), to be monitored for 18 months. You will receive $75/month with a $450 completion bonus.

Smart Road test-track testing (teens and parents)

- The Smart Road test-track portion will be completed at that time or during a separate session, and will last approximately 2 hours and pays $20/hour
    - For teens, follow-up Smart Road test-track sessions will be completed at 6, 12, & 18 months.

- For parents, follow-up Smart Road test-track sessions will be completed at 12 months.

Cortisol testing (teens only) - After the first test-track session, a separate Cortisol test (on a different date) will be scheduled, lasting approximately 2 hours, also paying $20/hour.

Appendix D – Letter to the Superintendent

November 1, 2005
Dr. Tiffany Anderson
Superintendent of Schools
Montgomery County
Christiansburg, VA

Dear Dr. Anderson,

The Virginia Tech Transportation Institute along with the National Institute for Child Health Development is conducting a study in an attempt to understand and help prevent motor vehicle crashes among newly licensed adolescent drivers. The goal of the study is to observe driving in a naturalistic setting by installing sensors and cameras inside vehicles to observe behavior leading up to crashes and near crashes, as well as to obtain a baseline of what constitutes "good driving" behavior. This collection effort is scheduled to span approximately 18 months and will require approximately 40 newly licensed participants. Our goal is to recruit participants for this study who are within 4 weeks or less of licensure; as part of the recruitment process, parental permission and involvement will be required. Before any participants are enrolled, permission will have been obtained from the Virginia Tech Institutional Review Board (IRB) for the protection of human subjects.

We are asking for your assistance in reaching potential participants and educating them on the importance of driving safety. To this end, we are offering to send one of our researchers into the driver's education classes taught throughout the county to teach a class session on driving hazards for young drivers. At the end of this class, we would have a brochure available for distribution describing the research and providing a contact number for those interested in further information. No pressure would be applied to these students to encourage their participation. Also, no teen participant would be enrolled into the study without formal parental consent and teen assent as prescribed by the IRB. If required, we also expect to recruit from Giles, Floyd, Pulaski, and Roanoke counties.

If you grant us permission to teach these classes, we will contact the principals of each high school directly for their permission as well and only then will we contact the driver education teachers to set up dates and times. We think that this research program has the potential to have long-term and lasting benefits for teen drivers, and we think the students of Montgomery County will benefit from participation.

Sincerely,
Dr. Tom Dingus
Director and Principal Investigator
Virginia Tech Transportation Institute

Appendix E – Telephone Screening Questionnaire

TELEPHONE DRIVER SCREENING AND DEMOGRAPHIC QUESTIONNAIRE

Driver Screening and Demographic Questionnaire Date __________

Good day. My name is Dave Ramsey and I am a research associate at the Virginia Tech Transportation Institute (VTTI) in Blacksburg, VA. The project is a two-part research effort. Experiment 1 is a test-track study using the Smart Road at VTTI to assess specific driver performance behaviors. Experiment 2 is a naturalistic instrumented vehicle study to observe and record data on drivers in a more natural setting. There will also be a day when we ask you to come in for Cortisol testing, which requires saliva samples and a math test.

For the Smart Road portion, you will drive our instrumented vehicle on a test-track with an experimenter. Each vehicle will be equipped with data collection equipment. For the on-road study, we will instrument your vehicle with data collection equipment and you will drive the vehicle, as you normally would, for a period of 18 months. All data shall only be used by VTTI and NIH researchers. Does this sound interesting to you? If yes:

Verbal Consent, Assent, and Permission:

Next, I would like to ask you several questions about your age, health, and driving history to see if you are eligible to participate. If there is a question you are uncomfortable with, you do not have to answer it. *For adult and teen participants*: Do I have your verbal permission to ask you these questions? (Y / N) *For parents of teen participants:* Do I have your verbal permission to ask your child these questions? (Y / N)

Signed: ___________________________________ ___________________________________

Interviewer Witness

Name: ______________________________ Gender: MALE FEMALE
Address: ____
Email: ___________________________________
Home Phone: _____________ Work Phone: __________Cell Phone ________ BTTC______

1. What is your age _____? (teens must be 16 or 17 years old; adults must be between 30 to 50 years old and a parent of one of the teen participants). And what grade are you in? ______ (Sophomore / Junior).

2. Do you have any health conditions or physical disabilities, including but not limited to night blindness, sleep disorders, or diabetes that affect your ability to drive safely?

Yes _____ No _____ If yes, what are they? ___________________________

3. Do you have a valid driver's license? Yes _____ No _____

a. For teens, what date did you receive (or expect to receive) a (provisional) driver license? (must not have been held for more than 3 weeks) _________

4. What kind of driver's licenses do you have?

1) Car Driver's License: Month/Year granted: __________

2) Motorcycle Driver's License: Month/Year granted: __________

3) Commercial Driver's License: Month/Year granted: __________

5. How long have you been driving? Years _____ Months ____

a. If a teen, do you have less than 100 miles of independent driving experience (that is, driving alone or without a parent or legal guardian present)?

6. Please briefly describe the driving you do

____

____

7. What is the make, model, and year of the car you currently drive? ___________________

a. Is this vehicle driven by you alone or shared with others? ________

8. How many miles do you drive on average per week? ________

9. How many hours do you drive on average per day? ________

a. On what day do you drive the most? ________________

b. On average, how many hours do you drive on that day? ________

10. Have you ever had any moving violations, such as for speeding, running a stop sign, etc.? ? If so, please explain.

Yes _____ No _____ ____

____

11. Have you been involved in any accidents? If so, please explain.

Yes _____ No _____

____

____

12. Have you had any DUI convictions? Yes _____ No _____ (Must not have any)

13. Do you have car insurance? Yes ____ No ____ (Must have liability

per VA law); (for teens: Do your parents have car insurance with you listed on the policy?)

14. a. Do you ordinarily wear prescription glasses while you drive? Yes ____ No ___
    b. How about sun glasses? Yes ____ No ___

If yes, on part 14b:

15. Would you be willing and able to drive without wearing sunglasses during the time you are driving our vehicle? Yes ____ No ____

16. Have you previously participated in any experiments at the Virginia Tech Transportation Institute? If so, can you briefly describe the study? Yes ____ No __

____
____

17. (Females only) Are you currently pregnant? Yes _____ No _____

If yes, when are you expecting? ____________
(If "yes" then read the following statement to the subject: "It is not recommended that pregnant women participate in this study. However, female subjects who are pregnant and wish to participate must first consult with their personal physician for advice and guidance regarding participation in a study where risks, although minimal, include the possibility of collision and airbag deployment.")

18. Are you currently taking any medications on a regular basis? If yes, please list them.

- Yes ____ ____
- No ____

19. Can you drive a vehicle with automatic transmission without assistive devices?

20. Do you own a cell phone? _____ How often do you use it? (daily, occasionally, rarely)

Eligibility requirements

1. Must hold a valid driver's license.
2. Must be between 16.25 and 17 years old or 30-50 years old.
3. Must be eligible for employment in the U.S.
4. Must drive at least 2 times a week (teens must have < 100 miles driving experience)
5. For teens: may not have held a (provisional) driver license for more than three weeks.
6. Must have normal (or corrected to normal) hearing and vision.
7. Must be able to drive an automatic transmission without special equipment.
8. Must not have more than two driving violations in the past three years.
9. Must not have caused an injurious accident in the past two years.
10. Cannot have lingering effects of heart condition, brain damage from stroke, tumor, head injury, recent concussion, or infection. Cannot have had epileptic seizures within 12 months, current respiratory disorders, motion sickness, inner ear problems, dizziness, vertigo, balance problems, diabetes for which insulin is required, chronic migraine or tension headaches.
11. Cannot currently be taking any substances that may interfere with driving ability (cause drowsiness or impair motor abilities).
12. Must not have participated in a similar study.

13. Both the teen and a parent must be willing to participate in both parts of the study.

Thank you for answering these questions. At this time you are/are not considered eligible for our study. (If eligible): The next step is to schedule an orientation meeting. What days and times work best for you?

M T W Th F Sat Sun 9 AM 12 PM 3 PM

Date: ________

(If not eligible): At this time for _________ reason, it appears that you are not eligible for this study. Thank you for your time.

Appendix F – Informed Consent for Adult Participation

Informed Consent Form

(For participants greater than 18 years of age only)

PREVENTING MOTOR VEHICLE CRASHES AMONG YOUNG DRIVERS: RESEARCH ON DRIVING RISK AMONG NOVICE TEEN DRIVERS
Experiment 2, Naturalistic Study

Investigators: Tom Dingus, Sheila Klauer, David Ramsey, Suzie Lee: Virginia Tech Transportation Institute
Bruce Simons-Morton, Erik Olsen, Marie Claude Ouimet: National Institute of Child Health and Human Development

I. THE PURPOSE OF THIS RESEARCH

The purpose of this research is to develop an understanding of driving skills of newly licensed teens and experienced adults.

II. PROCEDURES

You are being asked to participate in a naturalistic driving study. The study involves an 18 month data collection effort where a data acquisition system that contains an array of sensor and cameras will be installed in your personal vehicle for use in recording a multitude of driving variables.

You will be asked to make an appointment to drop your personal vehicle at VTTI for 4 to 8 hours to have the instrumentation package and cameras installed. VTTI will offer to provide drop off and pick up service that day to make the process as easy as possible for you. When you return to VTTI at the end of the day, you will be shown the instrumentation system.

You will be asked to schedule a return to VTTI at three month intervals in order to download data. You will be instructed to contact VTTI if you encounter any difficulties with your vehicle that could be related to the instrumentation system, or if you notice any maintenance issues with the system (e.g., a camera that comes loose and dangles). Finally, you will then be instructed to drive your vehicle as you normally would.

At the end of the study, you will be asked to return to VTTI for a final time for data download, and de-installation of the data collection equipment from your vehicle. At that time, you will receive final payment for participation.

As a participant in this study, you are requested to perform the following duties:

1. Carefully read this consent form and sign it if you agree to participate.
2. Agree to have a data acquisition system installed in your personal vehicle.
3. Schedule a return to VTTI at three month intervals for researchers to download data.

III. RISKS

The risk to you is no more than you would normally incur while driving. All data collection equipment is mounted such that, to the greatest extent possible, it does not pose a hazard in any foreseeable way. None of the data collection equipment will interfere with any part of your normal field of view. The addition of the data collection systems to the vehicle will in no way affect the operating or handling characteristics of your vehicles.

Please note that you are being asked not to wear sunglasses unless absolutely necessary; however, if at any time you are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and your surrounding environment, sunglasses are recommended.

IV. BENEFITS OF PARTICIPATION

While there are no direct benefits to you from this research, you may find the experiment interesting. No promise or guarantee of benefits is being made to encourage participation. Participation will help to improve the body of knowledge regarding driving behavior and performance.

V. CONFIDENTIALITY

Video information will be taken during the course of data collection. The data gathered in this experiment will be treated with confidentiality. Drivers' names will be separated from the collected data. A coding scheme will be employed to identify the data by subject number only (e.g., Driver No. 3).

The data from this study will be stored in a secured area at the Virginia Tech Transportation Institute. Access to the data will be under the supervision of Dr. Tom Dingus, Dr. Sheila Klauer, Mr. David Ramsey, and Dr. Suzie Lee, Dr. Bruce Simons-Morton, Dr. Erik Olsen, and Dr. Marie Claude Ouimet. Data reductionists assigned to work on this project will also have access to your data. Data reduction will consist of examining driving performance under various conditions. During the course of this study, the video will not be released to anyone other than individuals working on the project without your written consent. Following the study, some data may be made available to the contact sponsor, the National Institute of Child Health and Human Development.

If you are involved in a crash while participating in this study, the data collection equipment in your vehicle will likely capture the events leading up to the event. The data collection equipment SHOULD

NOT be given to police officers or any other party. You are under NO LEGAL OBLIGATION to mention that you are participating in this study.

We will do everything we can to keep others from learning about your participation in the research. To further help us protect your privacy, the investigators have obtained a Confidentiality Certificate from the Department of Health and Human Services. With this Certificate, the investigators cannot be forced (for example by court subpoena) to disclose information that may identify you in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. Disclosure will be necessary, however, upon request of DHHS for audit or program evaluation purposes.

You should understand that a Confidentiality Certificate does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. Note however, that if an insurer, employer, or someone else learns about your participation, and *obtains your consent* to receive research information, then the investigator may not use the Certificate of Confidentiality to withhold this information. This means that you and your family must also actively protect your own privacy. In addition to the Confidentiality Certificate, we have also obtained approval through the NHTSA Human Use Review Panel and the Virginia Tech Institutional Review Board for your protection.

Finally, you should understand that the investigator is not prevented from taking steps, including disclosing information to authorities, to prevent serious harm to yourself or others. For example, if we learned about offenses such as child abuse or habitual driving under the influence, we would take appropriate action to protect you and someone else, even though we will still maintain privacy of the data.

VI. COMPENSATION

Your child who is participating will receive payment for participation at $75 per month (paid every three months) and a bonus of $450 after successful completion of the entire study requirements, for a total of $1,800. You personally will not receive any compensation for this portion of the study.

VII. INSURANCE

Please note that since you are driving your own vehicle, Virginia Tech is not liable for the expenses incurred in any accident you may have. In the event of an accident, you are not responsible for coverage of the instrumentation in the vehicle.

Participants in a study are considered volunteers, regardless of whether they receive payment for their participation. Under Commonwealth of Virginia law, workers’ compensation does not apply to volunteers; therefore, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

If you should become injured in an accident, whether in or out of an automobile, the medical treatment available to you would be that provided to any person by emergency medical services in the vicinity where the accident occurs.

VIII. FREEDOM TO WITHDRAW

As a participant in this research, you are free to withdraw at any time without penalty. If you choose to withdraw, you will be compensated in accordance with the terms in Section VI of this document. If you choose to withdraw from Experiment 2, you will then lose your eligibility to participate in Experiment 1, the Smart Road Study.

IX. APPROVAL OF THIS RESEARCH

Before this experiment begins, the research must be approved by the Institutional Review Board for research involving human subjects at Virginia Tech. You should know that this approval has been obtained.

X. CONSENT

I ____________________have read and understand this consent form and conditions of participation. I understand what is being asked of me. My questions have been answered. I agree to participate. I understand that participation is voluntary and that I may withdraw at any time without penalty.

_________________________ ___________________________ _______

Participant/ (Print Name) Signature Date

__________________________ ___________________________ _______

Experimenter (Print Name) Signature Date

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Should I have any questions about this research or its conduct, I may contact:

Tom Dingus	Project Principal Investigator	(540) 231-1500
Sheila Klauer	Co-Principal Investigator	(540) 231-1500
David Moore	Chair, Institutional Review Board	(540) 231-4991

Appendix G - Informed Assent form for Teen Participation

Informed ASSENT Form

(For participants under 18 years of age only)

PREVENTING MOTOR VEHICLE CRASHES AMONG YOUNG DRIVERS: RESEARCH ON DRIVING RISK AMONG NOVICE TEEN DRIVERS
Experiment 2, Naturalistic Driving Study

Investigators: Tom Dingus, Sheila Klauer, David Ramsey, Suzie Lee: Virginia Tech Transportation Institute
Bruce Simons-Morton, Erik Olsen: National Institute of Child Health and Human Development

I. THE PURPOSE OF THIS RESEARCH

The purpose of this research is to develop an understanding of driving skills of newly licensed teens and experienced adults.

II. PROCEDURES

You are being asked to participate in a naturalistic driving study. The study involves an 18 month data collection effort where a data acquisition system that contains an array of sensor and cameras will be installed in your or your parents' personal vehicle for use in recording a multitude of driving variables.

You will be asked to make an appointment to drop your vehicle at VTTI for 4 to 8 hours to have the instrumentation package and cameras installed. VTTI will offer to provide drop off and pick up service that day to make the process as easy as possible for you. When you return to VTTI at the end of the day, you will be shown the instrumentation system.

You will be asked to schedule a return to VTTI at three month intervals in order to download data. You will be instructed to contact VTTI if you encounter any difficulties with your vehicle that could be related to the instrumentation system, or if you notice any maintenance issues with the system (e.g., a camera that comes loose and dangles). Finally, you will then be instructed to drive your vehicle as you normally would.

At the end of the study, you will be asked to return to VTTI for a final time for data download, and de-installation of the instruments in your vehicle.

As a participant in this study, you are requested to perform the following duties:

1. Carefully read this assent form and sign it if you agree to participate.
2. Agree to have a data acquisition system installed in your personal vehicle.
3. Schedule a return to VTTI at three month intervals for researchers to download data.

III. RISKS

The risk to you is no more than you would normally incur while driving. All data collection equipment is mounted such that, to the greatest extent possible, it does not pose a hazard in any foreseeable way. None of the data collection equipment will interfere with any part of your normal field of view. The addition of the data collection systems to the vehicle will in no way affect the operating or handling characteristics of your vehicles.

Please note that you are being asked not to wear sunglasses unless absolutely necessary; however, if at any time you are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and your surrounding environment, sunglasses are recommended.

IV. BENEFITS OF PARTICIPATION

While there are no direct benefits to you from this research, you may find the experiment interesting. No promise or guarantee of benefits is being made to encourage participation. Participation will help to improve the body of knowledge regarding driving behavior and performance.

V. CONFIDENTIALITY

Video information will be taken during the course of data collection. The data gathered in this experiment will be treated with confidentiality. Drivers' names will be separated from the collected data. A coding scheme will be employed to identify the data by subject number only (e.g., Driver No. 3).

The data from this study will be stored in a secured area at the Virginia Tech Transportation Institute. Access to the data will be under the supervision of Dr. Tom Dingus, Dr. Sheila Klauer, Mr. David Ramsey, and Dr. Suzie Lee, Dr. Bruce Simons-Morton, Dr. Erik Olsen, and Dr. Marie Claude Ouimet. Data reductionists assigned to work on this project will also have access to your data. Data reduction will consist of examining driving performance under various conditions. During the course of this study, the video will not be released to anyone other than individuals working on the project without your written consent. Following the study, some data may be made available to the contact sponsor, the National Institute of Child Health and Human Development.

If you are involved in a crash while participating in this study, the data collection equipment in your vehicle will likely capture the events leading up to the event. The data collection equipment SHOULD NOT be given to police officers or any other party. You are under NO LEGAL OBLIGATION to mention that you are participating in this study.

We will do everything we can to keep others from learning about your participation in the research. To further help us protect your privacy, the investigators have obtained a Confidentiality Certificate from the Department of Health and Human Services. With this Certificate, the investigators cannot be forced (for example by court subpoena) to disclose information that may identify you in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. Disclosure will be necessary, however, upon request of DHHS for audit or program evaluation purposes.

You should understand that a Confidentiality Certificate does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. Note however, that if an insurer, employer, or someone else learns about your participation, and *obtains your consent* to receive research information, then the investigator may not use the Certificate of Confidentiality to withhold this information. This means that you and your family must also actively protect your own privacy. In addition to the Confidentiality Certificate, we have also obtained approval through the NHTSA Human Use Review Panel and the Virginia Tech Institutional Review Board for your protection.

Finally, you should understand that the investigator is not prevented from taking steps, including disclosing information to authorities, to prevent serious harm to yourself or others. For example, if we learned about offenses such as child abuse or habitual driving under the influence, we would take appropriate action to protect you and someone else, even though we will still maintain privacy of the data.

VI. COMPENSATION

You will receive payment for participation at $75 per month (paid every three months) and a bonus of $450 after successful completion of the entire study requirements, for a total of $1,800.

VII. INSURANCE

Please note that since you are driving your own vehicle, Virginia Tech is not liable for the expenses incurred in any accident you may have. In the event of an accident, you are not responsible for coverage of the instrumentation in the vehicle.

Participants in a study are considered volunteers, regardless of whether they receive payment for their participation. Under Commonwealth of Virginia law, workers compensation does not apply to volunteers; therefore, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

If you should become injured in an accident, whether in or out of an automobile, the medical treatment available to you would be that provided to any person by emergency medical services in the vicinity where the accident occurs.

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VIII. FREEDOM TO WITHDRAW

As a participant in this research, you are free to withdraw at any time without penalty. If you choose to withdraw, you will be compensated in accordance with the terms in Section VI of this document. If you choose to withdraw from Experiment 2, you will then lose your eligibility to participate in Experiment 1, the Smart Road Study.

IX. APPROVAL OF THIS RESEARCH

Before this experiment begins, the research must be approved by the Institutional Review Board for research involving human subjects at Virginia Tech. You should know that this approval has been obtained.

XI. ADOLESCENT ASSENT

I _____________________ (teen's name) have read and understand this informed assent form and conditions of my participation in the Virginia Tech Transportation Institute research involving new drivers. I have had all my questions answered and agree to return at three month intervals for data download. If I participate, I understand that I may withdraw at any time without penalty.

_____________________________ _____________________________ ________

Teen Participant (Print Name) Signature Date

_____________________________ _____________________________ ________

Parent Consent (Print Name) Signature Date

_____________________________ _____________________________ ________

Experimenter (Print Name) Signature Date

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Should I have any questions about this research or its conduct, I may contact:

Tom Dingus	Project Principal Investigator	(540) 231-1500
Sheila Klauer	Co-Principal Investigator	(540) 231-1500
David Moore	Chair, Institutional Review Board	(540) 231-4991

Appendix H - Informed Consent form for Parental Permission for Teen Participation

Parental INFORMED consent Form

(For parents of participants less than 18 years of age)

PREVENTING MOTOR VEHICLE CRASHES AMONG YOUNG DRIVERS: RESEARCH ON DRIVING RISK AMONG NOVICE TEEN DRIVERS
Experiment 2, Naturalistic Study

Investigators: Tom Dingus, Sheila Klauer, David Ramsey, Suzie Lee: Virginia Tech Transportation Institute
Bruce Simons-Morton, Erik Olsen, Marie Claude Ouimet: National Institute of Child Health and Human Development

I. THE PURPOSE OF THIS RESEARCH

The purpose of this research is to develop an understanding of driving skills of newly licensed teens and experienced adults.

II. PROCEDURES

You child is being asked to participate in a naturalistic driving study. The study involves an 18 month data collection effort where a data acquisition system that contains an array of sensor and cameras will be installed in your or your child's personal vehicle for use in recording a multitude of driving variables.

Your child will be asked to make an appointment to drop their vehicle at VTTI for 4 to 8 hours to have the instrumentation package and cameras installed. VTTI will offer to provide drop off and pick up service that day to make the process as easy as possible for your child. When you return to VTTI at the end of the day, your child will be shown the instrumentation system.

Your child will be asked to schedule a return to VTTI at three month intervals in order to download data. Your child will be instructed to contact VTTI if they encounter any difficulties with their vehicle that could be related to the instrumentation system, or if your child notices any maintenance issues with the system (e.g., a camera that comes loose and dangles). Finally, your child will then be instructed to drive their vehicle as they normally would.

At the end of the study, your child will be asked to return to VTTI for a final time for data download, and de-installation of their vehicle. At that time, your child will receive final payment for participation.

As a participant in this study, your child is requested to perform the following duties:

1. Carefully read their assent form and sign it if they agree to participate.
2. Agree to have a data acquisition system installed in their personal vehicle.
3. Schedule a return to VTTI at three month intervals for researchers to download data.

III. RISKS

The risk to your child is no more than they would normally incur while driving. All data collection equipment is mounted such that, to the greatest extent possible, it does not pose a hazard in any foreseeable way. None of the data collection equipment will interfere with any part of your child's normal field of view. The addition of the data collection systems to the vehicle will in no way affect the operating or handling characteristics of the vehicle.

Please note that your child is being asked not to wear sunglasses unless absolutely necessary; however, if at any time they are suffering from glare problems (e.g., from the sun shining directly into your face) and cannot see the roadway and surrounding environment, sunglasses are recommended.

IV. BENEFITS OF PARTICIPATION

While there are no direct benefits to your child from this research, they may find the experiment interesting. No promise or guarantee of benefits is being made to encourage participation. Participation will help to improve the body of knowledge regarding driving behavior and performance.

V. CONFIDENTIALITY

Video information will be taken during the course of data collection. The data gathered in this experiment will be treated with confidentiality. Drivers' names will be separated from the collected data. A coding scheme will be employed to identify the data by subject number only (e.g., Driver No. 3).

The data from this study will be stored in a secured area at the Virginia Tech Transportation Institute. Access to the data will be under the supervision of Dr. Tom Dingus, Dr. Sheila Klauer, Mr. David Ramsey, and Dr. Suzie Lee, Dr. Bruce Simons-Morton, Dr. Erik Olsen, and Dr. Marie Claude Ouimet. Data reductionists assigned to work on this project will also have access to your data. Data reduction will consist of examining driving performance under various conditions. During the course of this study, the video will not be released to anyone other than individuals working on the project without your written consent. Following the study, some data may be made available to the contact sponsor, the National Institute of Child Health and Human Development.

If your child is involved in a crash while participating in this study, the data collection equipment in your vehicle will likely capture the events leading up to the event. The data collection equipment SHOULD NOT be given to police officers or any other party. Your child is under NO LEGAL OBLIGATION to mention participation in this study.

We will do everything we can to keep others from learning about your child's participation in the research. To further help us protect your child's privacy, the investigators have obtained a Confidentiality Certificate from the Department of Health and Human Services. With this Certificate, the investigators cannot be forced (for example by court subpoena) to disclose information that may identify your child in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. Disclosure will be necessary, however, upon request of DHHS for audit or program evaluation purposes.

You should understand that a Confidentiality Certificate does not prevent your child or a member of your family from voluntarily releasing information about your child or your child's involvement in this research. Note however, that if an insurer, employer, or someone else learns about your child's participation, and *obtains your consent* to receive research information, then the investigator may not use the Certificate of Confidentiality to withhold this information. This means that you and your family must also actively protect your child's privacy. In addition to the Confidentiality Certificate, we have also obtained approval through the NHTSA Human Use Review Panel and the Virginia Tech Institutional Review Board for your child's protection.

Finally, you should understand that the investigator is not prevented from taking steps, including disclosing information to authorities, to prevent serious harm to your child or others. For example, if we learned about offenses such as child abuse or habitual driving under the influence, we would take appropriate action to protect you and someone else, even though we will still maintain privacy of the data.

VI. COMPENSATION

Your child will receive payment for participation at $75 per month (paid every three months) and a bonus of $450 after successful completion of the entire study requirements, for a total of $1,800.

VII. INSURANCE

Please note that since your child is driving their own vehicle, Virginia Tech is not liable for the expenses incurred in any accident your child may have. In the event of an accident, you or your child are not responsible for coverage of the instrumentation in the vehicle.

Participants in a study are considered volunteers, regardless of whether they receive payment for their participation. Under Commonwealth of Virginia law, workers compensation does not apply to volunteers; therefore, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

If your child should become injured in an accident, whether in or out of an automobile, the medical treatment available to your child would be that provided to any person by emergency medical services in the vicinity where the accident occurs.
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VIII. FREEDOM TO WITHDRAW

As a participant in this research, your child is free to withdraw at any time without penalty. If your child chooses to withdraw, your child will be compensated in accordance with the terms in Section VI of this document. If your child chooses to withdraw from Experiment 2, your child will then lose eligibility to participate in Experiment 1, the Smart Road Study.

IX. APPROVAL OF THIS RESEARCH

Before this experiment begins, the research must be approved by the Institutional Review Board for research involving human subjects at Virginia Tech as well as the sponsor's human use review panel. You and your child should know that this approval has been obtained.

X. PARENTAL CONSENT

I ____________________ (teen's parent) have read and understand this consent form and conditions of participation. I understand what is being asked of my child. My questions have been answered. I agree to allow my child to participate. I understand that participation is voluntary and participants may withdraw at any time without penalty. I am signing this form in the presence of the experimenter listed below.

_________________________ _________________________ _______

Parent 1 (Print Name) Signature Date

_________________________ _________________________ _______

Parent 2 (Print Name) Signature Date

_________________________ _________________________ _______

Experimenter (Print Name) Signature Date

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Should I have any questions about this research or its conduct, I may contact:

Tom Dingus	Project Principal Investigator	(540) 231-1500
Sheila Klauer	Co-Principal Investigator	(540) 231-1500
David Moore	Chair, Institutional Review Board	(540) 231-4991

Appendix I –Reduced Variable Set

- **Vehicle Number**

Comment: Each vehicle will be assigned a vehicle number. Information will originate in the raw data stream.

FORMAT: Integer value.

- **File ID Number**

The File ID number is arranged by vehicle identification number, date and time. The first three numbers represent the vehicle identification number, the next two numbers represent the year (Ex. 03 for 2003), the next two numbers represents the month (Ex. 03 for March), the next two numbers represent the day of the month, the next four numbers represent the time in military time.

02 02 28 1209

- **Driver Subject Number**

Drivers subject number is identified starting with the first digit assigned a “1” in the hundreds. The next two numbers identify the specific number designated to a vehicle (1-45). The last number identifies the driver as the teen or adult driver; “1” designated to the teen and “2” designated for the adult. Example subject number: 1011

- **Number of Passengers**

Appendix J– Number of Crossing for each Participant

Research Question 1 Hypothesis 1

Teen N			
subj #	0-1	2-3	4-5
1	6	6	6
2	3	7	9
6	13	9	15
8	4	10	9
11	23	34	49
12	13	90	47
13	4	17	7
15	3	4	5
16	23	40	5
17	5	4	8
20	38	33	53
21	5	18	4
25	4	27	10
26	6	37	70
28	13	24	4
29	10	24	11
30	18	16	19
32	4	7	20
33	26	51	32
41	25	33	30

Subj #	Parent N
1	6
13	3
18	6
36	3
39	4
43	3
45	6

Research Question 1 Hypothesis 2

Teen N			
Subj#	0-1	2-3	4-5
1	8	8	5
6	8	5	11

Subj#	Parent N
1	14
3	19
6	18

8	5	10	7
11	41	42	44
12	49	47	33
13	18	14	5
15	7	5	11
16	22	14	8
17	6	12	11
20	35	43	30
21	17	16	8
25	9	15	10
26	7	24	19
28	25	25	5
29	13	11	5
30	38	26	12
32	5	15	29
33	11	13	6
36	8	9	15
41	19	38	12
43	10	3	6

8	4
13	10
15	4
18	16
28	4
33	14
35	9
36	30
38	3
39	20
42	3
43	7
44	6
45	45

Appendix K –ANOVA and T-Test Tables

Research Question 1 Hypothesis 1

Glance Duration

SUMMARY

Groups	*Count*	*Sum*	*Average*	*Variance*
1-2	20	10.1156	0.50578	0.09767
3-4	20	7.96963	0.39848	0.00142
5-6	20	8.06912	0.40346	0.00423

ANOVA

Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.14672	2	0.07336	2.13002	0.1282	3.15884
Within Groups	1.96318	57	0.03444			
Total	2.10991	59				

Mean Maximum Glance Duration

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
1-2	20	10.2	0.51	0.00516
3-4	20	10.5	0.525	0.00303
5-6	20	9.8	0.49	0.00726

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.01233	2	0.00617	1.19762	0.3094	3.15884
Within Groups	0.2935	57	0.00515			
Total	0.30583	59				

Research Question 1 Hypothesis 2

Glance Duration

Welch's T-test

	Teen	*Parent*
Mean	0.435906322	1.259325397
Variance	0.012579216	0.332609358
Observations	20	7
Hypothesized Mean Difference	0	
df	6	
t Stat	-3.75272903	
P(T<=t) one-tail	0.004739633	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.009479265	
t Critical two-tail	2.446911846	

Mean Maximum Glance Duration

	Teen	*Parent*
Mean	0.508333333	1.365
Variance	0.002675439	0.379186111
Observations	20	7
Hypothesized Mean Difference	0	
df	6	
t Stat	-3.676199671	
P(T<=t) one-tail	0.005188723	
t Critical one-tail	1.943180274	
P(T<=t) two-tail	0.010377447	
t Critical two-tail	2.446911846	

Research Question 1 Hypothesis 3

Percentage of Driving Related Glances

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
1-2	21	15.8369	0.75414	0.025553
3-4	21	15.7372	0.749389	0.01177
5-6	21	15.9333	0.758728	0.011047

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.000916	2	0.000458	0.028401	0.97201	3.15041
Within Groups	0.967402	60	0.016123			
Total	0.968318	62				

Mean Minimum Percentage of Driving Related Glances

SUMMARY				
Groups	*Count*	*Sum*	*Average*	*Variance*
1-2	21	6.23254	0.296788	0.11763
3-4	21	4.19987	0.199994	0.062513
5-6	21	4.25147	0.202451	0.071374

ANOVA						
Source of Variation	*SS*	*df*	*MS*	*F*	*P-value*	*F crit*
Between Groups	0.127921	2	0.063961	0.7629	0.47078	3.15041
Within Groups	5.030326	60	0.083839			
Total	5.158248	62				

Research Question 1 Hypothesis 4

Percentage of Driving Related Glances

Welch's T-test

	Teen	*Parent*
Mean	0.754085705	0.622724828
Variance	0.010296483	0.011253424
Observations	21	17
Hypothesized Mean Difference	0	
df	34	
t Stat	3.869795432	
P(T<=t) one-tail	0.000234768	
t Critical one-tail	1.690924198	
P(T<=t) two-tail	0.000469536	
t Critical two-tail	2.032244498	

Mean Minimum Percentage of Driving Related Glances

MM

	Teen	*Parent*
Mean	0.233077616	0.246279106
Variance	0.050441292	0.026401065
Observations	21	17
Hypothesized Mean Difference	0	
df	36	
t Stat	-0.20991882	
P(T<=t) one-tail	0.41745728	
t Critical one-tail	1.688297694	
P(T<=t) two-tail	0.834914561	
t Critical two-tail	2.028093987	

Research Question 2

Percent EOFR

Source of Variation	SS	df	MS	F	P-value
Experience	0.0017	1	0.0017	1.07	0.3171
Subj(Experience)	0.0257	16	0.0016		
Numbpass	0.0001	2	0.00005	0.12	0.8861
Experience*numbpass	0.000018	2	0.000009	0.02	0.9817
Subj*numbpass(Experience)	0.0157	32	0.00049		

Mean Maximum Percent EOFR

Source of Variation	SS	df	MS	F	P-value
Experience	0.124666	1	0.124666	2.63	0.1243
Subj(Experience)	0.758195	16	0.047387		
Numbpass	0.225606	2	0.112803	0.12	0.0169
Experience*numbpass	0.493732	2	0.024686	0.02	0.3728
Subj*numbpass(Experience)	0.776207	32	0.024256		

Tukey Number of passengers (Mean Maximum Percent EOFR)

Passengers	Mean
0	0.126235
1	0.289348
2+	0.206181

	0	1	2+
0		0.0154	0.3272
1	0.0154		0.2996
2+	0.3272	0.2996	