

Examining the Effect of Driving Experience on Teenage Driving Ability with
Secondary Tasks

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ABSTRACT

This research examined the relationship between experience and driving performance with secondary tasks. Data were collected from 42 teenage drivers and their parents using an instrumented vehicle for two one hour test track sessions spaced 12 months apart. For part of the sessions, participants followed a lead vehicle which allowed for range data to be collected.

Teenage and experienced drivers' driving were compared for cell phone and odometer tasks. Variables such as Speed, Range to Forward Vehicle, and Driving-Related Eyeglance percentages were all analyzed utilizing ANOVA. Post-hoc analysis on continuous data was performed using a Tukey HSD test. Lane Deviations were examined using Chi-Square analyses.

Experienced drivers drove faster overall than teenage drivers. Teenage drivers drove faster in the 12 month session than the first session. No significant effects were found for Speed Variance, Range Variance, or Lane Deviations. Experienced drivers had a higher percentage of driving-related glances than teenage drivers. For the odometer task, teenage drivers were found to follow further behind a lead vehicle than adults.

Driving experience was believed to have an effect on driver eyeglance patterns due to increased development of attentional control resulting in better switching between the task and the driving environment. Experienced drivers likely drove faster due to increased confidence in their driving ability. This research supports current GDL cell phone restrictions. A drivers' education lesson plan framework was developed to address these differences. Future research should focus on further refining GDL legislation to address the cognitive differences between teenage and experienced drivers.

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INTRODUCTION

With respect to the driving population as a whole, teenage drivers represent a minority that lays claim to a disproportionately large percentage of crashes and driving-related deaths. Over one third of all fatalities of individuals aged 15-20 result from automobile crashes (McCartt, Shabanova, & Leaf, 2003), with drivers younger than 20 representing 7% of the driving population but experiencing 14% of the traffic fatalities (Gonzales, Dickinson, DiGuseppi, & Lowenstein, 2004). Between the years of 1995 and 2004, crashes with 15-17 year old drivers claimed the lives of 30,917 people. Of that number, 11,177 were the drivers themselves, so clearly this is a problem that affects the entire driving population and thus merits national intervention efforts (FARS, 2004).

Ferguson, Teoh, and McCartt (2007) describe fatal and non-fatal crashes for teenage drivers between 1996 and 2005 utilizing the Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System (NASS)/General Estimates System (GES) databases. Sixteen-year-old drivers had the highest fatal crash rate amongst teenage drivers (11 fatal crashes for every 100 million miles traveled for 16-year-olds versus two per 100 million miles traveled for middle aged drivers). Female teenage drivers were found to have been involved in significantly fewer fatal crashes than male teenage drivers in every teenage age group, except sixteen-year-old.

Williams (2003) examined FARS as well as NASS/GES databases to examine crash rates and specific crash risks for teenage drivers. Williams' research suggests that the crash risk for teenage drivers depends highly upon the context of the driving environment. Several low risk situations are described (such as a male driver with a female passenger) and several high risk situations (such as a driving at night) are discussed in depth with regard to the change in crash

risk they present for teenage drivers. Notably, crashes for teenagers more commonly involved behaviors such as speeding and following too closely. Williams' analysis suggests that future studies should concentrate on further isolating individual crash risk factors to establish high-risk and low-risk situations which could be targeted by Graduated Driver Licensure (GDL) and drivers' education programs.

Dingus et al. (2006) performed a naturalistic driving study involving 109 vehicles with 109 primary drivers and 132 secondary drivers in the northern Virginia and DC metro areas. For this research, participants' cars were outfitted with cameras, sensors, and a processing unit that collected video and parametric data regarding participants' normal, daily driving. Data were collected over a period of 12-13 months per vehicle. This data was then examined by trained data reductionists and subsequently analyzed by researchers. This research found evidence to support a slight inverse relationship between experience and the probability of involvement in crash and near crash scenarios.

This research found evidence to support the concept of the driving population as having a segment of drivers who are significantly more risky in everyday driving than others. Several risky behaviors were seen in these "unsafe" drivers as opposed to other groups and included frequent: hard braking, driving inattention, and driving too close to a forward vehicle. These unsafe drivers tended to be younger and have less driving experience than safer drivers. These drivers, representing 7% of the population in the 100 Car Naturalistic Driving Study, were involved in at least three crashes or minor collisions within the 12-13 months of the study. Another segment of drivers, also 7% of the total population within this study, were not involved in any crashes or near crashes for the duration of the study (Dingus et al., 2006).

Stutts et al. (2005) also provided naturalistic evidence towards the prevalence of distractions while driving by studying 70 drivers over periods of one week each through installation of video cameras into participants' vehicles. The researchers examined three hours of video per participant due to heavy time requirements for analysis. Analysis of this video included descriptive coding of variables within the video, including how often drivers performed distractions such as smoking or using a cell phone. Stutts et al. (2005) found that participants were engaged in distracting activities for 14.5% of the total time their vehicles were moving. This study also noted that these distractions resulted in higher levels of driving with no hands on the steering wheel and significant increases in vehicle drift within participants' traffic lanes. This research suggests that distractions could potentially play a sizable role in crash risk for teenagers by increasing risky driving behaviors.

Several factors play a role in the teenage driving problem. Specifically, differences in several driving categories with regard to skill in relation to adult drivers are present. Numerous secondary tasks are commonly performed by teenage drivers. The tasks degrade these drivers' ability to maintain road position and avoid accidents. Differences in driving skill combined with the prevalence of secondary distractions serves to exacerbate the crash risk for this segment of the driving population.

PURPOSE AND OBJECTIVES

The purpose of this research is to examine the effect that experience has upon driving ability while performing secondary tasks: with regard to speed regulation, ability to regulate lane position, distance maintained from a forward vehicle, and eyeglance patterns. This research will be utilized to more effectively tailor driver training program design and Graduated Driver Licensure legislation towards young drivers.

RESEARCH QUESTIONS

1. Do experienced drivers more effectively regulate their speed and lane position while performing secondary tasks than less experienced, teenage drivers?

Hypotheses:

- 1.) With additional years of driving experience, ability to regulate vehicle speed while performing a secondary task is improved.
 - 2.) With additional years of driving experience, ability to avoid contacting lane lines while performing a secondary task is improved.
2. Do more experienced drivers maintain a larger, more consistent distance from a forward vehicle than less experienced, teenage drivers while performing a secondary task?

Hypotheses:

- 3.) With additional years of driving experience, ability to regulate a consistent headway from a forward vehicle while performing a secondary task is improved.
 - 4.) With additional years of driving experience, overall headway from a forward vehicle while performing a secondary task will be larger.
3. Do the eyeglance patterns of experienced drivers differ from those of less experienced, teenage drivers while performing a secondary task?

Hypotheses:

- 5.) With additional years of driving experience, percentage of driving-related glances compared to non-driving-related glances will increase.

LITERATURE REVIEW

TEENAGE VS. ADULT EYEGLANCER PATTERNS

Underwood, Chapman, Brocklehurst, Underwood, & Crundall (2003) reanalyzed data from an earlier study (Crundall & Underwood, 1998) and found eye scan pattern differences between inexperienced and experienced drivers. Their subjects consisted of the 32 participants with 16 novices (average age 19) and 16 experienced drivers (average age 27). These subjects then drove on various sections of roadway while fitted with an eye-tracking device to note their eyeglancc patterns. One minute sections out of the roughly 20 total minutes spent driving by the participants were analyzed frame by frame. This study specifically found that novice drivers tend to fixate on middle, far away portions of the roadway on all road types. Experienced drivers, on the other hand, tended to glance at many different locations on the roadway, including more glances to the sides of their field of vision and less fixation on the center of the roadway.

Underwood et al. (2003) go on to speculate as to why there is a discrepancy between novice and experienced driver eyeglancc patterns. They suggest that perhaps experienced drivers are using peripheral vision to watch the forward roadway while glancing elsewhere, allowing them greater freedom to view other parts of the roadway. This study suggests that experienced drivers utilize more efficient eyeglancc patterns when compared to inexperienced drivers. This inefficiency could ultimately serve to increase teenagers' cognitive workload while driving and may be responsible for higher crash rates when compared to adults.

Pollatsek, Fisher, and Pradhan (2006) also found a significant difference in eyeglancc patterns between novice and experienced drivers. Participant groups included drivers aged 60-75, younger drivers aged 18-26, and novice drivers aged 16-17, with 24 participants in each group. Participants utilized a simulator that included a Saturn (sedan) with a virtual environment present

on the windshield. Eyeglance measures were captured through an eyeglance tracker mounted on the participants' heads and a magnetic head tracking device.

This study (Pollatsek, Fisher, & Pradhan, 2006) specifically noted that inexperienced drivers look at appropriate areas of the roadway with important information less frequently than experienced drivers. An example situation utilized within this experiment is a crosswalk that has a truck parked on the shoulder in front of it. An area of important information would be the section of the truck nearest to the crosswalk, where a pedestrian could easily emerge unexpectedly. These results support the notion that novice drivers are less efficient at utilizing their mental resources to attend visually to areas of the roadway where potential hazards may appear. This phenomenon likely contributes to the discrepancy between inexperienced and experienced drivers in terms of crash rates and poorer overall driving performance.

TEENAGE VS. ADULT DRIVING WITH SECONDARY TASKS

Current research literature emphasizes significant performance differences between teenage and adult drivers that result partially because of differing levels of driving experience. Olsen, Simons-Morton, and Lee (2006) noted a difference between adult and teenage drivers on the Smart Road test track facility. In two test track sessions spaced six months apart, teenagers were noted to more willingly engage in secondary tasks as opposed to adults and were less likely to suspend a task when entering an intersection. This is supported by Olsen, Lerner, Perel, and Simons-Morton (2005), who through self-reports found higher overall and more frequent cell phone use and text messaging by teenage drivers. Olsen, Simons-Morton, and Lee (2006) also found a difference in intersection behavior between the initial session, which occurred at the teenagers' licensure dates, and the second session; six months after licensure. Teenagers were more confident in their ability to manage secondary task workload while driving in the six-month

session than in the initial session. These studies suggest that teenagers' perceived ability to drive in the presence of secondary tasks is much greater than that of adults, despite the increased crash risk present within this segment of the driving population.

Greenberg et al. (2003) examined 48 adult (25-66 years of age) as well as 15 teenage (16-18 years of age) participants on a high-fidelity, moving base simulator to determine the impact that eight different secondary tasks had upon their driving. Teenage drivers were recruited from local high schools and adult drivers were employees of the Ford Motor Company. During this experiment, participants drove on a simulated section of U.S. interstate and were instructed to remain in the right hand lane while following a lead vehicle. Other vehicles approached and interacted with the participants to test their ability to react to changes in the environment around them.

Greenberg et al. (2003) found that teenage participants drive in a riskier manner when compared to adults in terms of physical headway and the amount of time between a forward vehicle and themselves. Teenagers were also found to be more susceptible to secondary task distraction than adults; specifically on the lane deviations while performing a cell phone task. The 100 Car Study supports this concept with the finding that teenagers were found approximately four times more likely to be involved in a crash while performing complex secondary tasks, similar to text messaging, as compared to adults (Dingus et al., 2006). These studies support the notion that teenage drivers are less capable of dividing their attention between a secondary task and the primary task of driving.

CELL PHONE USE

Talking on cell phones while driving has been linked to significant performance degradation within the general driving population (Dingus et al., 2006; Rakauskas, Gugerty, &

Ward, 2004; Strayer, Drews, & Crouch, 2006; Lesch & Hancock, 2004). The driver is likely to be aware of the increase in mental driving workload that results from the addition of a cell phone task, as supported by self-reported levels of increasing subjective workload while driving in the presence of a cell phone task (Rakauskas, Gugerty, & Ward, 2004). Despite the self-reported increase of mental workload that is present with cell phone use while driving, drivers do not appear to be aware of the performance degradation seen in the presence of cell phone use while driving (Lesch & Hancock, 2004).

Rakauskas, Gugerty, and Ward (2004) examined 24 participants' performance on a driving simulator while talking on a cell phone. Participant age ranged from 18 to 32 years, with an average of 20 years of age. Participants drove on a simulated two-lane rural road while performing cell phone tasks of two different difficulty levels, as well as a control condition with no cell phone conversation for comparison. Participants then completed several questionnaires regarding their performance on the simulator after completing the experiment. This study found that cell phone conversations result in a driving task that is more mentally challenging and results in lowered ability to maintain a constant speed as well as lower overall vehicle speeds. Self-reported levels of workload increased in the presence of cell phone conversations while driving. Participants were also found to have greater variation in vehicle speed and accelerator position. The link between variation in speed with a secondary task present is an effect that is examined by this thesis in further detail and expanded by providing different secondary tasks to compare to cell phones.

The performance degradation found in Rakauskas, Gugerty, and Ward (2004) is supported by Greenberg et al. (2003). Greenberg et al. (2003) noted an increase in heading error and a decrease in ability to detect objects out of the rear view window when performing a cell

phone task. The finding of increased workload is supported by Slick, Cady, and Tran (2005), who found increased subjective workload of participants performing a cell phone task while driving on a simulator. These studies suggest that cell phone use while driving places a mental load upon the driver which hinders the ability to regulate certain aspects of movement while driving.

Olsen, Lerner, Perel, and Simons-Morton (2005) also examined the willingness of drivers of four age groups to participate in secondary tasks while driving. Forty-five individuals from the Washington, DC area participated. The drivers were divided into four age groups, 16-17, 18-24, 25-59, and 60+. In this study, participants drove their personal vehicle on public roadways with predetermined routes. At certain places and times during the routes, participants rated their/the level of risk as well as their willingness to engage in specific secondary tasks. This study found that teenagers' self-reported cell phone use was higher than other age groups.

Lerner & Boyd (2005) examined 88 participants divided into four groups: teenage, young, middle, and older drivers. Teenage drivers were 16-17, young drivers 18-24, middle drivers 25-59, and older drivers were 60+ years of age. Participants were then asked to drive their personal vehicle across a predetermined route on public roadways. This research examined participants' self-reported willingness to engage in specific secondary tasks while driving this route. Specifically, participants were asked to rate how willing they would be to engage in a specific secondary task at certain points along the route, without actually engaging in the task itself.

This research (Lerner & Boyd, 2005) found that teenage and young drivers were also much more willing to both initiate a cell phone call when bored and rate it as less risky as compared to other driver age groups. Teenage drivers were found to be more willing to engage in

activities while driving than other groups. Teenage drivers were also found to be generally more accepting of risk as a whole when compared to older drivers. The findings of Lerner and Boyd (2005) as well as Olsen, Lerner, Perel, and Simons-Morton (2005) serve to illustrate the higher prevalence of cell phone use among this specific age group compared to older drivers.

Lesch and Hancock (2004) recruited 36 participants from Massachusetts who drove an instrumented vehicle on a test track while utilizing a cell phone. Nineteen participants were between 25 and 36 years of age, making up the “young” group, and 17 other participants were between 55 and 65 years of age and were labeled the “older” group. Drivers were asked to memorize a cell phone number at the beginning of some trials and were presented with a number on a simulated cell phone on the dash of the vehicle. Participants were then asked whether or not this number matched the number they were asked to memorize in the beginning of the trial. Participants then completed questionnaires regarding their confidence in their ability to drive despite a cell phone distraction.

The questionnaires were designed to test the effects of distractions upon their driving as well as the accuracy of their opinions regarding their driving ability with a cell phone distraction present. Not surprisingly, the results of this study found no significant correlation between confidence in the ability to drive and driving performance while in the presence of secondary tasks. However, this research did suggest that drivers may be unaware of performance decreases that result from cell phone use while driving, as discovered by comparison of the questionnaire data and participants’ actual driving (Lesch & Hancock, 2004).

Strayer, Drews, and Crouch (2006) utilized a high-fidelity simulator to compare drivers talking on a cell phone with drivers who were intoxicated with alcohol to the 0.08 blood alcohol percentage level. Forty individuals between 22 and 34 years of age participated of an average 25

years of age. The simulated roadway was a 24 mile stretch of freeway highway, with the participant following a pace car in the right lane with other traffic passing on the left.

Participants were asked to utilize a cell phone while performing one portion of the study and were asked to drink alcohol to the 0.08% wt/vol intoxication level to compare performance degradation.

This research (Strayer, Drews, and Crouch, 2006) found that responses from participants while utilizing a cell phone showed a significant delay in response to stimuli within the driving environment of the simulator. Participants were also involved in significantly more traffic incidents when driving while performing this cell phone task. Interestingly, in debriefing sessions, many of the participants with high levels of cell phone use in their everyday driving suggested that driving while talking on a cell phone was no more difficult than driving while not on a cell phone. This suggests there is a disconnect between the performance degradation that results from cell phone use while driving and individuals' perceptions of this degradation which could ultimately serve to increase the risk posed by this secondary task.

Ultimately, Strayer, Drews, and Crouch (2006) suggest that cell phone use while driving produces a similarly profound impact on individuals' ability to drive as does driving while intoxicated with ethanol. This study highlights the potential impact of the use of cell phones while driving. This finding could also be more pronounced with teenage drivers who experience higher levels of mental workload while driving due to relative novelty of the task. This research does have several limitations that affect its validity; specifically, participants utilizing a cell phone were found to have more delayed reaction times to events in the roadway. In contrast, those intoxicated with alcohol drove more aggressively altogether, including following closer to forward vehicles. These performance effects are slightly different and limit comparisons

between the two conditions. Current research needs to delve further into this specific task to clarify its impact upon teenage driver crash risk.

TEXT MESSAGING

Text messaging is a dangerous secondary task which decreases driving performance as well as increases crash risk significantly for the general driving population (Hosking, Young, & Regan, 2006; Dingus et al., 2006; Greenberg et al., 2003). Hosking, Young, and Regan (2006) examined the effects of text messaging upon the performance of 20 young drivers between 18 and 21 years of age on a high-fidelity simulated roadway. This study had drivers negotiate several events, including a pedestrian suddenly entering into the roadway, following other vehicles, as well as lane change scenarios. Questionnaires were then administered regarding subjective workload increases while performing this simulator session. Text messaging, a common task that teenagers perform while driving, was found to be an especially risky driving behavior, increasing time spent by drivers' eyes off the forward roadway by 400%.

This finding of the research described above was similar to some of the results of Dingus et al. (2006), which discovered a comparable increase in time drivers spent looking away from the roadway while performing complex secondary tasks. This study also found that drivers tended to increase following distance from a forward vehicle when performing complex secondary tasks. This could indicate that that individuals engaged in these tasks while driving appear to realize the behavior is risky and are compensating for that risk. These results suggest that complex secondary tasks are extremely risky, as drivers spend much less time attending to events currently happening on the roadway.

Hosking, Young, & Regan (2006) also noted that drivers likely recognized the threat of increased crash risk that complex secondary tasks imposed upon their driving ability. While

performing these tasks, participants noticeably slowed down and increased following distance from a forward vehicle, another finding similar to that of Dingus et al. (2006). Greenberg et al. (2003) also found that text messaging was a significant distraction for drivers, considerably increasing the number of lane violations. Greenburg's study corroborates other research and suggests that sending and receiving text messages significantly interferes with drivers' ability to maintain a stable lane position and detect as well as respond to stimuli in the roadway. The study of text messaging is an emerging phenomenon, both in terms of its prevalence as a secondary task within the general driving population as well as studies that attempt to isolate its effects upon driving performance. Thus, literature within this topic is somewhat limited, but will stand to be expanded by future research.

MP3 PLAYERS

An emerging segment of novice driver literature examines the increasingly more common scenario of the use of mp3 players while driving upon performance. Chisholm, Caird, and Lockhart (2008) examined the effects of iPod tasks upon driving performance on a driving simulator. Nineteen young drivers, aged 18-22, were recruited to participate in seven sessions on a driving simulator at the University of Calgary. Participants within this study encountered several events while performing these tasks to test their ability to react to changing stimuli on the roadway. The events included: a pedestrian detection scenario, a parked car pulling out into the roadway scenario, and a lead vehicle braking scenario. Participants were found to have higher reaction times and a significant increase in crashes while performing iPod tasks. The researchers did, however, note an apparent learning effect in which participants got more effective at driving while utilizing iPods after several scenarios.

TEENAGE VS. ADULT EXECUTIVE CONTROL

In addition to the effect of driving experience upon performance, an additional explanation for deficits in adolescent driving ability also could relate to brain development, specifically in the area of executive control. Increases in executive control mark one of several major changes in adolescent cognitive development and are intimately related to the ability to divide attention between various stimuli (Kuhn, 2006). Deficits in executive control could explain variances within eye scanning patterns as the adolescent mind is presumed less capable of switching between multiple input streams resulting from both a secondary task and the driving task itself.

Luna et al. (2004) examined 245 participants' responses to a light fixation and distraction task. These participants ranged in age from 8 to 30 years. Participants were asked to concentrate on a specific light on a head mounted light array while other lights were turned on and off to test the ability of the participant to focus on one specific stimulus. This study found that the ability of participants to consciously suppress responses increased throughout adolescence. This decreased response control relates to adolescent drivers' increased crash risk by making them more susceptible to interference from secondary tasks in early adolescence, resulting in poorer driving performance.

Anderson et al. (2001) examined 138 children utilizing several intelligence, attentional control, cognitive flexibility, and goal-setting tests to measure the development of executive function from childhood through adolescence. The study examined executive control, but broke this broad term down into three components: Attentional Control – defined as selective attention and sustained attention, Cognitive Flexibility – defined as working memory, attentional shift, self-monitoring, and conceptual transfer, and Goal Setting – defined as initiating, planning,

problem solving, and strategic behavior. All three of these components of executive control are involved within the driving task as a whole. The performance of secondary tasks while driving also relies upon both attentional shifting and selective attention, components of attentional control and cognitive flexibility.

Anderson et al. (2001) found evidence to support a gradual increase in attentional capacity and mental processing speed through adolescence, extending into the period where adolescents begin to learn to drive. The study also found that older adolescents make significant gains in attentional control at this point in development as well. Attentional control specifically relates to driving performance in the presence of secondary tasks because a driver must divide his or her attention between the task itself and driving. Thus, the more effective a driver is at dividing and controlling their attention between scanning the roadway and performing the secondary task, the less performance degradation will be seen. This study helps to provide a cognitive background to the causes behind adolescent drivers' potential driving performance deficits.

Many factors, such as driving experience and risk perception, are likely involved in the increased crash risk seen with teenage drivers. However, a deficit in executive control is likely responsible for a sizable portion of the increased danger the population faces while driving with secondary tasks. Cognitive developments that occur throughout adolescent development and into adulthood result in an increased ability to regulate attention switching and response inhibition, which serves to lower the driving risk of adults compared to teenage drivers. Cognitive development along with increased driving experience is likely responsible for most of the decrease in crash risk that occurs throughout late adolescence and into the early twenties.

DRIVER TRAINING PROGRAMS

Driver's education programs consist of classroom training and actual driving sessions to teach driving skill to novice, teenage drivers. Current driver's education program curriculums vary heavily by locality. Vernick et al. (1998) performed a meta-analysis that included nine studies examining driver education programs that met specific criteria for validity. To meet the criteria for this meta analysis, studies must examine driver education programs for: individuals of high school age, must have included driver licensure rates, motor vehicle-related violations, or crashes, the results of these studies must not be self-reported, and the studies must also include a non-intervention control group.

This analysis (Vernick et al., 1998) found no support for formal driver's education programs leading to reduction in teenage driver crash rates. The authors go on to suggest that some driver's education programs are actually increasing teenage crash rates by allowing licensure at a slightly earlier age. The study also suggests that driver's education programs are ineffective not because they fail to provide basic driving information, but because they are unable to make teenage drivers take such information seriously. Ultimately, fundamental changes in these programs are necessary to further reduce the teenage driver crash problem.

Many alternative training programs have been examined in terms of the effectiveness they have at providing novice drivers with enhanced driving skills. Gregersen (1996) conducted a test track study in Sweden using two groups of 53 young drivers, aged 18-24, to test the effects of two different types of training scenarios upon teenage driver performance. One group received skills training to improve the actual driving performance. This training lasted 30 minutes and involved an instructor providing the driver basic information about the car as well as braking and avoidance maneuvering to increase the speed at which the driver could complete a set course.

The other group received “insight” training during which an instructor highlighted the limited ability drivers have in engaging in braking and avoidance in dangerous driving situations.

These drivers were then asked to drive a “Skid Car” designed to simulate low friction driving conditions on the Bromma test track in Sweden to test the results of this training. This research found that the group which received skills training designed to improve their driving had higher estimates of their own driving skill than the insight group. This suggests that by simply attempting to improve teenage drivers’ skill can actually cause them to place themselves in dangerous situations more frequently due to a higher confidence in their driving abilities (Gregersen, 1996).

Pollatsek, Fisher, and Pradhan (2006) studied 16-17-year-old drivers in a driving simulator and found that these individuals attend to important centers of information within the forward view driving environment less than experienced drivers. A computer training program was developed by these researchers to attempt to train novice driver eyeglance patterns to be more efficient and effective. This program, called Risk Awareness and Perception Training (RAPT), utilized a coaching scheme to guide younger drivers as to where attention should be focused while driving. This coaching scheme consisted of feedback as to where the appropriate eyeglance location is for various situations. This program was found to increase the effectiveness of novice drivers’ eyeglance patterns compared to that of untrained, experienced drivers. These results suggest that driver training programs have significant potential to increase the efficiency of eye scan patterns of novice drivers, which could certainly help to lower crash risk.

Fisher et al. (2002) performed a study to examine the effects of a computerized training program and experience upon teenage drivers’ performance on a high-fidelity simulator for several dangerous traffic scenarios. Thirty teenage drivers as well as 15 college-aged drivers

were divided into two groups, one which received a computer training session designed to promote risk awareness at least one day prior to the simulator session, and one which received no training. Additionally, the 15 college-aged drivers were college students who drove buses commercially in the surrounding area and were recruited to represent experienced drivers. All participants were recruited from a multi-college area in Massachusetts.

This study (Fisher et al., 2002) found that inexperienced drivers who are trained via a computer session reacted in a safer manner to risky situations when compared to inexperienced drivers who received no training. Inexperienced drivers who received the training were found to drive in a manner that was similar to that of the experienced group which received no computerized training. This research supports the notion that training to recognize risks within the driving environment can potentially improve teenage driver performance.

By altering driver's education programs to incorporate aspects of training programs such as those discussed above, perhaps further progress can be made on the teenage crash problem. Gregersen (1996) supports the notion that simply attempting to improve young drivers' driving skill level is ineffective at reducing crash rates. This training causes drivers to become more confident in their abilities and place themselves in riskier situations, which negate the benefits of the training. Other studies provide evidence for computer-based training programs which teach drivers to alter their driving behavior in specific targeted ways (Fisher et al., 2002; Pollatsek, Fisher, & Pradhan, 2006). Perhaps by developing a program which takes advantage of these findings, the teenage driver crash rates can be significantly reduced.

GRADUATED DRIVER LICENSURE

Graduated Driver Licensure programs are an international attempt at reducing the teenage crash problem. They utilize a three stage process to gradually introduce teenagers to the task of

driving. They consist of a learner's permit stage, restricted license stage, and an unrestricted license stage (Baker, Chen, & Li, 2007). Graduated Driver Licensure programs attempt to reduce teenage crash statistics by lengthening the "learning" phase of the licensure process and allowing teenagers to drive unsupervised after the learner's permit stage but with restrictions and contingencies, such as limits on the number of passengers they can have in their vehicle and curfews, that place limits on their behavior. This is thought to provide experience to teenagers while guarding them against riskier driving situations such as driving at night or where multiple passengers are present. Current research has supported this concept, noting that certain restrictions present within GDL programs can reduce teenage driver accidents substantially (Foss & Goodwin, 2003; McKnight & Peck, 2003; Hedlund, Shults, & Compton, 2003; Begg & Stephenson, 2003).

Baker, Chen, and Li (2007) examined compiled National Highway Traffic Safety Administration (NHTSA) fatal crash data, midyear population estimates from the U.S. Census Bureau, and individual state injury crash data. This research specifically examined and compared various states' current GDL laws and found a 19% reduction in teenage involvement in injurious crashes since the implementation of GDL components. This study also found an 11% overall reduction in teenage fatal crash involvement for states with various GDL laws. These fatal and injurious crash figures also included weaker states with fewer GDL components, which suggest that it probably underestimates the total potential effect of strong GDL programs upon teenage fatal and injurious crash involvement. Due to the higher reductions of fatal and injury crashes within states with strong GDL programs, a causal relationship is supported between GDL and lower crash rates for teenage drivers.

Ferguson, Teoh, & McCartt (2007) examined the Fatality Analysis Reporting System (FARS) and the National Automotive Sampling System(NASS)/General Estimates System(GES) databases to examine teenage drivers. They found a reduction between 1996 and 2005 in terms of fatal and non-fatal crash percentages for teenage drivers as a whole. Teenage male crash rates saw a greater reduction in crash rate than those of teenage females. The greatest crash reduction was seen in 16-year-old drivers, with less reduction being seen with each subsequent year of life experience. This analysis suggests that recent interventions, specifically GDL laws passed between 1996 and 2005, have had some degree of success in reducing the prevalence of crashes within teenage drivers. The authors also suggest that these reductions in crash rates are not likely to have been simply pushed into a different age group such as the late teens or early twenties. This lends credence to the pursuit of strong GDL programs throughout the United States.

Hedlund, Shults, and Compton (2003) note several advantages of GDL programs, which restrict drivers' licenses to allow them to drive unsupervised under set conditions such as only during the daytime. Several factors, such as alcohol use, safety belt use, fatigue, nighttime driving, the presence of passengers, and frequent distractions are linked to the high risk nature of teenage driving. In addition, teenagers perceive less risk in their driving behaviors when compared to experienced, adult drivers, further exacerbating the problem.

With regard to specific secondary tasks, much legislation has been introduced to restrict their prevalence while driving within the United States. Five states, California, Connecticut, New Jersey, New York, and Washington, as well as the Virgin Islands and the District of Columbia, have enacted a complete ban on the use of handheld cell phones while driving (Cell Phone Driving Laws, 2008). Seven states, including Alaska, California, Connecticut, Louisiana, Minnesota, New Jersey, and Washington as well as the District of Columbia, have enacted

complete ban on text messaging while driving (Cell Phone Driving Laws, 2008). In terms of novice driver-specific legislation, many attempts by various states have been made to limit inexperienced driver exposure to these secondary tasks. Seventeen states as well as the District of Columbia ban all cell phone use, both handheld and hands-free, by novice drivers (Cell Phone Driving Laws, 2008). Nine states specifically ban novice drivers from text messaging (Cell Phone Driving Laws, 2008).

In terms of the effectiveness of GDL laws, Hedlund, Shults, and Compton (2003) examined 12 background papers on GDL legislation to provide a summary of current GDL literature. This research noted that passenger restrictions are potentially effective, as passengers tend to increase teenagers' risk for crashes, but states that this factor is currently proving difficult to isolate. Also mentioned are several problems with current research regarding GDL programs, specifically noting gaps in the literature regarding in-vehicle distraction samples that specifically test teenagers' ability to handle these tasks while driving (Hedlund, Shults, & Compton, 2003). The current study helps to fill that gap by providing teenage-specific evidence of the effects that secondary tasks have upon teenage driving performance.

METHOD

PARTICIPANTS

Forty-two newly licensed teenage drivers (within three weeks of their licensure date) were recruited from the southwest Virginia area to represent inexperienced, new drivers. Necessary sample size power estimations were performed based upon a previous study and can be found in Appendix J. One of each of the teenagers' respective parents, a sample of 42 individuals ranging between 38 and 54 years of age at the start of the study, represented experienced adult drivers. Regarding ethnicity, one parent was Hispanic while 41 were non-Hispanic. In the teenage sample, two were Hispanic while 40 were non-Hispanic. In terms of the racial makeup of these participants, parents were comprised of 38 white, one black, one other, and two Asian individuals. With regard to race of the teenagers within this study, 38 were white, three Asian, and one other.

Data were collected over a roughly 22 month period beginning in June of 2006 and ending in April of 2008. All participants performed two sessions of approximately one hour each at 0 and 12 months. Attrition was a small factor, with one teenage participant (as well as the corresponding parent for that teenager) withdrawing from the study after the first session and one parent was not being required to perform the second session due to medical reasons. This brought the final number of teenagers down to 41 and parents down to 40. The participants were required to have at least 20/40 vision when corrected, if necessary. Participants were paid \$20 per hour for time spent on the test track as well as for filling out questionnaires.

The IRB approval letter for this study can be seen in Appendix A. The Continuing Review Form for 2007 can be found in Appendix B1. The Continuing Review Form for 2008

can be found in Appendix B2. The flyer used for recruitment of participants for this study can be found in Appendix C. Informed Telephone screening documentation used to ascertain whether the participant was eligible to participate can be found in Appendix D1 for teenagers and Appendix D2 for adults. Consent documentation for adults to participate can be found in Appendix E1. Informed Assent documentation for teenagers to participate can be found in Appendix E2. Informed Consent documentation for parental permission for teenage participation can be found in Appendix E3.

APPARATUS

TEST TRACK

The research was conducted at the Virginia Tech Transportation Institute's Smart Road, a 2.2 mile test track with guardrails where appropriate. This facility has an electronic gate controlled by a dispatch tower that restricts access to the test track to authorized vehicles only. The first half of a lap on the Smart Road slopes downhill, eventually going over the Smart Road bridge and entering a turnaround to begin the uphill, second half of a lap. A signalized intersection is present on this test track (Figure 1) and a Dedicated Short Range Communication (DSRC) unit located within the experimental vehicle controlled the light status as the vehicle approached.

VEHICLES

Test track sessions were performed utilizing a common instrumented vehicle for both sessions which was driven by all participants during the experiment. This vehicle was a 1999 Ford Taurus with standard ABS brakes, airbags, traction control, and an emergency foot brake located in the passenger side. The confederate van used was a white 16 passenger 1999 Chevrolet G30 Model T with its hazard lights turned on whenever present on the roadway. The

other confederate vehicle used for the following laps was a white 1999 Ford Contour with disabled brake lights. The brake lights on this vehicle were disabled by removing a fuse so as not to provide a distraction for the participant on the downhill section of the test track, which required steady braking from both vehicles to maintain a constant speed.

DATA ACQUISITION SYSTEM

The experimental vehicle was equipped with a Data Acquisition System (DAS) which included an array of cameras, bumper-mounted radar unit, and other data collection instruments to record parametric environmental data to a central unit located in the trunk of the vehicle. Parametric data collected included variables such as vehicle speed, distance to forward vehicles, turn signal status, and lane position. The radar units consisted of one TRW AC20 radar unit located on the front bumper (Figure 2) with a signal being emitted in an 11 degree angle from the unit at near ranges (1-40 meters) and at an 8 degree angle from the unit at intermediate ranges (40-100 meters). Most participants were within the near range for the majority of the sessions, however, some did cross into the intermediate range for parts of this study. A diagram of the radar position and angle can be seen in Figure 3. A computer in the backseat was utilized by an experimenter to manipulate the traffic light as well as record experimental conditions.

The cameras within the vehicle were monochrome charge coupled devices which recorded a view of the driver's face (Figure 4), a forward view out the front windshield of the car (Figure 5), a view of the participant's feet (Figure 6), and an over-the-shoulder view (Figure 7). Camera angles within the vehicle are illustrated within Figure 8. Each of the camera views was merged together to form a 4-way split screen with each view present (Figure 9).



FIGURE 1. SMART ROAD INTERSECTION



FIGURE 2. BUMPER-MOUNTED RADAR UNIT

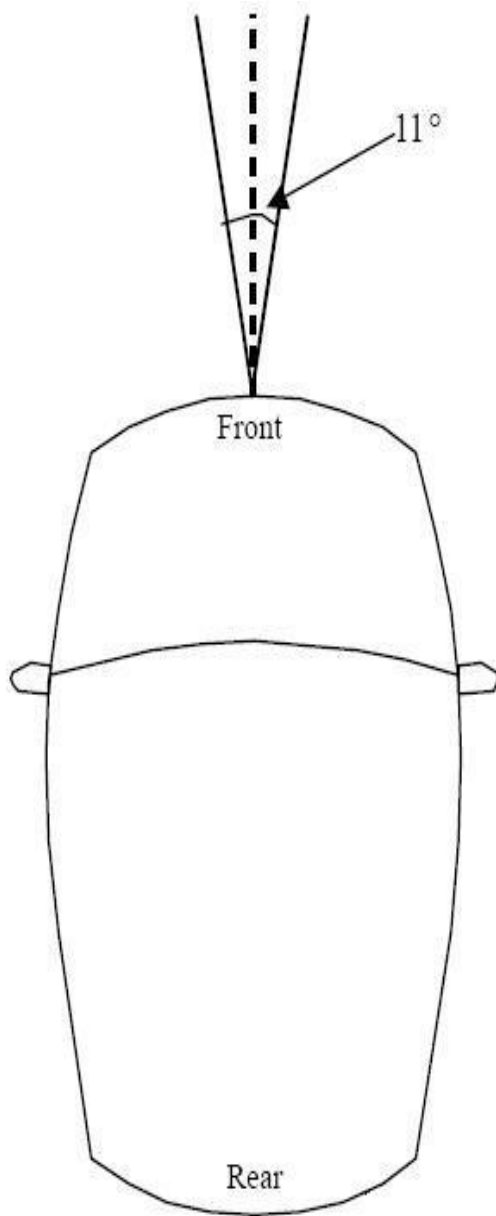


FIGURE 3. RADAR UNIT SIGNAL ANGLE



FIGURE 4. DRIVER'S FACE CAMERA



FIGURE 5. FORWARD VIEW CAMERA



FIGURE 6. FOOT VIEW CAMERA



FIGURE 7. OVER THE SHOULDER VIEW CAMERA

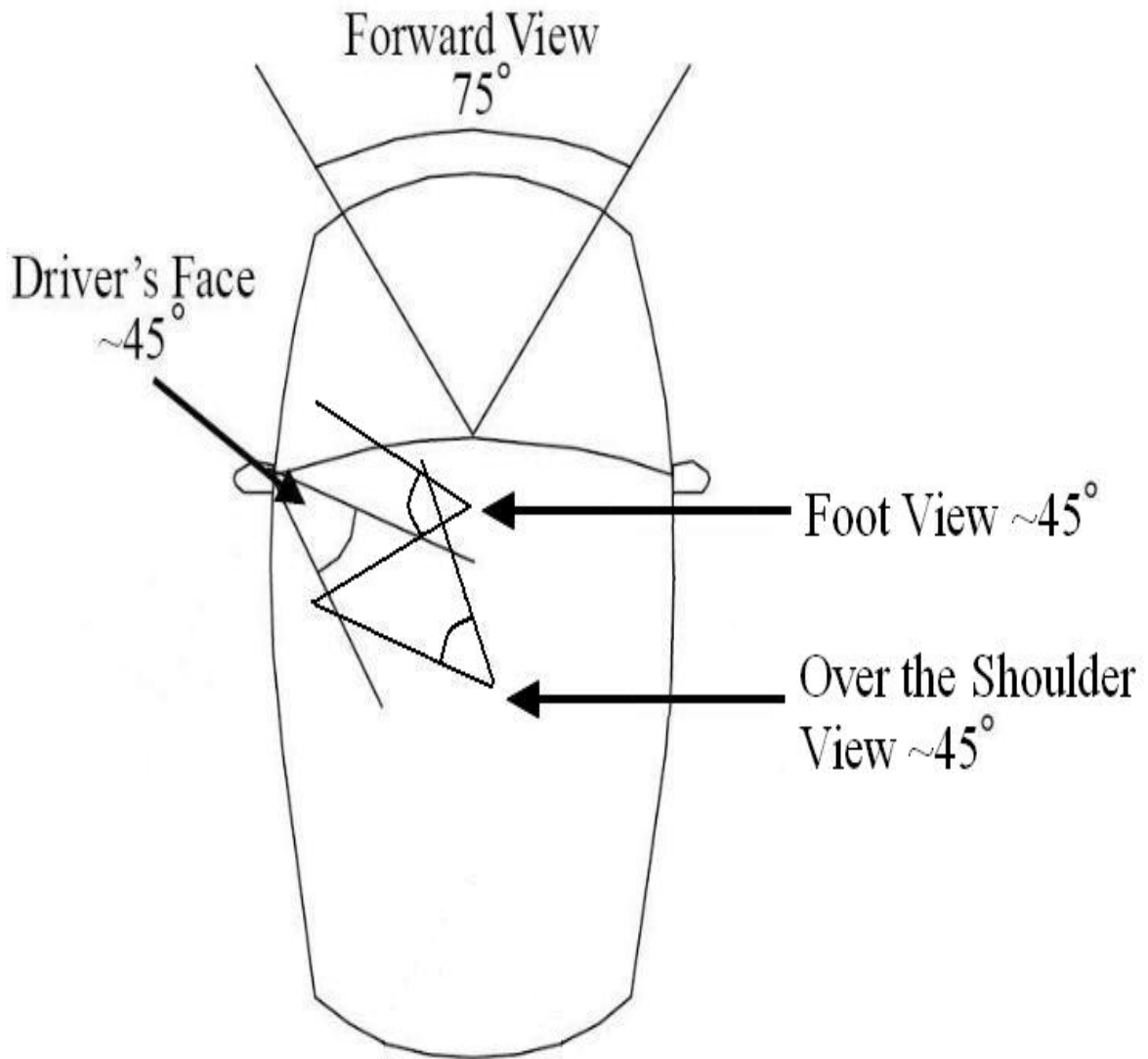


FIGURE 8. CAMERA LOCATIONS AND ANGLES OF COVERAGE

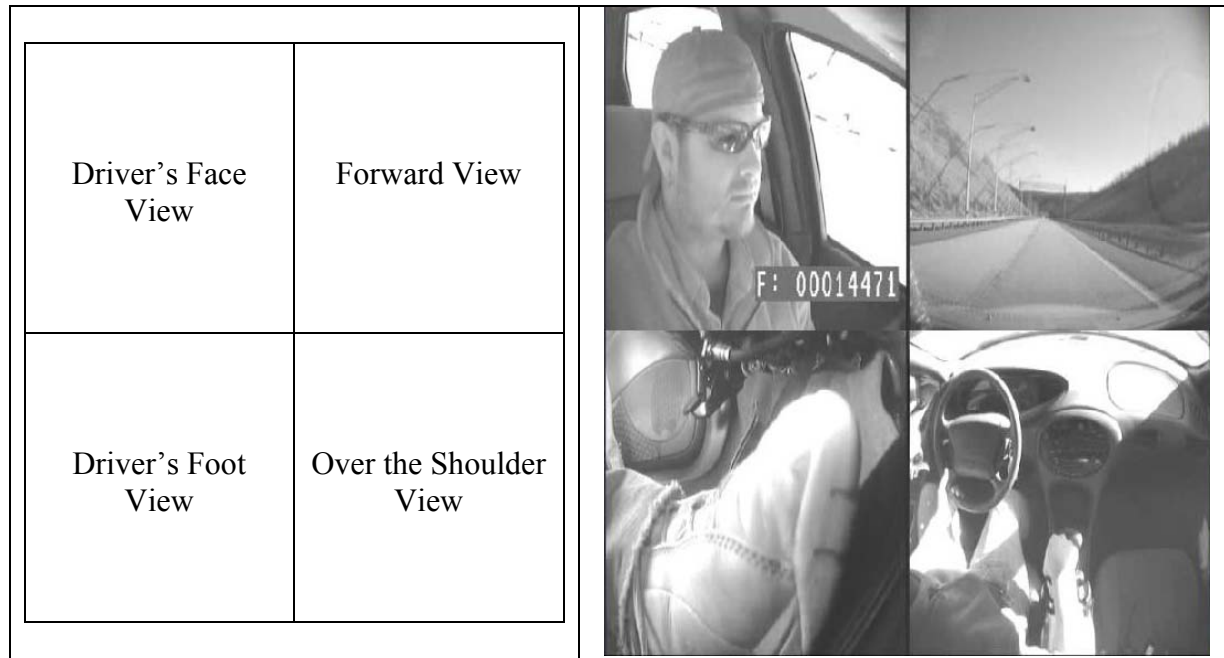


FIGURE 9. VIEW OF VIDEO WINDOWS

PROCEDURE

Participants were greeted and the Snellen Eye Test, Functional Acuity Contrast Test (FACT), and the PseudoIsoChromatic Color Vision Test were performed, with a required minimum of 20/40 rating on the Snellen. These tests were performed to ensure participants possessed normal vision. The form for inputting eye test information can be found on Appendix H. Participants were then taken to the instrumented vehicle where they became familiar with the vehicle controls, all secondary tasks were explained, and they became familiar with the devices used within the experiment. Participants were asked to obey all relevant traffic signals on the road, but not told specifically what signals they might encounter.

Participants were told that their instrumented vehicle, a maintenance crew, and forward vehicle for following tasks would be the only traffic on the roadway. The secondary tasks included use of an iPod, cell phone text messaging, use of a highway assistance service via cell phone, and a directions task. Traffic signals included a hidden stop sign, detour signs, and

several instances of passing through an intersection with a traffic light. Each session included a training period and a seven lap trip on the test track equipped with an intersection with traffic light while performing a different secondary task for each individual lap. This traffic light was located near the beginning of the first half of a lap and near the end of the second half of a lap, with participants driving through it twice for each lap around the test track.

Two sequences of lap and secondary task presentation were used to help counterbalance learning and stimulus presentation order effects. The first half of participants to enroll in the study and participate on the Smart Road was assigned the first lap sequence for the 0 month session and received the second lap sequence at the 12 month session. The second half of participants to enroll in the study and participate on the Smart Road was assigned the second lap sequence for the 0 month session and received the first lap sequence at the 12 month session.

An experimenter in the front passenger seat presented the secondary tasks at the end of each half loop around the test track. Upon explaining a task to a participant, the experimenter asked the participant to repeat the task, in order to demonstrate that the participant understood what was being asked of them. Tasks were stopped upon nearing the turnaround section at either end of the roadway, to allow the participant to navigate the turn effectively. Participants were told to maintain a comfortable speed for the first three laps. For laps four through six, participants had a confederate lead vehicle in front of them and were asked to maintain a comfortable following distance from this vehicle. For the seventh lap, participants were told to maintain 35 mph.

In the first lap, participants were asked to perform an odometer task in which they tell the experimenter whenever the trip odometer reached a 3, 6, or 9 in the last digit (representing tenths of a mile). In this lap, the intersection traffic light was turned off and a stop sign was obscured

behind the confederate van to test drivers' ability to detect the hidden sign. This lap served as a baseline to allow participants to become accustomed to the road and to performing secondary tasks with the experimental vehicle. During the second half of this lap, participants encountered a van driven by the confederate, which was parked on the right shoulder of the roadway, beyond the right hand lane line. The confederate experimenter stood at the rear of the van with the doors open until the participant vehicle reached a predetermined distance. The van doors were then shut and the confederate walked around to the front of the van using a route on the shoulder side of the van. The experimenter then walked across the front of the van, but not actually out into the roadway, to ascertain the drivers' ability to detect hidden pedestrians. The intersection light remained off for the first half of this lap to allow for stop sign detection, but was activated for the second half and remained green.

For the first half of the second lap, participants were asked to read the directions on a card that was handed to them by the front seat experimenter and answer the question on the back of the card out loud. For the second half of the second lap, participants were asked to perform a text messaging task in which they would text [Meet me in the lobby at 7 after work] using the provided phone. If they finished this first text message, participants were then instructed to text [Want to eat at Taco Bell at 6:30]. The confederate was now parked in the right hand lane with six cones closing the lane off and directing the participant to drive around the confederate van. The same pedestrian detection task seen in the first lap was also performed and the intersection traffic light again remained green throughout the lap.

For the first half of the third lap, participants were asked to use the iPod to play a specific song. If they found and successfully played this song, they were then asked to play an additional song, then to identify specific songs within the iPod. On the second half of the third lap,

participants were asked to call the 511 traffic information service and describe the first traffic incident on Interstate 81. If they finished this task, they were asked to find out if any traffic or construction delays currently exist on Interstate 77. During the second half of this lap, participants encountered a detour that bypassed a small section of the roadway. The pedestrian detection task occurred, but without the confederate walking across front of the van, and with a large stuffed dog placed there instead to test hidden hazard detection skills. The intersection light remained green throughout the entire lap. At the end of the third lap, the confederate experimenter drove the van off the Smart Road onto an access roadway while out of sight of the participant.

For the fourth, fifth, and sixth laps, there was a confederate lead vehicle (sedan) that the participant followed while performing secondary tasks. The confederate experimenter drove the Ford Contour out onto the Smart Road and waited for the experimental vehicle. Participants were asked to maintain a comfortable following distance and to remain in the right lane for this portion of the experiment. The confederate experimenter was driving the Ford Contour and was instructed to maintain 35 miles per hour regardless of participant speed. On the fourth lap, participants were asked to perform the same odometer task seen in the first lap to again provide a baseline for comparison to later laps. On the second half of this lap, the traffic light turned amber for 3.6 seconds when the subject vehicle reached 157 feet from the intersection and eventually red. The lead confederate vehicle went through the amber light to test subjects' reaction to the light.

On the first half of the fifth lap, participants were asked to send the following text message: [Hope you are feeling better today], If they finished this task prior to the beginning of the second half of the lap, they were asked to send this text message: [Let's meet at the duck

pond after the meeting]. During the second half of this lap, participants were asked to find a song on an iPod by a specific artist. If they finished this, they were asked to find the last artist on the iPod, how many songs start with the letter J, and to play the second song of a specific album. Also on the second half of this lap, the traffic light turned amber for 3.6 seconds when the subject vehicle reached 140 feet from the intersection and eventually red. The lead confederate vehicle went through the amber light to test subjects' reaction to the light.

For the first half of the sixth lap, participants were asked to call the 511 service and find out how many traffic and construction delays there were on Interstate 81. The traffic light turned amber for 3.6 seconds when the subject vehicle reached 174 feet from the intersection and eventually red. The lead confederate vehicle went through the amber light to test subjects' reaction to the light. If they finished this task prior to reaching the bridge, they were asked to dial a specific number and report the current time and temperature. For the second half of this lap, participants were asked to read the directions on a card that was handed to them by the front seat experimenter and answer the question on the back of the card out loud.

For the first half of the final lap, participants were asked to drive at 35 miles per hour without a lead vehicle and text the following message: [When do you want to meet at the library] If they finished this task prior to reaching the bridge, the next message to be sent was: [The car is ready to be picked up at the shop]. For the second half of this lap, participants were asked to call the 511 service and find out the mile marker for the first traffic incident on Interstate 81 northbound. If they completed this prior to the end of the lap, they were asked to call the 511 service again and find out whether there are any traffic incidents on Interstate 64. For this lap, the confederate was uninvolved and remained on the access road. The traffic light turned amber for 2.6 seconds and then red when the experimental vehicle reached 200 feet from the

intersection. This scenario provides the participant with inadequate time to completely go through the intersection without the light turning red, as it would take 4 seconds to traverse 200 feet at 35 mph. Thus, this portion of the experiment tests participants' reaction to the dilemma zone, or point at which a driver must decide between stopping very quickly or running through a red light in an intersection.

A second lap order was utilized to balance learning and task order effects. This second order had the same tasks and the same number of laps but in a different order. With the second order, the first lap would continue exactly the same as the first order, but laps 2-4 would include following the confederate lead vehicle and the participant would be performing the directions, text messaging, iPod, and 511 tasks seen in the first order's fourth through sixth laps. Laps 5-7 of the second order, on the other hand, did not have a forward vehicle and the participant performed the directions, text messaging, iPod, and 511 tasks seen in the first order's second, third, and seventh laps while maintaining a comfortable speed. Thus, the second order's fifth lap tasks were the same as the seventh lap in the first order. The second order's sixth lap tasks were the same as the second lap in the first order. Finally, the second order's seventh lap tasks were the same as the third lap in the first order.

This research specifically examined portions of several laps in order to study the difference between teenage and adult drivers with regard to a cell phone task. 511 cell phone tasks were compared to corresponding odometer tasks on different laps but at the same locations on the Smart Road test track. The odometer tasks served as a baseline lap for comparison with cell phone portions in order to examine differences in driving ability with different secondary task loads. Examples for the Directions task can be found in Appendix I. Instructions for the in-vehicle experimenter can be found in Appendix F1 for Lap Order 1 and Appendix F2 for Lap

Order 2. Instructions for the confederate can be found in Appendix G1 for Order 1 and Appendix G2 for Order 2.

For radar data, data cleaning was performed in order to facilitate analysis. The radar itself included four streams of information in which the target vehicle could potentially be represented. The radar also occasionally picked up objects on the side of the roadway, which could have potentially led to misleading data. Thus, to get the data into a usable format for statistical analysis, an experimenter went through each data video and noted which target accurately represented the forward vehicle. After that, the targets from each video were then used to filter the data with SAS and remove irrelevant data points. After this data cleaning process, the data were then analyzed normally.

EXPERIMENTAL DESIGN

INDEPENDENT VARIABLE

The Independent variable in this study, Participant Experience, is operationally defined for each of the three categories in Table 1.

TABLE 1: PARTICIPANT OPERATIONAL DEFINITIONS

Participant Experience	Operational Definition
0-month Teenage Driver	A teenager under the age of 18 within 3 weeks post-licensure date
12-month Teenage Driver	A teenage driver with 12 months of experience post-licensure date
Experienced Driver	Adult with many years of experience driving (21-40 years post-licensure)

DEPENDENT VARIABLES

The Dependent variables in this study, Participant Speed, Participant Lane Position, and Participant Headway, are defined Table 2.

TABLE 2: DEPENDENT OPERATIONAL DEFINITIONS

Roadway Performance Metric	Analytical Measure
Participant Speed	<ul style="list-style-type: none">• Average speed of subject vehicle• Standard deviation of speed of subject vehicle
Participant Lane Position	<ul style="list-style-type: none">• Average lane deviations of subject vehicle• Standard deviation of lane deviations of subject vehicle
Participant Headway	<ul style="list-style-type: none">• Average headway of subject vehicle• Standard deviation of headway of subject vehicle from forward vehicle
Participant Driving-Related Eyeglance	<ul style="list-style-type: none">• Average Percentage of Eyeglances that are Driving-Related

JUSTIFICATION FOR DEPENDENT VARIABLES

Participant Speed and Participant Headway were chosen due to the direct relationship they have with the available time to react to stimuli on the roadway. Participant Lane Position was chosen because of its relationship to run-off-road crashes, a common scenario for crashes involving teenage drivers. Participant Driving-Related Eyeglance was selected to examine how much a participant looks away from critical driving stimuli, which also directly relates to reaction times and crash risk.

RESEARCH QUESTIONS AND DATA ANALYSIS

RESEARCH QUESTION 1: Do experienced drivers more effectively regulate their speed and lane position while performing secondary tasks than less experienced, teenage drivers?

The purpose of this question is to examine the role that various levels of driving experience has upon the ability of a driver to maintain a stable position in the roadway while performing a task not central to driving itself. This question is examined through the following two hypotheses below.

HYPOTHESIS 1:

With additional driving experience, ability to regulate vehicle speed while performing a secondary task is improved.

H0: There is no difference between teenage drivers within several weeks of licensure, teenage drivers with one year of driving experience, and experienced drivers in ability to regulate vehicle speed while performing a secondary task.

H1: Increased driving experience leads to significantly more consistent vehicle speeds while performing a secondary task.

HYPOTHESIS 2:

With additional driving experience, ability to avoid contacting lane lines while performing a secondary task is improved.

H0: There is no difference between teenage drivers within several weeks of licensure, teenage drivers with one year of driving experience, and experienced drivers in ability to regulate lane position while performing a secondary task.

H1: Increased driving experience leads to significantly fewer lane deviations while performing a secondary task.

RESEARCH QUESTION 2: Do more experienced drivers maintain a larger, more consistent distance from a forward vehicle than less experienced, teenage drivers while performing a secondary task?

The purpose of this question is to examine the role that various levels of driving experience has upon the distance a driver attempts to maintain from a forward vehicle while performing a task not central to driving itself. This question is examined through the following two hypotheses below.

HYPOTHESIS 3:

With additional driving experience, ability to regulate a consistent headway from a forward vehicle while performing a secondary task is improved.

H0: There is no difference between teenage drivers within several weeks of licensure and experienced, adult drivers in regulating headway consistency while performing a secondary task.

H1: Increased driving experience leads to significantly more consistent headway from a forward vehicle while performing a secondary task.

HYPOTHESIS 4:

With additional driving experience, overall headway from a forward vehicle while performing a secondary task will be larger.

H0: There is no difference between teenage drivers within several weeks of licensure and experienced, adult drivers in headway distance while performing a secondary task.

H1: Increased driving experience leads to significantly more overall headway from a forward vehicle while performing a secondary task.

RESEARCH QUESTION 3: Do the eyeglance patterns of experienced drivers differ from those of less experienced, teenage drivers while performing a secondary task?

The purpose of this question is to examine the role that various levels of driving experience has upon driver eyeglance patterns in the presence of secondary tasks. This question is examined through the following hypothesis below.

HYPOTHESIS 5:

With additional driving experience, percentage of driving-related glances compared to non-driving-related glances will increase.

H0: There is no difference between teenage drivers within several weeks of licensure and experienced, adult drivers in driving-related glances while performing a secondary task.

H1: Increased driving experience leads to a significantly higher percentage of driving-related glances while performing a secondary task.

DATA ANALYSIS

HYPOTHESIS 1:

This hypothesis was tested by examining the recorded vehicle speed and finding the average speed and standard deviation of speed for parent versus teenage drivers at the start of the study versus teenage drivers one year after the start of the study. The hypothesis H1 was analyzed utilizing a within-subjects design ANOVA for each of the two sessions including time between sessions (0 months versus 12 months) as the within-subjects factor. The hypothesis H2 was analyzed utilizing a between-subjects design ANOVA with amount of driving experience (experienced drivers vs. teenagers with one year of driving experience) as the between-subjects factor. The hypothesis H3 was analyzed utilizing a between-subjects design ANOVA with amount of driving experience (experienced drivers vs. teenagers within several weeks of licensure) as the between-subjects factor. This research question was analyzed using data from self-selected speed portions of the test track sessions, using the odometer task as a baseline and the 511 cell phone task as the experimental condition.

HYPOTHESIS 2:

This hypothesis was analyzed by examining the average lane deviations per lap and standard deviation of lane deviations for parent versus teenage drivers at the start of the study. The hypothesis H1 was examined with Chi-Square analysis for each of the two sessions including time between sessions (0 months versus 12 months) as the within-subjects factor. The hypothesis H2 was examined with Chi-Square analysis with amount of driving experience (experienced drivers vs. teenagers with one year of driving experience) as the between-subjects factor. The hypothesis H3 was examined with Chi-Square analysis with amount of driving

experience (experienced drivers vs. teenagers within several weeks of licensure) as the between-subjects factor. This research question was analyzed using data from self-selected speed as well as self-selected following distance portions of the test track sessions, using the odometer task as a baseline and the 511 cell phone task as the experimental condition.

HYPOTHESIS 3:

This hypothesis was analyzed by examining the recorded vehicle headway from the forward vehicle and finding the average headway and standard deviation of headway for each driver. The hypothesis H1 was analyzed utilizing a within-subjects design ANOVA for each of the two sessions including time between sessions (0 months versus 12 months) as the within-subjects factor. The hypothesis H2 was analyzed utilizing a between-subjects design ANOVA with amount of driving experience (experienced drivers vs. teenagers with one year of driving experience) as the between-subjects factor. The hypothesis H3 was analyzed utilizing a between-subjects design ANOVA with amount of driving experience (experienced drivers vs. teenagers within several weeks of licensure) as the between-subjects factor. This research question was analyzed using data from self-selected following distance portions of the test track sessions, using the odometer task as a baseline and the 511 cell phone task as the experimental condition.

HYPOTHESIS 4:

This hypothesis was tested by examining the recorded vehicle headway from the forward vehicle and finding the average headway. The hypothesis H1 was analyzed utilizing a within-subjects design ANOVA for each of the two sessions including time between sessions (0 months versus 12 months) as the within-subjects factor. The hypothesis H2 was analyzed utilizing a between-subjects design ANOVA with amount of driving experience (experienced drivers vs. teenagers with one year of driving experience) as the between-subjects factor. The hypothesis H3

was analyzed utilizing a between-subjects design ANOVA with amount of driving experience (experienced drivers vs. teenagers within several weeks of licensure) as the between-subjects factor. This research question was analyzed using data from self-selected following distance portions of the test track sessions, using the odometer task as a baseline and the 511 cell phone task as the experimental condition.

HYPOTHESIS 5:

This research question was answered by examining eyegance data from both the odometer task and 511 cell phone tasks, both in the presence of a forward vehicle and in self-selected speed conditions. This hypothesis was tested by a frame-by-frame analysis of driver eyegance patterns within each session and finding the percentage of time spent by the driver engaged in driving-related glances. Driving-related glances are defined as the driver looking at one of the following: Forward roadway, Rearview Mirror, Left Window/Mirror, Right Window/Mirror, Left Windshield, and Right Windshield. Glances were not considered driving-related if the driver is looking at one of the following: Instrument Cluster (Speedometer, Odometer, etc), Over their shoulder (typically seen in backing scenarios), Center Stack (Radio, Climate Control, etc), Cell Phone, Interior Object, Passenger, iPod, or Other.

RESULTS

Statistical analysis was performed with the SAS statistical software package (v. 9.2 for Windows). Results were considered significant at $p \leq 0.05$, with $p \leq 0.10$ being considered indicative of trends within the data. Continuous data (Speed, Lane Deviation Duration) were analyzed using ANOVA procedures, while Categorical data (Lane Deviation Frequency Counts) were analyzed using Chi-Square tests. Post-hoc analysis on relationships within the continuous data was performed utilizing the Tukey Honestly Significant Difference (HSD) test.

MEAN SPEED

Analysis of variance was performed on mean speed data to test driving performance across conditions for self-selected speed laps (Laps 2 and 7A, with no forward vehicle present). With regard to mean speed, the 160 experienced drivers ($M = 43.917$, $SD = 5.184$) were found to drive significantly faster regardless of session than the 158 teenage drivers ($M = 40.35$, $SD = 5.107$), $F(1, 82) = 94.82$, $p < .0001$. This is seen in Figure 10. The 160 experienced drivers ($M = 43.917$, $SD = 5.184$) were also found to drive significantly faster regardless of task (odometer or cell phone) than the 158 teenage drivers ($M = 40.35$, $SD = 5.107$), $F(1, 82) = 7.05$, $p = .0085$. The 157 participants performing the odometer task ($M = 43.719$, $SD = 5.525$) traveled significantly faster than the 161 participants performing the cell phone task ($M = 40.612$, $SD = 4.904$), $F(1,82) = 12.66$, $p = 0.0006$. The ANOVA table for these results can be found in Table H1 (in Appendix H).

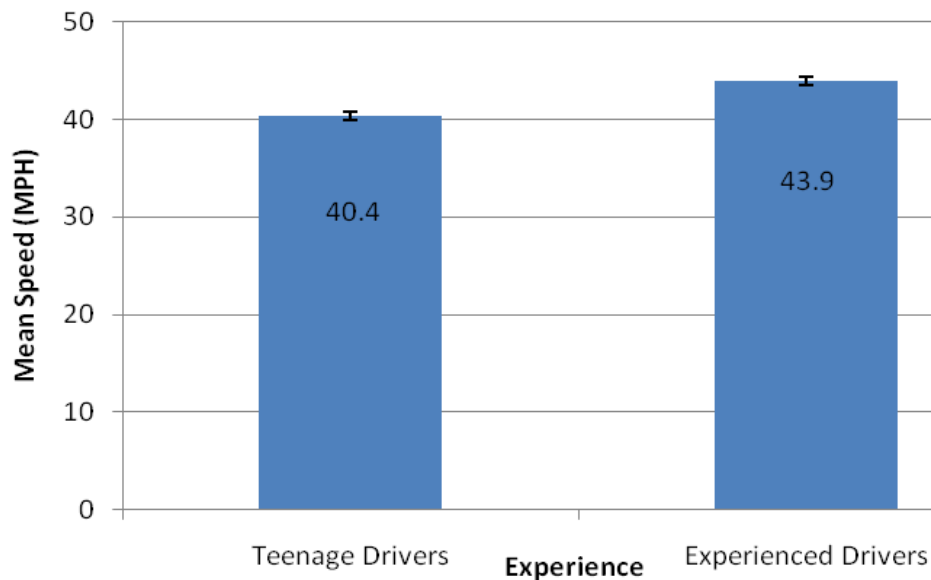


FIGURE 10. MEAN SPEED FOR TEENAGE AND EXPERIENCED DRIVERS WITH STANDARD ERROR BARS.

When comparing all the drivers present at the session at the start of the study (0 month) versus all the drivers present at the session one year into the study (12 months), no significant difference in mean speed was found. When comparing only the experienced drivers at the beginning of the study (0 month) versus the session one year into the study (12 months), there was no significant difference in mean speed.

An overall effect was found between Experience (Teenage or Experienced Driver) and Time of Session (0 or 12 months). A post-hoc Tukey's HSD test was performed and found several significant effects. The 79 teenage drivers present during the 12 month session drove significantly faster ($M = 41.12$, $SD = 5.79$) than the 79 teenage drivers in the 0 month session ($M = 39.59$, $SD = 4.22$), $F(1, 227) = 2.89$, $p = .0215$. This is seen in Figure 11.

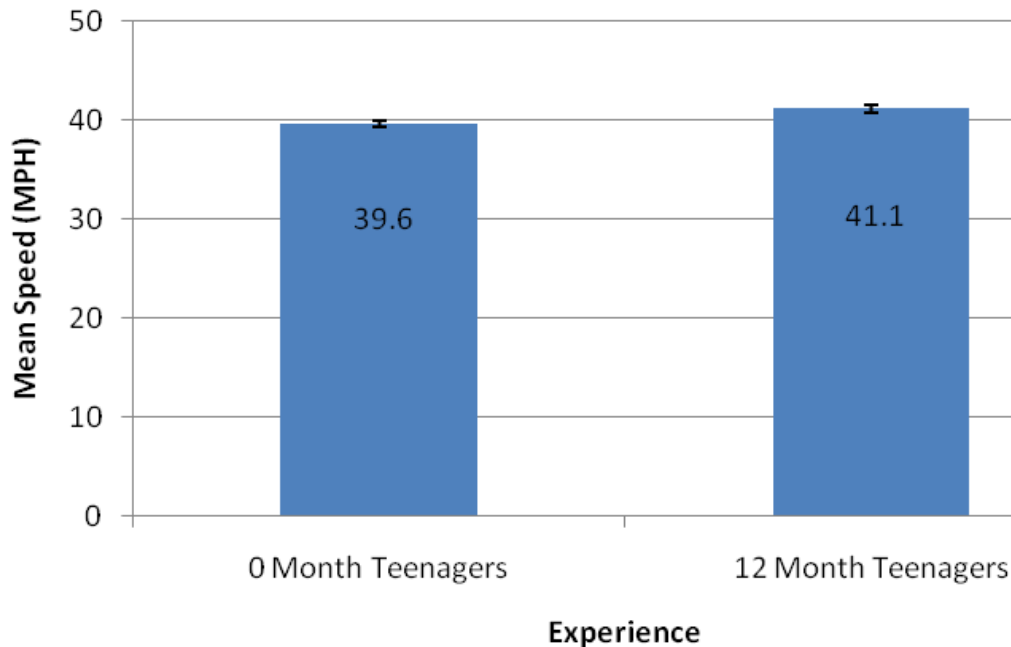


FIGURE 11. MEAN SPEED OF TEENAGE DRIVERS AT THE 12 MONTH AND 0 MONTH SESSIONS WITH STANDARD ERROR BARS

SPEED VARIANCE

Analysis of Variance was performed on the standard deviation of speed and overall speed range (maximum speed minus minimum speed). No significant effects relevant to the tested hypotheses were found between participant age, session, task, or any combination of the three conditions.

LANE DEVIATIONS

In the analysis of lane bust data, Chi-Square tests were performed on lane deviation frequency counts and an analysis of variance was performed on the duration of lane deviations. Little statistical power was achieved through this research with regard to lane deviations because of their relatively infrequent occurrence for these tasks. Thus, no significant effects were found

in terms of lane deviations and lane deviation duration between participant age, session, task, or any combination of the three conditions.

MEAN RANGE

Radar range data was examined through Analysis of Variance to test driving performance in the presence of secondary tasks across conditions self-selected following distance laps (Laps 8 and 12, with a forward vehicle present). When comparing the session at the start of the study (0 month) versus the session one year into the study (12 months), no significance was found. When broken down by individual tasks without regard to session, 79 teenagers were found to travel significantly further away ($M = 42.733$, $SD = 18.961$) on average from a forward vehicle on the odometer task (Task 8) than 80 experienced drivers ($M = 36.175$, $SD = 12.846$), $F(1, 82) = 3.37$, $p = 0.0049$. This is seen in Figure 12. A trend was found towards 78 teenagers on the odometer task (Task 8) ($M = 42.733$, $SD = 18.961$) traveling further away from 79 teenagers on the cell phone task (Task 12) ($M = 37.825$, $SD = 19.468$), $F(1, 82) = 2.51$, $p = 0.061$. No other task, age, or session effects were found. The ANOVA table for these results can be found in Table H2 (in Appendix H).

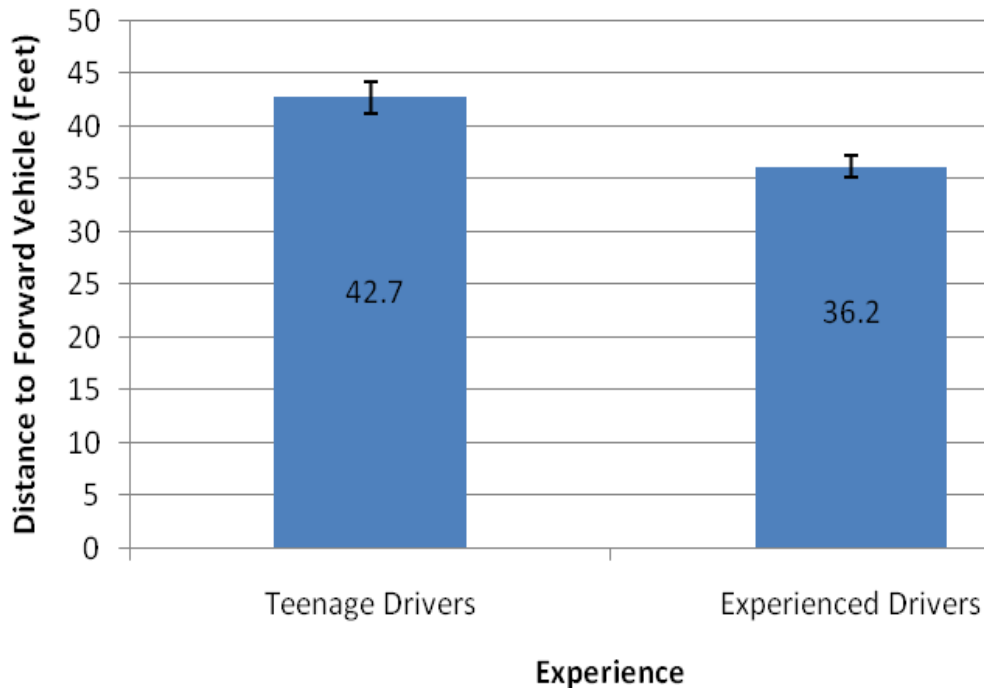


FIGURE 12. DISTANCE TO A FORWARD VEHICLE WHILE PERFORMING THE ODOMETER TASK FOR TEENAGE AND EXPERIENCED DRIVERS WITH STANDARD ERROR BARS.

RANGE VARIANCE

The overall range of distances between the subject vehicle and the forward vehicle along with the standard deviation of range were also tested via Analysis of Variance to determine differences between experienced and teenage drivers. In the analysis of Standard Deviation of Range, 158 participants performing the odometer task (Task 8) had significantly less range variation ($M = 9.480$, $SD = 8.280$) than 159 participants performing the cell phone task (Task 12) ($M = 12.816$, $SD = 12.559$), $F(1, 82) = 5.80$, $p = 0.018$. When the effect of Age is examined, 80 experienced drivers performing the odometer task (Task 8) were found to have significantly less range variation ($M = 8.705$, $SD = 8.074$) than 80 experienced drivers performing the cell phone

task (Task 12) ($M = 12.816$, $SD = 12.559$), $F(1, 82) = 3.41$, $p = 0.004$. No other Age, Session, or Task effects were found.

In analyzing the overall range of distances between the subject vehicle and the forward vehicle data, a trend was found between 158 participants performing the odometer task (Task 8) having a lower range of range values ($M = 54.431$, $SD = 38.521$) than 159 participants performing task 12 ($M = 64.693$, $SD = 57.629$), $F(1, 82)$, $p = 0.084$. No other Age, Session, or Task effects were found.

PERCENT OF DRIVING-RELATED GLANCES

Analysis of variance was performed on eyeglance data to test driving performance across conditions for self-selected speed laps (both the cell phone and odometer tasks with no forward vehicle present) and self-selected following distance laps (both the cell phone and odometer tasks with a forward vehicle present). With regard to driving-related glances, the 319 drivers ($M = 58.7\%$, $SD = 10.3\%$) at the 0 month session were found to have a significantly lower percentage of driving-related glances than the 320 drivers at the 12 month session, regardless of driver age or task ($M = 60.8\%$, $SD = 10.0\%$), $F(1, 82) = 10.65$, $p = 0.0012$.

An overall effect was found between Experience (Teenage or Experienced Driver) and percentage of driving-related glances. The 323 Experienced drivers were found have a significantly higher percentage of driving-related glances ($M = 60.8\%$, $SD = 10.8\%$) than the 316 inexperienced, teenage drivers regardless of session or task ($M = 58.6\%$, $SD = 9.4\%$), $F(1, 82) = 7.22$, $p = 0.0074$. This is seen in Figure 13. The ANOVA table for these results can be found in Table H3 (in Appendix H).

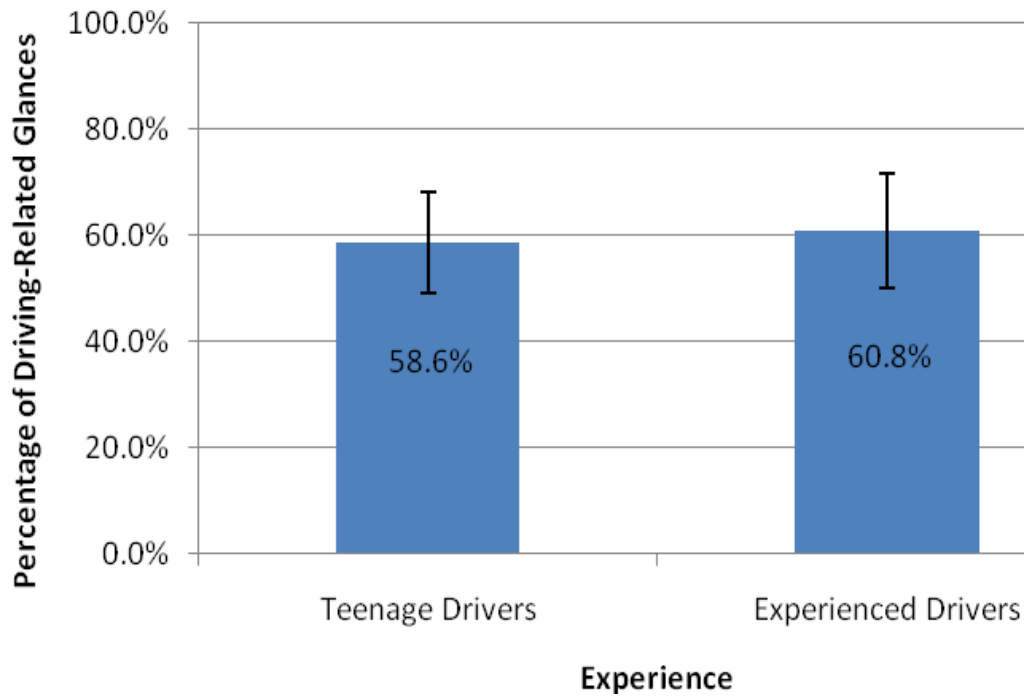


FIGURE 13. PERCENTAGE OF DRIVING-RELATED GLANCES FOR TEENAGE AND EXPERIENCED DRIVERS WITH STANDARD ERROR BARS.

The cell phone task in the presence of a forward vehicle (Task 12) had a significantly higher percentage of driving-related glances ($M = 64.2\%$, $SD = 10.1\%$) than any other task (Odometer task, no forward vehicle: $M = 58.7\%$, $SD = 8.6\%$, Cell phone task, no forward vehicle: $M = 59.3\%$, $SD = 9.5\%$, Odometer task with forward vehicle: $M = 56.6\%$, $SD = 10.9\%$), $F(1, 82) = 4.74$, $p < 0.0001$. No other interactions were found.

DISCUSSION

This research investigated the link between driving experience and driving performance while performing a secondary task. Five hypotheses were posited to test the connection between experience and driving performance and are examined below.

HYPOTHESIS 1: With additional years of driving experience, ability to regulate vehicle speed while performing a secondary task is improved.

The first hypothesis was not supported. In terms of regulating speed (measured by standard deviation of speed and speed range), no overall differences were found between teenage drivers and experienced drivers. Experienced drivers were found to drive similarly in both the 0 month and 12 month sessions. Experienced drivers also drove with a significantly faster mean speed than teenage drivers regardless of session or the secondary task being performed. Teenage drivers were, however, found to drive significantly faster during the 12 month session as opposed to the 0 month session.

Perhaps average speed related to confidence in one's driving ability, which would coincide with experienced drivers driving faster overall as well as with teenagers driving faster in the 12 month session versus the 0 month session. Increases in attentional capacity as well as cognitive flexibility, in terms of switching between secondary tasks and the driving task itself, could have led teenagers to feel more comfortable when driving while performing a secondary task in the 12 month session than in the 0 month session.

Experienced drivers also drove similarly for both sessions, which is probably due to relatively minor or potentially insignificant gains in experience as well as executive control and

mental capacity for the driving task they gained from one additional year of driving when compared to the 20+ years of experience they already had. Teenage drivers, on the other hand, gained a very large amount of experience during that year, relative to the driving experience they had at the 0 month session. That year of experience also happens to have occurred during a significant period in individual development, which could have provided increased ability to perform the task to complement the experience they received by driving for 12 months.

HYPOTHESIS 2: With additional years of driving experience, ability to avoid contacting lane lines while performing a secondary task is improved.

The second hypothesis was not supported. Few lane deviations were observed within this research which resulted in insignificant results for all comparisons. The insignificance of this data ultimately does not support the notion that secondary tasks, specifically the cell phone and odometer tasks, contribute significantly to lane deviations. Given additional cell phone data, preferably within real-world driving, perhaps conclusions regarding the link between experience and lane position maintenance could be further explored with much more power and depth than the current study. This study did not, however, analyze some of the more challenging tasks performed during this study, such as the reading and text messaging tasks, which are expected to show more significant results with regard to this variable.

HYPOTHESIS 3: With additional years of driving experience, ability to regulate a consistent headway from a forward vehicle while performing a secondary task is improved.

The third hypothesis was not supported. No significant effects were found to support more consistency with regard to range from a forward vehicle with increased experience. This

suggests that the ability to regulate consistency of following distance from a forward vehicle is a relatively quickly learned and stable aspect of driving overall. However, the cell phone task did lead to significantly more variance in range than did the odometer task, both for experienced drivers and when inexperienced and experienced drivers were pooled together, regardless of experience. Essentially, this result means drivers are less able to maintain a consistent distance from themselves and a forward vehicle when driving while performing a cell phone task. This suggests that using a cell phone while driving uses up significant resources and makes the driver pay, at least to some degree, less attention to the driving task as a whole.

Ultimately, this research supports the current literature which states that cell phone use while driving increases crash risk. This finding also helped to define specifically how drivers' performance is degraded through the presence of these tasks. When performing cell phone tasks, drivers ultimately see a significant loss in the ability to consistently maintain distance from a forward vehicle due to the demands of the secondary task itself. This likely represented a strong component of the overall increased crash risk that is seen from individuals performing these tasks while driving. The attentional demands of both the task itself and switching between the task and the driving environment likely significantly affect the ability of the driver to maintain range consistency while driving with a distraction. This finding also supports future research into other secondary tasks, most obviously text messaging, to understand specifically how they degrade driving performance.

HYPOTHESIS 4: With additional years of driving experience, overall headway from a forward vehicle while performing a secondary task will be larger.

The fourth hypothesis was not supported. No significant effects were found to suggest that driving experience correlated with an increased mean following distance from a forward vehicle while performing a secondary task. When examined by a task comparison, teenagers traveled further away than experienced drivers from the forward vehicle on the odometer task. This result suggests that there is perhaps a link between experience and following distance while performing simple as opposed to complex secondary tasks. Speculatively, this may be due to a lack of confidence in driving ability in the teenage participants.

A trend was also found that suggested teenagers traveled significantly further from the forward vehicle on the simpler odometer task as opposed to the cell phone task. This suggests a possible link between the complexity of the secondary task being performed and the degradation of ability to maintain a forward distance from a forward vehicle in novice drivers, but warrants further investigation as significance was not achieved.

HYPOTHESIS 5: With additional years of driving experience, percentage of driving-related glances compared to non-driving-related glances will increase.

The fifth hypothesis was supported. While the difference in driving-related glances versus non-driving-related glances is small (roughly 2%), with increased experience, drivers were found to look significantly more at the forward roadway and mirrors as opposed to inexperienced, teenage drivers. This is perhaps due to increases in attentional control which allow experienced drivers to concentrate more on the driving task itself as well as switch between the secondary task and driving more effectively. This could also potentially occur because experienced drivers have attached a higher importance to the driving task itself than the

secondary task, while teenage drivers place slightly more importance on the secondary task when compared to experienced drivers.

Experienced drivers were found to have a significantly higher percentage of driving-related glances in the 12 month session as opposed to the 0 month session. This is perhaps due to increased familiarity with cell phones as well as technology in general during the 12 months between sessions, resulting in a small but significant increase (3%) in driving-related glances while performing secondary tasks. This could also represent a potential learning effect with regard to the equipment utilized in this experiment (the instrumented vehicle and the Smart Road test track).

Olsen, Lee, and Simons-Morton (2007) also examined teenage versus experienced drivers with regard to eyeglance behavior while performing secondary tasks on the same test track utilized within this research. Their study had similar results to this research, noting an increase in eyes-on-road glance behavior for experienced drivers the beginning and six month sessions. Of note is the fact that the eyes-on-road glance behavior analysis in their study is slightly different than the driving-related glances utilized within this study. Eyes-on-road glances are specifically on the forward roadway and were utilized within Olsen, Lee, and Simons-Morton (2007), while driving-related glances included the forward roadway and mirrors, which was utilized in this research.

Despite this difference, both this thesis research and the results of Olsen, Lee, and Simons-Morton in 2007 support the notion that experienced drivers' eyeglance patterns change from their first test track session to their second test track session. This is hypothesized to be due to the novelty of the test track itself, which is a closed roadway and thus not available for the

general public to use. Once a driver has experience with the test track, it is postulated that they resume normal scanning and glance behavior.

Interestingly, performing a cell phone task with a forward vehicle present correlated with a higher percentage of driving-related glances for all drivers, regardless of experience. Perhaps the presence of a more complicated secondary task coupled with the crash risk potential of a forward vehicle leads to drivers attempting to cope by paying more attention to the forward roadway. Yet despite this increase in driving-related glance percentages, drivers were still significantly less consistent in their range from a forward vehicle. This suggests that drivers shift their attention towards the forward roadway more when performing a complex secondary task to compensate for the complexity of the task itself. As a result, driving performance is still significantly degraded and thus, crash risk remains elevated while performing these tasks despite efforts by the driver to compensate for the cognitive requirements of the task.

CONCLUSION

Several inferences are supported by the results of this research. Experienced drivers were found to drive significantly faster overall than teenage drivers. Teenage drivers drove significantly faster with one year of unsupervised driving experience as opposed to within several weeks of licensure. When performing the odometer task, teenage drivers followed significantly further behind lead vehicles than experienced drivers. Experienced drivers were found to have a significantly higher percentage of driving-related glances than teenage drivers across the study as a whole. Participants at the beginning of the study were found to have a significantly lower percentage of driving-related glances than drivers one year into the study.

Speed and range differences between experienced and inexperienced drivers are probably the result of increases in confidence that comes with increased driving experience leading to participants driving in a slightly riskier manner. The comparable lack of driving experience and cognitive maturation seen in adolescent drivers is also likely responsible for decreased ability to switch between secondary tasks and the driving task itself when compared to experienced drivers. This could explain teenagers' lower driving-related eyeglance percentages and larger following distances on the odometer task when compared to experienced drivers. There is also likely some sort of learning effect present in this study with regard to eyeglance percentages differences between sessions which is probably the result of increased cell phone ubiquity during the study's time frame.

This study highlights the relationship between crash risk, driving experience, and cognitive development. This relationship likely accounts for the bulk of the decrease in crash risk that is seen as drivers progress both in terms of age and experience with the driving task itself. A model was developed to represent the changes that occur with regard to crash risk as a driver

develops and gains experience with driving, and is seen in Figure XX. Note that with Novice Teenage Drivers, a lack of cognitive maturity along with little task experience pushes crash risk up. With novice adult drivers, who learned to drive after adolescence, cognitive maturation serves as a protective effect and lowers crash risk, but is counteracted by an overall lack of experience with the driving task itself. For experienced drivers, cognitive maturity along with years of experience with the driving task, results in the lowest crash risk of the three groups.

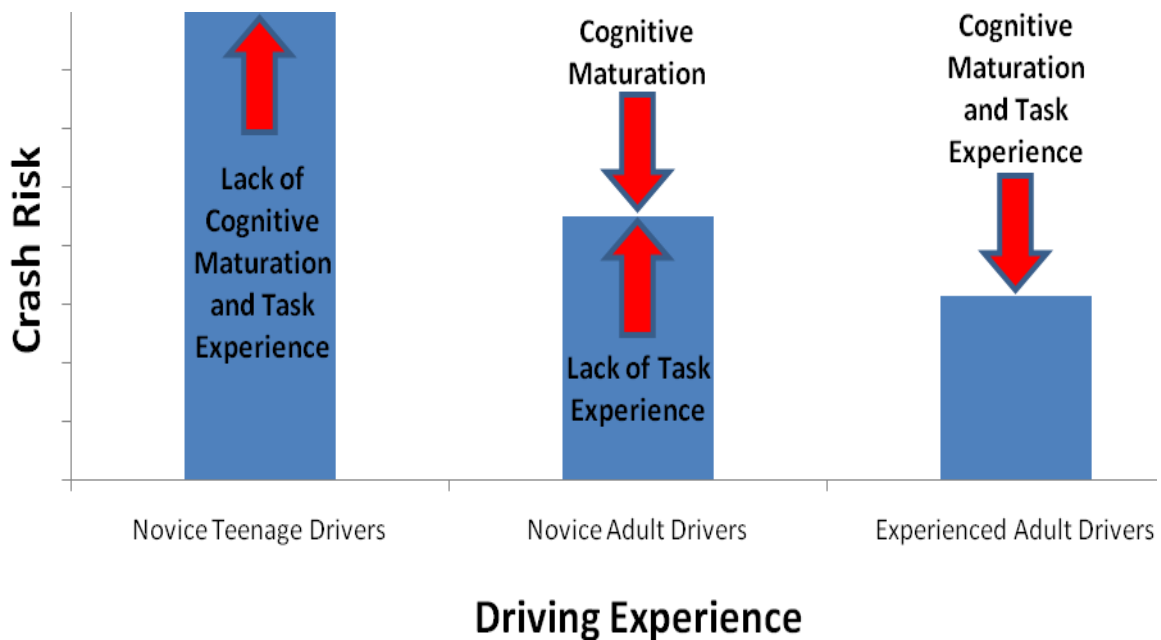


FIGURE 14. THE RELATIONSHIP BETWEEN COGNITIVE MATURATION AND TASK EXPERIENCE ON CRASH RISK.

This study also provides evidence that teenage drivers are less able to switch their attention between the driving task and a secondary task than experienced drivers. This supports the current literature as well as Graduated Driver Licensure (GDL) laws that limit or prohibit cell phone use while driving for teenage drivers within the first years of licensure. This research also provides evidence that suggests teenage drivers to some degree compensate for decreased driving

experience through behavioral safeguards like decreasing speed in the presence of a secondary task.

This research also supports current legislation that limits the use of cell phones while driving due to degradation in following distance consistency. The findings of this study also contradict the notion that drivers can simply pay more attention to the forward roadway while performing these tasks to compensate for increased crash risk. This study suggests that drivers still maintain a less consistent distance from a forward vehicle while performing these tasks. Thus, this research supports overall cell phone legislation to limit both teenage and experienced driver cell phone use while driving.

DRIVER TRAINING/EDUCATION PROGRAMS

This research provides suggestions for improvements for driver's education and training programs. Exposure programs could be developed to target specific, risky behaviors through exposure to and hopefully reduce their occurrence in teenage driving as a whole. Analysis of the stated hypotheses could help guide drivers' education programs in terms of letting teenagers know what specific weaknesses they tend to have upon licensure and after 12 months of experience. Driver training programs could also potentially target certain secondary tasks or specific issues such as lane deviations by allowing teenagers to engage in practice sessions on closed tracks to provide situation-specific experience. A possible implementation for the results of this research in the form of a drivers' education lesson plan framework will also be discussed in detail in a later section of this thesis.

POTENTIAL BENEFITS OF THIS RESEARCH

The goal of this research was to further explore the effect of experience upon driving while performing secondary tasks on a closed-loop test track in southwest Virginia. Participants

in this study were recruited for an 18-month naturalistic teenage driving study funded by the National Institutes of Health that involved the installation of DAS into teenage drivers' vehicles to study their driving behavior.

The 511 cell phone task was chosen over the text messaging or iPod tasks as a certain degree of experience the teenagers have with iPods as well as the text messaging function of cell phones would potentially serve to bias their performance compared to adults. By choosing a neutral task that both participant groups are unlikely to have significant experience with along with the likelihood that few participants had experience with the specific cell phone used in this study served to help counteract the confounding variables of cell phone, text messaging, and iPod experience from this research.

This study furthers research done previously by Olsen, Simons-Morton, and Lee (2006) in several important ways. This study is able to test whether participants' driving ability significantly changed over a 12-month period as opposed to a six-month period. Other secondary tasks such as the 511 cell phone task and a simple odometer task were also analyzed, which allows for a richer understanding of teenage driving ability within the context of several different tasks.

This study also examined the following distance of the participants from a lead vehicle on three of the seven laps on the Smart Road, as well as recording when the participant crosses lane lines. These analyses allowed for objective analysis of participants' ability to manage secondary tasks while driving on the Smart Road by giving concrete, objective measures with which to examine driving behavior. This ultimately facilitates the study in greater depth the effect that these distractions have upon participants' ability to drive.

This research also furthers current teenage driving literature by providing specific data regarding individual secondary tasks and their effect on teenagers' ability to drive safely. Some studies have also taken a naturalistic, real world approach to data collection with non-teenage-specific drivers (Dingus et al., 2006; Stutts et al., 2005). Additional studies have examined the effect of specific secondary tasks upon driving ability on simulators (Fisher et al., 2002; Greenberg et al., 2003; Rakauskas et al., 2004; Slick et al., 2005; Hosking et al., 2006; Strayer, Drews, & Crouch, 2006).

In contrast to simulator studies, this study provides results that are more generalizable to teenage drivers by using an instrumented vehicle with actual teenage drivers performing specific secondary tasks. The parents of these teenagers are also performing the same tasks in the same lap presentation orders as the teenagers, which provides a group of experienced drivers in which to compare performance results. This study also allowed for the controlled testing of several specific scenarios that would have proven difficult in terms of resources needed, however not impossible, to study using a purely naturalistic approach. A naturalistic study of secondary tasks performed by teenage drivers relies upon capturing random situations where the teenagers performed such tasks, which has the disadvantage of unpredictability. Ultimately, the results from this study help provide a clearer insight as to exactly how teenage driving performance is affected while performing each task in each of the Smart Road sessions.

The current research further explores teenage driver speeding and following too closely, while performing secondary tasks. This was accomplished through examination of speed and range data while in the presence of secondary tasks. A basic analysis of distance maintained from the forward vehicle on following laps was performed to highlight any differences in following distance between inexperienced and experienced drivers. As following distance is directly related

to the amount of time a teenager has to react to sudden situations that may occur on the roadway, such as a forward vehicle braking hard, this is certainly an important factor to explore. Studies such as NHTSA (2006) estimate that 28% of fatal crashes are the result of running off the side of the roadway. This statistic is being further explored within the teenage segment of the driving population by examining the effect that secondary tasks has upon lane position and lane deviations, further extending teenage driver literature.

Data specific to drivers with one year of driving experience (within this study, 17 year old novice drivers with one year of driving experience post-licensure date at age 16) is scarce. This is an age group affected by most GDL legislation within the United States and warrants examination within research literature to tailor such programs to this age group. Data from this research provides an indication of what performance differences they have compared to newly licensed and experienced drivers. From the results of this data, GDL legislation can be guided to more effectively target this age group, ensuring GDL is effective throughout all of its stages, not simply for 16-year-olds. Through a more thorough understanding of crash risk factors, researchers can better understand teenage driving risks and concentrate more effectively on particularly risky behaviors.

GRADUATED DRIVER LICENSURE PROGRAMS

The information from this research provides insight towards specific secondary tasks that can potentially be restricted within GDL programs to increase the safety of teenage drivers. For example, cell phones could potentially be targeted by GDL programs because of their deleterious effect upon teenagers' ability to maintain stable lane positioning. Results from this study can also be compared to current GDL laws and modifications can be suggested based on any specific weaknesses in teenage driver performance that are discovered.

This study will also help to establish the effect, if any, that one year of driving experience has upon teenage driving performance with secondary tasks by providing data for comparison from both points in time for teenage drivers within this study. This research highlights the performance differences seen between drivers with one year of experience versus newly licensed and experienced drivers while engaged in a cell phone or odometer task. This could help to make GDL laws more appropriate for teenage drivers by suggesting approximate points in time where specific aspects of their driving performance, such as ability to maintain lane position, improve or degrade. For example, based on those performance differences, restrictions for cell phone use while driving could be tightened or lifted for various age groups. Thus, GDL legislation could be further tailored to drivers with one year of driving experience by providing a basis for comparison between various levels of experience and driving performance differences.

SYNTHESIS OF RESULTS

These results suggest that years of driving experience imparts skill and confidence which leads to traveling at higher rates of speed. While an interesting finding, it remains a difficult to utilize in GDL interventions and driver education programs, as it suggests that teenage drivers already attempt to drive more safely than experienced drivers to compensate for a lack of experience. A lack of significant results with regard to both lane deviations and headway variance ultimately renders that data similarly difficult to utilize in teenage crash risk interventions.

With regard to overall mean headway from forward vehicles, teenagers were found to drive significantly further away from a forward vehicle than experienced drivers while performing the simple odometer task. With the more complex cell phone task, no average headway difference was found between experienced and teenage drivers. These findings could

potentially support the notion that teenagers are more able to cope with their lack of experience and driving prowess when performing simple secondary tasks as opposed to complex secondary tasks. This result supports current GDL restrictions on teenage driver cell phone use, which could potentially lead to teenagers following more closely to forward vehicles, ultimately increasing crash risk.

Driving-related eyeglance percentages were found to be significantly higher in experienced drivers as opposed to teenage drivers. This could potentially be an issue that ultimately adds to the increased crash risk of teenage drivers, and as such, is an area that could be targeted by driver education programs. Teenage drivers in drivers' education programs should be notified that they look at the forward roadway while performing secondary tasks significantly less than experienced drivers. This knowledge will perhaps aid GDL legislative efforts and help to dissuade teenage drivers from performing complex secondary tasks while driving.

This research presents significant evidence that complex secondary tasks such as cell phone tasks significantly increase the cognitive workload of drivers and degrade driving performance. Individuals performing a cell phone task have significantly more variance in the range they maintain from a forward vehicle, in spite of apparent attempts to negate this risk by lowering overall speed and looking at the forward roadway more frequently. In terms of the policy implications, this research provides evidence in favor of legislation limiting various complex secondary tasks while driving, such as cell phone use, text messaging, and other tasks for the driving population as a whole.

With regard to teenage drivers, this research suggests that they attempt to compensate for lack of driving experience through countermeasures such as traveling further away from a forward vehicle while performing a simple secondary task and maintaining a lower overall speed

regardless of the secondary task being performed. Despite these attempts to compensate, teenage drivers have a lower percentage of driving-related glances than experienced drivers do and have a similar following distance while performing a complex secondary task. Thus, this research supports GDL legislative efforts to specifically restrict complex secondary tasks, specifically cell phone use, within this segment of the driving population.

Furthermore, drivers' education programs should disseminate information about both the dangers of cell phone use while driving as well as the failure of drivers' efforts to reduce the risk they face when performing these tasks while driving. Examples of drivers' compensatory efforts could include behaviors such as traveling more slowly or looking at the roadway more frequently. Emphasizing the danger of these tasks as well as the fact that countermeasures implemented by drivers to mitigate the risks of complex secondary tasks are ineffective can then be coupled with legislative efforts to provide both a reason and an incentive for teenage drivers to comply. Ultimately, this will likely reduce the crash risk of these individuals as well as the driving population as a whole.

ADDIE DESIGN MODEL

To aid in the dissemination of the information within this research, the ADDIE design model was utilized to develop a lesson plan framework for a Driver Education-based secondary task intervention. The acronym "ADDIE" stands for: Analysis, Design, Development, Implementation, and Evaluation, which are all phases of the training design process within this model (Strickland, 2006). This model helped to tailor the framework to the teenage driving population and their needs, based upon the constraints of a classroom environment. It aided in developing the organization of the framework as well as a method of obtaining feedback from

students in order to evaluate the effectiveness of the program. The results of this development are seen in the following section.

ADDIE DESIGN MODEL DEVELOPMENT

STEP 1: ANALYSIS

- Who is the audience and what are their characteristics?
 - Audience: Teenagers in the Learner Permit Phase of GDL of approximately 15 years of age enrolled in high school and a driver's education program.
 - Characteristics: Excellent ability to learn, react to sensory input, and develop reflexes for the driving task. This is contrasted by both general inexperience with regard to the driving task and general lack of independent driving.
- What do they need to learn?
 - The dangers of distracted driving, their overall driving performance relative to the rest of the driving population, and their driving performance while performing secondary tasks.
- What are the delivery options?
 - Powerpoint presentation from Teacher
 - Including a video for the in-class distraction demonstration
 - Projector
 - Worksheets
 - Quizzes/Tests
 - Speakers
- What types of learning constraints exist?

- Computer resources – cost of upgrading systems if they are unable to run Microsoft Powerpoint, potential cost of installing Powerpoint if this does not already exist on school computers
- Student Age
- Student Driving Inexperience
- What is the timeline for project completion?
 - 1-2 days of classroom instruction

STEP 2: DESIGN

- Objectives:
 - Teach students about various common driving distractions and specifically how they relate to crash risk.
 - Contrast the driving performance of experienced and inexperienced drivers.
 - Provide a “real-world” demonstration of the divergence between perception of driving performance degradation and actual driving performance degradation.
- Learning Activities:
 - Worksheets/ FARS database activity
 - In-class discussion of distraction risks with student anecdotes
 - Distraction Log
 - In-Class Distraction Activity
- How should content be organized and presented?
 - A Powerpoint presentation will be developed that utilizes information such as statistics and video to relate the dangers of various distractions to students.

- Worksheets will be designed that accurately test the retention of information presented to students.
- A standardized format will be developed for students' secondary task logs that facilitates accurate data.
- Student Progress Evaluation:
 - Worksheets
 - Questions to the class

STEP 3: DEVELOPMENT

- Production of a prototype lesson plan that delivers the information required using the various resources and media available (seen in Appendix M).

STEP 4: IMPLEMENTATION

- Standardized Powerpoint presentation, worksheets, distraction logs, and the lesson plan can be delivered to all Driver's Education teachers as part of the curriculum on a USB drive or in CD format.

STEP 5: EVALUATION

- An evaluation package will be sent along with the lesson materials to gather feedback regarding the course after it has been implemented.
 - Student opinions:
 - Is the lesson effective?
 - Is the lesson interesting?
 - Teacher opinions:
 - What were the strengths and weaknesses of the lesson plan?
 - Did the lesson plan keep students' attention?

- Objective feedback:
 - Student grades on the worksheets and distraction logs
- The feedback will then be examined and the lesson plan can be adapted or tailored to more effectively meet students' needs, if necessary.

The resulting framework provides a methodology for producing driver's education lesson plans that disseminate general driving risk information along with specific statistics regarding secondary task crash risk and comparing parents and teens. Statistics were provided to give students empirical evidence to support the lesson itself in terms of how risky teenagers are when compared to their parents and how dangerous secondary tasks can be. Sample in-class activities are provided that demonstrate basic secondary task impairment along with providing information regarding the prevalence of secondary tasks within students' own driving. Additionally, students are allowed time to discuss their own experiences in order to tie them into real world scenarios. The resulting framework is seen below.

DRIVER'S EDUCATION LESSON PLAN FRAMEWORK

Date: 12/2/2009

Grade: 10

Teacher Name: E. Henry Howard

Subject: Driver's Education

1. Topic-

Distracted Driving

2. Content-

Driving statistics, videos, a quiz, and a demonstration of distracted driving.

3. Goals: Aims/Outcomes-

Students will:

1. Be familiar with various common driving distractions.
2. Understand the increased crash risk involved with various distractions.
3. Learn about their driving performance with distractions relative to experienced drivers' performance with distractions.

4. Objectives-

After completing this section, students will note the most frequent driving distractions. They will also note the increase in crash risk seen when performing various secondary tasks while driving. Finally, they will be asked to contrast the driving performance of experienced drivers and teenage drivers when distracted.

5. Materials and Aids-

Projector, computer, worksheets, cellular phone

6. Procedures/Methods-

A. Introduction-

1. Various general crash pictures and video will be demonstrated.
2. The odds of being involved in a crash while distracted will be discussed relative to the students (i.e. "One in four of you will be involved in a distracted driving crash by age 18")

B. Development-

1. Various statistics will be discussed, including the results of my own research and the frequency of distractions in crashes.
2. Events that have happened within the surrounding area can be discussed if related to distracted driving.
3. Students will be provided a brief period to discuss any stories or experience they might have with distracted driving.

C. Practice-

The instructor will ask students to bring their cell phones to class for this day or alternatively, provide a cell phone. A video will be shown of a driving scenario involving several hidden hazards, such as a pedestrian getting ready to enter into a crosswalk in front of the student. While this video is being shown, a student will be asked to perform a pre-determined cell phone task such as dialing 511 or text messaging. The student will then be asked to recall specific events of the video such as whether a vehicle was present behind the subject vehicle, if a pedestrian was present at a crosswalk, etc. This will be repeated for several students. Alternatively, this could be performed on either a closed test track facility or a simple computer simulator based off of a desktop PC with a steering wheel/pedal attachment and the actual performance of the student could be monitored.

D. Independent Practice-

1. The students shall keep a log for three days where they note the different secondary tasks they perform while driving. Highlights of these logs will be announced anonymously to the class.
2. Students will query the FARS database and fill out a worksheet with various information and facts available from it, such as How many teenage crashes occurred in 2007 as a result of Operating the Vehicle in a Careless or Inattentive manner?

E. Checking for understanding-

1. Questions will be asked out loud at the end of the presentation for all students to answer to review the basic information provided about distracted driving.
2. For the distraction log, sample entries will be provided for demonstration. After the first day, the logs will be briefly reviewed by instructors to make sure they're being completed correctly.

F. Closure-

1. Students will turn in their logs and worksheets.
2. Students will then be able to discuss their experiences within the class activities and provide feedback.

7. Evaluation-

1. Students will be quizzed on various statistics presented in class and in the worksheet.

2. The log and worksheet will be graded. The log will be based upon completion as long as a perceived legitimate effort has been made to accurately finish it. The worksheet will be graded on a pass/fail basis.

8. Teacher Reflection-

IMPLICATIONS FOR FUTURE RESEARCH

Ultimately, future research should capitalize on the findings of this study to further isolate factors relevant to teenage crash risk. Several of the results of this research support the notion that the underlying effects of driving experience upon driving behavior are relatively complex and ambiguous, hampering attempts to curtail teenage fatal and non-fatal crashes. Specifically, there seems to be an inverse relationship between average speed while performing a secondary task and driving experience. Experienced drivers drove faster than teenage drivers overall and teenage drivers at the 12 month session drove significantly faster than teenage drivers at the 0 month session.

Researchers should specifically delve further into eyeglance and headway measures to further understand differences between teenage drivers and more experienced drivers. Eyeglance data should be collected from alternative scenarios, such as driving in the presence of teenage passengers, under inadequate sleep conditions, in early morning, and at nighttime. This data could be examined to further understand the relationship between driving experience and eyeglance patterns and potentially support driver education intervention efforts which could inform teenage drivers of the effects of said situations upon their driving.

Additional study into the nature of lane deviations and the underlying effects that cause them would also be helpful in further understanding teenage crash risk. A run-off-road crash is defined as a single-vehicle crash characterized by the vehicle deviating from its lane and exiting the roadway into an object, animal, pedestrian, or other vehicle. Run-off-road crashes represent a sizable portion of teenage crash risk and the underlying causes of lane deviations needs to be examined to attempt to reduce the risk associated with them. This study had relatively few lane deviations which significantly limits any conclusions that could be made based upon this data.

Long term naturalistic data collection involving instrumenting participant vehicles could perhaps provide a higher volume of lane deviation events to analyze which could provide significant results to guide GDL legislation.

Study into the efficacy of the proposed driver's education lesson plan framework is necessary to determine whether additional tailoring and development is needed for that type of intervention. Study into the effect this framework has upon crash risk is needed to establish whether or not widespread implementation should be considered. If proven ineffective, perhaps a different approach than education and warning about secondary task risk, such as systems that disable cell phones while a vehicle is moving, are necessary to reduce crash risk within this segment of the driving population.

Consideration of the findings of this research could potentially contribute significantly to the reduction of teenage crash risk. Through additional study into various aspects of this segment of the driving population, the danger associated with learning to drive could be reduced through targeted risk management efforts. Ultimately, through a more thorough understanding of the strengths and weakness of teenage drivers, researchers could potentially increase the safety of the driving population as a whole.

LIMITATIONS

This research has several limitations which hamper the generalizability of the findings presented. As a controlled experiment where the participants knew they were being tested, behavior modification representative of the Hawthorne effect could have impacted the results in such a manner as to be extremely difficult to separate from genuine driving behavior. This effect likely influenced all sources of data and likely resulted in participants driving more conservatively under all experimental situations. Participants were also driving a vehicle that was likely different than their normal vehicle and on a roadway with which they had no prior experience, which could also have altered their behavior while performing the sessions. Individual participant experience with cell phones, specifically the 511 service, and cell phone use while driving could have significantly impacted driving performance.

Another major factor to consider is the selection of the participants themselves. Teenagers were recruited from the southwestern Virginia area, which represented a relatively rural environment. Thus, these results may not be particularly useful in examining teenage drivers in a more urban environment. The selection of experienced drivers was also potentially problematic, as they were all parents of one of the teen participants. This could have led to similar driving behaviors between the two groups as the parents were likely at least partially responsible for teaching the teenagers to drive. These issues could have significantly impacted the findings of this research and limit the generalizability of the findings presented here.

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APPENDIX A: IRB APPROVAL LETTER




Institutional Review Board

Dr. David M. Moore
IRB (Human Subjects) Chair
Assistant Vice President for Research Compliance
1880 Pratt Drive, Suite 2006(0497), Blacksburg, VA 24061
Office: 540/231-4991; FAX: 540/231-0939
email: moored@vt.edu

DATE: February 2, 2006

MEMORANDUM

TO: Thomas A. Dingus VTTI - Administrative
Sheila Klauer VTTI-Crash Causation, Human Factors
David Ramsey

FROM: David Moore 

SUBJECT: **IRB Full Review Approval:** "Preventing Motor Vehicle Crashes Among Young Drivers: Research on Driving Risk Among Novice Teen Drivers" IRB # 05-799

The above referenced protocol was submitted to the Virginia Tech IRB for full review and approval at its January 9, 2006 meeting. The IRB, at that meeting, voted approval for this protocol for a period of (12) months, effective as of January 9, 2006.

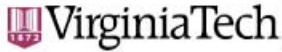
Approval of your research by the IRB provides the appropriate review as required by federal and state laws regarding human subject research. It is your responsibility to report to the IRB any adverse reactions that can be attributed to this study.

To continue the project past the 12-month approval period, a continuing review application must be submitted (30) days prior to the anniversary of the original approval date and a summary of the project to date must be provided. Our office will send you a reminder of this (60) days prior to the anniversary date.

Virginia Tech has an approved Federal Wide Assurance (FWA00000572, exp. 7/20/07) on file with OHRP, and its IRB Registration Number is IRB00000667.

cc: File
Department Reviewer: Suzanne E. Lee
OSP 0170

APPENDIX B1: IRB CONTINUING REVIEW LETTER – 2007




Office of Research Compliance
Institutional Review Board
1880 Pratt Drive (0497)
Blacksburg, Virginia 24061
540/231-4991 Fax: 540/231-0959
E-mail: moored@vt.edu
www.irb.vt.edu
FWA00000572, expires 7/20/07
IRB # is IRB00000667.

DATE: January 10, 2007

MEMORANDUM

TO: Thomas A. Dingus
Sheila Klauer
David Ramsey

FROM: David M. Moore 

Approval date: 1/9/2007
Continuing Review Due Date: 11/26/2007
Expiration Date: 1/8/2008

SUBJECT: **IRB Full Review Continuation 1:** "Preventing Motor Vehicle Crashes Among Young Drivers: Research on Driving Risk Among Novice Teen Drivers", OSP #431462, IRB # 05-799

This memo is regarding the above referenced protocol which was previously granted approval by the IRB. The proposed research, having been previously approved at a convened IRB meeting, required full IRB review prior to granting an extension of approval, according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. The above referenced protocol was submitted for full review continuation and approval by the IRB at its most recent meeting. Pursuant to your request, I, as Chair of the Virginia Tech Institutional Review Board, have, at the direction of the IRB, granted approval for this study for a period of 12 months, effective January 9, 2007.

Approval of your research by the IRB provides the appropriate review as required by federal and state laws regarding human subject research. As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtain re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

cc: File
Department Reviewer: Suzanne E. Lee
OSP

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APPENDIX B2: IRB CONTINUING REVIEW LETTER – 2008



VirginiaTech

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Institutional Review Board
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FWA0000572, expires 1/20/2010
IRB # H IRB0000567

DATE: December 11, 2007

MEMORANDUM

TO: Thomas A. Dingus
Charlie Klauer
David Ramsey

Approval date: 1/9/2008
Continuing Review Due Date: 12/25/2008
Expiration Date: 1/8/2009

FROM: David M. Moore 

SUBJECT: IRB Expedited Continuation 2 of previous Full Review: "Preventing Motor Vehicle Crashes Among Young Drivers: Research on Driving Risk Among Novice Teen Drivers", OSP #431462, IRB # 05-799

This memo is regarding the above referenced protocol which was previously granted Full IRB approval. The proposed research is now eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. Pursuant to your request of last week, as Chair of the Virginia Tech Institutional Review Board, I have granted approval for extension of the study for a period of 12 months, effective as of January 9, 2008.

Approval of your research by the IRB provides the appropriate review as required by federal and state laws regarding human subject research. As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtain re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

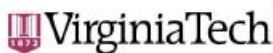
As indicated on the IRB application, this study is receiving federal funds. The approved IRB application has been compared to the OSP proposal listed above and found to be consistent. Funds involving procedures relating to human subjects may be released. Visit our website at www.irb.vt.edu for further information

cc: File
Department Reviewer: Suzanne E. Lee
OSP

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APPENDIX B3: IRB CONTINUING REVIEW LETTER – 2009



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FWA000005721 expires 1/20/2010
IRB # is IRB00000567

DATE: December 16, 2008

MEMORANDUM

TO: Thomas A. Dingus
Charlie Klauer
David Ramsey

Approval date: 1/9/2009
Continuing Review Due Date: 12/25/2009
Expiration Date: 1/8/2010

FROM: David M. Moore 

SUBJECT: IRB Expedited Continuation 3 of previous Full Review: "Preventing Motor Vehicle Crashes Among Young Drivers: Research on Driving Risk Among Novice Teen Drivers", OSP #431462, IRB # 05-799

This memo is regarding the above referenced protocol which was previously granted Full IRB approval. The proposed continuing review request is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval for extension of the study for a period of 12 months, effective as of January 9, 2009.

Approval of your research by the IRB provides the appropriate review as required by federal and state laws regarding human subject research. As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtain re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

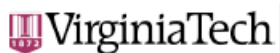
As indicated on the IRB application, this study is receiving federal funds. The approved IRB application has been compared to the OSP proposal listed above and found to be consistent. Funds involving procedures relating to human subjects may be released. Visit our website at www.irb.vt.edu for further information

cc: File
Department Reviewer: Suzanne E. Lee
OSP

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APPENDIX B4: IRB CONTINUING REVIEW LETTER – 2010



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e-mail moored@vt.edu
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FWA00000572 (expires 1/20/2010)
IRB # is IRB00000667

DATE: December 9, 2009

MEMORANDUM

TO: Thomas A. Dingus
Charlie Klauer
David Ramsey

Approval date: 1/9/2010
Continuing Review Due Date: 12/25/2010
Expiration Date: 1/8/2011

FROM: David M. Moore 

SUBJECT: **IRB Expedited Continuation 4 of previous Full Review:** "Preventing Motor Vehicle Crashes Among Young Drivers: Research on Driving Risk Among Novice Teen Drivers", OSP #431462, IRB # 05-799

This memo is regarding the above referenced protocol which was previously granted Full IRB approval. The proposed continuing review request is eligible for expedited review according to the specifications authorized by 45 CFR 46.110 and 21 CFR 56.110. As Chair of the Virginia Tech Institutional Review Board, I have granted approval for extension of the study for a period of 12 months, effective as of January 9, 2010.

Approval of your research by the IRB provides the appropriate review as required by federal and state laws regarding human subject research. As an investigator of human subjects, your responsibilities include the following:

1. Report promptly proposed changes in previously approved human subject research activities to the IRB, including changes to your study forms, procedures and investigators, regardless of how minor. The proposed changes must not be initiated without IRB review and approval, except where necessary to eliminate apparent immediate hazards to the subjects.
2. Report promptly to the IRB any injuries or other unanticipated or adverse events involving risks or harms to human research subjects or others.
3. Report promptly to the IRB of the study's closing (i.e., data collecting and data analysis complete at Virginia Tech). If the study is to continue past the expiration date (listed above), investigators must submit a request for continuing review prior to the continuing review due date (listed above). It is the researcher's responsibility to obtain re-approval from the IRB before the study's expiration date.
4. If re-approval is not obtained (unless the study has been reported to the IRB as closed) prior to the expiration date, all activities involving human subjects and data analysis must cease immediately, except where necessary to eliminate apparent immediate hazards to the subjects.

As indicated on the IRB application, this study is receiving federal funds. The approved IRB application has been compared to the OSP proposal listed above and found to be consistent. Funds involving procedures relating to human subjects may be released. Visit our website at www.irb.vt.edu for further information

cc: File
Department Reviewer: Suzanne E. Lee
OSP

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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 3 months (between March and July) 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@vti.vt.edu

APPENDIX D1: TELEPHONE DRIVER SCREENING AND DEMOGRAPHIC QUESTIONNAIRE FOR YOUTH

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 involves a series of driving tests conducted in a special vehicle on a test-track. Experiment 2 involves the collection of data while you drive your own vehicle over an 18 month period. Also, you will be asked you to come in for Cortisol testing, which requires saliva samples and a math test.

All data will be strictly confidential, available only to the research team.

Verbal Consent, Assent, and Permission:

Does this sound interesting to you? If yes, Let me to ask you some 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. Do I have your verbal permission to ask you these questions ?

Signed:

Interviewer

Witness

Youth Participant Information

What is your name?: _____

Are you : MALE or FEMALE

1. What is your age in years and months?

Years _____ Months _____ Date of Birth _____

What is the last grade in school that you completed?

- ___ 9th
- ___ 10th
- ___ 11th
- ___ 12th

2. Do you have any health conditions or physical disabilities that affect your ability drive? Examples of these include night blindness, sleep disorders, and hearing impairment.

No _____

Yes _____ If yes, please describe _____

Females only: Are you pregnant?

_____ No
_____ Yes [If yes, mention need for doctor's permission (provide form)]

Are you currently taking any prescription medications on a regular basis?

_____ No
_____ Yes Please provide the names of each medicine and describe why you take it.

3. Do you ordinarily wear prescription glasses while you drive? Yes _____ No _____

4. Would you be willing and able to drive the instrumented vehicle without wearing sunglasses during the 18 months of the study?

Yes _____
No _____

5. Do you have a valid driver's license allowing you to drive a passenger vehicle without supervision? This does not include a motorcycle license.

Yes _____
Date of receipt _____ Month _____ Year _____
License number _____

No _____
When do you expect to receive it? Month _____ Year _____

6. How many miles have you driven without supervision since receiving your license?

Miles _____

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

Mileage _____

Is this vehicle driven by you alone or shared with others? _____

Are you included on the liability insurance for the car you would drive in this study?

Yes _____ [Mention that we will require policy number at baseline assessment]
No _____

8. How many days per week do you expect to drive each week over the next month?

__ 0 __ 1 __ 2 __ 3 __ 4 __ 5 __ 6 __ 7 __

Eligibility Determination

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

Eligibility requirements

1. Must hold a valid driver's license allowing independent, unsupervised driving.
2. May not have held a (provisional) driver license for more than three weeks.
3. Must be between 16.25 and 17 years old.
4. Must **not** have completed the 12th grade.

5. Must be eligible for employment in the U.S.
6. Must drive at least 2 days a week
7. Must not have more than 100 miles driving experience.
8. Must have normal (or corrected to normal) hearing and vision.
9. Cannot have lingering effects of any conditions which could affect driving, including night blindness, sleep disorders, and hearing impairment.
10. Cannot currently be taking any substances that may interfere with driving ability (cause drowsiness or impair motor abilities).
11. Both the teen and a parent must be willing to participate in both parts of the study.

If eligible: Thank you for answering these questions. We would like to obtain your contact information so that we can have you come in for an orientation session (*for those not yet licensed, add:* near the time when you receive your license).

What is your mailing address?

What is your email address?: _____

What are your phone numbers?

Home : _____ Phone: _____ Phone _____ BTTC _____

Which is the best number to use to contact you? _____

The next step is to schedule an orientation meeting. In general, what days and times work best for you?

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

Schedule date if already licensed. Date: _____

Someone will call you to remind you. At that time you will need to provide evidence of liability insurance, your driver's license (*or learner's permit for those not licensed*) and provide more detailed health information.

[Write down the time and date and provide directions and any information they need to bring.]

If licensure is not to occur for a few weeks:

We will contact you to set up an orientation meeting when your licensing date gets closer.

APPENDIX D2: TELEPHONE DRIVER SCREENING AND DEMOGRAPHIC QUESTIONNAIRE FOR PARENT

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 involves a series of driving tests conducted in a special vehicle on a test-track. Experiment 2 involves the collection of data while you drive your own vehicle over an 18 month period. Also, your child will be asked to come in for Cortisol testing, which requires saliva samples and a math test.

All data will be strictly confidential, available only to the research team.

Verbal Consent, Assent, and Permission:

Does this sound interesting to you? If yes,
Let me to ask you some 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. Do I have your verbal permission to ask you these questions? Y / N
Do I have your verbal permission to ask your child these questions? Y / N

Signed: _____ _____
 Interviewer Witness

Parent Participant Information

What is your name?: _____
Are you : MALE or FEMALE

1. What is your age in years and months?

Years _____ Months _____ Date of Birth _____

2. Do you have any health conditions or physical disabilities that affect your ability drive?
Examples of these include night blindness, sleep disorders, and hearing impairment.

No _____
Yes _____ If yes, please describe _____

Females only: Are you pregnant?
_____ No
_____ Yes [If yes, mention need for doctor’s permission (provide form)]

Are you currently taking any prescription medications on a regular basis?

_____ No

_____ Yes Please provide the names of each medicine and describe why you take it.

Has your child been diagnosed with ADHD or attention disorder? Yes _____ No _____

3. Do you ordinarily wear prescription glasses while you drive? Yes _____ No _____

4. Would you be willing and able to drive the instrumented vehicle without wearing sunglasses during the 18 months of the study?

Yes _____

No _____

5. Do you have a valid driver's license allowing you to drive a passenger vehicle? This does not include a motorcycle license.

Yes _____

Date of receipt _____ Month _____ Year _____

License number _____

No _____

(then not eligible)

6. What is the make, model, and year of the car you currently drive? _____

Mileage _____

Is this vehicle driven by you alone or shared with others? _____

Teen's Vehicle: _____ Mileage _____

Do you currently have at least liability insurance for the car you would drive in this study?

Yes _____ [Mention that we will require policy number at baseline assessment]

No _____

7. How many days per week do you expect to drive each week over the next month?

__ 0 __ 1 __ 2 __ 3 __ 4 __ 5 __ 6 __ 7 __

Eligibility Determination

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

Eligibility requirements for Parents

1. Must hold a valid driver's license allowing independent, unsupervised driving.
2. Must be between 30-50 years old .
3. Must be eligible for employment in the U.S.

4. Must drive at least 2 days a week
5. Must have normal (or corrected to normal) hearing and vision.
6. Cannot have lingering effects of any conditions which could affect driving, including night blindness, sleep disorders, and hearing impairment.
7. Child cannot have been diagnosed with ADHD.
8. Cannot currently be taking any substances that may interfere with driving ability (cause drowsiness or impair motor abilities).
9. Both the teen and a parent must be willing to participate in both parts of the study.

If eligible: Thank you for answering these questions. We would like to obtain your contact information so that we can have you come in for an orientation session (*for those with children not yet licensed, add:* near the time when your child receives their license).

What is your mailing address?

What is your email address?: _____

What are your phone numbers?

Home : _____ Phone: _____ Phone _____ BTTC _____

Which is the best number to use to contact you? _____

The next step is to schedule an orientation meeting. In general, what days and times work best for you?

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

Schedule date if already licensed. Date: _____

Someone will call you to remind you. At that time you will need to provide evidence of liability insurance, your driver's license (*or learner's permit for those not licensed*) and provide more detailed health information.

[Write down the time and date and provide directions and any information they need to bring.]

If licensure is not to occur for a few weeks:

We will contact you to set up an orientation meeting when your licensing date gets closer.

APPENDIX E1: EXPERIMENT 1 INFORMED CONSENT FORM FOR ADULT PARTICIPATION

Informed consent Form

(For adult/parent participants greater than 18 years of age only)

PREVENTING MOTOR VEHICLE CRASHES AMONG YOUNG DRIVERS: RESEARCH ON DRIVING RISK AMONG NOVICE TEEN DRIVERS: EXPERIMENT 1, TEST TRACK (SMART ROAD) STUDY

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

I. THE PURPOSE OF THIS RESEARCH

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

II. Procedures

You will first be asked to answer a series of questionnaires relating to psycho-social, behavioral, and demographic measures and to complete a series of vision tests. You will then be asked to drive a research vehicle on a test-track. The Smart Road is a controlled, two lane road that is 2.2 miles long. The research vehicle is equipped to assess the behavior of the vehicle and the driver with sensors and tiny video cameras located in the vehicle. The equipment will not interfere with the operation of the vehicle or your driving.

An experimenter will accompany you in the vehicle to provide instructions. In addition to routine driving procedures, such as stopping, changing lanes, and maintaining speed, you will be asked to perform selected other tasks, such as inserting a CD into an entertainment console, having a conversation, and answering a cell phone call. Before testing, the tasks will be described to you and you will be able to practice them.

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. Complete a series of tasks while driving on the Smart Road. This should take no more than 3 hours to complete, including the following activities:
 - a. Complete a questionnaire about your health and driving experience.
 - b. Get oriented to the vehicle, test track, and tasks.

- c. Drive the test vehicle on the test track, following the instructions of the experimenter who will be riding with you.
- d. After the driving session, complete a brief questionnaire
- e. Provide ratings when asked.

III. Risks and Discomforts

Participating in this study may have the following risks:

1. You could be involved in an accident.
2. You may be asked to quickly brake, bringing the vehicle to a complete stop.
3. You could experience fatigue.
4. You cannot wear sunglasses while being tested.
5. If you have had previous eye injuries and/or surgeries, you are at an increased risk of further eye injury by participating in this study where risks, although minimal, include the possibility of collision and airbag deployment.
6. In case of an incident, according to the Blacksburg Rescue Squad, it is estimated that response time to the Smart Road would be approximately 5 minutes

The following precautions are in place to ensure that risks are minimized:

1. The Smart Road is designed for safety, with restricted access, nothing for a vehicle to hit, carefully placed guardrails, and many other safety features.
2. Only authorized professionals will be present on the road and in the vehicle with you.
3. The research vehicle is equipped with airbags, anti-lock brakes, and other safety equipment.
4. The special equipment in the research vehicle is out of the way. It will not obstruct your view or bother your driving.
5. A trained experimenter will be in the passenger seat next to you and can stop the vehicle using a separate brake pedal.
6. The experimenter and control tower staff will be in radio contact at all times.
7. You will be required to use the seat belt and shoulder strap and follow safe driving procedures.
8. You will not be asked to do anything that is known to be dangerous
9. You may ask for a break if you become fatigued.

IV. Benefits of Participation

The potential benefit of participating in this research is that you may enjoy participating in the driving tests. No promise or guarantee of benefits is being made to encourage participation. Participation may have an impact on teen driving safety and future methods for driver education.

V. Confidentiality

The information gathered in this experiment will be securely stored and treated confidentiality to the extent allowed by law.

1. The information will be used for research purposes only.
2. The information will be seen only by the researchers.
 - a. The information will not be shared with anyone else.
3. The information will be pooled with that of the other study participants.
4. Your name and other identifiers will be removed from the data forms.
5. You will not be identified personally in reports or for any reason.
6. The video images of your face were collected to determine your eye movement while driving, will be securely stored, held in confidence, and not used for any other purpose without your express written consent.
7. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States Government that is used for auditing or evaluation of Federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Food and Drug Administration (FDA).

You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information.

The Certificate of Confidentiality does not prevent the researchers from disclosing voluntarily matters such as child abuse, or subject's threatened violence to self or others.

VI. Compensation

You will receive \$20 for each hour you participate in this experiment. Compensation will be provided only for time spent in the vehicle or in direct participation in this experiment. Each driving session will take no more than 1.5 hours to complete, and paperwork and screening should take no more than one hour (with a limit of \$30 for time spent completing paperwork; if you require reading assistance, please inform the experimenter and they will assist by reading the forms and questionnaires to you).

VII. Medical Treatment and Insurance

In the event of an accident or injury in an automobile, the automobile liability coverage for property damage and personal injury is provided. The total policy amount per occurrence is \$2,000,000. This coverage (unless the other party was at fault, which would mean all expense would go to the insurer of the other party's vehicle) would apply in case of an accident for all volunteers and would cover medical expenses up to the policy limit.

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, if not in an automobile, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

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 1, you will then lose your eligibility to participate in Experiment 2, the Naturalistic On-road Driving Experiment.

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 this approval has been obtained.

X. Participant's Responsibilities

If you voluntarily agree to participate in this study, you will have the following responsibilities while driving the research vehicles:

1. Complete the necessary pre and post study questionnaires.
2. Be free of alcohol and other drugs that may impair your driving ability.
3. Conform to the laws and regulations of driving on public roadways.
4. Follow the safety instructions of the experimenter.
5. Inform an experimenter if you have questions or encounter difficulties.
6. If you are pregnant, you have reviewed this consent form with your obstetrician and discussed the risks of participating in this study with him/her. You are willing to accept all possible risks of participation.

Check one of the following:

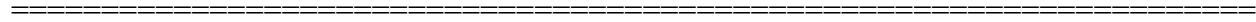
- | |
|--|
| <p><input type="checkbox"/> I have not had an eye injury/eye surgery (including, but not limited to, LASIK, Radial Keratotomy, and cataract surgery.)</p> <p><input type="checkbox"/> I have had an eye injury/eye surgery and I've have been informed of the possible risks to participants who have had eye surgery. I choose to accept this possible risk to participate in this study.</p> |
|--|

XI. CONSENT

I _____ (participant) 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



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 E2: EXPERIMENT 1 INFORMED ASSENT FORM FOR TEEN PARTICIPATION

Participant assent Form

(For participants younger than 18 years of age only)

PREVENTING MOTOR VEHICLE CRASHES AMONG YOUNG DRIVERS: RESEARCH ON DRIVING RISK AMONG NOVICE TEEN DRIVERS: EXPERIMENT 1, TEST TRACK (SMART ROAD) STUDY

Investigators: Tom Dingus, Sheila Klauer, David Ramsey, Suzie Lee: Virginia Tech Transportation Institute
Bruce Simons-Morton, Marie Claude Ouimet, 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 will first be asked to answer a series of questionnaires relating to psycho-social, behavioral, and demographic measures and to complete a series of vision tests. You will then be asked to drive a research vehicle on a test-track. The Smart Road is a controlled, two lane road that is 2.2 miles long. The research vehicle is equipped to assess the behavior of the vehicle and the driver with sensors and tiny video cameras located in the vehicle. The equipment will not interfere with the operation of the vehicle or your driving.

An experimenter will accompany you in the vehicle to provide instructions. In addition to routine driving procedures, such as stopping, changing lanes, and maintaining speed, you will be asked to perform selected other tasks, such as inserting a CD into an entertainment console, having a conversation, and answering a cellular telephone call. Before testing, the tasks will be described to you and you will be able to practice performing them.

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 come to the Smart Road facility and perform a series of tasks now and again at 6, 12 and 18 months from now. Each of these four visits to the Smart Road will take no more than 3 hours to complete, and will include the following activities:
 - a. Complete a questionnaire about your health and driving experience.

- b. Get oriented to the vehicle, test track, and tasks.
- c. Drive the test vehicle on the test track, following the instructions of the experimenter who will be riding with you.
- d. After the driving session, complete a brief questionnaire.
- e. Provide ratings when asked.

III. RISKS AND DISCOMFORTS

Participating in this study may have the following risks.

- 1. You could be involved in an accident.
- 2. You may be asked to quickly brake, bringing the vehicle to a complete stop.
- 3. You could experience fatigue.
- 4. You cannot wear sunglasses while being tested.
- 5. If you have had previous eye injuries and/or surgeries, you are at an increased risk of further eye injury by participating in this study where risks, although minimal, include the possibility of collision and airbag deployment.
- 6. In case of an incident, according to the Blacksburg Rescue Squad, it is estimated that response time to the Smart Road would be approximately 5 minutes

The following precautions are in place to ensure that risks are minimized:

- 1. The Smart Road is designed for safety, with restricted access, nothing for a vehicle to hit, carefully placed guardrails, and many other safety features.
- 2. Only authorized professionals will be present on the Smart Road and in the vehicle with you.
- 3. The research vehicle is equipped with airbags, anti-lock brakes, and other safety equipment.
- 4. The special equipment in the research vehicle is out of the way. It will not obstruct your view or bother your driving.
- 5. A trained experimenter will be in the passenger seat next to you and can stop the vehicle using a separate brake pedal.
- 6. The experimenter and control tower staff will be in radio contact at all times.
- 7. You will be required to use the seat belt and shoulder strap and follow safe driving procedures.
- 10. You will not be asked to do anything that is known to be dangerous

You will be allowed to take a break if you experience fatigue.

IV. BENEFITS OF PARTICIPATION

The potential benefit of participating in this research is that you may enjoy participating in the driving tests. No promise or guarantee of benefits is being made to encourage participation. Participation may have an impact on teen driving safety and future methods for driver education.

V. CONFIDENTIALITY

The information gathered in this experiment will be securely stored and treated confidentiality to the extent allowed by law.

1. The information will be used for research purposes only.
2. The information will be seen only by the researchers.
 - a. The information will not be shared with anyone else.
3. The information will be pooled with that of the other study participants.
4. Your name and other identifiers will be removed from the data forms.
5. You will not be identified personally in reports or for any reason.
6. The video images of your face were collected to determine your eye movement while driving, will be securely stored, held in confidence, and not used for any other purpose without your express written consent.
7. To help us protect your privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify you, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States Government that is used for auditing or evaluation of Federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Food and Drug Administration (FDA).

You should understand that a Certificate of Confidentiality does not prevent you or a member of your family from voluntarily releasing information about yourself or your involvement in this research. If an insurer, employer, or other person obtains your written consent to receive research information, then the researchers may not use the Certificate to withhold that information.

The Certificate of Confidentiality does not prevent the researchers from disclosing voluntarily matters such as child abuse, or subject's threatened violence to self or others.

VI. COMPENSATION

You will receive \$20 for each hour you participate in this experiment. Compensation will be provided only for time spent in the vehicle or in direct participation in this experiment. Each driving session will take no more than 1.5 hours to complete, and paperwork and screening should take no more than one hour (with a limit of \$30 for time spent completing paperwork; if you require reading assistance, please inform the experimenter and they will assist by reading the forms and questionnaires to you).

VII. MEDICAL TREATMENT AND INSURANCE

In the event of an accident or injury in an automobile, the automobile liability coverage for property damage and personal injury is provided. The total policy amount per occurrence is \$2,000,000. This coverage (unless the other party was at fault, which would mean all expense would go to the insurer of the other party's vehicle) would apply in case of an accident for all volunteers and would cover medical expenses up to the policy limit.

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, if not in an automobile, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

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 1, you will then lose your eligibility to participate in Experiment 2, the Naturalistic On-road Driving Experiment.

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. PARTICIPANT'S RESPONSIBILITIES

If you voluntarily agree to participate in this study, you will have the following responsibilities while driving the research vehicles:

1. Complete the necessary pre and post study questionnaires.
2. Be free of alcohol and other drugs that may impair your driving ability.
3. Conform to the laws and regulations of driving on public roadways.
4. Follow the safety instructions of the experimenter.
5. Inform an experimenter if you have questions or encounter difficulties.
6. If you are pregnant, you have reviewed this consent form with your obstetrician and discussed the risks of participating in this study with him/her. You are willing to accept all possible risks of participation.

Check one of the following:

- I have **not** had an eye injury/eye surgery (including, but not limited to, LASIK, Radial Keratotomy, and cataract surgery.)
- I **have** had an eye injury/eye surgery and I've have been informed of the possible risks to participants who have had eye surgery. I choose to accept this possible risk to participate in this study.

XI. ASSENT

I _____ (participant) have read and understand this assent 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 participants may withdraw at any time without penalty.

Initial Evaluation

Participant/ (Print Name) Signature Date

6 Month Evaluation

Participant/ (Print Name) Signature Date

12 Month Evaluation

Participant/ (Print Name) Signature Date

18 Month Evaluation

Participant/ (Print Name) Signature Date

Parent Consent (Print Name) Signature Date

Experimenter (Print Name) Signature Date

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 E3: EXPERIMENT 1 INFORMED CONSENT FORM FOR PARENTAL PERMISSION FOR TEEN PARTICIPATION

Parental Informed Consent Form

(For parents of participants younger than 18 years old)

PREVENTING MOTOR VEHICLE CRASHES AMONG YOUNG DRIVERS: RESEARCH ON DRIVING RISK AMONG NOVICE TEEN DRIVERS Experiment 1, Test Track (Smart Road) 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

Your child will first be asked to answer a series of questionnaires relating to psycho-social, behavioral, and demographic measures and to complete a series of vision tests. Your child will then be asked to drive a research vehicle on a test-track. The Smart Road is a controlled, two lane road that is 2.2 miles long. The research vehicle is equipped to assess the behavior of the vehicle and the driver with sensors and tiny video cameras located in the vehicle. The equipment will not interfere with the operation of the vehicle or your child's driving.

An experimenter will accompany your child in the vehicle to provide instructions. In addition to routine driving procedures, such as stopping, changing lanes, and maintaining speed, your child will be asked to perform selected other tasks, such as inserting a CD into an entertainment console, having a conversation, and answering a cellular telephone call. Before testing, the tasks will be described to your child and your child will be able to practice performing them.

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

1. Carefully read their informed assent form and sign it if they agree to participate.

2. Agree to have your child come to the Smart Road facility and perform a series of tasks now and again at 6, 12 and 18 months from now. Each of these four visits to the Smart Road will take no more than 3 hours to complete, and will include the following activities:
 - a. Complete a questionnaire about health and driving experience.
 - b. Get oriented to the vehicle, test track, and tasks.
 - c. Drive the test vehicle on the test track, following the instructions of the experimenter who will be riding with your child.
 - d. After the driving session, complete a brief questionnaire
 - e. Provide ratings when asked.

III. RISKS AND DISCOMFORTS

Participating in this study may have the following risks.

1. Your child could be involved in an accident.
2. Your child may be asked to quickly brake, bringing the vehicle to a complete stop.
3. Your child could experience fatigue.
4. Your child cannot wear sunglasses while being tested.
5. If your child has had previous eye injuries and/or surgeries, he/she is at an increased risk of further eye injury by participating in this study where risks, although minimal, include the possibility of collision and airbag deployment.
6. In case of an incident, according to the Blacksburg Rescue Squad, it is estimated that response time to the Smart Road would be approximately 5 minutes

The following precautions are in place to ensure that risks are minimized:

1. The Smart Road is designed for safety, with restricted access, nothing for a vehicle to hit, carefully placed guardrails, and many other safety features.
2. Only authorized professionals will be present on the Smart Road and in the vehicle with your child.
3. The research vehicle is equipped with airbags, anti-lock brakes, and other safety equipment.
4. The special equipment in the research vehicle is out of the way. It will not obstruct your child's view or bother your child's driving.
5. A trained experimenter will be in the passenger seat next to your child and can stop the vehicle using a separate brake pedal.
6. The experimenter and control tower staff will be in radio contact at all times.
7. Your child will be required to use the seat belt and shoulder strap and follow safe driving procedures.
8. Your child will not be asked to do anything that is known to be dangerous
9. Your child will be able to take a break if he or she becomes fatigued.

IV. BENEFITS OF PARTICIPATION

The potential benefit of participating in this research is that your child may enjoy participating in the driving tests. No promise or guarantee of benefits is being made to

encourage participation. Participation may have an impact on teen driving safety and future methods for driver education.

V. CONFIDENTIALITY

The information gathered in this experiment will be securely stored and treated confidentiality to the extent allowed by law.

1. The information will be used for research purposes only.
2. The information will be seen only by the researchers.
 - a. The information will not be shared with anyone else.
3. The information will be pooled with that of 24 other study participants.
4. Your child's name and other identifiers will be removed from the data forms.
5. Your child will not be identified personally in reports or for any reason.
6. The video images of your child's face were collected to determine your child's eye movement while driving, will be securely stored, held in confidence, and not used for any other purpose without your and your child's express written consent.
7. To help us protect your child's privacy, we have obtained a Certificate of Confidentiality from the National Institutes of Health. With this Certificate, the researchers cannot be forced to disclose information that may identify your child, even by a court subpoena, in any federal, state, or local civil, criminal, administrative, legislative, or other proceedings. The researchers will use the Certificate to resist any demands for information that would identify you, except as explained below.

The Certificate cannot be used to resist a demand for information from personnel of the United States Government that is used for auditing or evaluation of federally funded projects or for information that must be disclosed in order to meet the requirements of the federal Food and Drug Administration (FDA).

You should understand that a Certificate of Confidentiality 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. If an insurer, employer, or other person obtains yours and your child's written consent to receive research information, then the researchers may not use the Certificate to withhold that information.

The Certificate of Confidentiality does not prevent the researchers from disclosing voluntarily matters such as child abuse, or subject's threatened violence to self or others.

VII. COMPENSATION

Your child will receive \$20 for each hour of participation in this experiment. Compensation will be provided only for time spent in the vehicle or in direct participation in this experiment. Each driving session will take no more than 1.5 hours to complete, and paperwork and screening should take no more than one hour (with a limit of \$30 for time spent completing paperwork; if your child requires reading assistance, they should inform the experimenter, who will assist by reading the forms and questionnaires to your child).

VII. MEDICAL TREATMENT AND INSURANCE

In the event of an accident or injury in an automobile, the automobile liability coverage for property damage and personal injury is provided. The total policy amount per occurrence is \$2,000,000. This coverage (unless the other party was at fault, which would mean all expense would go to the insurer of the other party's vehicle) would apply in case of an accident for all volunteers and would cover medical expenses up to the policy limit.

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, if not in an automobile, the participants are responsible for their own medical insurance for bodily injury. Appropriate health insurance is strongly recommended to cover these types of expenses.

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, he/she will be compensated in accordance with the terms in Section VI of this document. If your child chooses to withdraw from Experiment 1, they will then lose their eligibility to participate in Experiment 2, the Naturalistic On-road Driving 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. PARTICIPANT'S RESPONSIBILITIES

If your child voluntarily agrees to participate in this study, your child will have the following responsibilities while driving the research vehicles:

1. Complete the necessary pre and post study questionnaires.
2. Be free of alcohol and other drugs that may impair their driving ability,
3. Conform to the laws and regulations of driving on public roadways.
4. Follow the safety instructions of the experimenter.
5. Inform an experimenter if they have questions or encounter difficulties.

6. If your child is pregnant, you have reviewed this consent form with their obstetrician and discussed the risks of participating in this study with him/her. You and your child are willing to accept all possible risks of participation.

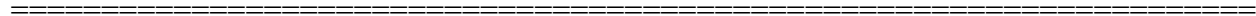
XI. CONSENT

I _____ (parent) have read and understand this permission form and conditions of participation. I understand what is being asked of my child. My questions have been answered. I agree to my child’s participation. I understand that participation is voluntary and participants may withdraw at any time without penalty. This form needs to be signed in the presence of the experimenter listed below.

Parent 1 (Print Name)	Signature	Date
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Parent 2 (Print Name)	Signature	Date
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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 F1: IN-VEHICLE EXPERIMENTER ORDER 1 INSTRUCTIONS

BEFORE DRIVING

While heading toward vehicle in front parking lot:

For this study you will be asked to drive this vehicle (point to car) on the Smart Road. Let's go ahead and have you take a seat.

Introduce vehicle controls:

Now let's adjust the seat so it is comfortable for you. How are the rear view mirror and side mirrors? Is this a comfortable temperature?

Introduce in-vehicle device controls:

Now I'll explain some of the basic functions of the devices we will be using today. Feel free to ask questions at any time. I will demonstrate how to use each device and then have you practice tasks while we are parked here.

iPod Orientation

Do you have an iPod? Have you ever used one before? (If the answer to both questions is "No," you may need to provide them with extra time to become familiar with it).

- 1. Turn the power on by pressing the play button. (After each instruction, demonstrate, and then have the participant do the same).*
- 2. Once the iPod is on, you can scan through the selections by rolling your thumb around the control pad.*
- 3. To make the desired selection on the menu, press the center button.*
- 4. If you make a mistake and need to go to the previous screen hit the MENU button.*
- 5. To play a specific song, once you arrive at the desired selection press the middle button.*

When performing tasks on the road between iPod tasks you may need to return to the main menu before beginning a new task.

Do you have any questions?

• **Practice iPod Task**

OK, let's practice. I will tell you what the task is and ask that you repeat it to me. Start the task when I say "Begin."

Your task is to say aloud the song that starts with the word "Lazy" Please repeat the task.

Begin. (Correct answer = "Lazy Days")

(After completed): Sometimes we will do multiple tasks in a row. In this case, you do not have to repeat the instructions for the task for the second, third, or additional cases of that task. I will remind you of this when this is needed.

Reading Directions Task

For this task, you will read a set of driving directions to yourself and then say out loud the answer to the question on the back. The answer will always be the number of left or right turns indicated in the directions. When I say “begin” take the placard from my hand.

Have Placard 1 ready and then say: Your task is to read the directions to yourself and then say out loud the number of left or right turns. Please repeat the task (wait for response). Begin. When done: OK, thank you. While driving I will continuously be passing you placards, after you are finished with one I will immediately hand you another.

Cell Phone Orientation

I will now explain the functions of the cell phone that we will be using. I will demonstrate each control and then have you practice.

- 1. For the cell phone tasks you will be using this cell phone (show phone). For cell phone tasks, I will hold the phone for you and you will simply take it from my hand when I say “Begin.”*
- 2. Enter numbers using the corresponding key pad.*
- 3. Numbers will show up on the display here.*
- 4. Use this button to delete a number if needed.*
- 5. Hit this green button (pointing to button on left) to make a call once it is entered.*
- 6. Hit this red button (on right) to end a call and go back to main menu.*
- 7. After you place a call, follow the remaining instructions.*
- 8. Hit the red button to hang up and end the task.*

Any questions?

• **Practice Cell Phone Task**

The next task will be cell phone task. We are NOT going to place an actual call.

Your task is simply to dial your home phone number with the area code and then hit the red “end” button. Please repeat the task (wait for response). Begin. When done: OK, thank you.

• **Cell Phone Task – 511 Virginia**

OK, let’s have you try another phone task. This time you will be dialing 511. Are you familiar with 511? It is a service provided by the State of Virginia that has recorded information on traffic conditions. It has voice-activated menus to go to the correct menu and you’ll be calling 511 to get some information. So you dial and then speak in to the phone. Ready?

Your task is to call 511 to find out how many traffic and construction incidents there are for I-81. Please repeat the task. Begin

Text Messaging Functions

Now I will introduce and demonstrate the text messaging functions of the phone

- 1. First enter the number you will send the text message to.*
- 2. Press ‘Options’*
- 3. Scroll down to ‘Send Message’*

4. *Press Select*
5. *Enter the text message*
6. *Press Options*
7. *Select Send*

When performing the task on the road if you make a typo don't worry about fixing it; just continue on with the task.

- **Cell Phone Text Messaging Practice Task**

OK, let's have you try a text messaging task. I will describe the task and place a placard on the dash with the number and text messages, please enter the text exactly as it appears on the card. Your next task is to dial 357-1501 and send the message "How are you?" (Put placard on dashboard with phone number and text). Please repeat the task. Begin.

Smart Road Script for Order 1

BEFORE ENTERING SMART ROAD

*OK, now we will drive down to enter the Smart Road. I'll provide instructions to get there. (Call dispatch, enter road, and have participant stop at the top of the hill – **verify that the gate is closed**). Please stop at the top of the hill and put the car into Park.*

(After stopped): Today we will be on the Smart Road. It is a controlled access facility; this means there will be no other traffic or pedestrians on the road unless they are part of the experiment, however a maintenance crew may be present on the road. The purpose of this study is to develop an understanding of driving skills of a variety of drivers in a controlled setting. We want you to drive as you normally would, and to obey all traffic regulations as you normally would. Any decisions you make should reflect the same choice you would normally make.

*We will be driving continuously with very few stops. I'll provide instructions before each task, and then have you repeat the task out loud just like we practiced. The tasks will be performed **while you are driving** and will be similar to those we just practiced. The tasks are continuous and you may receive a new task directly after completion of the previous. Some of the tasks are purposely difficult and may take longer to complete or you may not have enough time to complete the task - just do the best you can. Because we want to maintain the same conditions for all of our participants, we will not be able to talk while you are driving except for instructions or questions related to the experiment. Occasionally, you may receive instructions from the back seat experimenter as well. Any questions?*

EXPERIMENTAL TASKS: Task List for 40 Teen Smart Road Protocol

Task#	Description	Instructions
1	Stop sign detection (LOOP 1, down). <u>A</u> dvance (start) task as they leave the upper turnaround. Light is turned off on first loop down road; stop sign is hidden in front of van. <u>E</u> nd task after intersection.	<i>Please stay in the right lane and maintain a comfortable speed. Say out loud anytime the trip odometer reaches a 3, 6, or 9 in the last digit. Please repeat the task. Begin. (FSE: Reset the odometer to zero; BSE: Remember to turn light to green <u>after</u> the intersection)</i>
2	Self-selected speed, baseline (LOOP 1, down) <u>A</u> dvance task after through intersection. <u>E</u> nd task at beginning of small bridge	
3	Self-selected speed, pedestrian detection (LOOP 1, up) <u>A</u> dvance task as they cross small bridge. Van is on right shoulder of road, no cones, and pedestrian walks around and to front of van as subject vehicle approaches. <u>E</u> nd task as they enter the upper turnaround, after intersection.	As the participant reaches top turn around “ <i>Please stay to the left and continue around the loop at a comfortable speed.</i> ”
4	Self-selected speed, directions task (LOOP 2, down). <u>A</u> dvance task as they leave the upper turnaround. <u>E</u> nd task as they enter the long bridge. Repeat as many times as necessary.	<i>Your next task is to read the directions to yourself and answer the question on the back of the card out loud. Please repeat the task. Begin.</i>
5	Self-selected speed, text messaging task + pedestrian detection (LOOP 2, up). <u>A</u> dvance task as they leave the long bridge. Repeat as necessary. Cones are set up to block right lane, and van is parked next to cones. Pedestrian walks around and to front of van as subject vehicle approaches. <u>E</u> nd task as they enter the upper turnaround.	<i>Your next task is to dial 357-1501 and send the text message: Meet me in the lobby at 7 after work. (Put placard on dashboard with phone number and text). Please repeat the task. Begin. (Extra 1: Want to eat at Taco Bell at 6:30?)</i>
6	Self-selected speed, iPod task (LOOP 3, down). Advance task as they leave the upper turnaround. <u>E</u> nd task as they enter the long bridge. Repeat as many times as necessary.	<i>Your next task is say out loud the song listed after the song Forever on the IPOD, Please repeat the task. Begin. (Extras: Say out loud a song with the word “Boston” in the title; What is the name of the fourth Hank Williams song? How many Genres are listed? How many albums are there?)</i>
7	Self-selected speed, cell phone task + animal detection plus detour (LOOP 3, up) <u>A</u> dvance task as they leave the long bridge. Repeat as necessary. Cones are set up to block right lane with detour sign inserted, and van is parked next to cones. Pedestrian walks around van as subject	<i>Your next task is to call 511 and describe the first traffic incident on Interstate 81. Please repeat the task. Begin. (Extra: Call 511 and find out whether there are any traffic and construction delays on Interstate 77.)</i>

Task#	Description	Instructions
	vehicle approaches, but stays on side of van. Large dog is placed in front of van. <u>End</u> task as they enter the upper turnaround.	
8	Self-selected following distance, baseline (LOOP 4,down). <u>A</u> dvance task as they leave the upper turnaround. Stop light is green. <u>E</u> nd task at beginning of small bridge	<p>As the participant approaches the turn around. <i>As you reach the end of the turn around please slow down and come to a stop at the top of the hill where we stopped before and place the vehicle in park.</i></p> <p><i>As you approach the intersection you will see a vehicle begin moving, please follow that vehicle at a comfortable distance and maintain that distance. Do you have any questions</i></p> <p><i>For your next task please stay in the right lane and maintain a comfortable following distance. Say out loud anytime the trip odometer reaches a 3, 6, or 9 in the last digit. Please repeat the task. Begin.</i></p>
9	Self-selected following distance, dilemma zone (LOOP 4, up) <u>A</u> dvance task as they cross small bridge. Light changes to amber at 157 feet. <u>E</u> nd task as they enter the upper turnaround.	None.
10	Self-selected following distance, text messaging task (LOOP 5, down). <u>A</u> dvance task as they leave the upper turnaround. <u>E</u> nd task as they enter the long bridge. Repeat as many times as necessary.	<p><i>Your next task is to dial 357-1501 enter the text message: Hope you are feeling better today. Please repeat the task. Begin.</i></p> <p><i>(Extra: Let's meet at the Duck Pond after the meeting.) Please repeat the task. Begin.</i></p>
11	Self-selected following distance, iPod task plus dilemma zone (LOOP 5, up) <u>A</u> dvance task as they leave the long bridge. Light changes to amber at 140 feet. Repeat as necessary. <u>E</u> nd task as they enter the upper turnaround.	<p><i>Your next task is to name out loud the last song by Kid Rock. Please repeat the task. Begin.</i></p> <p><i>(Extras: Who is the last Composer listed?; How many songs start with the letter J?; Name out loud the second song in the Court and Spark album. How many artists are listed in the iPod, Who is the 10th composer listed on the iPod, What is the last song on the love songs album)</i></p>

Task#	Description	Instructions
12	Self-selected following distance, cell phone task (LOOP 6, down) plus dilemma zone. <u>A</u> dvance task as they leave the upper turnaround. <u>E</u> nd task as they enter the long bridge. Repeat as many times as necessary. Light turns to amber at 174 feet.	<i>Your next task is to call 511 and find out how many traffic and construction delays there are on Interstate 81. Please repeat the task. Begin.</i> (Extra: call 511 and report the weather conditions for Blacksburg.)
13	Self-selected following distance, directions task (LOOP 6, up) <u>A</u> dvance task as they leave the long bridge. Repeat as necessary. <u>E</u> nd task as they enter the upper turnaround. Light is green.	<i>Your next task is to read the directions to yourself and answer the question on the back of the card out loud. Please repeat the task. Begin.</i> Lead vehicle turns off of road.
14	Text message task (LOOP 7, down). <u>A</u> dvance task as they leave the upper turnaround. <u>E</u> nd task as they enter the long bridge. Repeat as many times as necessary.	<i>For your next task please drive at about 35 mph during this loop. Please dial 357-1501 and send the text message: When do you want to meet at the library? Please repeat the task. Begin.</i> (Extra: The car is ready to be picked up at the shop.) Please repeat the task. Begin.
15	Cell phone plus 200 foot amber light (with shortened amber cycle) (LOOP 7, up) <u>A</u> dvance task as they leave the long bridge. Repeat as necessary. <u>E</u> nd task as they enter the upper turnaround. Light turns amber at 200 feet but with a shortened amber cycle of 2.6 seconds (normally 3.6 seconds).	<i>Your next task is to call 511 and find out the mile marker for the first traffic incident on Interstate 81 Northbound. Please repeat the task. Begin.</i> (Extra: Call 511 and find out whether there are any traffic incidents on Interstate 64.)

APPENDIX F2: IN-VEHICLE EXPERIMENTER ORDER 2 INSTRUCTIONS

BEFORE DRIVING

While heading toward vehicle in front parking lot:

For this study you will be asked to drive this vehicle (point to car) on the Smart Road. Let's go ahead and have you take a seat.

Introduce vehicle controls:

Now let's adjust the seat so it is comfortable for you. How are the rear view mirror and side mirrors? Is this a comfortable temperature?

Introduce in-vehicle device controls:

Now I'll explain some of the basic functions of the devices we will be using today. Feel free to ask questions at any time. I will demonstrate how to use each device and then have you practice tasks while we are parked here.

iPod Orientation

Do you have an iPod? Have you ever used one before? (If the answer to both questions is "No," you may need to provide them with extra time to become familiar with it).

6. *Turn the power on by pressing the play button. (After each instruction, demonstrate, and then have the participant do the same).*
7. *Once the iPod is on, you can scan through the selections by rolling your thumb around the control pad.*
8. *To make the desired selection on the menu, press the center button.*
9. *If you make a mistake and need to go to the previous screen hit the MENU button.*
10. *To play a specific song, once you arrive at the desired selection press the middle button.*

When performing tasks on the road between iPod tasks you may need to return to the main menu before beginning a new task.

Do you have any questions?

• **Practice iPod Task**

OK, let's practice. I will tell you what the task is and ask that you repeat it to me. Start the task when I say "Begin."

Your task is to say aloud the song that starts with the word "Lazy" Please repeat the task.

Begin. (Correct answer = "Lazy Days")

(After completed): Sometimes we will do multiple tasks in a row. In this case, you do not have to repeat the instructions for the task for the second, third, or additional cases of that task. I will remind you of this when this is needed.

Reading Directions Task

For this task, you will read a set of driving directions to yourself and then say out loud the answer to the question on the back. The answer will always be the number of left or right turns indicated in the directions. When I say “begin” take the placard from my hand.

Have Placard 1 ready and then say: Your task is to read the directions to yourself and then say out loud the number of left or right turns. Please repeat the task (wait for response). Begin. When done: OK, thank you. While driving I will continuously be passing you placards, after you are finished with one I will immediately hand you another.

Cell Phone Orientation

I will now explain the functions of the cell phone that we will be using. I will demonstrate each control and then have you practice.

- 9. For the cell phone tasks you will be using this cell phone (show phone). For cell phone tasks, I will hold the phone for you and you will simply take it from my hand when I say “Begin.”*
- 10. Enter numbers using the corresponding key pad.*
- 11. Numbers will show up on the display here.*
- 12. Use this button to delete a number if needed.*
- 13. Hit this green button (pointing to button on left) to make a call once it is entered.*
- 14. Hit this red button (on right) to end a call and go back to main menu.*
- 15. After you place a call, follow the remaining instructions.*
- 16. Hit the red button to hang up and end the task.*

Any questions?

• **Practice Cell Phone Task**

The next task will be cell phone task. We are NOT going to place an actual call.

Your task is simply to dial your home phone number with the area code and then hit the red “end” button. Please repeat the task (wait for response). Begin. When done: OK, thank you.

• **Cell Phone Task – 511 Virginia**

OK, let’s have you try another phone task. This time you will be dialing 511. Are you familiar with 511? It is a service provided by the State of Virginia that has recorded information on traffic conditions. It has voice-activated menus to go to the correct menu and you’ll be calling 511 to get some information. So you dial and then speak in to the phone. Ready?

Your task is to call 511 to find out how many traffic and construction incidents there are for I-81. Please repeat the task. Begin

Text Messaging Functions

Now I will introduce and demonstrate the text messaging functions of the phone

- 8. First enter the number you will send the text message to.*
- 9. Press ‘Options’*
- 10. Scroll down to ‘Send Message’*

11. *Press Select*
12. *Enter the text message*
13. *Press Options*
14. *Select Send*

When performing the task on the road if you make a typo don't worry about fixing it; just continue on with the task.

- **Cell Phone Text Messaging Practice Task**

OK, let's have you try a text messaging task. I will describe the task and place a placard on the dash with the number and text messages, please enter the text exactly as it appears on the card. Your next task is to dial 357-1501 and send the message "How are you?" (Put placard on dashboard with phone number and text). Please repeat the task. Begin.

Smart Road Script for Order 2

BEFORE ENTERING SMART ROAD

*OK, now we will drive down to enter the Smart Road. I'll provide instructions to get there. (Call dispatch, enter road, and have participant stop at the top of the hill – **verify that the gate is closed**). Please stop at the top of the hill and put the car into Park.*

(After stopped): Today we will be on the Smart Road. It is a controlled access facility; this means there will be no other traffic or pedestrians on the road unless they are part of the experiment, however a maintenance crew may be present on the road. The purpose of this study is to develop an understanding of driving skills of a variety of drivers in a controlled setting. We want you to drive as you normally would, and to obey all traffic regulations as you normally would. Any decisions you make should reflect the same choice you would normally make.

*We will be driving continuously with very few stops. I'll provide instructions before each task, and then have you repeat the task out loud just like we practiced. The tasks will be performed **while you are driving** and will be similar to those we just practiced. The tasks are continuous and you may receive a new task directly after completion of the previous. Some of the tasks are purposely difficult and may take longer to complete or you may not have enough time to complete the task - just do the best you can. Because we want to maintain the same conditions for all of our participants, we will not be able to talk while you are driving except for instructions or questions related to the experiment. Occasionally, you may receive instructions from the back seat experimenter as well. Any questions?*

EXPERIMENTAL TASKS: Task List for 40 Teen Smart Road Protocol

Task#	Description	Instructions
1	Stop sign detection (LOOP 1, down). <u>A</u> dvance (start) task as they leave the upper turnaround. Light is turned off on first loop down road; stop sign is hidden in front of van. <u>E</u> nd task after intersection.	<i>Please stay in the right lane and maintain a comfortable speed. Say out loud anytime the trip odometer reaches a 3, 6, or 9 in the last digit. Please repeat the task. Begin. (FSE: Reset the odometer to zero; BSE: Remember to turn light to green <u>a</u>fter the intersection)</i>
2	Self-selected speed, baseline (LOOP 1, down) <u>A</u> dvance task after through intersection. <u>E</u> nd task at beginning of small bridge	
3	Self-selected speed, pedestrian detection (LOOP 1, up) <u>A</u> dvance task as they cross small bridge. Van is on right shoulder of road, no cones, and pedestrian walks around and to front of van as subject vehicle approaches. <u>E</u> nd task as they enter the upper turnaround, after intersection.	As the participant reaches top turn around <i>“Please stay to the left and continue around the loop at a comfortable speed.”</i>
8	Self-selected following distance, baseline (LOOP 4,down). <u>A</u> dvance task as they leave the upper turnaround. Stop light is green. <u>E</u> nd task at beginning of small bridge	As the participant approaches the turn around. <i>As you reach the end of the turn around please slow down and come to a stop at the top of the hill where we stopped before and place the vehicle in park.</i> <i>As you approach the intersection you will see a vehicle begin moving, please follow that vehicle at a comfortable distance and maintain that distance. Do you have any questions</i> <i>For your next task please stay in the right lane and maintain a comfortable following distance. Say out loud anytime the trip odometer reaches a 3, 6, or 9 in the last digit. Please repeat the task. Begin.</i>
9	Self-selected following distance, dilemma zone (LOOP 4, up) <u>A</u> dvance task as they cross small bridge. Light changes to amber at 157 feet. <u>E</u> nd task as they enter the upper turnaround.	None.
10	Self-selected following distance, text messaging task (LOOP 5, down). <u>A</u> dvance task as they leave the upper turnaround.	<i>Your next task is to dial 357-1501 enter the text message: Hope you are feeling better today. Please repeat the task.</i>

Task#	Description	Instructions
	<u>End</u> task as they enter the long bridge. Repeat as many times as necessary.	<i>Begin.</i> (Extra: Let's meet at the Duck Pond after the meeting.) Please repeat the task. <i>Begin.</i>
11	Self-selected following distance, iPod task plus dilemma zone (LOOP 5, up) <u>Advance</u> task as they leave the long bridge. Light changes to amber at 140 feet. Repeat as necessary. <u>End</u> task as they enter the upper turnaround.	<i>Your next task is to name out loud the last song by Kid Rock. Please repeat the task.</i> <i>Begin.</i> (Extras: Who is the last Composer listed?; How many songs start with the letter J?; Name out loud the second song in the Court and Spark album. How many artists are listed in the iPod, Who is the 10 th composer listed on the iPod, What is the last song on the love songs album)
12	Self-selected following distance, cell phone task (LOOP 6, down) plus dilemma zone. <u>Advance</u> task as they leave the upper turnaround. <u>End</u> task as they enter the long bridge. Repeat as many times as necessary. Light turns to amber at 174 feet.	<i>Your next task is to call 511 and find out how many traffic and construction delays there are on Interstate 81. Please repeat the task. Begin.</i> (Extra: call 511 and report the weather conditions for Blacksburg.)
13	Self-selected following distance, directions task (LOOP 6, up) <u>Advance</u> task as they leave the long bridge. Repeat as necessary. <u>End</u> task as they enter the upper turnaround. Light is green.	<i>Your next task is to read the directions to yourself and answer the question on the back of the card out loud. Please repeat the task. Begin.</i> Lead vehicle turns off of road.
14	Text message task (LOOP 7, down). <u>Advance</u> task as they leave the upper turnaround. <u>End</u> task as they enter the long bridge. Repeat as many times as necessary.	<i>For your next task please drive at about 35 mph during this loop. Please dial 357-1501 and send the text message: When do you want to meet at the library?</i> <i>Please repeat the task. Begin.</i> (Extra: The car is ready to be picked up at the shop.) Please repeat the task. <i>Begin.</i>
15	Cell phone plus 200 foot amber light (with shortened amber cycle) (LOOP 7, up) <u>Advance</u> task as they leave the long bridge. Repeat as necessary. <u>End</u> task as they enter the upper turnaround. Light turns amber at 200 feet but with a shortened amber cycle of 2.6 seconds (normally 3.6 seconds).	<i>Your next task is to call 511 and find out the mile marker for the first traffic incident on Interstate 81 Northbound. Please repeat the task. Begin.</i> (Extra: Call 511 and find out whether there are any traffic incidents on Interstate 64.)
4	Self-selected speed, directions task (LOOP 2, down). <u>Advance</u> task as they leave the upper turnaround. <u>End</u> task as they enter the long bridge. Repeat as many times as necessary.	<i>Your next task is to read the directions to yourself and answer the question on the back of the card out loud. Please repeat the task. Begin.</i>

Task#	Description	Instructions
5	Self-selected speed, text messaging task + pedestrian detection (LOOP 2, up). <u>A</u> dvance task as they leave the long bridge. Repeat as necessary. Cones are set up to block right lane, and van is parked next to cones. Pedestrian walks around and to front of van as subject vehicle approaches. <u>E</u> nd task as they enter the upper turnaround.	<i>Your next task is to dial 357-1501 and send the text message: Meet me in the lobby at 7 after work. (Put placard on dashboard with phone number and text). Please repeat the task. <i>Begin.</i> (Extra 1: <i>Want to eat at Taco Bell at 6:30?</i>)</i>
6	Self-selected speed, iPod task (LOOP 3, down). Advance task as they leave the upper turnaround. <u>E</u> nd task as they enter the long bridge. Repeat as many times as necessary.	<i>Your next task is say out loud the song listed after the song <i>Forever on the IPOD</i>, Please repeat the task. <i>Begin.</i> (Extras: Say out loud a song with the word “Boston” in the title; What is the name of the fourth Hank Williams song? How many Genres are listed? How many albums are there?)</i>
7	Self-selected speed, cell phone task + animal detection plus detour (LOOP 3, up) <u>A</u> dvance task as they leave the long bridge. Repeat as necessary. Cones are set up to block right lane with detour sign inserted, and van is parked next to cones. Pedestrian walks around van as subject vehicle approaches, but stays on side of van. Large dog is placed in front of van. <u>E</u> nd task as they enter the upper turnaround.	<i>Your next task is to call 511 and describe the first traffic incident on Interstate 81. Please repeat the task. <i>Begin.</i> (Extra: Call 511 and find out whether there are any traffic and construction delays on Interstate 77.)</i>

APPENDIX G1: CONFEDERATE ON-ROAD PROTOCOL: ORDER 1

Drive the Contour down to the Vicki Lane gate: leave it parked there on the right side facing the Smart Road. Keep the keys with you, but leave the vehicle doors unlocked. Set up cones behind the vehicle, blocking that side of the road.

Load Van: 2 white cones, 2 grey cones, 21 orange cones, 3 detour signs (2 lefts, 1 right), 1 orange vest, Roadkill, 1 clipboard, 1 pen, and a radio.

Enter Smart Road and unload van:

- Put 2 sets of 2 orange cones topped with 1 white cone each and 1 detour sign (left) on Vicki Lane- lay them down.
- 2 sets of 2 orange cones topped with one grey cone each and 1 detour sign (right) on Ron Road- lay them down
- 1 orange cone to block the drive to the pump house gate
- Divide the remaining cones into 1 set of 6 and 2 sets of 3 and place them just off the side of the road, spaced evenly down the road. Place the remaining detour sign (left) with the first set of 6 cones (closest to the intersection).
- Set up stop sign at the start of the intersection where the grey tape is (the stop sign should already be laying flat on the side of the road).

Exit the Smart Road via Vicki Lane: Park the van on the left side facing the Smart road. Set up cones behind the van so that the entrance to Vicki Lane is blocked off. Wait until Dave radio's that he is ready for Erik in the Taurus, then enter the Smart Road leaving the Vicki Lane gate open.

Prep for Loop 1 down: Park the van in front of the stop sign to block the participant's view, with the front left tire of the van centered at the piece of grey tape. Make sure to turn on the hazard lights in the van. Pretend to be working while the participant passes- do not stare at them! As soon as the participant is clear from view, set up for Loop 1 up.

Prep for Loop 1 up: Take down the stop sign (lay it flat on side of road), and park van on right shoulder of road where the first detour sign will be. Make sure the hazard lights are still on. *DO NOT SET UP ANY CONES FOR THIS LOOP.* Stand at the back of the van with the doors open, holding a clipboard and pretend to be working until the participant passes about halfway across the bridge. At that time, close the van doors, and walk around the right side of the van, stopping about halfway across the front of the van. After participant passes, get clear and remain clear for Loop 2 down. Once participant has passed over the bridge, set up for Loop 2 up.

Prep for Loop 2 Up: Set up CONES ONLY on Vicki Lane and Ron Road. Leave the detour signs laying face down on the ground behind the cones. Park the van close to the center lane line, with the stack of 6 cones set up in front of it, the detour sign laying face down on the ground next to them, and the remaining 6 cones set up behind the van to close off the right lane (look for grey

tape). Stand at the back of the van with the doors open, pretending to be working until the participant passes about halfway across the bridge. At that time, close the van doors, and walk around the right side of the van, stopping about halfway across the front of the van. After participant passes, get clear and remain clear for Loop 3 down. Once participant has passed over the bridge, set up for Loop 3 Up.

Prep for Loop 3 Up: RUN TO THE INTERSECTION! Set up detour signs on Vicki Lane and Ron Road, and make sure they are pointing in the correct direction. RUN BACK TO THE VAN! Split the first set of 6 cones into stacks of 3, move them into position to block the roadway (look for grey tape), and set up the detour sign. Place Roadkill in front of the van. Stand at the back of the van with the doors open, pretending to be working until the participant passes about halfway across the bridge. At that time, close the van doors, and walk around the right side of the van, stopping when you reach the front corner. Do not be in view of the participant when they pass- Roadkill is the intended target for this dilemma. Once the participant clears the van, quickly pick up all the cones starting behind the van and place them off the side of the road. Move the 6 cones in front of the van and the detour sign off the road, and put Roadkill back in the van. Knock over the cones/detour signs at Ron Road and Vicki Lane, and park the van on Vicki Lane outside the gate. Grab your radio, get in the Aurora and pull out into the intersection, stopping just past the light. Wait until the participant gets close to the intersection before slowly accelerating to 35mph in 2nd gear.

Loops 4, 5, and 6: drive the Contour up and down the road with the brake lights disabled, maintaining 35 mph. As you approach the intersection each time, watch for the stoplight to change to yellow, and watch in the rear view mirrors to see if the subject stops. If so, you need to stop as quickly as possible. Be careful to maintain speed and lane position, especially during these times. Throughout each turnaround, be careful not to get too far ahead of the participant. You do not need to maintain 35mph in the turnaround; slow down to a safe speed and make sure the participant is close behind you. After entering the top turnaround at the end of Loop 6, shift the vehicle back into “Drive” and accelerate through the turn. Put as much distance between you and the participant as is safely possible. Initiate the turn signal and turn left at the intersection onto Vicki Lane, parking the vehicle outside the gate.

Loop 7: Once the participant is clear, turn the van around and park it at the Vicki Lane gate. Sit in the van and relax until the participant finishes this loop.

Clean up: Wait until the participant passes through the intersection at the end of Loop 7. Dave will instruct the participant to pull over and stop the vehicle just past the intersection in order to do eye glance calibrations. At this time, you may enter the Smart Road and pick up all the cones and detour signs, loading them in the van. Turn off the intersection before exiting the road through Vicki Lane, and lock the gate behind you. Take down the cones blocking the entrance to Vicki Lane, and head back up to the parking lot. Erik will give you a ride back down to the Contour, and move it back to the parking lot as well.

When you reach the building return all keys to the proper places, and turn in your radio. Be sure not to leave any trash in the vehicles when you are done for the day.

APPENDIX G2: CONFEDERATE ON-ROAD PROTOCOL: ORDER 2

Drive the Contour down to the Vicki Lane gate: leave it parked there on the right side facing the Smart Road. Set up cones behind the vehicle, blocking that side of the road.

Load Van: 2 white cones, 2 grey cones, 21 orange cones, 3 detour signs (2 lefts, 1 right), 1 orange vest, Roadkill, 1 clipboard, 1 pen, and a radio.

Enter Smart Road and unload van:

- Put 2 sets of 2 orange cones topped with 1 white cone each and 1 detour sign (left) on Vicki Lane- lay them down.
- 2 sets of 2 orange cones topped with one grey cone each and 1 detour sign (right) on Ron Road- lay them down
- 1 orange cone to block the drive to the pump house gate
- Divide the remaining cones into 1 set of 6 and 2 sets of 3 and place them just off the side of the road, spaced evenly down the road. Place the remaining detour sign (left) with the first set of 6 cones (closest to the intersection).
- Set up stop sign at the start of the intersection where the grey tape is (the stop sign should already be laying flat on the side of the road).

Exit the Smart Road via Vicki Lane: Park the van on the left side facing the Smart road. Set up cones behind the van so that the entrance to Vicki Lane is blocked off. Wait until Dave radio's that he is ready for Erik in the Taurus, then enter the Smart Road leaving the Vicki Lane gate open.

Loop 1 down: Park the van in front of the stop sign to block the participant's view, with the front left tire of the van centered at the piece of grey tape. Make sure to turn on the hazard lights in the van. Pretend to be working while the participant passes- do not stare at them! As soon as the participant is clear from view, set up for Loop 1 up.

Loop 1 up: Take down the stop sign (lay it flat on side of road), and park van on right shoulder of road where the first detour sign will be. Make sure the hazard lights are still on. *DO NOT SET UP ANY CONES FOR THIS LOOP.* Stand at the back of the van with the doors open, holding a clipboard and pretend to be working until the participant passes about halfway across the bridge. At that time, close the van doors, and walk around the right side of the van, stopping about halfway across the front of the van. After participant passes get back in the van and wait for them to pass out of sight in the top turn around. At that time, exit the road through Vicki Lane and park the van outside the gate. Make sure to turn the hazard lights off! Get in the Contour and verify that the brake fuse has been pulled (circled in blue near the pedals). Pull out into the intersection, stopping just past the light. Wait until the participant gets close to the intersection before gradually accelerating to 35mph.

Loops 2, 3, and 4: Drive the Contour up and down the road with the brake lights disabled, maintaining 35 mph. As you approach the intersection each time, watch for the stoplight to change to yellow, and watch in the rear view mirrors to see if the subject stops. If so, you need to stop as quickly as possible. Be careful to maintain speed and lane position, especially during these times. Throughout each turnaround, be careful not to get too far ahead of the participant. You do not need to maintain 35mph in the turnaround; slow down to a safe speed and make sure the participant is close behind you. After entering the top turnaround at the end of Loop 4 up accelerate through the turn, putting as much distance between you and the participant as is safely possible. Initiate the turn signal and turn left at the intersection onto Vicki Lane, parking the vehicle outside the gate. Remain in the vehicle until the participant passes out of view. Once clear, get back in the van and wait.

Loop 5: Remain clear for this loop. Do not do anything to draw attention to you.

Loop 6: Once the participant has passes the bridge going down the hill, initiate emergency flashers and enter the road. Set up CONES ONLY on Vicki Lane and Ron Road. Leave the detour signs laying face down on the ground behind the cones. Park the van close to the center lane line, with the stack of 6 cones set up in front of it, the detour sign laying face down on the ground next to them, and the remaining 6 cones set up behind the van to close off the right lane (look for grey tape). Stand at the back of the van with the doors open, pretending to be working until the participant passes about halfway across the bridge. At that time, close the van doors, and walk around the right side of the van, stopping about halfway across the front of the van. After participant passes, get clear and remain clear until the participant has passed over the bridge. Set up for Loop 7.

Loop 7: Set up detour signs on Vicki Lane and Ron Road, and make sure they are pointing in the correct direction. If the wind is strong, place 1 stone on each stack of cones to weigh them down (usually prevents the signs from getting blown over). Get back to the van and split the first set of 6 cones into stacks of 3, move them into position to block the roadway (look for grey tape), and set up the detour sign (use stones if necessary). Place Roadkill in front of the van. Stand at the back of the van with the doors open, pretending to be working until the participant passes about halfway across the bridge. At that time, close the van doors, and walk around the right side of the van, stopping when you reach the front corner. Do not be in view of the participant when they pass- Roadkill is the intended target for this dilemma. Once the participant clears the intersection the in-vehicle experimenter will instruct the participant to stop so they can do eye glance calibrations. Begin clean up at this time.

Clean up: Pick up all the cones and detour signs, loading them in the van. Turn off the intersection (if summertime; during the winter leave it running so the batteries don't freeze) before exiting the road through Vicki Lane, and lock the gate behind you. Take down the cones blocking the entrance to Vicki Lane, and head back up to the parking lot. Erik will give you a ride back down to the Contour, and move it back to the parking lot as well.

When you reach the building return all keys to the proper places, and turn in your radio. Be sure not to leave any trash in the vehicles when you are done for the day.

APPENDIX H: ANOVA TABLES

TABLE H1: ANOVA TABLE FOR MEAN SPEED

Source of Variation	df	SS	MS	F	P
Age	1	1047.00	1009.52	12.15	<0.0001
Session	1	11.37	11.37	1.03	0.3113
Task	1	735.18	735.18	12.66	0.0006
Participants(Age)	82	4761.85	58.07		
Experience x Task	1	77.88	77.88	7.05	0.0085
Experience x Session	1	214.25	214.25	19.40	<0.0001
Experience x Session x Task	2	28.44	14.22	1.29	0.2779
Session x Task x Participants(Experience)	227	2506.48	11.04		

Note: Results that are in bold are significant at the 0.05 level or less.

TABLE H2: ANOVA TABLE FOR MEAN RANGE (ODOMETER TASK)

Source of Variation	df	SS	MS	F	P
Experience	1	347.24	347.24	2.32	0.1292
Session	1	20.81	20.81	0.14	0.7096
Task	1	29.06	29.06	0.04	0.8385
Participants(Age)	82	56721.60	691.73		
Experience x Task	1	1390.16	1390.16	9.28	0.0026
Experience x Session	1	502.48	502.48	3.36	0.0683
Experience x Session x Task	1	168.41	84.20	0.56	0.5707
Session x Task x Participants(Experience)	227	33992.90	149.75		

Note: Results that are in bold are significant at the 0.05 level or less.

TABLE H3: ANOVA TABLE FOR DRIVING-RELATED GLANCES

Source of Variation	df	SS	MS	F	P
Experience	1	0.08297	0.08297	10.65	0.0012
Session	1	0.05623	0.05623	7.22	0.0074
Task	3	0.49350	0.16450	8.06	<.0001
Participants(Experience)	82	1.67395	0.02041		
Experience x Task	3	0.04833	0.01611	2.07	0.1033
Experience x Session	1	0.00951	0.00951	1.22	0.2697
Experience x Session x Task	6	0.03590	0.00598	0.77	0.5951
Session x Task x Participants(Experience)	541	4.21346	0.00779		

Note: Results that are in bold are significant at the 0.05 level or less.