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OLDER DRIVER SIMULATOR BASED INTERSECTION TRAINING: THE EVALUATION OF TRAINING EFFECTIVENESS AND SIMULATOR SICKNESS

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OLDER DRIVER SIMULATOR BASED INTERSECTION TRAINING: THE EVALUATION OF TRAINING EFFECTIVENESS AND SIMULATOR SICKNESS

A Master's Project Presented

by

Craig A. Schneider

Submitted to the Graduate School of the

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AUGUST 2015

OLDER DRIVER SIMULATOR BASED INTERSECTION TRAINING: THE EVALUATION OF TRAINING EFFECTIVENESS AND SIMULATOR SICKNESS

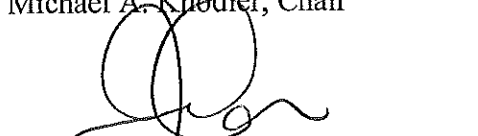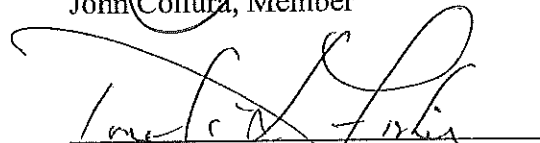A Master's Project Presented

by

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ABSTRACT

Older Driver Simulator Based Intersection Training: The Evaluation of Training

Effectiveness and Simulator Sickness

AUGUST 2015

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Older drivers are over involved in intersection crashes. The evidence to date suggests that this is primarily because they fail to look for potential threat vehicles after they enter a stop-controlled intersection. These secondary glances are absolutely critical when the built or natural environment obscures such vehicles while the driver is stopped before entering the intersection. Simulator-based older driver training programs exist which double the frequency of secondary glances that older drivers take up to two years after training. However, almost 40% of those who participate in such training never finish because of Simulator Adaptation Syndrome (SAS, or "simulator sickness"). Two factors are believed to contribute to the high simulator sickness rates: 1) the relatively high-immersion at each point in time and 2) the relatively long period of time over which the training occurs in the simulator. In this experiment, simulator micro-scenarios were designed to train older drivers to take secondary looks. These micro-scenarios take no more than 30 to 45 seconds to complete and are much shorter than the 20 minute training programs now available. In addition, level of immersion was varied, from relatively low

(the virtual world was projected onto three 22" diagonal LCD monitors) to medium (the virtual world was projected onto one to three 60" screens). A total of five groups of older drivers (91 total between the ages of 67 and 86) were run in the experiment. Three of the groups were given active, secondary glance training on a driving simulator -- one on a low-immersion simulator and two on a medium-immersion simulator (one group utilized all three screens and one group utilized only one screen) -- one of the groups was given passive, secondary glance training using a PowerPoint presentation and one of the groups received no training at all, control group. After the training was delivered participants in all five groups were evaluated in the field while driving alone in their own vehicle as they wore a head mounted camera. Secondary glances were recorded from the videos of the drives captured by the camera. The simulator training dropout rate was reduced radically from what has been reported in the literature (roughly 40%), to 14.3% in the three screen medium-immersion simulator, 6.3% in the one screen medium-immersion simulator and 11.8% in the low-immersion simulator. The percentage of secondary glances in the field increased significantly for the group given active, 3-screen medium-immersion simulator training (82%) above those given passive, PowerPoint training (69%) and those who received no training, control group (42%). There was no statistically significant difference between the group given active, low-immersion simulator training (74%) and the group given passive, PowerPoint training; however, statically significance exists between the three active training groups and the 1-screen medium immersion simulator training (58%). It is clear that the design of micro-scenarios in a lower immersion environment decreased simulator sickness and increased the frequency of secondary glances.

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CHAPTER 1: INTRODUCTION

Older drivers (65 years old and older) are becoming an increasingly larger percentage of the active driver population. This group is the fastest growing demographic in the United States. From 1993 to 2003, the senior population's growth rate has increased more than 15% of the total population (1). Since 2002 there are 19.9 million licensed older drivers, this population is projected to more than double by 2020 to 40 million as the baby boomer generation grows older (2). In 2010, more recent trends have shown that older drivers are expected to increase over 100% from 40.2 million to an estimated 88.5 million by 2050 (3). It is projected that the older driver demographic will account for more than half of the total increase in fatal crashes and about 40% of the expected increase in all crash involvement. By 2030, senior drivers are expected to account for as much as 25% of total driver fatalities, which is slightly more than double then their current total driver fatality percent, 14%. It is also expected that older drivers involved in police reported crashes will increases significantly, nearly 178% (4).

The number of crashes involving older drivers has increased per vehicle mile traveled (VMT) as the number of licensed drivers older than 65 has increased (5). This trend is especially true for those over the age of 70 as collisions per VMT begin to significantly increase (1). Crash rate per VMT for each age group resembles a positive parabolic curve, where younger drivers and older drivers represent each ends of the curve (*Figure 1*). This general trend has been proven in numerous studies (4; 6; 7; 8; 9).
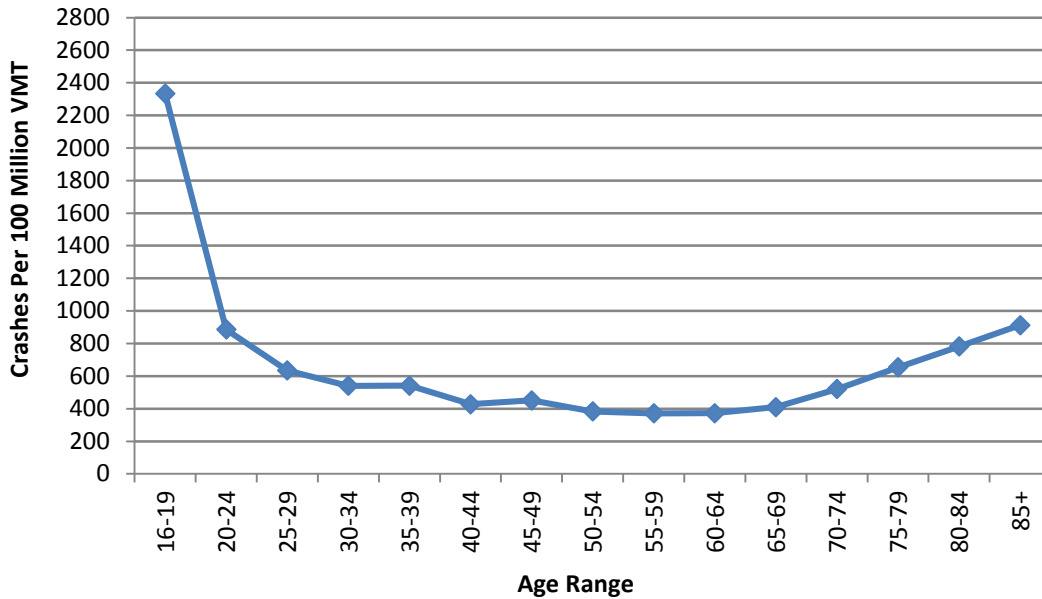
Figure 1: Accident Rate per VMT vs. Age Group Curve

Senior drivers, especially those between the ages of 75 and 79, are at a higher risk, approximately two to three times more likely, of being involved in crashes while driving when compared to senior drivers between the ages of 65 to 69 (1; 4; 8; 10). As crash frequency increases so does crash fatalities. Older drivers are nearly three times as likely to be killed in a crash due to drivers increased frailty as they age (4; 8).

Although there is research that describes the negative aspects of the older driver demographic on driver statistics and performance there are positive benefits in active training, specifically long term simulator training (6). Recent research has shown that the percentage of older drivers taking secondary looks, glances and scanning behavior that is exhibited after a driver enters an intersection, can be increased, thus decreasing angled impact crashes, by using active training strategies (6; 11; 12). However, simulator training has been conducted on high-immersion simulators and this has shown high dropout rates with the older population, 38%, due to Simulator Adaption Syndrome (SAS), also known as "simulator sickness" (13). There is a

need to investigate the use of simulator technology and the correlation between simulator fidelity and SAS. This research explores the effects of short-term simulator training with the use of less immersive simulator technology, medium and low immersion simulators, as it affects older drivers. The research conducted in this thesis outlines a methodology that was employed to evaluate the effects of three simulator training programs on driver performance and SAS. These results provided describe the nature of the relationship between active and passive training on driver safety as well as secondary glances.

1.1 Problem Statement

The older driver demographic is involved in more angled impact crashes than any other crash category, more than 50% of all total crashes. Angled crash totals vary for each age group within the older driver demographic: 54.0% of crashes for drivers aged 70-74, 51.8% of crashes for drivers aged 75-79 and 54.4% of crashes for drivers age 80 and older (7). This number is relatively high when comparing angled crashes to drivers between the ages of 25 and 59, which only account for 30% to 36%. Angled impact crashes are the only category to see a significant increase with age, whereas other crash categories, such as directional and single vehicle crashes, show a decrease with age (6). It is also reported that 44% of older drivers were noted to be unaware of the other vehicle before crash impact occurred (14). These scenarios occur during merges, left or right turns at intersections, turns cross-traffic that have the right of way and lane changes. Older drivers are at the highest crash risk when they are in situations in which hazards appear peripherally on either side of the vehicle (6).

Active training strategies engage the participants in the learning process, thus giving participants an opportunity to make an error, learn from the error and provide them an opportunity to practice the correct behavior. An example of an active training strategy that is

administered on a driving simulator is Simulator-Based Intersection Negotiation Training (Sim-INT). This training program was developed to improve secondary glance performance of older drivers after they have entered an intersection; however, SimINT training has a high dropout rate with 38% of participants experiencing SAS (6; 13). Previous research has shown the effectiveness of the SimINT secondary glances training, nearly a 100% increase, in those older drivers that were able to complete the training without experiencing the effects of SAS (11). Retesting two years later with the same participants showed that this form of training resisted extinction with a majority of drivers scanning at or near the same levels as two year prior (12).

The efficacy of low and medium immersion simulator training, when combined with SimINT, remains withdrawn from the current literature. This form of simulator training, coupled with micro-scenarios, could be an effective method in reducing the effects of SAS on the older driver population (micro-scenarios are defined as a scenario in which it takes no more than 30 to 45 seconds to complete the training scenario). Analysis on the benefits and effectiveness of this training has not been fully investigated, thus there is a need for exploring this impact on driver behavior. Specifically, there is a need to compare the frequency of secondary glances at intersections after older drivers received training. Lastly, the need to evaluate SAS before and after training as well as the effect of simulator sickness throughout time as training is administered.

1.2 Research Hypotheses and Objectives

Identified in the problem statement, the major goal of this research was to evaluate the impacts resulting from the use of low and medium immersion active simulator training. Inside the structure of this goal, a series of research hypotheses and objectives were created and outline.

Objective 1: Understand the effects that low and medium simulator immersion has on dropout rates. The hypothesis is that the decreased immersion and smaller field of vision will have increased effect on simulator sickness tolerance and thus it will have a lower dropout rate than the higher-immersion simulator, 38%.

Objective 2: Understand the effects of SAS symptoms before and after administering the active simulator training based on the type of simulator immersion. The hypothesis is that the lower the immersion and smaller the field of vision the effects of SAS symptoms will be diminished.

Objective 3: Understand the effects of simulator sickness throughout the administration of active simulator training based on the type of simulator immersion. It has been hypothesized that as participants become more comfortable with simulator training (the driving controls, visual flow and active training procedure) simulator sickness will affect the participant less over time; however, if the participant becomes uncomfortable, simulator sickness will increase rather rapidly.

Objective 4: Understand the effectiveness of different training procedures and how simulation immersion can play a role. It is hypothesized that active simulator training, with a higher level of immersion, will have a greater affect on secondary glance retention and driver performance. Whereas lower immersion active simulator training will have less of an effect and passive training, a PowerPoint presentation, will be the least effective.

1.3 Scope

Numerous factors are believed to influence peoples driving behavior and a glance technique, the purpose of this study is focused solely upon head movements and not peripheral vision. A secondary glance is defined as a glance or a look in which the participant exhibits head

movement after they enter and intersection. A primary glance is the glance or look in which the participant exhibits a head movement before they enter the intersection.

Note that all participants head movements were determined with the use of a field assessment, also known as a field drive, in which a headband camera was worn during the participants drive. Field drives were then blindly evaluated to determine training effectiveness.

CHAPTER 2 BACKGROUND

Concepts relating to both effective training methods and the reduction of simulation sickness have been the primary focus copious experimentation. Published literature was evaluated and complied to identify previous works related to the older driver population and these topics are presented within this chapter. This reviewed focused on three topics of interest: the effectiveness of active training, the effects and causes of simulation sickness and effective ways to reduce simulation sickness. The reviewed literature portrays the benefits of training programs and how they effectively improve driver behavior and safety for the older driver population.

2.1 Effectiveness of Active Training

Driving simulator are becoming an increasingly more popular research tool as they offer many advantages (such as reducing risk and negative consequences) when compared to on-road testing (15; 16; 17). These simulator-based experimentation allows insights into driver behavior through a wide range of various conditions that are nearly impossible to test for during on-road field assessments, which can be used for training purposes (6; 11; 12; 15; 16; 17; 18; 19; 20). Familiarity with the simulator is the key to the driving/training experience. Giving ample practice drives is essential to provide the user with more time to be comfortable and confident. If participants remain unfamiliar with the device than the realism will be lost from the experimentation as users will proceed with caution, less-confidence and anxiety (15).

Research has shown that active training methods are a more effective tool for all age groups, including children, when compared to more traditional passive training methods (6; 11; 21; 22; 23). The older driver population frequently seeks out knowledge, that they perceive as critical, to allow them to continue to function in modern day society (24). Many older drivers

explore training alternatives to help enhance their driving abilities. Traditionally, they refer to passive material such as videos, interactive CDs and workbooks (25). However, passive training methods provide no significant improvement for driver behavior. Active training when compared to passive training is a more effective strategy for raising awareness and improving driver behavior. Most adults have more effective and longer lasting results from active training methods as they provide the driver with personalized feedback (6; 11; 19). Older drivers have been able to focus on particular flaws (such as scanning behavior at intersections (26)) and drive safer by changing their scanning behavior through active training programs such as SimINT training (6; 13). After enough repetitions participants begin to incorporate these skills as a matter of habit and potentially extend the number of years in which they can operate a vehicle safely (6; 11; 13; 19; 18).

There are also psychological benefits that older drivers experience from lengthening their driving career. As older drivers increase their transportation mobility they avoid physical, cognitive and emotional deteriorate (6; 27; 28). Active training not only improves the participants driving behavior, but it creates a safer roadway for all users.

2.2 Simulation Sickness – Cause and Effect

Today most encounters occur due to simulators, virtual environments and video games, which create the illusion of motion that negatively affect operational responses among susceptive individuals (29). With the elimination of crash risks other risks becomes introduced, simulation and motion sickness (17). Motion sickness can occur during or after exposure to certain dynamic visual displays as a result of visually perceived motion, SAS or more commonly known as simulation sickness. This affect can take place even without the presence of inertial motion (30). Three general groups of effects are related to the symptoms in which they cause: nausea (N),

oculomotor (O) and disorientation (D). Nausea relates to gastrointestinal distresses (i.e. nausea, stomach awareness, salivation and burping), whereas oculomotor effects relate to visual disturbances (i.e. eyestrain, difficulty focusing, blurred vision and headaches). Lastly, disorientation relates to vestibular disturbances, such as dizziness and vertigo (31). Through a series of rating individual side effects (rated based on none, slight, moderate and severe) these 3 factors weighted scores are produce to evaluate overall sickness. This test is known as a Simulation Sickness Questionnaire, SSQ (31).

In a study in 2006 (32) analyses were conducted on 3 different types of simulators (2 types of flight simulators: fixed and rotary and 1 driving simulator) using SSQ profile data. Significant differences between simulators emerged with driving simulators producing the largest mean proportional disorientation score. The trend of O > D > N was revealed for driving simulators and it was noted that nausea scores were comparable across all simulators that were tested (32; 33). It was concluded that the SSQ scoring was a descriptive method for categorizing symptoms through various simulators with recurring profiles. A general consistency within simulators compared to between simulators regardless of training scenarios emerged, even with differences in scenario, based on the equipment tested. It was determined that it be possible to use the symptom subscales of SSQ to distinguish the various types of simulated environments based on the symptoms experienced by each participant over a vast set of exposures (32; 33).

Older adults tend to be more susceptible to simulator sickness than younger participants (6; 11; 17; 34). Simulator sickness may vary depending on the time of exposure and studies have shown that symptoms increase, from as little as 1 minute up to an hour, during exposure to the virtual environmental before returning to nominal levels approximately 15 minutes later (20; 35; 36). During this adaption period, some participants may become too ill and dropout. As a recent

study has shown by Brooks et al., 2010 the two contributing causes are gastrointestinal and central oculomotor effects (17). In regards to the effects of motion and simulator sickness there are four theories that contribute to the theory of why they occur. The most widely accepted theory is the Sensor Conflict Theory (37; 36) and Eye Movement Theory (38; 39).

The Sensor Conflict Theory states that conflict between or within the sensory systems, specifically the motion in which the participant sees and the motion that they are experiencing, causes motion sickness symptoms to become present and arise. Due to the conflicts between the structures within the vestibular system, which detect and perceive direction and the acceleration of motion, contribute to motion and simulator sickness (17; 37; 40). The second theory, Eye Movement Theory, suggests the motion and simulation sickness will occur when tension is created in the eye muscles caused by certain stimuli. These tensions are created by eye movements; specifically, the optokinetic nystagmus and vestibular ocular response movements (38; 39). Errors in these eye movements cause headaches, eye strain and difficulty concentrating. They come about in two ways: 1) the eye can no longer pursue an object any further, thus snapping back to the far side of the visual field where the eye begins to pursue again and 2) the vestibular ocular response which keeps the target object on the center of the retina, where vision is the sharpest. The response causes the eye to rotate in the opposite direction of the head when it is moved (38; 39).

In Brooks et al., 2010 study 15 participants (9 males and 6 females) over the age of 65 dropped out due to simulator sickness. Of the 15, 11 participants progressively felt worse as training progressed, while 4 suddenly experienced a high severity of symptoms causing them to dropout (17). The experiment concluded that older drivers possibly dropout out due increased number of balance and dizziness problems that are experienced with aging. This can be caused

from the clogged or narrow ear canals, posterior cerebral circulation strokes or the simple loss of positional sense (17; 41).

2.3 Ways to Reduce Simulation Sickness

User comfort during simulated driving is one of the most important factors, this is because reduced comfort can alter behavior, confound data, limit training effectiveness and increase dropout rates (17; 35; 42; 43). Many participants experience discomfort during and sometimes after using the driving simulator (13; 17; 20; 32; 33; 35; 36; 42). In a recent study conducted by Jäger et al., 2014 3 treatment methods yielded positive results in reducing simulator sickness. These 3 treatment methods were combined together on a medium-immersion simulator to create the affects of a "low-immersion" simulator (Figure 2). These 3 treatment methods are as follows: 1) scene optimization, reducing the optical flow, 2) superimposing of an Independent Visual Background (IVB), a stable background point of reference, to provide visual motion and orientation cues that match those from the vestibular responses and 3) a decrease in screen brightness of the lateral projection to further reduce optimal flow (36).

Figure 2: Screenshots of Medium-Immersion (upper image) and "Low-Immersion" scenes (bottom image)

The overall effectiveness was evaluated with the use of SSQ scores and the effect was plotted overtime as the experiment lasted 10 minutes. The results suggested that the reduction in scene complexity presumably influenced driver performance (36). A study by Jones, Kennedy & Stanney, 2004 concluded a similar observation: that changes in the simulation scene content may affect the likelihood and severity of simulation sickness; however, it is important to note that each participants responds differently (44). The Jäger et al., 2014 study did conclude that the decrease in screen brightness was a contributing factor in avoiding flicker perception, which is linked to simulator sickness. However, since the 3 treatment methods were tested in combination with one-another it is hard to deduce which treatment of the three is the most influential. These treatments may improve user comfort and decrease dropout rates; however, the mean age of participants was 27.7 years so its affect on the older driver, 65 years and older, is inconclusive (36).

An effective approach to reducing the symptoms of simulator sickness in the older driver is implementing the use of adaption, as known as time delay. Studies have shown a decrease in simulator sickness symptoms with repeated exposure within and between days (45; 46; 47; 48). The reduction in symptoms due to time delay between simulator sessions has been shown to resist distinguishing effects up to a month or longer (45). Symptoms of simulator sickness have been shown to decrease over a period of 10 days of simulator exposure with a session on each day (46). SSQ scores have been shown that older adult participants (65 – 84 years old) adapted to simulation over sessions; furthermore, after the fifth session older drivers' SSQ scores did not differ between the initial baseline conditions in a high-immersion simulator (47).

Group	Session 1				LAG DAY	Session 2			
Lag n = 48	RSSQ C1	Acclimation	RSSQ C2	Cognitive Testing		RSSQ D3	Acclimation	Driving Testing	RSSQ D4
Immediate n = 47	RSSQ D1	Acclimation	Driving Testing	RSSQ D2		RSSQ C3	Acclimation*	RSSQ C4	Cognitive Testing

C = computer session; D = driving session

*This acclimation did not include the auto-drive and cruise control scenarios, so was somewhat shorter than the corresponding computer-session adaptation in the Lag group.

Figure 3: Adaption Order of Tasks and RSSQ Administration by Session & Group

When using the revised SSQ (RSSQ) scores on the older driver population for a 2 day testing the results were similar to previous research (46; 47; 48). Of the 40 older drivers (60 – 90 years old) tested in the Domeyer et al., 2013 study, 12 older driver participants dropout due to simulator sickness symptoms during the adaption process (Figure 3). This high-immersion simulation (Figure 4) test showed that severity scores decreased through time; however, nausea scores did not. The results of the experimentation partially supported the notion that simulator sickness is related to the participant's level of experience with the simulated environment (48).

Figure 4: Domeyer et al. High-Immersion Driving Simulator

Shortened adaptation simulator schedules are a possible surrogate for driver assessment and post-assessment remediation of driver performance deficits. Specifically, when a driver's safety behind the wheel is questioned, the use of field assessment would be unadvisable (48). Overall the use of simulator training/testing may help reduce the numbers of crashes involving older drivers, thus reducing injuries, fatalities and the costs associated with them (6; 11; 18; 19; 48).

Further research is warranted to expand upon this section of the literature review; the following research represents contributions to the reduction of simulator sickness in the older driver population and the impact of training efficiency due to the degraded field of vision and simulator immersion.

CHAPTER 3 METHODOLOGY

As briefly touched upon in the literature review, the quality of life for older drivers is directly related to their ability to drive. In the United States, we as a nation/culture, are very car-centric and have designed our way of living around the use of the automobile. European nations have taken a rather different approach and have a much more walkable environment. One could walk to a café, grocery store, church and a friend's residence all within close proximity of their own house. The latter has more dependency on the automobile for aiding daily activities, needs and care. For older drivers having to give up driving has significantly bad effects on their quality of life. Depression and the rapid deterioration of their cognitive abilities are just two negative consequences that the elderly face after surrendering their license (28).

Through experimentation we have seen positive strides in simulator-based training especially for older drivers. There have been positive results and attitudes towards simulator-based active training within the older driver community (6; 11; 12; 19; 18). However, there is a need to explore the effects of lower immersion (low and medium immersion) simulators and micro-scenario training on the older driver community. This training program outlines the details of the two sessions, two and a half week, regiment that addresses the objectives and evaluates the established hypotheses.

2.4 Participants

A total of 91 older, licensed driver (42 males, M_{age} = 75.8 years, $Range_{age}$ = 67-86 years) participated in this study (Figure 6). Participants were recruited from local retirement centers, the older and retired facility/staff population of the University of Massachusetts, Amherst campus and western Massachusetts area volunteers (Figure 5).
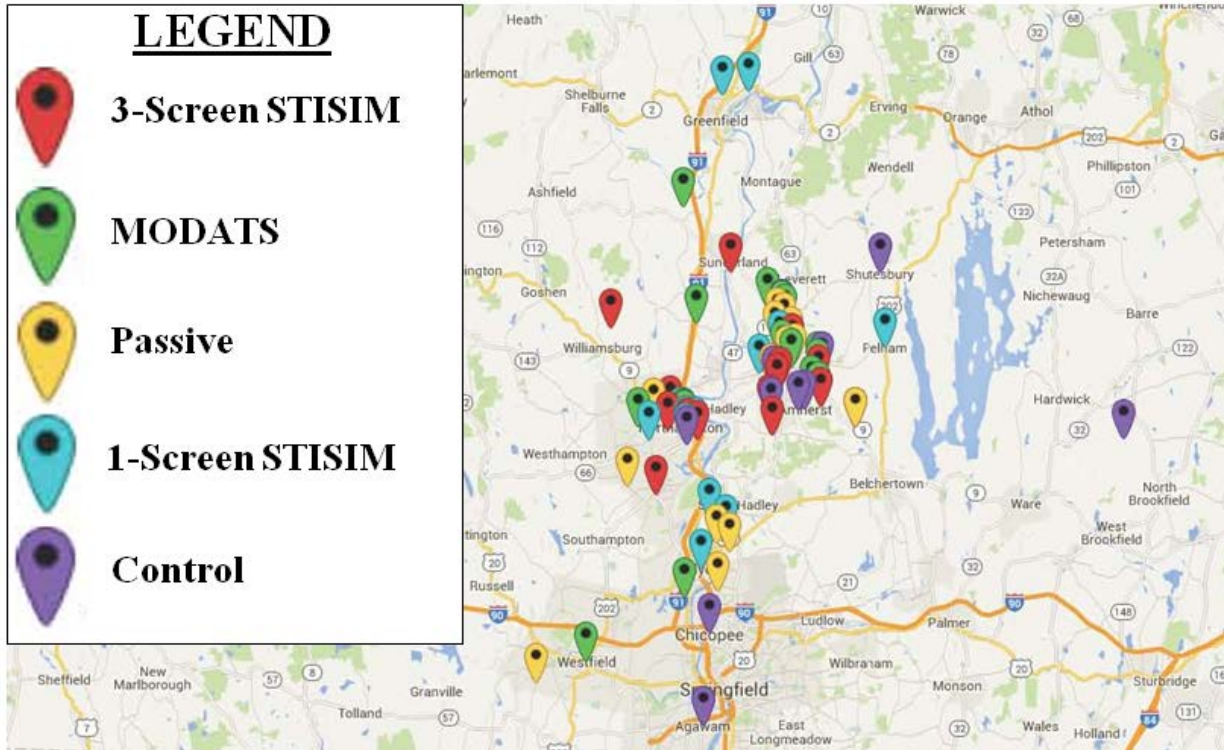
Figure 5: Participant Locations Throughout Western Massachusetts

Participants were recruited with the use of internet postings, flyers, word-of-mouth, mailings and emails. For their help in this research participants were compensated $75 for their participation, if both sessions were completed. If any participants aborted the experiment due to simulator sickness or for any other reason, they were compensated $25. Control group participants were compensated $40 since they were only completed one session rather than two. All study protocols were approved by the Institutional Review Board (IRB).
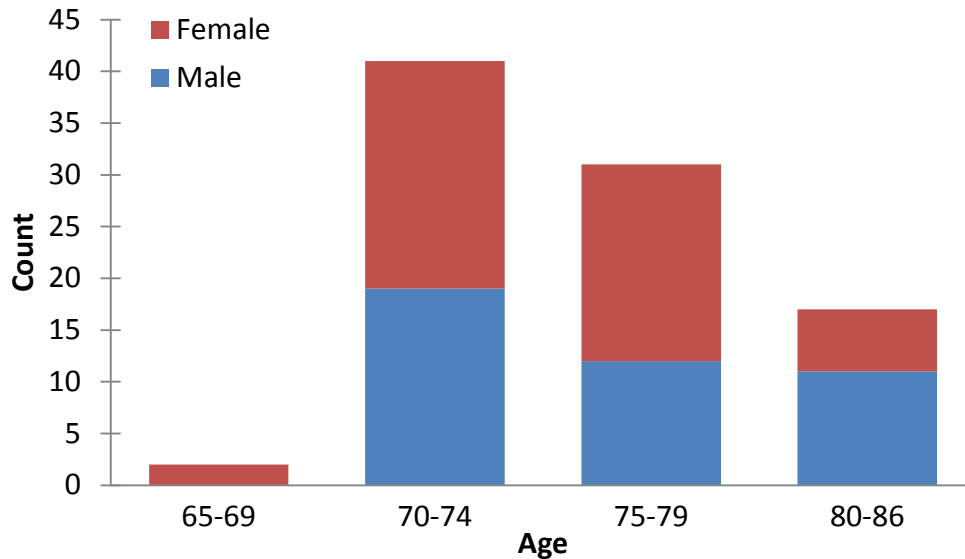
Figure 6: Breakdown of Participant Age & Gender

2.5 Driving Simulators and Equipment

Three groups used active simulator training combined with micro-scenario: 1) MODATS (Mobile Older Driver Assessment and Training Simulator) group (low-immersion), 2) STISIM (Systems Technology, Inc Simulator) 3-Screen group (medium-immersion) and 3) STISIM 1-Screen (medium-immersion).

3.2.1 MODATS Simulator

MODATS is a portable, desktop/chair-like, medium fidelity, relatively inexpensive driving simulator system, compared to other simulators, used in older driver assessment and training (Figure 7) purchased from STI and built for our particular purposes (mobility, among other things). It consists of a Dell Precision T3600 desktop PC and three display monitors (22 inch, 1680 x 1050 pixels) giving a 150º horizontal field of view. Driver controls include a Fanatec Porsche 911 GT3 RS V2 Wheel and a ClubSport Pedals V2. Note that the participant can almost see all of the room when seated at the controls (thus, the characterization as low-immersion).

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Figure 7: MODATS Low-Immersion　　　　　　*Figure 8: STISIM 3-Screen Medium-Immersion*

3.2.2　STISIM Simulator

The STISIM (STI) simulator operates across three different computer channels denoted as left, center and right. These channels operate in parallel in order to produce driving images projected with a resolution of 1024 by 768 pixels and these images are generated at 30 Hz. The images produced by the three computer channels are presented on three 60" screens by three short throw HITACHI PC-A100 projectors. The screens cover up to 160º of horizontal visual angle with respect to the participant. The chassis and cab environment consists of a build-up cab that has an adjustable seat, a wheel to steer and pedals to accelerate and brake. Lastly, a sound system is incorporated to create sounds similar to the driving environment (Figure 78). Note that the three screens occupy almost half of the participant's field of view here (thus, the characterization as medium-immersion). For the group 2, STISIM 3-Screen, all three channels were enabled and the image was projected to display all 160º of view. For group 3, STISIM 1-Screen, all three channels were enabled; however, the image was only projected on the center screen to display only 100º of view. To switch between left and right views, thus simulating head movements when driving, drivers hit a button to toggle these displays onto the center screen.

2.6 Driving Scenarios

All scenario graphics were generated using STISIM Drive® software. MODATS and STISIM simulators used STISIM v2.08 to retain training continuity with prior work (11). A total

of 17 micro-scenarios (1 practice, 8 pre-test/training, 8 post-test) were designed for this study and they were modeled after individual SimINT scenarios. The micro-scenarios took anywhere between 30 and 45 seconds to complete. Auditory and graphic turn instructions were added to relay navigation instructions. Once the secondary glance opportunity towards a hazard point was passed and/or drivers completed a movement (e.g., an intersection turn) the scenario automatically paused. The eight pre/post-test/training micro-scenarios were categorized into four different types of intersection families as described below and shown in Figure 9.

3.3.1 Scenario Family A

- Scenario A1: The driver was instructed to turn right at the T-intersection (see Figure 9). A parked bus on the near left corner obscured potential cross-traffic. A secondary glance was needed towards the left prior to turning. Distance travelled: 300 feet.

- Scenario A2: The driver was instructed to turn left at the T-intersection. Bushes and a curved road on right obscured potential cross-traffic. A secondary glance was needed towards the right prior to turning. Distance travelled: 200 feet.

3.7.2 Scenario Family B

- Scenario B1: The driver was instructed to continue straight at the intersection. A curved road and buildings obscured potential cross-traffic. A secondary glance was needed towards the left and right. Distance travelled: 220 feet.

- Scenario B2: The driver was instructed to continue straight at intersection (Figure 9). A curved road and bushes obscured potential cross-traffic. A secondary glance was needed towards the left and right. Distance travelled: 220 feet.

3.7.3 Scenario Family C

- Scenario C1: The driver was instructed to turn left at a signalized intersection. A curved road ahead obscured potential oncoming traffic. A secondary glance was needed towards the oncoming lane prior to turn. Distance travelled: 200 feet.

- Scenario C2: The driver was instructed to turn left at signaled intersection (Figure 9). A hill dropping road ahead obscured potential oncoming traffic. A secondary glance was needed towards the oncoming lane prior to turn. Distance travelled: 300 feet.

3.7.4 Scenario Family D

- Scenario D1: The driver was instructed to continue straight through an intersection using the right travel lane. A large vehicle stopped in left travel lane obscured a potential pedestrian. A secondary glance was needed towards the left. Distance travelled: 600 feet.

- Scenario D2: The driver was instructed to continue straight (Figure 9). A large vehicle parked on right obscured a potential pedestrian. A secondary glance was needed towards the right. Distance travelled: 570 feet.
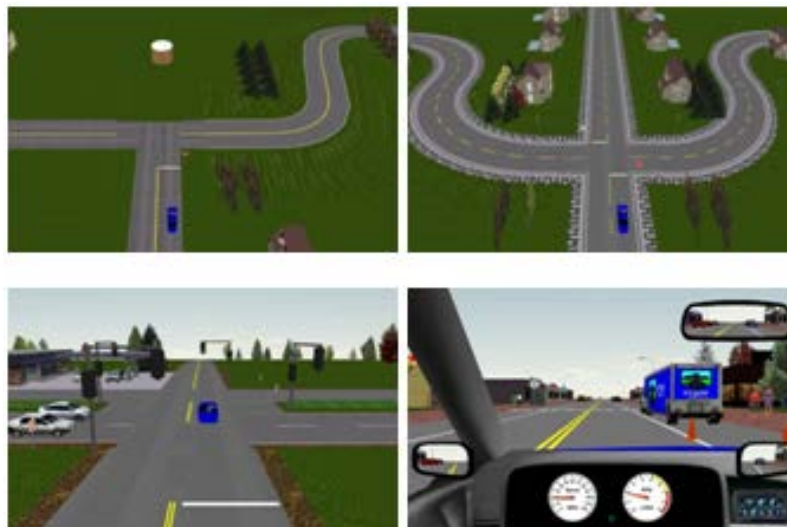
Figure 9: Micro-Scenario Examples Clockwise Top Left to Bottom Left– Family A: Scenario A1, Family B: Scenario B2, Family D: Scenario D2, Family C: Scenario C2

2.7 Head Mounted Camera

All simulators included a head camera (640 x 480 pixels) with a headband for recording where the driver was looking (Figure 10). Eye movements were inferred from large head movements, which were almost always needed at intersections. This head mounted camera was also used in the field assessment to evaluate secondary glances after training was completed.

Figure 10: A Participant Wearing the Head Mounted Camera

2.8 Training Curriculum

Training was conducted under the guidance and feedback of a trained experimenter. Active training proceeded in order by scenario Family A to D. For each scenario family, training included: 1) an instructional narrated video of the scenario using different perspectives (top down, driver) highlighting the potential hazard and correct secondary glance behavior (lasting 3 to 4 minutes), 2) a head camera video replay of the pre-test scenario, 3) repeat of the pre-test scenario on the simulator to correct/confirm correct glance behavior, 4) practice with the second scenario in the family not initially presented at pre-test, and 5) repeat of the last scenario as needed. For scenario Family B, no instructional video was provided since the materials resembled the lesson for scenario Family A. The passive training group listened to a PC narrated series of PowerPoint slides (26 total) covering the same material as seen in the instructional videos with various statistics and examples. The key difference between the active and passive

training programs was that the passive group was not able to practice these skills in the laboratory on a driving simulator. A control group was run with no prior exposure to any training material that was presented for both active and passive groups.

2.9 Experimental Design

There were 4 training groups: 1) MODATS group (low-immersion; full training), 2) Systems Technology, Inc. Simulator (STISIM) 3-Screen group (medium-immersion, full training), 3) STISIM 1-Screen group (medium-immersion, full training) and 4) a passively trained group (PowerPoint presentation; full training). A fifth group was run as a Control group (no training, 1 session). The number of participants assigned to the groups and related demographic information is displayed in Table 1. Half of the participants received Scenarios A1, B1, C1, D1 as pre-test drives while the other half received Scenarios A2, B2, C2, D2. It is important to note that the pre-test scenarios were presented in a random order. The post-test scenarios presented the remaining half of the scenarios that were not received in pre-test drives immediately followed by the other half of the scenario's family (e.g., if A1 is received for pre-test scenario then post-test would be in order A2 followed by A1). The training scenarios, as indicated above, were always presented in the order A, B, C, and D.

Table 1: Training Groups, Stimulatory Immersion and Sample Sizes

Treatment Groups	Driving Simulator Immersion		Sample Sizes						
	Session 1	Session 2	Sex		Age Groups				Total
	Training	Post-Test	M	F	65-69	70-74	75-79	80-86	
MODATS	Low	Field	9	8	0	10	6	1	17
STISIM 3-Screen	Med	Field	10	11	0	11	8	2	21
STISIM 1-Screen	Med	Field	8	8	0	8	4	4	16
Passive	---	Field	6	12	0	9	6	3	18
Control	---	Field	9	10	2	6	6	5	19
			42	49	2	44	30	15	91

2.10   Procedure

The experiment consisted of two sessions with each participant: 1) a training session in the Arbella Insurance Human Performance Laboratory (HPL) at University of Massachusetts, Amherst and 2) a field assessment/drive in which participants drove their own vehicle to a familiar destination (e.g., grocery store, church, etc.) located approximately 15 minutes away then returned home (total travel time 30 minutes). However, the control group consisted of one condensed session with each participant, which combined the pre-screening assessments with the field assessment.

3.7.1   Session 1

All participants were initially screened for physical, visual and cognitive impairments. Screening tests included: Mini-Mental State Examination (49), Trail-making A & B, Snellen Visual Eye Chart, and a Get-Up-&-Go Test. A pre-training questionnaire was administrated to collect basic medical background, driving history and self-assessments in driving ability for the study.

For the active training participants, specific SAS symptoms were measured using the SSQ (31) prior to any simulator exposure and at the conclusion of Session 1. In addition, after each micro-scenario practice drive, pre-test drive, and training drive participants rated general SAS symptoms using a 7-Point Rating Scale (SS-7) that used pain facial icons that depict increasing states of distress: 1=no symptoms, 7=severe symptoms. Normalized values: 1=none, 1-1.5=slight discomfort, 1.25-2=moderate discomfort, 2-3=significant discomfort, 3+=severe discomfort.

The active training participants were then shown the relevant driving simulator (either MODATS or STISIM). Once the participants made themselves comfortable, the practice drive

was enabled and they were shown how to exaggerate head movements properly, thus demonstrating a secondary glance. Multiple practice drives were presented as required until the participants felt comfortable with the simulator and its controls. The practice drive was designed to familiarize participants with simulator displays, simulator controls, and the environment. Participants practiced one left and one right turn which lasted 2 to 3 minutes. The subject traversed a distance of 0.4 miles with 3 stop-controlled intersections.

Active training participants were then asked to navigate the four pre-test drives (one from each scenario family) assigned to them. Secondary glance performance was manually recorded by the experimenter with no performance feedback provided to the participants. After the pre-test scenarios, the training curriculum was provided and SSQ was collected after training was completed. The total time for Session 1 for the active training participants lasted 1.5 to 2 hours for each participant.

After the screening and pre-training questionnaire were completed, the passive training participants were seated in front of PC and the PowerPoint presentation would commence. Participants received similar material, as seen in the active training instructional videos, with various statistics and applicable secondary glance examples. The total time for Session 1 for the passive training lasted between 0.75 to 1 hour for each participant.

3.7.2 Session 2

After 2 to 3 weeks ($M_{session}$ = 2.78 weeks, SD = 1.40), the second session was conducted. A technician would travel to each participant's house of residence to conduct a post-training field assessment. All participants (both those receiving active training and those receiving passive training) drove their own vehicles unaccompanied to a familiar destination that they drove to with regularity, which involved numerous right and left turns, thus having an opportunity to

exercise the secondary glance scanning behavior as learned in training. All participants were fitted with a head mounted camera to track head movements while driving (it is important to note that the camera only recorded visuals and not audio for privacy concerns). After the field drive was completed a post-training questionnaire was administered. Participants were then debriefed, compensated for their participation ($75) and excused. The total time for Session 2 lasted .75 hours for each participant.

3.7.3 Control Group

Participants were able to complete their portion of the experiment in one through session. This session consisted of aspects presented in session 1 and session 2. The technician would drive out to each participant's house of residence and conduct screening tests. These tests are the same as noted above (Mini-Mental State Examination (49), Trail-making A & B, Snellen Visual Eye Chart, and a Get-Up-&-Go Test) followed by a pre-training questionnaire and consent form. After these tests were completed and the participant was deemed fit the field assessment was then conducted. All control participants drove their own vehicle, unaccompanied, to a destination that was familiar to them and that they drove to with regularity. The participant was instructed to drive as they normally would and then fitted with a head mounted camera to track head movements white driving (again, the camera only recorded visuals and not audio for privacy concerns). After the field assessment was completed participants were then debriefed, compensated for their participation ($40) and excused. The total time for each control session lasted 1 hour to 1.5 hours.

2.11   Field Assessment Video Scoring

After all drivers were completed, field videos were analyzed by the experimenter. The experimenter was blind to which group a driver had been assigned. The videos were manually scored for each participant up to a maximum of 25 secondary glance maneuvers during the

participant's field drive. For each possible secondary glance the maneuver type (1-7) and compliance were recorded (0 or 1). The maneuver types were recorded as 1) Right Turn Merge, 2) Left Turn Merge, 3) Left Turn at a Light, 4) Right Turn at a Light, 5) Straight Away, 6) Left Turn Across Traffic (a non-protected left turn or passive-permissive green light indication), and 7) Merge (highway merge or a dedicated right turn lane merge). The compliance was measured in terms of binary elements: 1) yes/obeyed and 0) no. Figure 11 shows a subject approaching a stop sign at a T-Intersection making a left turn merge (maneuver type 2). This frame-by-frame image, depicted left to right and top to bottom, shows how the driver came to a complete stop and then the scanned in both directions. After scanning both left and right while stopped, primary glances, the driver made a quick glance back against traffic as they inched out into the intersection, a secondary glance, before they started their left turn merging into the perpendicular street.

Figure 11: Frame-by-Frame Depiction of a Left Turn Merge at a Stopped Controlled Intersection

In Session 1 data was collected that was used to measure the prevalence of SAS symptoms (pertaining to dropout rates, SSQ and SS-7 Point Scale) during the administration of training (Groups 1 – 3). In Session 2, and Control Group, data was collected which could be used to evaluate the effectiveness of training in the field assessment. A total of 91 participants were evaluated during training with a total of 78 complete evaluations.

4.1 Dropout Rates

Session 1 dropout rates due to SAS symptoms from pre-test and training scenarios varied. Participants exposed to the medium-immersion with all three displays engaged (STISIM-3 Screen simulator) had a 14.3% (3/21 participants) dropout rate while the low-immersion MODATS simulator had an 11.8% (2/17 participants) dropout rate. Lastly, participants exposed to the medium-immersion with only one screen of vision (STISIM-1 Screen simulator) had a 6.3% (1/15 participants) dropout rate. A Chi Squared Analysis was performed to determine the significance of the dropout rates. Dropout rates were not statistically different from one another: $\chi^2(2) = 0.6045$, $p < .25$. However, all were significantly lower than the dropout rates observed in Romoser & Fisher (2009; 38%): MODATS versus Romoser & Fisher (34 dropout, 54 pass) -- $\chi^2(1) = 4.566$, $p < .05$; STISIM 3-Screen versus Romoser & Fisher -- $\chi^2(1) = 4.483$, $p < .05$; STISIM 1-Screen versus Romoser & Fisher -- $\chi^2(1) = 6.360$, $p < .01$ (Table 2).

Table 2: Chi Squared Analysis for Dropout Rates - (Chi Square Value, P-Value)

	MODATS	STISIM-3	STISIM-1	Romoser & Fisher 2009
MODATS	--	X2(1) = 0.052254, p< 0.25	X2(1) = 0.303309, p< 0.25	*X2(1) = 4.566235, p< 0.05*
STISIM-3	--	--	X2(1) = 0.608157, p< 0.25	*X2(1) = 4.483481, p< 0.05*
STISIM-1	--	--	--	*X2(1) = 6.359797, p< 0.01*
Romoser & Fisher 2009	--	--	--	--

4.2 Simulator Sickness Questionnaire (SSQ)

A simulator group (3: Low, Med-3 & Med-1) x time (2: baseline, post-training) mixed design ANOVA was performed for SSQ total scores from non-dropout participants, $n = 48$, $\alpha = .05$. No interaction ($p = 0.770$, F = 0.260) or main effects for time ($p = 0.258$, F = 1.29) or simulator group ($p = 0.885$, F = 0.120) were found. For participants that completed the Session 1 training, SSQ total scores indicated that symptoms were generally low with no differences between simulator immersion groups (Figure 12). Similar results were found when SSQ scores were analyzed based on nausea, oculomotor and disorientation symptoms.
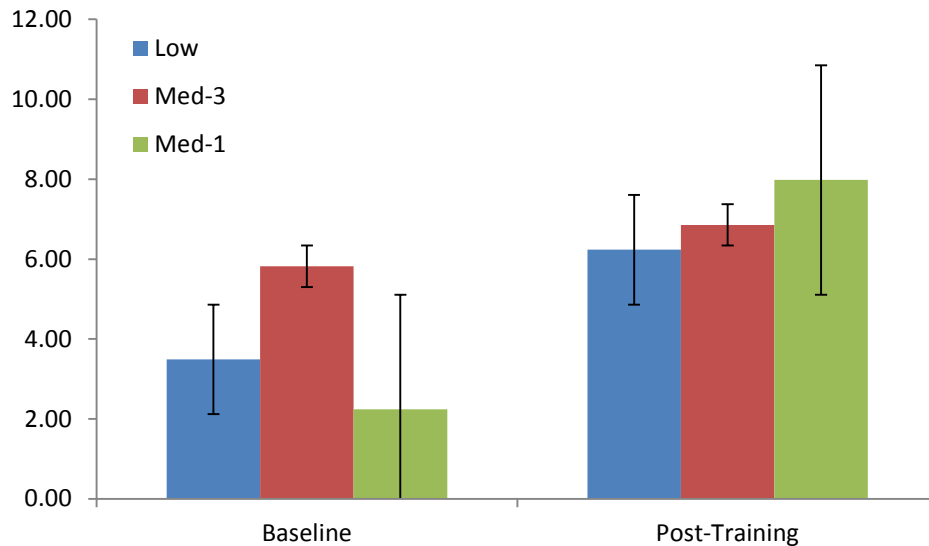
Figure 12: Mean SSQ Total Scores with 95% CIS By Immersion

As seen in Figure 12 each simulator group shows an increase in SAS symptoms from before the training starts to after it is completed. The 3-screen medium-immersion, STISIM-3 Screen, simulator group shows the smallest increase between groups, 1.039 SSQ point increase. Whereas the low-immersion, MODATS, simulator group shows a larger increase of 2.730 SSQ points. The most notable change is the drastically high increase, 5.735 SSQ points, for the 1-screen medium-immersion, STISIM-1 Screen, simulator group. The Estimated Marginal Means

were graphed to verify that there was no interaction between simulator groups (Figure 13). It was interesting to see that the 1-screen medium-immersion, STISIM-1 Screen, simulator group crossed both the low-immersion and 3-screen medium-immersion simulator groups; therefore, the figure depicted a statistically significant an interaction between training groups.
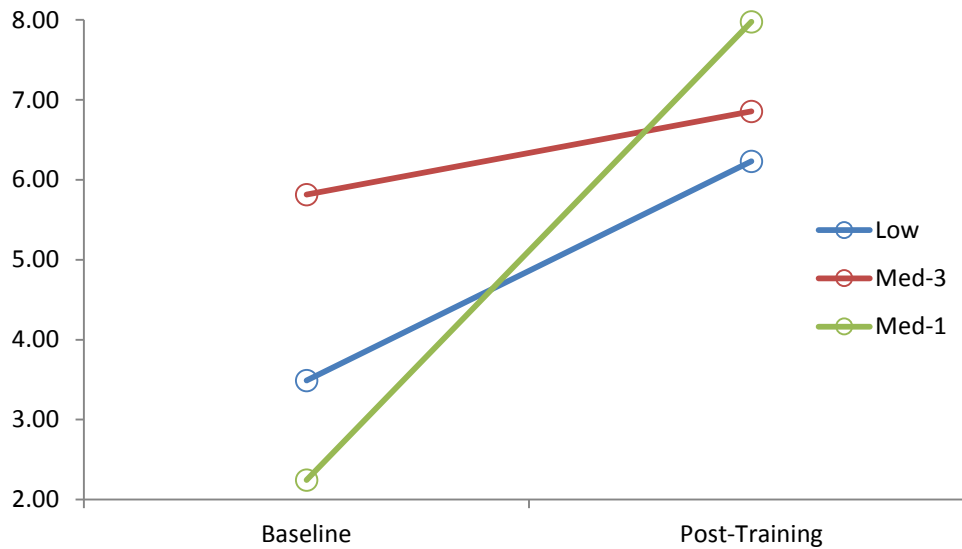
Figure 13: Estimated Marginal Means for SSQ Scores

After reviewing the data it was noticed that the 1-screen medium-immersion, STISIM-1 Screen, simulator group had a hyper-sensitive user. Outliers have a negative effect, which distort the differences between the relating groups, on mixed ANOVA analysis so this participant was removed from the sample set. The assumptions for ANOVA were checked before analyses were rerun on the data set. The data set was determined to contain independence within and between samples based on the experimental methodology and followed a normal distribution. However, this data set did not have equal variances and was determined to be heterogeneous. Levene's test of equality of error variances was conducted to verify this trend: Baseline ($p = 0.019$, F = 4.362) Post-Training ($p = 0.041$, F = 3.443). Since this mixed ANOVA analysis is being run between-subject and within-subjects with unequal sample sizes there is substantial error that can occur. To

reduce false conclusions and Type I error, the variances were stabilized between groups with the use of data transformation.

Originally logarithmic transformations were applied to the data set since this method is applied to measured data; however, the results again concluded unequal variances, heterogeneity. The Box-Cox power transformation was applied to homogenize the data set. Please note that Box-Cox requires values no less than 1 for the transformation to apply, thus SSQ scores were adjusted accordingly. Box-Cox transformations for both Baseline and Post-Training SSQ scores produced an adjustment $\lambda = -1$, thus each sample set was adjusted by raising it to the power of -1. Mauchly's test of sphericity was determined to be nonsignificant thus satisfying our assumed condition of homogeneity, normally only applies when there is more than 3 factors. Also, Levene's test of equality of error variances produced no statistically significant results: Baseline ($p = 0.085$, F = 2.611) Post-Training ($p = 0.055$, F = 3.107).

Afterwards, a mixed design ANOVA was rerun on the Box-Cox transformed SSQ scores, $n = 47$, $\alpha = .05$. No interaction ($p = 0.693$, F = 0.157) or main effects for time ($p = 0.230$, F = 1.52) or simulator group ($p = 0.210$, F = 1.62) were found (Figure 14). Two groups, low-immersion and 1-screen medium-immersion, experienced an increase in SSQ total scores. The greatest change is means occurred in the low-immersion, MODATS, simulator group, 0.0507 SSQ point increase. The 3-screen medium-immersion, STISIM-3 Screen, simulator group was the only group to experience a decrease in simulation sickness, 0.0433 SSQ total score points. The 1-screen medium-immersion, STISIM-1 Screen, simulator group had the smallest change in symptoms throughout the training program, 0.0175 SSQ point increase.
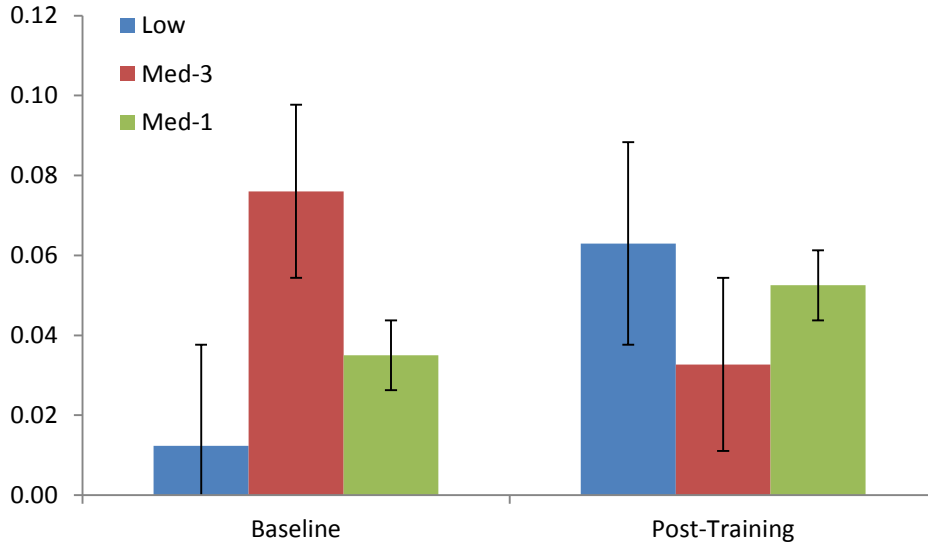
Figure 14: Box-Cox Mean SSQ Total Scores with 95% CIS by Immersion

The Estimated marginal means were again graphed to verify no interactions between simulator treatments or main effects occur (Figure 15).
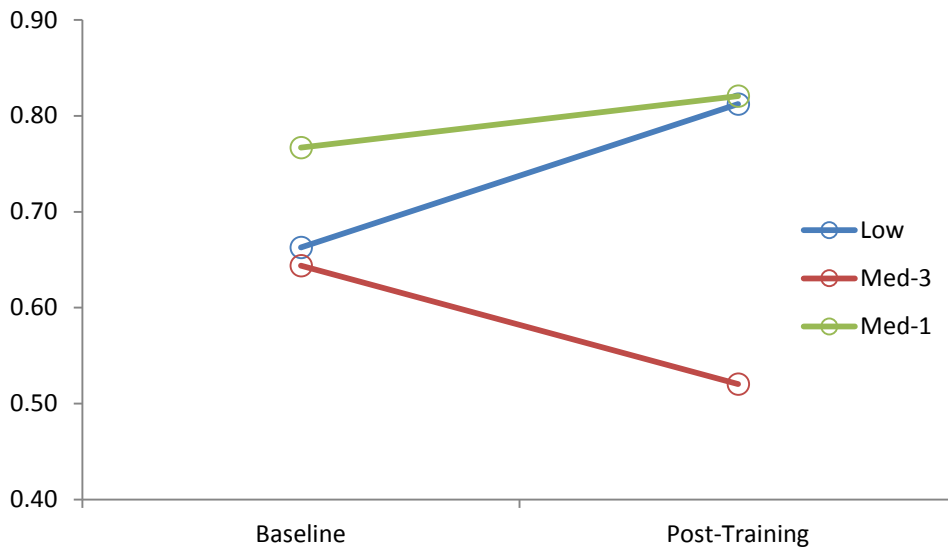
Figure 15: Box-Cox Estimated Marginal Mean for SSQ Total Scores

A Bonferroni correction Post-Hoc analysis was conducted to test for comparisons between treatment groups (MODATS, STISIM-3 Screen and STISIM-1 Screen) and time (Baseline and Post-Training). However, there was no statistical significant between treatment

groups (Table 3) and time (p = 0.693 for both factors). Tukey-Kramer Post-Hoc analysis was conducted, used instead of Tukey's HSD due to the difference in group sizes, to determine whether treatment groups within the data set vary across time. All treatment groups were not statically significant and are different from one another (Table 3).

Table 3: SSQ Treatment Group Comparisons- Bonferroni and Tukey-Kramer

		Bonferroni	Tukey-Kramer
Treatment	Mean Difference	P Value	P Value
MODATS – STISIM-3	0.155	0.627	0.416
STISIM-1 - MODATS	0.056	1.000	0.902
STISIM-1 – STISIM-3	0.212	0.287	0.216

4.3 SS-7 Point Scale

A simulator group (3: Low, Med-3 & Med-1) x time (13: 1 practice, 4 pre-test, 8 training) mixed design ANOVA was performed for SS-7 Point Scale scores from non-dropout participants, n = 48, α = .05. No interaction (p = 0.612, F = 0.910) or main effects for time (p = 0.059, F = 1.640) or simulator group (p = 0.886, F = 0.120) were found. Similar to SSQ results, SS-7 Point Scale ratings remained relatively low (Figure 16).
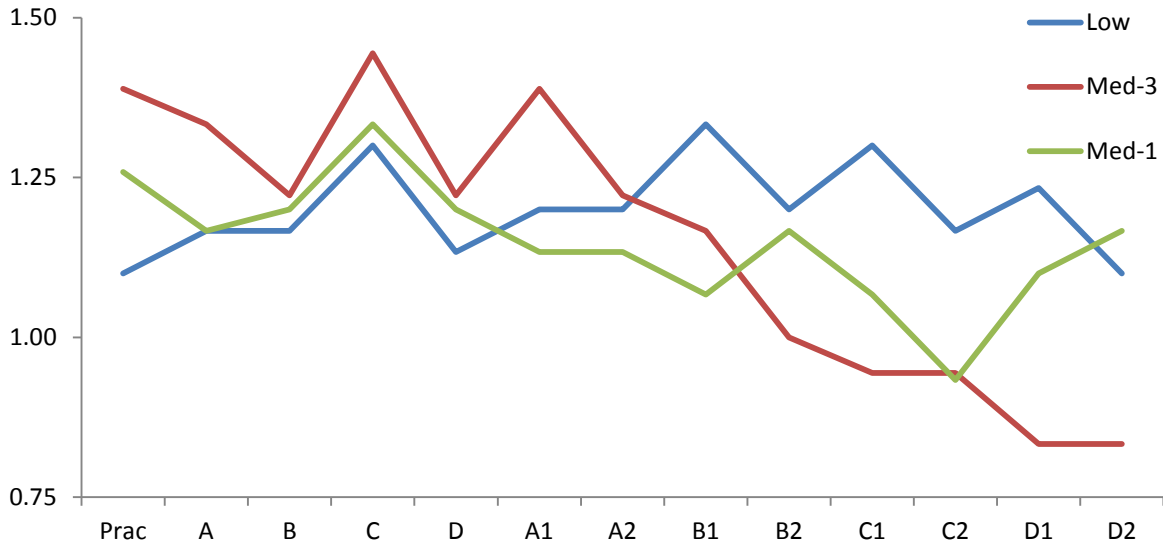
Figure 16: Mean SS-7 Point Scale Scores after Each Scenario by Immersion

Again, after reviewing the data it was noticed that the 1-screen medium-immersion, STISIM-1 Screen, simulator group had a hyper-sensitive user. Outliers negatively distort the differences between the relating groups on mixed ANOVA analysis so this participant was removed from the sample set. The assumptions for ANOVA were checked before analyses were rerun on the data set. Just like SSQ, the data set was determined to contain independence within and between samples based on the experimental methodology and followed a normal distribution. Again, this data set did not have equal variances and was determined to be heterogeneous. Mauchly's test of sphericity was determined to be statistically significant ($p = 0.001$) thus Greenhouse-Geisser was used to make a conservative correction and reduce Type I error. Levene's test of equality of error variances was conducted to confirm the trend of heterogeneity as time progressed throughout simulation training (Table 4). Just as in SSQ, false conclusions and Type I error were reduced by stabilizing the variances between groups with the use of a Box-Cox power transformation to homogenize the data set.

Table 4: Levene's Test of Equality of Error Variances: Before & After Transformation

Simulation	Original Data		Box-Cox Power Transformation	
	F Value	P Value	F Value	P Value
Practice	12.39	0.001	2.263	0.116
A	3.754	0.031	2.032	0.143
B	0.407	0.668	1.171	0.319
C	0.249	0.781	2.977	0.061
D	1.039	0.362	1.039	0.362
A1	3.081	0.056	2.642	0.082
A2	0.324	0.725	0.992	0.379
B1	1.301	0.282	1.482	0.238
B2	0.293	0.747	0.249	0.781
C1	3.448	0.041	7.188	0.002
C2	2.877	0.067	4.412	0.018
D1	2.437	0.099	4.652	0.015
D2	0.613	0.546	1.435	0.249

Note: Gray Boxes signify P Values that were significant and therefore heterogeneous

Unlike in the Box-Cox power transformation for SSQ the adjustment λ varied between simulations. These adjustment λ's were mostly equal to -5 but two groups experienced a different adjustment factor: Practice, $\lambda = -3$, and C, $\lambda = -4$. Levene's test was run with the adjusted data set (Table 4). This changed the simulations that were significant to nonsignificant, with the exception of simulation C1 which remained significant. Unfortunately, simulations C2 and D1 became significant with this transformation; however, this transformation yield better results than other variance transformations, but errors may exist within the analysis due to the presence of heterogeneity within the transformed data set.

A mixed design ANOVA was rerun on the SS-7 Point Scale scores, $n = 47$, $\alpha = .05$. Interaction was statistically significant $p = 0.034$, F = 1.613); however, main effects ($p = 0.255$, F = 1.300) and simulator group ($p = 0.824$, F = 0.195) were not found to be significant (Figure 17).
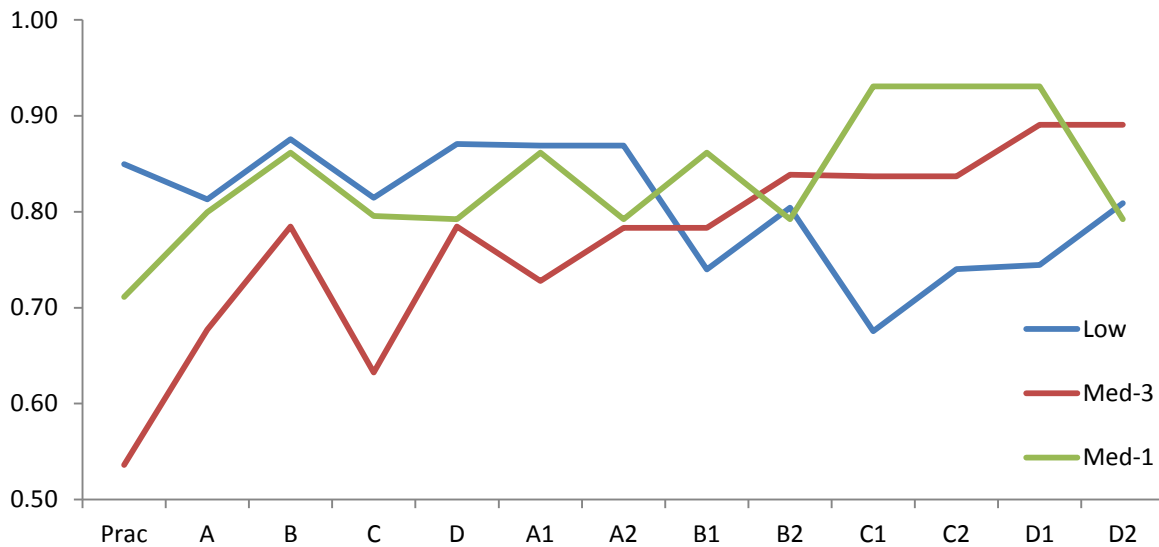
Figure 17: Box-Cox Mean SS-7 Point Scale Scores after Each Scenario by Immersion

Post-Hoc analyses were conducted to test for comparisons between treatment groups (MODATS, STISIM-3 Screen and STISIM-1 Screen) and simulation throughout training time (Practice – D2). Bonferroni correction was not significant for all treatment groups (all $p = 1.000$) and time (almost all were $p = 1.000$). The mean difference for treatment groups was rather small (between 0.029 to 0.065 SS-7 points). The mean difference for simulation through time varied (ranged between 0.001 to 0.121 SS-7 points). Games-Howell Post-Hoc analysis was conducted on treatment cross simulations through time produced statistically nonsignificant results and thus are different from one another (Table 5). This Post-Hoc analysis was run because we did not completely satisfy the requirement of being completely homogenous, 3 groups were heterogeneous, for simulations through time.

		Bonferroni	Games-Howell
Treatment	Mean Difference	P Value	P Value
MODATS – STISIM-3	0.036	1.000	0.937
STISIM-1 - MODATS	0.029	1.000	0.962
STISIM-1 – STISIM-3	0.065	1.000	0.803

4.4 Training Effectiveness

Of the 91 participants trained a total of 6 participants dropped out due to SAS symptoms, as stated, these participants were not evaluated in the field assessment because they were not able to complete training. A total of 79 participants were evaluated in the field assessment for training effectiveness (5 participants were removed for technical failure and 1 was removed due to timing between session 1 and 2; see limitation for explanations). For field drive data (Figure 18), a one-way between-participants (Group: Medium-Immersion (3 and 1 Screen), Low-Immersion, Passive Training, Control) ANOVA was performed for the total proportion of secondary glances taken, $n = 25$. A main effect for group was found, $F(4, 74) = 22.80$, $p = 0.00$, with Bonferroni comparisons indicating that the 3-screen medium-immersion (STISIM-3 Screen) group had the highest proportion of secondary glances ($M = .82$, $SD = .15$) compared to the low-immersion (MODATS) group ($M = .74$, $SD = .14$), the passive training group ($M = .69$, $SD = .10$), 1-screen medium-immersion (STISIM 1-Screen) group ($M = .58$, $SD = .16$) and control group ($M = .42$, $SD = .11$).
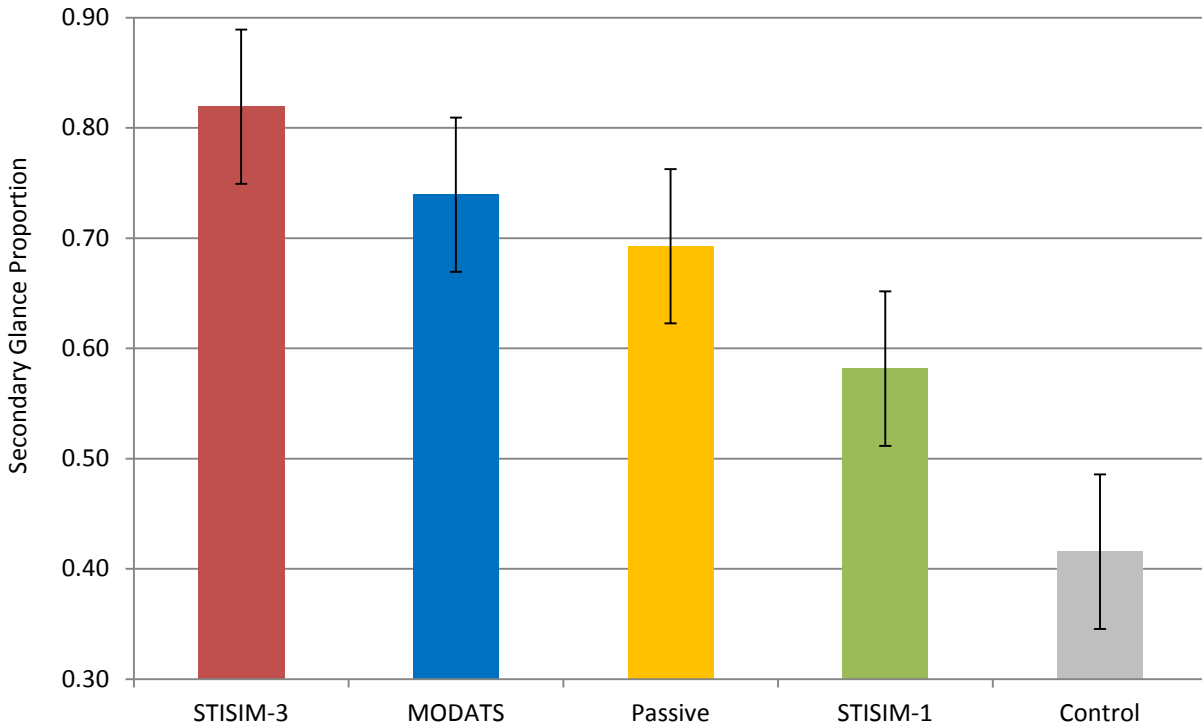
Figure 18: Mean Secondary Glances with 95% CIS by Training Groups

The data was checked to determine if compliance was normally distributed for each training group as assumed in the ANOVA analysis. It can be seen that all training groups exhibited a compliance that was fairly normally distributed with the exception of the 3-screen medium-immersion, STISIM-3, simulator group (Figure 19). When the p-values are observed for the results of the probability plot for the normality test for each simulator group it can be noted that the low-immersion ($p = 0.048$), MODATS, and 3-screen medium-immersion ($p = 0.009$), STISIM-3, simulator groups have values less than .05 and thus are not normally distributed. Sample size may have played a factor when analyzing the results, sample sizes varied between 13 to 18 participants per group.
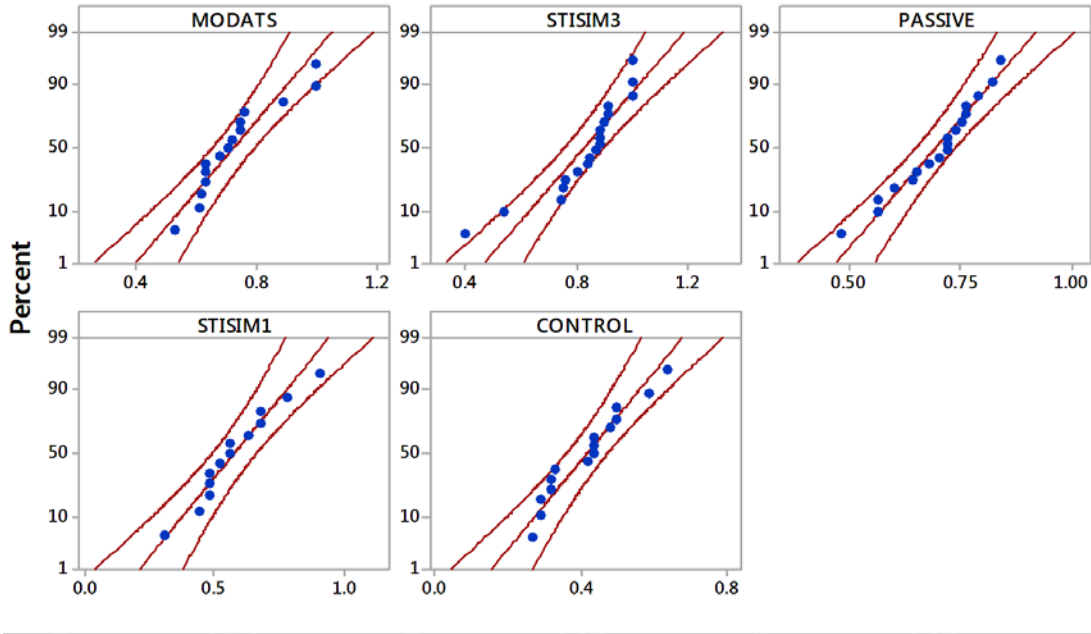
Figure 19: Probability Plot with 95% CIS by Training Group

A normal probability plot of residuals was graphed to validate the normality of the data set (Figure 20).
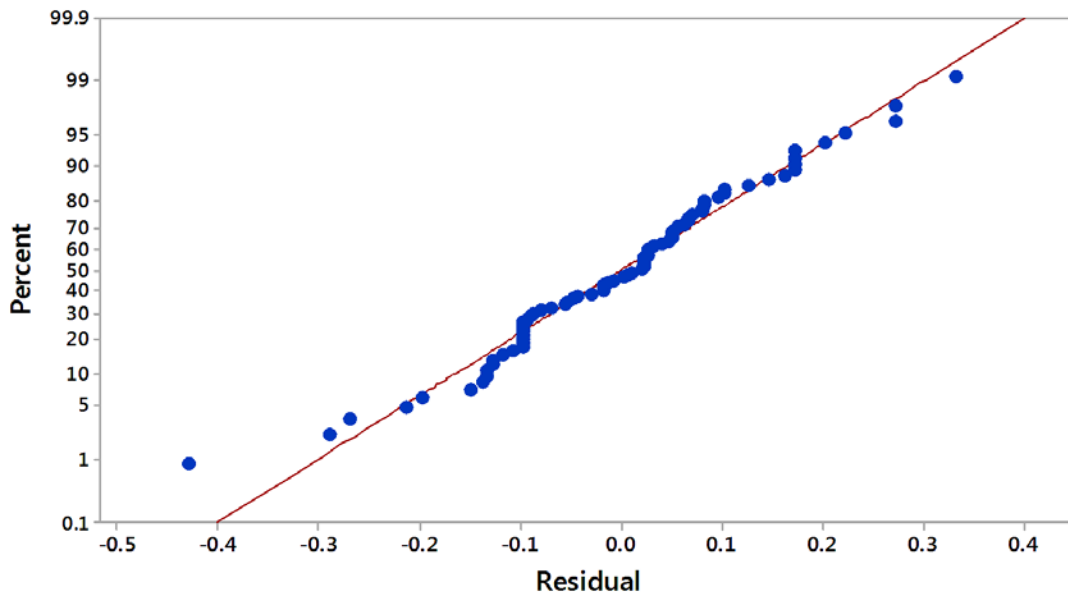
Figure 20: Normal Probability Plot of Residuals

Due to the differences in sample sizes the variances were analyzed to determine if they were equal (based on the collected sample set) . Both tests, multiple comparisons ($p = 0.476$) and

Levene tests ($p = 0.739$), were not statistically significant and thus the variance were deem equal, homogenous, satisfying the ANOVA criteria (Table 6).

Table 6: 95% Bonferroni Confidence Intervals

Treatment	N	Standard Deviation	99% Individual Confidence Interval	
MODATS	15	0.141	0.0767	0.3063
STISIM-3	18	0.154	0.0728	0.3803
Passive	18	0.097	0.0620	0.1749
STISIM-1	13	0.157	0.0859	0.3603
Control	15	0.114	0.0739	0.2093

Standard deviations between all training groups are statistically similar at a 95% confidence interval. This relationship, overlap of training group intervals, can be seen in Figure 21.
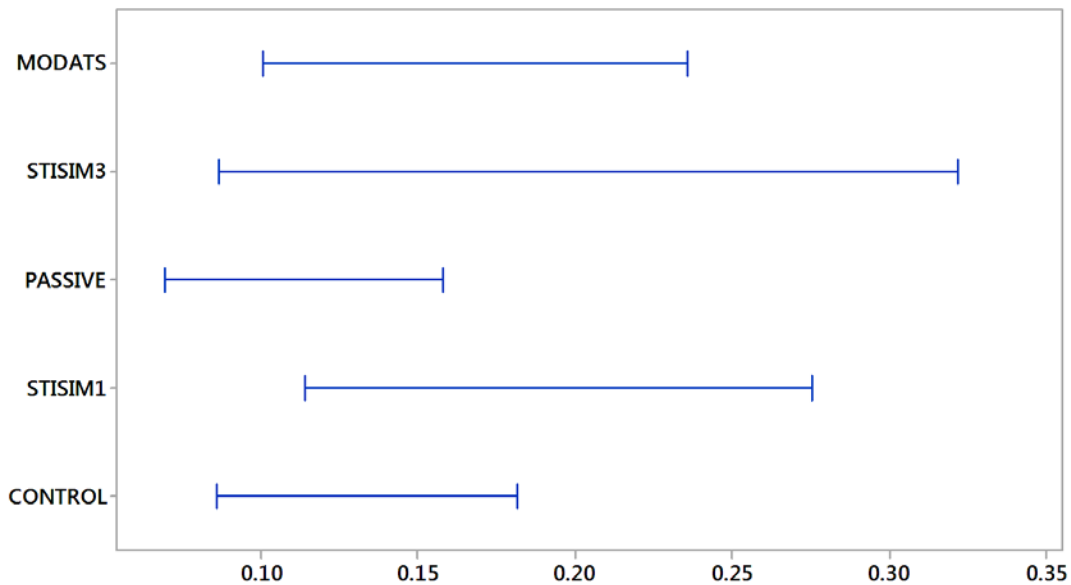
Figure 21: Comparison Intervals of the Standard Deviation with 95% CIS

A Post-Hoc Tukey-Kramer pairwise means comparison was conducted to determine the significance of each training group. When plotted, the difference between individual training

groups becomes distinguishable (Figure 22). Of the 10 training group comparisons 7 are significantly different from one another, as denoted with an asterisk. The remaining groups were determined to be significant similar in nature: STISIM-3 – MODATS, Passive training – MODATS and STISIM-1 – Passive training.
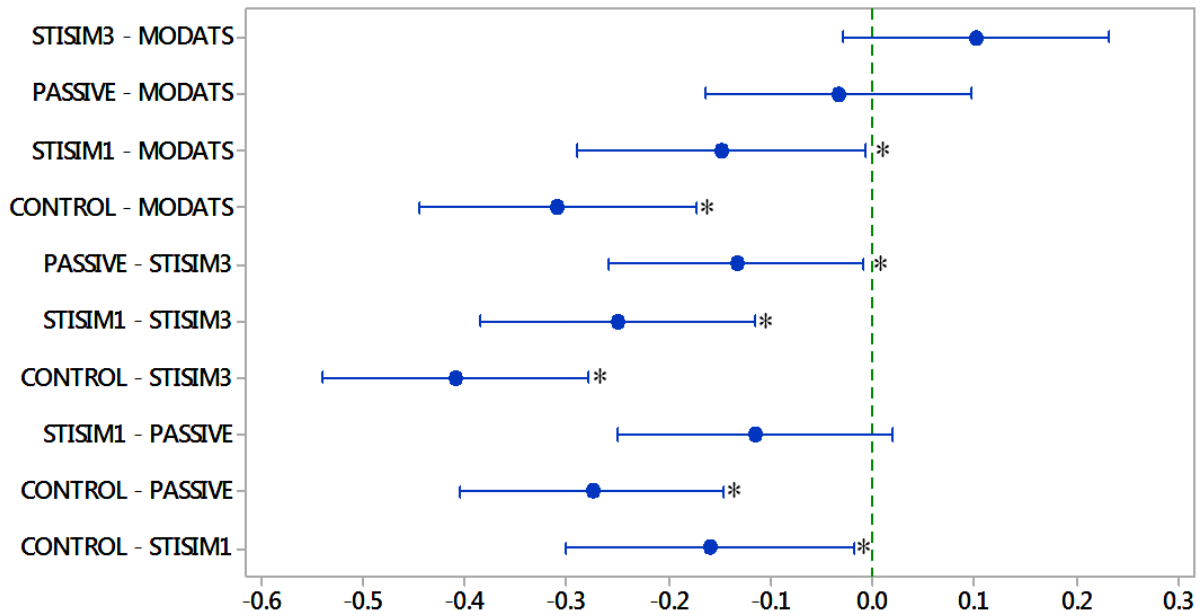
Figure 22: Tukey-Kramer Pairwise Means Comparison with 95% CIS by Training Groups
* Denotes Significantly Different Means

There was no statistically significant difference between the medium-immersion, 3 and 1 screen groups, and low-immersion when compared to the passive training group as determined from a Chi Squared Analysis: 3-screen medium-immersion, $\chi^2(1) = 2.409$, $p < 0.12$; 1-screen medium-immersion, $\chi^2(1) = 2.033$, $p < 0.15$; and low-immersion, $\chi^2(1) = 0.0303$, $p < 0.25$. However, there was a statistically significant difference when comparing all types of immersion training and passive training to the control group: 3-screen medium-immersion, $\chi^2(1) = 24.24$, $p < 0.001$; 1-screen medium-immersion, $\chi^2(1) = 5.008$, $p < 0.025$; low-immersion, $\chi^2(1) = 15.47$, $p < 0.001$; and passive training, $\chi^2(1) = 13.75$, $p < 0.002$ (Table 7).

As seen in Table 7 when Chi Squared Analyses was performed there was statistical significance when comparing the 3-screen medium-immersion and low-immersion group with the 1-screen medium-immersion group: 3-screen medium-immersion, $\chi^2(1) = 7.760$, $p < 0.005$; and low-immersion, $\chi^2(1) = 3.291$, $p < 0.07$. It is important to note that with more data points available for the field drive, subject variance was naturally smaller.

Table 7: Chi Squared Analysis Field Assessment – (Chi Squared Value, P-Value)

MODATS	--	X2(1) = 0.738842, p< 0.25	*X2(1) = 3.29119, p< 0.07*	X2(1) = 0.303614, p< 0.25	*X2(1) = 15.47368, p< 0.001*
STISIM-3	--	--	*X2(1) = 7.75993, p< 0.005*	X2(1) = 2.408912, p< 0.12	*X2(1) = 24.24298, p< 0.001*
STISIM-1	--	--	--	X2(1) = 2.033159, p< 0.15	*X2(1) = 5.008162, p< 0.025*
Passive	--	--	--	--	*X2(1) = 13.74887, p< 0.002*
Control	--	--	--	--	--
	MODATS	**STISIM-3**	**STISIM-1**	**Passive**	**Control**

Note: Statistically Significant Comparisons are Highlighted in Gray

This study examined the effect of low and medium immersion training on both SAS symptoms (compared to each other and Romoser & Fisher, 2009) and secondary glances (compared to each other, passive and control training). The results show that 3-screen medium-immersion simulator training, STISIM-3, when combined with micro-scenarios is an effective tool for training the older driver population (compared to the passive training and control group) which can significantly reduce the prevalence of simulator sickness (compared to Romoser & Fisher).

5.1 Dropout Rates

There was a large effect on the prevalence of simulator sickness when comparing these results to Romoser & Fisher, 2009. In the earlier study 38% (34 dropout, 54 passed) of participants dropout due to SAS symptoms when using the high-immersion simulator (11; 12). This high-immersion driving simulator utilizes Realtime Technologies, Inc. (RTI) simulator platform projected onto 3 screens to create 160º of view in the horizontal direction (degrees of view same as the STISIM). Just like the STISIM the three channels (left, center and right) operate in parallel in order to produce driving images as they are projected onto the 3 screens with a resolution of 1024 by 768 pixels; however, these images are generated at 60 Hz, where as the medium-immersion, STISIM, simulator generates images at 30 Hz. Another noticeable difference is that in this high-immersion driving simulator participants sit in a full sized Saturn sedan and operate the controls just as they would in the real world.

It was hypothesized that two factors are believed to contribute to the high "simulator sickness" rates: the relatively high-immersion at each point in time and the relatively long period of time over which the training occurs in the simulator. These two hypothesizes were verified

through experimentation. As visual flow was reduced the dropout rate decreased: 3-screen medium-immersion, 14.3%; low-immersion 11.8%; and 1-screen medium-immersion, 6.3%. Therefore, this reduction of visual flow combined with micro-simulation had a positive effect on reducing simulator sickness rates. Statistically, the magnitude of the discrepancy between the experimental dropout rates was significant when compared to Romoser & Fisher, 2009.

5.2 Simulator Sickness Questionnaire (SSQ)

Participant's simulator sickness was analyzed after their baseline and post-training was completed. SSQ is comprised of 3 components: nausea, oculomotor and disorientation symptoms, which are used to determine each SSQ total score. When drivers were trained in a medium-immersion, specifically in the 1-screen training group, driver simulator sickness changed slightly (this is when the hyper-sensitive participant is removed); whereas, the low-immersion driver simulator produced a high increase in symptoms. The only group to experience a decrease in SSQ score was the 3-screen medium-immersion, STISIM-3 Screen, simulator group. Statically, there is no significant difference between simulator treatment groups, interaction and main effects for time. Thus, the treatment factors of immersion, display size and screen usage did not directly affect the outcomes of experimentation; however, more experimentation may be need. The SSQ score was also not affected through time, as a result an increase or decrease in points was not directly related to the time spent in active simulation training.

All treatment groups were proven to be different from one another through Post-Hoc analyses. All groups varied and showed no comparison between treatment groups for its affect on SSQ total score. With significantly different means the data shows that the low-immersion, MODATS, and 1-screen medium-immersion, STISIM-1 Screen, simulator treatment groups are

very different from one another. As was predicted when the simulator treatment groups were created. Both medium-immersion, STISIM, simulator groups even though they were statistically not significant were somewhat similar, with the only major difference being the change in the participants' field of vision. Low-immersion, MODATS, and 3-screeen medium-immersion, STISIM-3 Screen, simulator groups had high differences between them but it was not as extreme as the differences that occurred between the 1-screen medium-immersion and low-immersion simulator groups.

5.3 SS-7 Point Scale

As training progressed the symptom severity showed an overall decreased affect for the low-immersion simulator group, which is contradictory of most studies. The 3-screen medium-immersion simulator group showed the opposite trend where severity had an overall increasing affect as training progressed. It is interesting to note that the 1-screen medium-immersion simulator group had an overall increase symptom severity, similar to the 3-screen simulator group; however, as training progressed severity greatly fluctuated. For the 1-screen medium-immersion simulator group there is a key drop-off in symptom severity after scenario D1 is completed. If this scenario was removed the overall effect would be similar to the 3-screen medium-immersion simulator group, but rather with a higher overall effect in symptom severity. Please note that this data was still heterogeneous when results were inferred after Box-Cox transformations were applied. This limits the actual depiction of symptom severity through treatment and time; however, this transformation was the best application for making variances equal.

It is interesting to note that all, besides the 1-screen medium-immersion, simulator groups had a point where symptom severity stabilized. For the low-immersion simulator group after

scenario A2 and B2 symptom severity decreased significantly. Towards the end of training there was a slight rise in severity, C1 through D2; however, overall the participants became more comfortable with this lessened exposure. The increase in severity towards the end of active training may have been caused by the responsiveness of the controls (see limitations for further elaboration). After scenario B1 the 3-screen medium-immersion simulator group had an overall increasing severity; however, these increases remain rather slight, which shows the participants became rather comfortable to the simulation exposure. The major severity increase occurs in the beginning of exposure, as seen after the practice, A and D scenarios. This high rise in symptom severity may be attributed to the higher level immersion, when compared to the other simulator groups, that participants had to adapt to at the start of training.

The 1-screen medium-immersion simulator group experienced the greatest amount of fluctuations as training persisted. These severity spikes remained moderately low until the C1 scenario was presented. Severity remained constant until the D2 scenario which seemed to alleviate the severity. It is interesting to see, as with the 3-screen simulator group, an initial rise in symptom severity when training commences. For the 1-screen simulator group this effect has a higher severity effect within the first three scenarios and a smaller decrease. In general, it can be inferred that symptom severity tends to have an initial start up discomfort as training begins. The 1-screen method of using a toggle button to switch between visuals may have been the cause of the fluctuation of this treatment group (see limitations).

5.4 Training Effectiveness

The effect of training in this study was positive, with all training groups showing a higher frequency of secondary glances compared to the control group. The frequency of secondary glances varied from 42% to 82%. The 3-screen medium-immersion simulator group had the

highest use of secondary glances, whereas the 1-screen medium-immersion simulator group had the lowest use, 58%. The low-immersion simulator group was the second highest group, 74%, followed by passive training, 69%. All forms of training, both active and passive, were statically significant when compared to the control group. As visual flow was decreased or reduced, in the case of the 1-screen medium-immersion group, the effectiveness of the training decreased.

It is also interesting to note that all active training groups (STISIM-3 Screen and MODATS) were statically significant when compared to the 1-screen medium-immersion, STISIM-1 Screen, group. This could possibly be caused by the low amount of participants in the sample size, 13 subjects. All other groups (MODATS, STISIM-3 Screen, passive and control groups) consisted of 15 to 18 participants.

Post-Hoc analysis concluded secondary glance compliance interactions occur between limited treatment groups. Three groups exhibited statistically similar relationship that was not due to chance: STISIM-3 Screen to MODATS, Passive to MODATS and STISIM-1 Screen to Passive. The main cause of these similarities is not for certain; however, visual flow and type of immersion may have an effect on secondary glance compliance.

5.5 Limitations

There were several limitations that occurred for both the laboratory training and field assessment portions of the experimentation. The post-training questionnaire responses to simulator training yielded an interesting response in which participants voiced some displeasure with the "clunkiness" of the controls, especially in the low-immersion MODATS simulator. Participants wanted more responsive controls to provide a more realistic vehicle handling experience. Similar displeasure was voiced with the 1-screen medium-immersion STISIM simulator. Many participants did not like how they had to toggle a button to glance to the left or

right. They believed this was very unrealistic and took away from the overall training experience. In addition to the responsiveness of controls and visual restrictions some participants stated that both simulator graphics, low and medium immersion simulators, lacked a component of realism. In line with the desire for more realism, all participants would have liked the micro-simulations to last longer than a 45 second run time. Participants believed that training would have been more effective if they could have completed their turning movements (adding 5 more seconds) before the micro-scenarios paused to decrease exposure; however, it can be argued that the completing the turning movement could increase simulator sickness due to the visual flow moving from one screen onto the other (this would not be a factor in the 1-screen medium immersion simulator group). These factors may have had a negative effect on training causing participants to not take the simulator training as seriously as they should have.

The field assessment had several limitations as well, specifically the road conditions, seasonal effects and traffic patterns due to location and time of day. All participants completed field drives between the hours of 8am – 5pm, this time was adjusted for daylight savings time to 9am – 4pm, so that darkness would not be a contributing factor, thus reducing the participant's sight distance. Participants were run, for almost a years, between the months of July 2014 through May 2015. It is important to note that participants were not run during adverse weather conditions (i.e. heavy rain, snow, fog, etc.) so that these effects would be minimized; however, it is important to note several participants did conduct field drives during light rain and scattered drizzle.

As mentioned above that during severe and adverse weather participants were not expected to conduct the field assessment for their own safety and to preserve the quality of data. Participants were not rescheduled until the pavement was sufficiently cleaned (i.e. no snow was

on the pavement and heavily salted areas were clean, etc.). Due to the excessive amounts of snow in the New England area, one participant's field assessment was not evaluated/scored because they conducted the field assessment outside of the maximum three week assessment time (conducted field drive 19.9 weeks after training in session 1). The driver was not told their field assessment was going to excluded from the training effectiveness data set and they received the entire compensation for completing both sessions of training ($75).

The last limitation pertained to the use of the equipment. Since drivers were unaccompanied when driving, therefore creating an undistracted environmental, the equipment cord, from the camera to the recording device, could be accidentally severed with sudden "jerking" movements (.i.e. predominantly when drivers entered and exited their vehicles). Because of this participants were fitted with the head mounted camera when they were already seating in their vehicle (3 cases of this occurred). Another technological limitation that occurred was the participant would pin the recording device up against their center console or seatbelt. This would cause the camera to turn on and off creating a flickering image that hindered the ability to score the field assessment (2 cases occurred). Because of this participants were told to place the recording pack into their cup holders of their vehicles and to limit their interaction with the pack. Both of these equipment malfunctions were classified as technical failures and their results were not included in field driving assessment/training effectiveness results (5 total technical failures).

CHAPTER 6 CONCLUSION

This research investigated the effects of simulation sickness over time on the older driver population caused by the type of simulation immersion/training. This research also focused on the type of simulation immersion/training on older driver secondary glance compliance. The previous chapters' results and discussion ascertained a number of deductions and conclusions, which are as follows.

6.1 Dropout Rates

The effects of dropout rates in this study were significantly lower than the dropout rates of Romoser & Fisher (2009) study. Approximately 40% of older driver participants were excused from training because they exhibited signs of simulator sickness. In this experiment dropout rates were able to be reduced to less than 15% by decreasing immersion and reducing visual flow. When visual flow was reduced, 1-screen medium-immersion, dropout rates were at their lowest, 6.3%. As immersion diminished dropout rates decreased as well: low-immersion 11.8% and 3-screen medium-immersion, 14.3%. It can be inferred that if both immersion and visual flow are reduced dropout rates will even lower; however, a 1-screen low-immersion group was not tested. Future research is warranted to verify this inference.

6.2 Simulation Sickness

Simulation sickness was able to be counteracted with manipulation of simulator immersion and its field of vision. The result for simulation sickness scores was statistically not significant stating that the difference of means over the level of immersion collapsed over the level of time was cause by chance. As immersion increased the more simulator sickness was reduced. However, when field of vision is reduced simulation sickness tends to increase.

As immersion increased symptom severity increased throughout the process of training. Field of vision had a slightly increased effect on symptom severity; however, severity mostly fluctuated throughout the active training process. Immersion and field of vision may not have contributed directly to the effect of symptom severity as micro-simulation could have also affected the results of this measure; more research is needed to verify this trend.

6.3 Training Effectiveness

The effect of training in this study was decidedly less than the effect of training in the Romoser & Fisher (2009) study. In the latter study, the frequency of secondary glances increased from 40% to 80%. In this study, the frequency of secondary glances increase from 42% to 82% (in the 3-screen medium-immersion group). There are many differences in the study so it is difficult to identify what is the cause of the larger effect in the Romoser & Fisher study. However, perhaps the micro-scenarios, while helping reduce the prevalence of SAS, reduce the effectiveness of the training (the comments of the participants indicate as much; see limitations). More research is clearly needed to validate this notion.

The difference between the frequency of secondary glances of the drivers receiving MODATS, low-immersion simulator training and passive training did not differ from one another (though the difference was in the predicted direction). However, all forms of training, both active and passive, were significant when compared to the control group. As visual flow was decreased the effectiveness of the training decreased.

It is important to note that the time between the training and field evaluation in this study was roughly three weeks, which is significantly less than the time between the training and the field evaluation in the Romoser & Fisher (2009) study (roughly three months). One could reasonably argue that the effects of passive training extinguish after three months, but are still

present after one week. Thus, although passive training may be effective over the short term, such may not be the case over the long term. Of course, some other explanation for the discrepancy is possible. It may just be that low-immersion and 1-screen medium-immersion training is not effective, either because of the particular implementation (as discussed below in limitations) or because of the need for higher levels of immersion. Further studies are clearly warranted.

6.4 Future Work

Additional research questions remain despite the conclusions from this experimentation pertaining to dropout rates, simulator sickness and training treatments. Specifically, in regards to expanding on this experimentation, it would be beneficial to add a 1-screen low-immersion simulator group and evaluate its results.

Retesting should occur at a later date to see if secondary glance compliance has changed over a longer period of time. Specifically, explaining when passive training experiences an extinguishing effect for secondary glance compliance. It has been shown in the 2009 study for Romoser & Fisher that over a period of 3 months passive training is an ineffective tool for training older drivers. Also, it would allow comparisons to be drawn for extinguishing effects in regards to active treatment groups with less immersion and reduced visual flow.

The effects of micro-simulation have yet to be explored and should be compared across treatment groups to verify the changes in immersion and field of vision are the contributing factors to the reduction of simulator sickness for the older driver population.

APPENDIX A: FIELD ASSESSMENT SCORES

Key:
- 1 RTM
- 2 LTM
- 3 LT Light
- 4 RT Light
- 5 Straight
- 6 LTAT
- 7 Merge

MODRATS (Low Immersion Training) / Post Training

Participant IDs: IA01, IA02, IA03, IA04, IA05, IA06, IB01, IB02, IB03, IB04, IB05, IB06, IC01, IC02, IC03, IC04, IC05, IC06

PASSIVE TRAINING GROUP [PowerPoint Training]

Key:
1 RTM
2 LTM
3 LT Light
4 RT Light
5 Straight
6 LTAT
7 Merge

VIDEO # Participant	3A01	3A02	3A03	3A04	3A05	3A06	3B01	3B02	3B03	3B04	3B05	3B06	3C01	3C02	3C03	3C04	3C05	3C06	Σ	Avg
TOTA	18	12	18	15	21	14	14	13	11	17	18	14	18	17	18	16	18	18	233	
Turns	25	16	25	25	25	22	25	20	23	25	25	22	23	25	23	24	25		423	
%	0.7600		0.7800	0.7200	0.6000	0.9400	0.5364	0.5600	0.6500	0.4783	0.6800	0.7200	0.5600	0.8182	0.7391	0.7200	0.65957	0.73913	0.7600	63.27%	

PROPORTION
T-INT	LGT	LTAT	STA

COUNT
T-INT	LGT	LTAT	STA	LFT
280	96	0	34	182
15.56	5.33	0.00	1.89	10.67

STIGMA 13 SCREEN (Mac-Immersion Training) — **Post Training**

Key:
1 RTM
2 LTM
3 LT Light
4 RT Light
5 Straight
6 LTRT
7 Merge

VIDEO # Participe	Age	Gender	Miles	TOTA	Turns	X	PROP T-INT	PROP LGT	PROP LTAT	PROP STA	CT T-INT	CT LGT	CT LTAT	CT STA	CT LFT
4A01		M		11	21	0.5238	0.5		0	0.666667	16	1	1	3	4
4A02		F		10	16	0.6250	0.55556	0.666667	NID	0.666667	9	3	0	3	5
4A03		M		19	21	0.9048	0.909090	1	NID	0.666667	11	3	1	3	5
4A04		F		17	25	0.6800	0.705882	0.25	0	1	17	4	1	3	10
4A05		F		18	23	0.7826	0.782623	0.8	0	1	13	5	1	3	10
4A06		F		12	25	0.4800	0.43175	0.2	1	1	16	5	1	3	11
4B01		M		14	25	0.5600	0.42105	1	NID	1	19	2	0	2	11
4B02		M		17	25	0.6800	0.666667	1	0	0.666667	18	3	1	3	10
4B03		M		14	25	0.5600	0.5	0.8	1	0.666667	14	5	0	3	8
4B04		F		0	0	X	NID	NID	NID	NID	0	0	0	0	0
4B05		F		0	0	X	NID	NID	NID	NID	0	0	0	0	0
4B06		F		0	0	X	NID	NID	NID	NID	0	0	0	0	0
4C01		F		4	13	0.3077	0.33333	0	NID	1	9	3	0	1	6
4C02		M		0	0	X	NID	NID	NID	NID	0	0	0	0	0
4C03		F		12	25	0.4800	0.5	1	0	0.33333	18	1	1	3	8
4C04		F		11	25	0.4400	0.523091	0	NID	0	21	2	0	1	14
4C05 *Timed Out OUTLYER*		F		11	18	0.6111	0.58825	1	NID	1	16	1	0	1	7
4C06		F		12	25	0.4800	0.42087	0.5	0	1	14	4	1	1	11
Σ				**171**	**294**	**58.163**	7.81 / 0.56	3.22 / 0.66	4.00 / 0.44	10.67 / 0.76	**211 / 12**	**42 / 2**	**9 / 1**	**33 / 2**	**120 / 7**

HUMAN
PERFORMANCE
LABORATORY

Contact: Craig Schneider
Phone: 413-404-6960
Email: hpl.umass@gmail.com

Website:
http://www.ecs.umass.edu/hpl

SENIOR DRIVERS NEEDED!

Senior Driver Training Research at the University of Massachusetts, Amherst

Participate in our study investigating methods of training designed specifically for older drivers.

Looking For Participants 70 – 85 years old

- Participation involves 1 session - 60 to 75 minutes
- Participation pays $40 at the conclusion of the study
- Drive at least 1,000 miles per year
- You must currently still be driving with no restrictions
- You must have had your license for at least 10 years
- Appointments can be scheduled for weekdays or weekends at your convenience
- **For More Information Please Contact Us**

Study Will Be Open Until May 8th

The Study Specifics

• Who?

If you are 70 to 85 years of age of generally good health you are eligible to participate in the study. You must have been driving for at least ten years and have no suspensions or restrictions on your license.

• Where?

Sessions will take place at your home The HPL is a part of the School of Mechanical & Industrial Engineering. When you make your first appointment, you will be asked to provide your address for a technician to meet you at your residents or the University of Massachusetts, Amherst (whichever is preferable to you).

• What?

We are studying various methods of training older drivers to better recognize road hazards and ways to raise awareness of how age related changes can impact how older drivers process traffic-related information.

Participation involves meeting researchers one time for a session that will last approximately 30 to 60 minutes. Upon completion of the session, you will be paid a stipend of $40.

• Why?

It is our belief that with proper training, older drivers can extend their driving careers by several years. This is your chance to become involved in ground-breaking research while also learning how to improve your own driving ability.

• When?

Sessions will begin this spring, March through May. Upon the completion the session, you will be asked to paid for you participation.

TEAR ONE OFF

UMass Older Driver Training Study
CONTACT: Matthew Romoser
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EMAIL: hpl.umass@gmail.com

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Dr. Matthew R. E. Romoser
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Department of Mechanical
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Month XX, 2015

«First» «Last»
«Street_No» «Street» «Apt»
«Town», MA «Zip»

Dear «First»,

My name is Dr. Matthew Romoser and I am a research professor at the University of Massachusetts Amherst who has been conducting older driver research for the last ten years. I would like to invite you to participate in one of our lab research studies on older driver training and safety. In this particular study we are looking for currently active drivers between the ages of 70 and 85 years of age who drive at least 1,000 miles per year. To participate, you must have your driving license up to date with at least ten years of driving experience and still eligible to drive a vehicle. Participation consists of a half hour field drive in your own vehicle. The purpose of this study is to gather information on driver behavior and help us develop effective training and feedback for older drivers to help them become safer drivers and lengthen their driving careers. Our lab has conducted many driving related studies designed to investigate such things as driver risk awareness, signage, age differences, training, driver distraction, etc. Our goal is to increase the safety of the driving environment and help older drivers improve their skills. With your help we can accomplish our objective!

Each individual is paid $75.00 for participation upon successful completion of the study. The study consists of two sessions that would typically last sixty to ninety minutes. **NOTE:** *Drivers who experience motion sickness, either in their own car as a passenger or driver, or in other modes of transport, should not participate.*

If you are interested, please feel free to bring a spouse, partner, or a friend - spreading the word is always appreciated as we run many studies! Please call if you are interested in participating at **(413) 545-3393** or email our lab at **hpl.umass@gmail.com**. Please feel free to contact us if you'd like more information about the study, have questions, or would like a tour of the lab before participating.

Thank you and we hope to hear from you soon!

Sincerely,

Matthew R. E. Romoser, Ph.D.
Research Assistant Professor

Department of Mechanical & Industrial Engineering
University of Massachusetts Amherst

Arbella Insurance Human Performance Laboratory

EMail for Campus Departmental EMail Lists (to be forwarded only with permission of department representative – Training Groups

PARTICIPANTS 70-85 YEARS OLD WANTED FOR OLDER DRIVER STUDY

The Arbella Insurance Human Performance Laboratory at the University of Massachusetts-Amherst is looking for healthy, independently living licensed older drivers 70-85 years old to participate in older driver training research study.

To participate: Participants should be senior drivers willing to participate in two to three sessions with researchers for assessment and training. Participants should meet the following criteria:

- Generally healthy and living at home
- 70 to 85 years of age
- Willing to participate in 2 sessions each lasting 60 to 90 minutes
- Currently still driving
- Must have been driving for last 10 years at a minimum
- No medical or state-imposed restrictions on driving

Participants who complete the entire study will be compensated $75 and will receive training and field drive assessments as part of the research. Participants will receive partial compensation of $25 per session completed if they discontinue the study before it is complete.

If you are interested in participating in this study, please contact the graduate student researcher conducting this study, Craig Schneider or the principal investigator, Dr. Matthew Romoser, at 413-545-3393, or send an email directly to hpl.umass@gmail.com or navigate to http://www.ecs.umass.edu/hpl/signup.html and fill out our online form.

For more information about the lab and its research, please visit the lab's web site (www.ecs.umass.edu/hpl) or contact the lab at 545-3393 or hpl@ecs.umass.edu.

Arbella Insurance Human Performance Laboratory

EMail for Campus Departmental EMail Lists (to be forwarded only with permission of department representative - Control Group

<u>PARTICIPANTS 70-85 YEARS OLD WANTED FOR OLDER DRIVER STUDY</u>

The Arbella Insurance Human Performance Laboratory at the University of Massachusetts-Amherst is looking for healthy, independently living licensed older drivers 70-85 years old to participate in older driver research study.

<u>To participate:</u>   Participants should meet the following criteria:

- Generally healthy and living at home
- 70 to 85 years of age
- Willing to participate in 1 session lasting 75 to 85 minutes.
- Currently still driving and drive at least 1,000 miles per year
- Must have been driving for last 10 years at a minimum
- No medical or state-imposed restrictions on driving

The study session will take place at your home and will involve some short physical and cognitive tests (taking 10 minutes total) and then a field drive (30-40 minutes) starting from your home in your own car. The whole session including the introduction and getting ready for the field drive will take 75 to 85 minutes. Participants who complete the session will be compensated $40 for their time, and partial compensation is available to participant who decide to end their session early.

If you are interested in participating in this study, please contact the graduate student researcher conducting this study, Craig Schneider or the principal investigator, Dr. Matthew Romoser, at 413-545-3393, or send an email directly to hpl.umass@gmail.com or navigate to http://www.ecs.umass.edu/hpl/signup.html and fill out our online form.

For more information about the lab and its research, please visit the lab's web site (www.ecs.umass.edu/hpl) or contact the lab at 545-3393 or hpl@ecs.umass.edu.

Informed Consent
Older Drivers – Training Program

1. WHAT IS THIS FORM?

This is an Informed Consent Form. It will give you information about the study so you can make an informed decision about participation. Your signature on this form indicates that you are giving your permission to participate in this study.

2. WHO IS ELIGIBLE TO PARTICIPATE?

Drivers between the age of 70 and 85 who have a valid drivers license and drive at least 1,000 miles per year, have been actively driving for at least ten years, and are capable of driving themselves to and from their appointments at the lab are eligible to participate in this study (a driver is considered active in this case if he or she has driving on average at least once a week without assistance).

3. WHO IS SPONSORING THIS STUDY?

This study is being sponsored by the consortium of National Institute of Aging, which is a part of the National Institutes of Health. The Principal Investigator of this study is Research Assistant Professor Matthew Romoser, Department of Mechanical & Industrial Engineering, University of Massachusetts Amherst.

4. WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this study is to evaluate various strategies of training older drivers to better detect road hazards.

5. WHERE WILL THE STUDY TAKE PLACE AND HOW LONG WILL IT LAST?

This study consists of a total of two sessions taking place over the course of 6 to 8 weeks. The first session will take place at the human performance laboratory and will consist of a series of cognitive and physical screening tests and PC training session. The second session will take place at your home and will consist of a field drive in your own vehicle around your home.   Each session will take approximately 60 to 90 minutes (for a total of 2 to 3 hours for the entire study).

6. WHAT WILL I BE ASKED TO DO?

You are being asked to participate in a total of two sessions, each lasting approximately 60 to 90 minutes, over the course of six to eight weeks. The sessions you will be participating in are described below:

(a)   (b)

Figure 1. Field drive camera system. (a) You will be wearing a lightweight, wireless headband camera. (b) We will install three cameras on the roof of your car with a felted, industrial strength magnet to prevent scratching or movement.

Session 1: PC Training at UMass Amherst – For the first session, you will come to the lab for PC-based training. A series of short cognitive and physical screening tests will be administered. Afterward, you will be given instructions and will be provided lecture-style training session on the rules of the road and driving safety.. This session should last no longer than 60 - 90 minutes.

Session 2: Field Drive from Your Home – Approximately 6 to 8 weeks after Session 1 you will participate in a field drive starting at your own home. In this field drive, you will be driving your own vehicle to a location from your home that you normally drive to at least twice per month (such as the grocery, pharmacy, a park, a friend's house, etc.). While doing so, you will be wearing a very lightweight, wireless scene camera on your head (see **Figure 1a**). It will feel like you're wearing a light hat. In addition to the head-mounted camera, three additional external cameras will be attached to the outside of your car using a fixture attached to a strong, industrial-strength magnet (See **Figure 1b**). The magnet is felted to prevent scratching and has been tested under emergency stop conditions with no movement. There will be no damage to your vehicle. The recording equipment that these cameras are attached to will be in your backseat and will be strapped down using your vehicle's seat belts.

Before the drive, you will sit down with the project administrator and decide on a driving route that starts at your house and ends at a destination approximately 15 to 20 minutes away from your home. The destination you choose should be one that you drive to at least twice per month. You will go over the route once again and then the portable recording equipment will be installed in your car. There will be no damage to your car during the installation and removal process of the cameras – the entire assembly is very portable and easy to put in place. Once the cameras are installed in your vehicle, you will be fitted for the lightweight, wireless scene camera. You will then be seated in your car and the system will be tested.

Once the administrator has confirmed the system is working properly, you will be first given a chance to practice driving while wearing the scene camera by driving a short distance (approximately one minute) then returning to your driveway. Any adjustments will be made at that time. The administrator will then set the system to record and you will drive to your chosen destination where you will turn around and return home using the same route (if possible), or the fastest route if one-way roads are involved. Afterwards, the camera system will be removed from your car and the drive will be over.   You will also be provided a walkie-talkie to communicate with the administrator if the need arises and you cannot return home. At this time you will be done and will receive the $75 stipend for your participation in the study.

7. ARE THERE ANY RISKS OR BENEFITS ASSOCIATED WITH PARTICIPATION?

The Risks.

Field Drive (Session 2). You will be asked to wear a very lightweight wireless scene camera while driving your car on a predetermined route. In addition, three additional cameras will be mounted to the outside roof of your car to record the straight-ahead, left and right side views relative to your vehicle. There is no impediment to your peripheral vision. You can see as far to the side as would normally be the case without wearing safety glasses. In addition, there is no impediment to your head movement.   You have complete freedom of head movement in all directions. Although crashes are not expected as part of the research experiment several additional precautions have been taken to further assure a safe driving environment. The recording equipment for the cameras and their power source will be secured in the rear seat of your vehicle by straps which keep it from moving about the cabin of the automobile in the event a crash does occur. Additionally, the external cameras are mounted securely to a magnetic fixture that has been tested under emergency stop conditions without moving.

Neither the headband camera or external camera will impede your vision or driving in any way.

The Benefits. Older adults, especially older adults who drive very little during the year, are at a greatly increased risk of crashing. It has been hypothesized that one of the reasons for this increased risk is the failure of older adults to detect certain hazards.

8. WHO WILL SEE THE RESULTS OF MY PERFORMANCE ON THE FIELD DRIVE OR ON THE TRAINING?

The data we collect from you today will be stored under a randomly selected subject number. We will keep a separate key which associates your name and other identifying information with your randomly selected subject number. It will therefore **not** be possible for any unauthorized person(s) to later associate your name with the data as stored on our computers since they will not have access to the key. We will combine your results with those of other subjects taking part in the study. This combined information will be used when we write up the study to share it with other researchers. Individual data may also be presented. However, your name will never appear in any publication. Your face will not be visible in any video and audio is not recorded as part of the system.

It is possible that your research record, including sensitive information and/or identifying information, may be inspected and/or copied by the study sponsor (and/or its agent), the Food and Drug Administration (FDA), or federal or state government agencies, in the course of carrying out their duties. If your record is inspected by the study sponsor (and/or its agents), or by any of these agencies, your confidentiality will be maintained to the extent permissible by law.

9. WILL I RECEIVE ANY PAYMENT FOR TAKING PART IN THE STUDY?

Yes, at the conclusion of the study (2-sessions) over the course of 6 to 8 weeks, you will receive a stipend of $75.00 for your participation. If for any reason you chose not to continue in the study or cannot continue, then your stipend will be $25 if terminating during the 1st session and $75 if terminating during the 2nd session.

10. WHAT IF I HAVE QUESTIONS?

If you have questions about the study, you can contact the Principal Investigator, Dr. Matthew Romoser at 413-545-4543 or mromoser@ecs.umass.edu. If, during the study or later, you wish to discuss your participation or concerns regarding it with a person not directly involved in the research, you can talk with *the Human Subjects Administrator at humansubjects@ora.umass.edu; (413) 545-3428.* A copy of this consent form will be given to you to keep for your records and review.

11. WHAT IF I AM INJURED?

The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subjects research but the study personnel will assist you in getting treatment should the need arise.

12. WHAT IF MY VEHICLE IS DAMAGED BY THE EQUIPMENT?

The University of Massachusetts does not have a program for compensating subjects for damages to their vehicle.

13. WHAT IF I AM IN AN ACCIDENT WITH MY VEHICLE?

If you are in an accident, your automobile insurance will be the primary insurance. The University will not be held liable for damages done to your vehicle or held liable for third party damage as the result of an automobile accident.

14. WHAT IF I DO NOT WANT TO USE MY VEHICLE? CAN I USE A UNIVERSITY VEHICLE?

In order to participate in this study, you must be willing to use your own personal vehicle. You must have, and be able to produce a valid driver's license and valid automobile insurance.

15. WHAT IF I REFUSE TO GIVE OR WITHDRAW MY PERMISSION?

You should recognize that your participation is voluntary and that you may refuse to participate or may withdraw consent and discontinue participation in the study at any time without prejudice.

16. SUBJECT STATEMENT OF VOLUNTARY CONSENT

By signing below, I the participant confirm that the experimenter has explained to me the purpose of the research, the study procedures that I will undergo and the possible risks and discomforts as well as benefits that I may experience. Alternatives to my participation in the study have also been discussed. I have read and I understand this consent form.

_____
Participant's Name (printed)

_____   _____
Particpant's Signature   Date

(Please do not write below this line)
(Experimenter use only)

17. EXPERIMENTER STATEMENT STATEMENT OF DELIVERY AND RECEIPT OF VOLUNTARY CONSENT

By signing below, I the experimenter indicate that I have explained the purpose of the research, the study procedures, the possible risks and discomforts, the possible benefits, and have answered any questions to the best of my ability:

_____   _____
Signature of person obtaining informed consent   Date

Informed Consent
Older Drivers Study - Control

1. WHAT IS THIS FORM?

This is an Informed Consent Form. It will give you information about the study so you can make an informed decision about participation. Your signature on this form indicates that you are giving your permission to participate in this study.

2. WHO IS ELIGIBLE TO PARTICIPATE?

Drivers between the age of 70 and 85 who have a valid driver's license and drive at least 1,000 miles per year, have been actively driving for at least ten years, and are capable of driving themselves to and from their appointments at the lab are eligible to participate in this study (a driver is considered active in this case if he or she has driving on average at least once a week without assistance).

3. WHO IS SPONSORING THIS STUDY?

This study is being sponsored by the consortium of National Institute of Aging, which is a part of the National Institutes of Health. The Principal Investigators for this study include Dr. Matthew Romoser, an assistant research professor, and Dr. Siby Samuel, a post-doc researcher, both affiliated with the Human Performance Lab (HPL) in the Department of Mechanical & Industrial Engineering at the University of Massachusetts Amherst.

4. WHAT IS THE PURPOSE OF THIS STUDY?

The purpose of this study is to evaluate various strategies of training older drivers to better detect road hazards.

5. WHERE WILL THE STUDY TAKE PLACE AND HOW LONG WILL IT LAST?

This study consists of one session taking place over the months of March through May (weather dependent). The session will take place starting at your home. At this session, you and the researcher will review this consent form, and you be asked to provide your consent to take part in this study. After you have provided consent, the researcher will give you a series of short cognitive and physical screening tests, which will take approximately 10 minutes in total. You will then

be asked to do a field drive near your home for approximately 30-40 minutes. The whole session will take approximately 75to 85 minutes.

6. WHAT WILL I BE ASKED TO DO?

You are being asked to participate in a session, lasting approximately 75 to 85 minutes. The session you will be participating in is described below:

(a)

Figure 1. Field drive camera system. (a) You will be wearing a lightweight, wireless headband bullet camera.

Beginning of the Session - At this session, you and the researcher will review this consent form, and you be asked to provide your consent to take part in this study. After you have provided consent, the researcher will give you a pre-study questionnaire (5-10 minutes) which will ask you about your driving history, ask you to assess your driving, and collect demographic data. You will also be given a series of short cognitive and physical screening tests, which will take approximately 10 minutes in total. You will then be asked to do a field drive near your home for approximately 30-40 minutes.

Field Drive from Your Home – In this field drive, you will be driving your own vehicle to a location from your home that you normally drive to at least twice per month (such as the grocery, pharmacy, a park, a friend's house, etc.). While doing so, you will be wearing a very lightweight, wireless scene camera on your head (see **Figure 1a**). It will feel like you're wearing a light hat. The recording equipment that the headband camera is attached to will be in your placed in your pocket or a secure location within your vehicle during the drive.

Before the drive, you will sit down with the project administrator and decide on a driving route that starts at your house and ends at a destination approximately 15 to 20 minutes away from your home. The destination you choose should be one that

you drive to at least twice per month. You will be fitted for the lightweight, wireless scene camera. You will then be seated in your car and the system will be tested.

Once the administrator has confirmed the system is working properly, you will be first given a chance to practice driving while wearing the scene camera by driving a short distance (approximately one minute) then returning to your driveway. Any adjustments will be made at that time. The administrator will then set the system to record and you will drive to your chosen destination where you will turn around and return home using the same route (if possible), or the fastest route if one-way roads are involved. Afterwards, the camera system will be removed from your car and the drive will be over.

After the Field Drive - At this time you will be asked to do a short questionnaire about your experience in the study, and you will receive the $40 stipend for your participation.

7. ARE THERE ANY RISKS OR BENEFITS ASSOCIATED WITH PARTICIPATION?

The Risks. You will be asked to wear a very lightweight wireless scene camera while driving your car on a predetermined route. There is no impediment to your peripheral vision. You can see as far to the side as would normally be the case without wearing safety glasses. In addition, there is no impediment to your head movement. You have complete freedom of head movement in all directions. Although crashes are not expected as part of the research experiment several additional precautions have been taken to further assure a safe driving environment. The recording equipment for the camera and their power source will be secured in the vehicle to keep it from moving about the cabin of the automobile in the event a crash does occur. The headband camera will impede your vision or driving in any way.

The Benefits. Older adults, especially older adults who drive very little during the year, are at a greatly increased risk of crashing. It has been hypothesized that one of the reasons for this increased risk is the failure of older adults to detect certain hazards.

8. WHO WILL SEE THE RESULTS OF MY PERFORMANCE ON THE FIELD DRIVE OR ON THE TRAINING?

The data we collect from you today will be stored under a randomly selected subject number. We will keep a separate key which associates your name and

other identifying information with your randomly selected subject number. It will therefore **not** be possible for any unauthorized person(s) to later associate your name with the data as stored on our computers since they will not have access to the key. We will combine your results with those of other subjects taking part in the study. This combined information will be used when we write up the study to share it with other researchers. Individual data may also be presented. However, your name will never appear in any publication. Your face will not be visible in any video and audio is not recorded as part of the system.

It is possible that your research record, including sensitive information and/or identifying information, may be inspected and/or copied by the study sponsor (and/or its agent) or other federal or state government agencies in the course of carrying out their duties. If your record is inspected by the study sponsor (and/or its agents), or by any of these agencies, your confidentiality will be maintained to the extent permissible by law.

9. WILL I RECEIVE ANY PAYMENT FOR TAKING PART IN THE STUDY?

Yes, at the conclusion of the study, you will receive a stipend of $40.00 for your participation. If you chose to end your session early, you will receive partial compensation.

10. WHAT IF I HAVE QUESTIONS?

If you have questions about the study, you can contact the primary graduate student researcher for this study, Craig Schneider at caschnei@umass.edu (413-404-6960), the HPL Lab Manager, Tracy Zafian at tzafian@engin.umass.edu (413-545-3393), or one of the study's Principal Investigators, Dr. Siby Samuel at ssamuel@umass.edu (413-695-1587). If, during the study or later, you wish to discuss your participation or concerns regarding it with a person not directly involved in the research, you can talk with the Human Subjects Administrator at humansubjects@ora.umass.edu; (413) 545-3428. A copy of this consent form will be given to you to keep for your records and review.

11. WHAT IF I AM INJURED?

The University of Massachusetts does not have a program for compensating subjects for injury or complications related to human subjects research but the study personnel will assist you in getting treatment should the need arise.

12. WHAT IF I AM IN AN ACCIDENT WITH MY VEHICLE?

If you are in an accident, your automobile insurance will be the primary insurance. The University will not be held liable for damages done to your vehicle or held liable for third party damage as the result of an automobile accident.

13. WHAT IF I DO NOT WANT TO USE MY VEHICLE? CAN I USE A UNIVERSITY VEHICLE?

In order to participate in this study, you must be willing to use your own personal vehicle. You must have, and be able to produce a valid driver's license and valid automobile insurance.

14. WHAT IF I REFUSE TO GIVE OR WITHDRAW MY PERMISSION?

You should recognize that your participation is voluntary and that you may refuse to participate or may withdraw consent and discontinue participation in the study at any time without prejudice.

15. SUBJECT STATEMENT OF VOLUNTARY CONSENT

By signing below, I the participant confirm that the experimenter has explained to me the purpose of the research, the study procedures that I will undergo and the possible risks and discomforts as well as benefits that I may experience. Alternatives to my participation in the study have also been discussed. I have read and I understand this consent form.

_____
Participant's Name (printed)

_____   _____
Participant's Signature   Date

(Please do not write below this line)
(Experimenter use only)

16. EXPERIMENTER STATEMENT STATEMENT OF DELIVERY AND RECEIPT OF VOLUNTARY CONSENT

By signing below, I the experimenter indicate that I have explained the purpose of the research, the study procedures, the possible risks and discomforts, the possible benefits, and have answered any questions to the best of my ability:

_____   _____
Signature of person obtaining informed consent   Date

PRE-STUDY QUESTIONNAIRE
Please fill out and bring with you to the first session.

This is a ***strictly confidential*** questionnaire. Only a randomly generated participant ID number, assigned by the research administrator, will be on this questionnaire. No information reported by you here will be traced back to you personally in any way.   Please feel free to skip any question you do not feel comfortable answering.

Section 1:   Demographics

Race / Ethnicity: ☐ Black / African American   ☐ Asian
(check all that apply) ☐ Caucasian   ☐ American Indian / Native Alaskan
☐ Hispanic / Latino   ☐ Other

Gender: ☐ Male   ☐ Female

Date of Birth: (Month / Day / Year): _____/_____/____   Age: _____

What kind of vehicle do you drive? ☐ 4 door sedan ☐ 2 door coupe ☐ Minivan ☐ SUV
☐ Pickup truck ☐ Other (please describe) _____

Section 2:   Driving History

Have you participated in a study at or lab in the past?   ☐ Yes   ☐ No
If so, how many times? _____

Are you a licensed driver in the U.S.?   ☐ Yes   ☐ No

Do you have at least 10 years driving experience?   ☐ Yes   ☐ No

Are you currently still driving?   ☐ Yes   ☐ No

Approximately how many miles per year do you drive (best guess)? _____

Do you drive less now than you did 5 years ago? ☐ Yes ☐ No   10 years ago? ☐ Yes ☐ No

Do you actively avoid driving in any of the following situations (check all that apply)?

☐ Snow   ☐ Rain   ☐ Nighttime   ☐ Fog / Low visibility
☐ Heavy Traffic   ☐ Interstate highways   ☐ Unfamiliar areas / roads

If you checked any of the boxes in the previous question, how recently did you start doing these things?
☐ I've always avoided these situations   ☐ Within the last 20 years
☐ Within the last 10 years   ☐ Within the last 5 years
☐ Within the last year or so

Section 2:   Driving History (continued)

Do you have any other restrictions on your driver's license?   ☐ Yes   ☐ No

If yes, please describe: _____

Are you currently on any over-the-counter
or prescription medications that make it difficult to drive?   ☐ Yes   ☐ No

If yes, please describe: _____

Within the last three years, have you had any moving violations? ☐ Yes   ☐ No

If so, what type and how many?   ☐ Speeding   How many times? _____
                                    ☐ Running red light   How many times? _____
                                    ☐ Running stop sign   How many times? _____
                                    ☐ Failure to yield   How many times? _____
                                    ☐ Other _____   How many times? _____

Within the last three years, have you been involved
in any automobile accidents?   ☐ Yes   ☐ No

If so, what type of accident(s)?   ☐ Head-on collision (front of car to front of car contact)
(Please check all that apply)   ☐ Rear-end collision (front of car to rear of car contact)
                                    ☐ Side impact or angled collision (front of car to side of
car contact)
                                    ☐ Sideswipe (door to door contact)
                                    ☐ Single car accident (struck tree, sign, pedestrian)
                                    ☐ Multiple car accident (more than two cars involved)
                                    ☐ Other
                                    ☐ I don't remember

In just a few sentences per accident only, please describe the accident(s). Please

_____
_____
_____
_____
_____
_____

Section 3:   Basic Medical Background

Does your license require you to wear
glasses or contact lenses?   ☐ Yes   ☐ No

If you responded "yes" to the above   ☐ Contacts   ☐ Glasses
question, what type of glasses / contacts?   ☐ Bifocals   ☐ Trifocals
(check all that apply)   ☐ Other

Do you currently have any of the following   ☐ Cataracts   (if yes which eye(s) ☐ left ☐
right)
vision conditions?   ☐ Glaucoma
                                                           ☐ Macular Degeneration
                                                           ☐ Color Blindness
                                                           ☐ Blurred Vision

Do you currently have any conditions such as arthritis, rheumatism, or muscle stiffness that
would restrict your mobility and / or flexibility?

       ☐ Yes   ☐ No

If so, what area(s) of your body are affected (please check all that apply)?

       ☐ Hands   ☐ Neck   ☐ Shoulders   ☐ Hips   ☐ Knees

Have do you taken a fall (such as from a step stool) in the last 2 years? ☐ Yes   ☐ No

Have you experienced a seizure(s)? ☐ Yes ☐ No   If yes, has it affected your vision? _____

                                         Your ability to drive? _____

(continued on next page)

Section 4:   Self Assessment

How do you rate the overall quality of your driving skills and ability when compared to the population as a whole in the following age groups?

1)   Compared to drivers between the ages of 16 and 25 I am

☐ Much worse   ☐ Somewhat worse   ☐ About the same   ☐ Somewhat better   ☐ Much better

2)   Compared to drivers between the ages of 35 and 55 I am

☐ Much worse   ☐ Somewhat worse   ☐ About the same   ☐ Somewhat better   ☐ Much better

3)   Compared to drivers in my age range (3 years younger to 3 years older) I am

☐ Much worse   ☐ Somewhat worse   ☐ About the same   ☐ Somewhat better   ☐ Much better

4)   Compared to drivers who are older than me (5+ years older) I am

☐ Much worse   ☐ Somewhat worse   ☐ About the same   ☐ Somewhat better   ☐ Much better

Please put an X in the column that describes how well you do the following things while driving.

WHILE DRIVING I AM ABLE TO	Excellent	Good	Fair	Poor
1. Focus on more than one thing at a time (For example, watching for pedestrians or cross traffic, while paying attention to Stop signs and traffic lights)				
2. Remember important things (For example, the posted speed limit, or directions to turn, or to stay in the right lane)				
3. Quickly decide what to do during dangerous situations (For example, braking or steering to avoid crashes.)				
4. Remain patient and cautious even if frustrated (For example, when behind a slow moving vehicle in front of me, or when trying to change lanes or turn left.)				

Section 4:   Self Assessment (continued)

Please put an X in the column that best describes your behavior.

|	Consistently	Often	Occasionally	Rarely	Never
1. When stopped at an intersection, I look left or right before proceeding into the intersection to make sure that there are no oncoming cars.					
2. When I am confronted with making a difficult left turn, I will try to make three right turns instead.					
3. I avoid driving at night.					
4. After stopping at an intersection, I look a second time to the left or right during the turn to make sure that there are no oncoming cars.					
5. When turning, I try to match my speed to that of traffic as quickly as is reasonably possible					
6. When another driver does something I don't like, my first inclination is to blast my horn at the other driver.					
7. I avoid driving during rush hour.					
8. When approaching a marked crosswalk, I look far to the left and right to see whether there are any approaching pedestrians or bicyclists.					
9. When driving in familiar areas, I get lost.					
10. When changing lanes on a freeway, I glance into the lane into which I am changing to make sure that there is no other traffic in that lane.					
11. I avoid driving on heavily trafficked roads such as interstates or state highways.					
12. I avoid driving when it's raining.					
13. When I walk out to my car, I realize that I've forgotten something (such as the keys) and have to go back inside to look for it / them.					
14. I check my rear-view mirrors for other traffic.					
15. I use my turn signals.					

POST-TRAINING QUESTIONNAIRE

This is a *strictly confidential* questionnaire. Only a randomly generated participant ID number, assigned by the research administrator, will be on this questionnaire. No information reported by you here will be traced back to you personally in any way.

Section 1: Overall Training Effectiveness

On a *scale of zero to ten* where ten is "Extremely Effective" and zero is "Extremely Ineffective", please rate how well the training you received helped you do the following things (place an "X" on the scale).

For example, if you rate something a "7 on a scale of 0 to 10" you would mark it as such:
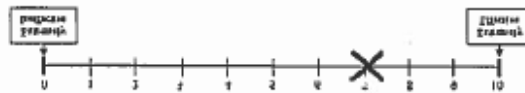
1) On a scale of 0 to 10, I would rate the training's effectiveness in raising my awareness of how age-related decline in mental and physical functioning can impact my driving as a ...
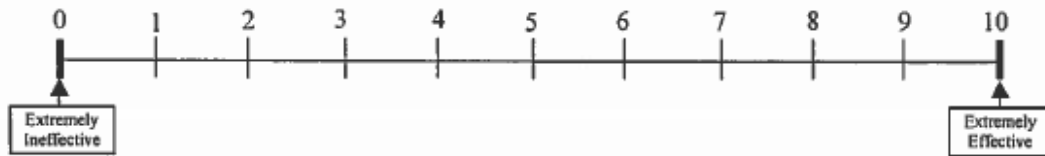
2) On a scale of 0 to 10, I would rate the training's effectiveness in teaching me how to better scan the road for hazards as a ...
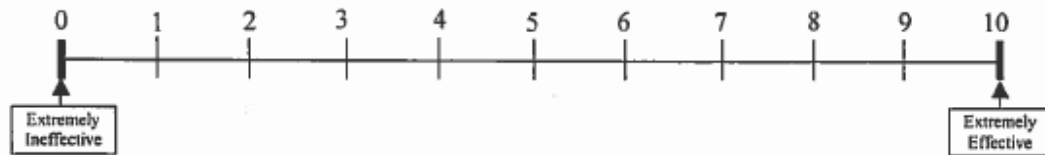
3) On a scale of 0 to 10, I would rate the training's effectiveness in teaching me how to better incorporate head turning behavior into my driving as a ...
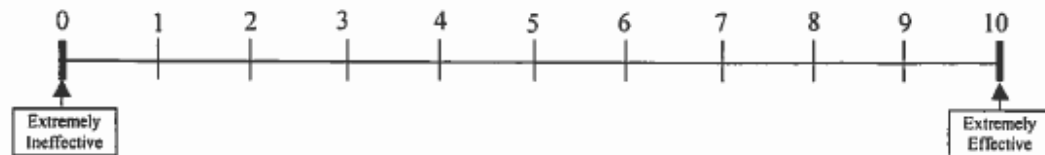
4) On a scale of 0 to 10, I would rate the training's overall effectiveness as a ...

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |

Extremely Ineffective

Extremely Effective
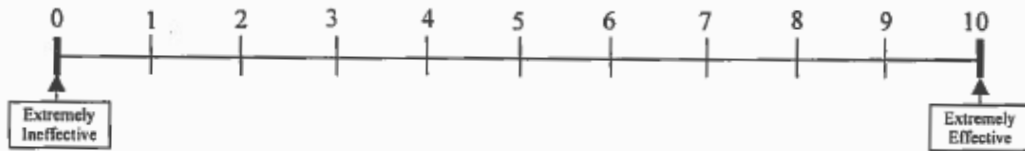
Please state the degree to which you agree or disagree with the following statements.

1)   *I feel I am a better driver as a result of this training.*

☐ Strongly disagree ☐ Somewhat disagree ☐ Not sure   ☐ Somewhat agree   ☐ Strongly agree

2)   *I plan on incorporating the skills I learned during training into my day-to-day driving routine.*

☐ Strongly disagree ☐ Somewhat disagree ☐ Not sure   ☐ Somewhat agree   ☐ Strongly agree

3)   *I believe training such as this should be made available to all drivers over seventy years old.*

☐ Strongly disagree ☐ Somewhat disagree ☐ Not sure   ☐ Somewhat agree   ☐ Strongly agree

4)   *Before the training, I underestimated the effect age-related physical and cognitive decline could have on my abilities to detect hazards.*

☐ Strongly disagree ☐ Somewhat disagree ☐ Not sure   ☐ Somewhat agree   ☐ Strongly agree

4)   *Before the training, I overestimated my skills of scanning in intersections for hazards.*

☐ Strongly disagree ☐ Somewhat disagree ☐ Not sure   ☐ Somewhat agree   ☐ Strongly agree

In a few sentences, what did you like the most about the training?

In a few sentences, what did you like the least?

What would you change about the training you received?

Section 2: Post-Training Self-Assessment

Based upon what you learned about yourself and your driving skills during the training, again rate the overall quality of your driving skills and ability *before you received training* when compared to the population as a whole in the following age groups. Again, you are rating yourself as you were *before training*:

1)   Compared to drivers between the ages of 16 and 25 I am

☐ Much worse   ☐ Somewhat worse   ☐ About the same   ☐ Somewhat better   ☐ Much better

2)   Compared to drivers between the ages of 35 and 55 I am

☐ Much worse   ☐ Somewhat worse   ☐ About the same   ☐ Somewhat better   ☐ Much better

3)   Compared to drivers in my age range (3 years younger to 3 years older) I am

☐ Much worse   ☐ Somewhat worse   ☐ About the same   ☐ Somewhat better   ☐ Much better

4)   Compared to drivers who are older than me (5+ years older) I am

☐ Much worse   ☐ Somewhat worse   ☐ About the same   ☐ Somewhat better   ☐ Much better

Based upon what you learned about yourself and your driving skills during the training, again rate how well you do the following things while driving:

WHILE DRIVING I AM ABLE TO	Excellent	Good	Fair	Poor
1. Focus on more than one thing at a time (For example, watching for pedestrians or cross traffic, while paying attention to Stop signs and traffic lights)				
2. Remember important things (For example, the posted speed limit, or directions to turn, or to stay in the right lane)				
3. Quickly decide what to do during dangerous situations (For example, braking or steering to avoid crashes.)				
4. Remain patient and cautious even if frustrated (For example, when behind a slow moving vehicle in front of me, or when trying to change lanes or turn left.)				

80

Please put an X in the column that best describes to what degree you will change your driving behavior after having received training.

I THINK THAT:	Much More Often	More Often	About the Same as Before	Less Often	Much Less Often
1. When stopped at an intersection, I will look left or right before proceeding into the intersection to make sure that there are no oncoming cars.					
2. After stopping at an intersection, I will look again to the left or right during the turn to make sure that there are no oncoming cars.					
3. When turning, I will increase my turning speed to match the speed of the traffic I am merging with.					
4. When approaching a marked crosswalk, I will look far to the left and right to see whether there are any approaching pedestrians or bicyclists.					
5. When changing lanes on a freeway, I will glance into the lane into which I will be changing to make sure that there is no other traffic in that lane.					

Folstein Mini-Mental State Exam

I. ORIENTATION (Ask the following questions; correct = ☑)	Record Each Answer:	(Maximum Score = 10) Score: _____
What is today's date?	Date (eg, May 21)	1 ☐
What is today's year?	Year	1 ☐
What is the month?	Month	1 ☐
What day is today?	Day (eg, Monday)	1 ☐
Can you also tell me what season it is?	Season	1 ☐
Can you also tell me the name of this hospital/clinic?	Hospital/Clinic	1 ☐
What floor are we on?	Floor	1 ☐
What city are we in?	City	1 ☐
What county are we in?	County	1 ☐
What state are we in?	State	1 ☐

II. IMMEDIATE RECALL	(correct = ☑)	(Maximum Score = 3) Score: _____
Ask the subject if you may test his/her memory. Say "ball," "flag," "tree" clearly and slowly, about on second for each. Then ask the subject to repeat them. Check the box at right for each correct response. The first repetition determines the score. If he/she does not repeat all three correctly, keep saying them up to six tries until he/she can repeat them	Ball	1 ☐
	Flag	1 ☐
	Tree	1 ☐
		NUMBER OF TRIALS: _____

III. ATTENTION AND CALCULATION		
A. Counting Backwards Test	(Record each response, correct = ☑)	(Maximum Score = 5)
Ask the subject to begin with 100 and count backwards by 7. Record each response. Check one box at right for each correct response. Any response 7 or less than the previous response is a correct response. The socre is the number of correct subtractions. For example, 93, 87, 80, 72, 66 is a score of 4; 93, 86, 78 70, 62, is 2; 92, 87, 78, 70, 65 is 0.	93	1 ☐
	86	1 ☐
	79	1 ☐
	72	1 ☐
	65	1 ☐
B. Spelling Backwards Test		
Ask the subject to spell the word "WORLD" backwards. Record each response. Use the instructions to determine which are correct responses, and check one box at right fore each correct response.	D	1 ☐
	L	1 ☐
	R	1 ☐
C. Final Score	O	1 ☐
Compare the scores of the Counting Backwards and Spelling Backwards tests. Write the greater of the two socres in the box labeled FINAL SCORE at right, and use it in deriving the TOTAL SCORE.	W	1 ☐
		FINAL SCORE_____ (Max of 5 or Greater of the two Scores)

IV. RECALL	(correct = ☑)	(Maximum Score = 3) Score: _____
Ask the subject to recall the three words you previously asked him/her to remember. Check the Box at right for each correct response.	Ball	1 ☐
	Flag	1 ☐
	Tree	1 ☐

V. Language	(correct = ☑)	(Maximum Score = 9) Score: _____
Naming	Watch	1 ☐
Show the subject a wrist watch and ask him/her what it is. Repeat for a pencil.	Pencil	1 ☐
Repetition		

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Ask the subject to repeat "No, ifs, ands, or buts."	Repetition	1 ☐
Three -Stage Command		
Establish the subject's dominant hand. Give the subject a sheet of blank paper and say, "Take the paper in your right/left hand, fold it in half and put it on the floor."	Takes paper in hand	1 ☐
	Folds paper in half	1 ☐
	Puts paper on floor	1 ☐
Reading		
Hold up the card that reads, "Close your eyes." So the subject can see it clearly. Ask him/her to read it and do what it says. Check the box at right only if he/she actually closes his/her eyes.	Closes eyes	1 ☐
Writing		
Give the subject a sheet of blank paper and ask him/her to write a sentence. It is to be written sponataneously. If the sentence contains a subject and a verb, and is sensible, check the box at right. Correct grammar and punctuation are not necessary.	Writes sentence	1 ☐
Copying		
Show the subject the drawing of the intersecting pentagons. Ask him/her to draw the pentagons (about one inch each side) on the paper provided. If ten angles are present and two intersect, check the box at right. Ignore tremor and rotation.	Copies pentagons	1 ☐

DERIVING THE TOTAL SCORE	
Add the number of correct responses. The maximum is 30.	TOTAL SCORE _____
23-30 = Normal / 19-23 = Borderline / <19 = Impaired	

Folstein MF, Folstein SE, and McHugh PR, 1975

CLOSE YOUR EYES

(Draw Intersecting pentagons on the back of this page before testing subject)

Snellen Test   www.provisu.ch

E   1   20/200

F P   2   20/100

T O Z   3   20/70

L P E D   4   20/50

P E C F D   5   20/40

E D F C Z P   6   20/30

F E L O P Z D   7   20/25

D E F P O T E C   8   20/20

L E F O D P C T   9

F D P L T C E O   10

P E Z O L C F T D   11

In order to perform this test, please follow the instructions:

Trail Making Test Part A – *SAMPLE*
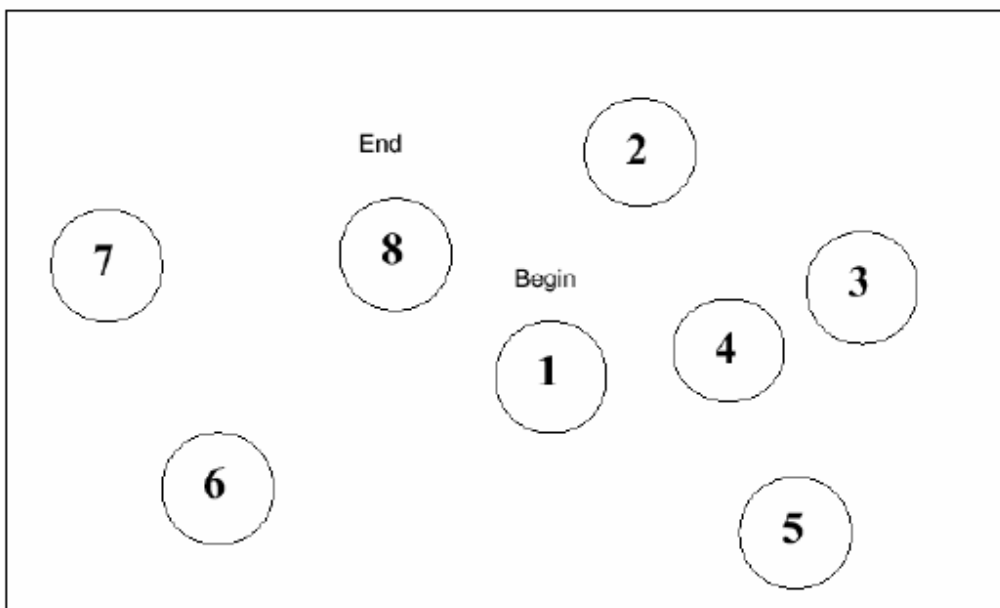
Trail Making Test Part A

Patient's Name: _____   Date: _____
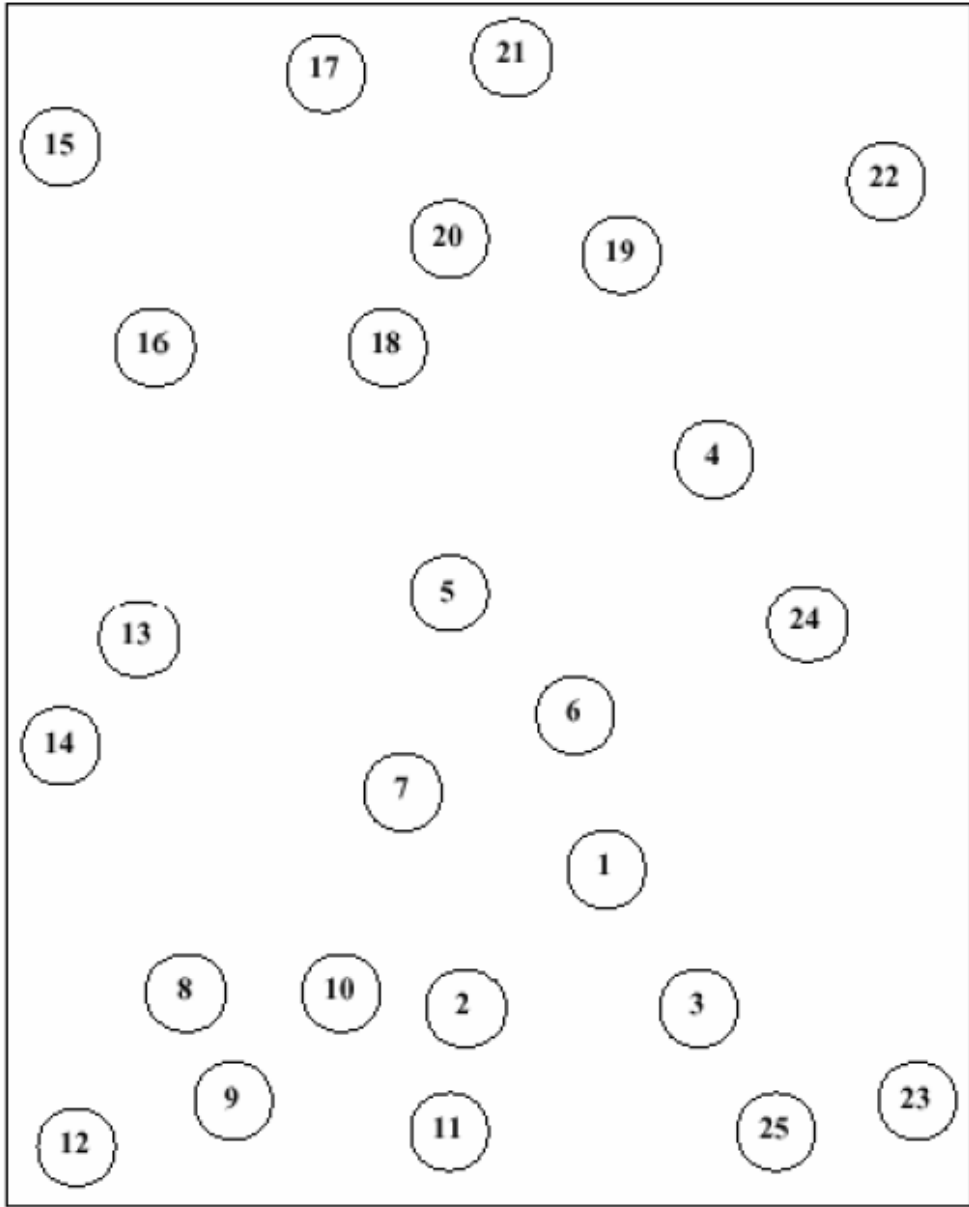
Trail Making Test Part B – *SAMPLE*
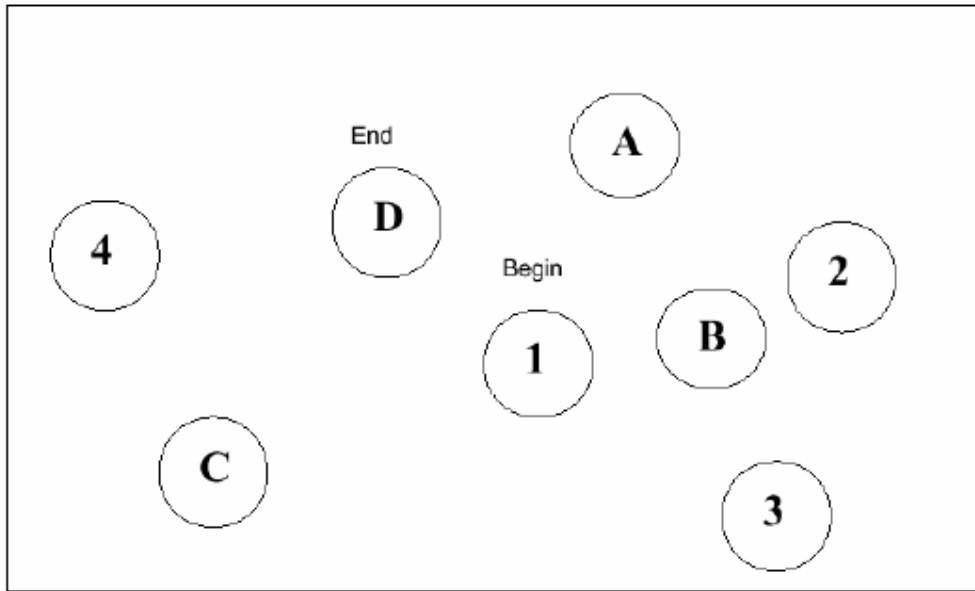
Trail Making Test Part B

Patient's Name: _____   Date: _____
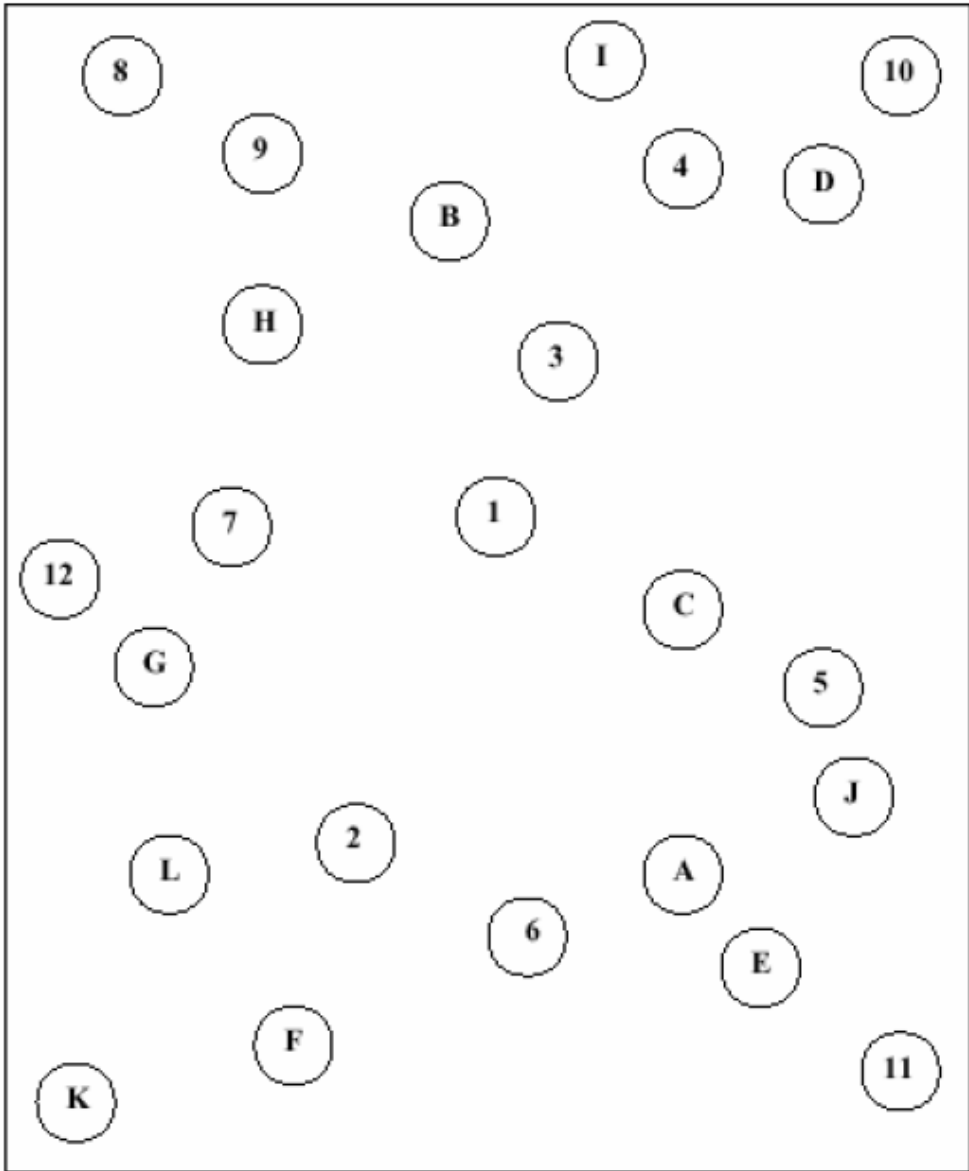
SIMULATOR SICKNESS QUESTIONNAIRE (SSQ)

INFORMATION PROVIDED ON THIS QUESTIONNAIRE IS STRICTLY CONFIDENTIAL.

Participant ID: _____   **Date:** _____

THIS SECTION OF THE QUESTIONNAIRE IS COMPLETED BEFORE USING THE DRIVING SIMULATOR

PRE-EXPOSURE BACKGROUND INFORMATION

1.   How long has it been since your last exposure in a simulator?   _____ days

How long has it been since your last flight in an aircraft?   _____ days

How long has it been since your last voyage at sea?   _____ days

How long has it been since your last exposure in a virtual environment?   _____ days

2.   What other experience have you had recently in a device with unusual motion?

PRE-EXPOSURE PHYSIOLOGICAL STATUS INFORMATION

3.   Are you in your usual state of fitness? (Circle one)   YES   NO
      If not, please indicate the reason:

4.   Have you been ill in the past week? (Circle one)   YES   NO
      If "Yes", please indicate:
      a)   The nature of the illness (flu, cold, etc.):

      b)   Severity of the illness: Very _____ Very
                                            Mild   Severe

      c)   Length of illness: _____ Hours / Days

      d)   Major symptoms:

      e)   Are you fully recovered?   YES   NO

5.   How much alcohol have you consumed during the past 24 hours?
      _____ 12 oz. cans/bottles of beer   _____ ounces wine   _____ ounces hard liquor

6.   Please indicate all medications you have used in the past 24 hours. If none, check the
      first line:
      a) NONE   _____
      b) Sedatives or tranquilizers   _____
      c) Aspirin, Tylenol, other analgesics   _____
      d) Antihistamines   _____
      e) Decongestants   _____
      f) Other (specify):   _____

7. a) How many hours of sleep did you get last night?   _____   hours

    b) Was this amount sufficient? (Circle one)   YES   NO

8. Please list any other comments regarding your present physical state which might affect your performance on our test.

BASELINE (PRE) EXPOSURE SYMPTOM CHECKLIST

Instructions: Please fill this out BEFORE you go into the virtual environment. Circle how much each symptom below is affecting you right now.

#	Symptom	Severity			
1.	General discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Boredom	None	Slight	Moderate	Severe
4.	Drowsiness	None	Slight	Moderate	Severe
5.	Headache	None	Slight	Moderate	Severe
6.	Eye strain	None	Slight	Moderate	Severe
7.	Difficulty focusing	None	Slight	Moderate	Severe
8a.	Salivation increased	None	Slight	Moderate	Severe
8b.	Salivation decreased	None	Slight	Moderate	Severe
9.	Sweating	None	Slight	Moderate	Severe
10.	Nausea	None	Slight	Moderate	Severe
11.	Difficulty concentrating	None	Slight	Moderate	Severe
12.	Mental depression	None	Slight	Moderate	Severe
13.	"Fullness of the head"	None	Slight	Moderate	Severe
14.	Blurred Vision	None	Slight	Moderate	Severe
15a.	Dizziness with eyes open	None	Slight	Moderate	Severe
15b.	Dizziness with eyes closed	None	Slight	Moderate	Severe
16.	*Vertigo	None	Slight	Moderate	Severe
17.	**Visual flashbacks	None	Slight	Moderate	Severe
18.	Faintness	None	Slight	Moderate	Severe
19.	Aware of breathing	None	Slight	Moderate	Severe
20.	***Stomach awareness	None	Slight	Moderate	Severe
21.	Loss of appetite	None	Slight	Moderate	Severe
22.	Increased appetite	None	Slight	Moderate	Severe
23.	Desire to move bowels	None	Slight	Moderate	Severe
24.	Confusion	None	Slight	Moderate	Severe
25.	Burping	None	Slight	Moderate	Severe
26.	Vomiting	None	Slight	Moderate	Severe
27.	Other				

*   Vertigo is experienced as loss of orientation with respect to vertical upright.

**   Visual illusion of movement or false sensations of movement, when not in the simulator, car, or aircraft.

***   Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

THIS SECTION OF THE QUESTIONNAIRE IS COMPLETED AFTER USING THE DRIVING SIMULATOR

POST 00 MINUTES EXPOSURE SYMPTOMS CHECKLIST

Instructions: Circle how much each symptom below is affecting you right now.

#	Symptom	Severity			
1.	General discomfort	None	Slight	Moderate	Severe
2.	Fatigue	None	Slight	Moderate	Severe
3.	Boredom	None	Slight	Moderate	Severe
4.	Drowsiness	None	Slight	Moderate	Severe
5.	Headache	None	Slight	Moderate	Severe
6.	Eye strain	None	Slight	Moderate	Severe
7.	Difficulty focusing	None	Slight	Moderate	Severe
8a.	Salivation increased	None	Slight	Moderate	Severe
8b.	Salivation decreased	None	Slight	Moderate	Severe
9.	Sweating	None	Slight	Moderate	Severe
10.	Nausea	None	Slight	Moderate	Severe
11.	Difficulty concentrating	None	Slight	Moderate	Severe
12.	Mental depression	None	Slight	Moderate	Severe
13.	"Fullness of the head"	None	Slight	Moderate	Severe
14.	Blurred Vision	None	Slight	Moderate	Severe
15a.	Dizziness with eyes open	None	Slight	Moderate	Severe
15b.	Dizziness with eyes closed	None	Slight	Moderate	Severe
16.	*Vertigo	None	Slight	Moderate	Severe
17.	**Visual flashbacks	None	Slight	Moderate	Severe
18.	Faintness	None	Slight	Moderate	Severe
19.	Aware of breathing	None	Slight	Moderate	Severe
20.	***Stomach awareness	None	Slight	Moderate	Severe
21.	Loss of appetite	None	Slight	Moderate	Severe
22.	Increased appetite	None	Slight	Moderate	Severe
23.	Desire to move bowels	None	Slight	Moderate	Severe
24.	Confusion	None	Slight	Moderate	Severe
25.	Burping	None	Slight	Moderate	Severe
26.	Vomiting	None	Slight	Moderate	Severe
27.	Other				

* Vertigo is experienced as loss of orientation with respect to vertical upright.
** Visual illusion of movement or false sensations of movement, when not in the simulator, car or aircraft.
*** Stomach awareness is usually used to indicate a feeling of discomfort which is just short of nausea.

POST-EXPOSURE INFORMATION

1. While in the virtual environment, did you get the feeling of motion (i.e., did you experience a compelling sensation of self motion as though you were actually moving)? *(Circle one)*

                    YES   NO   SOMEWHAT

2. On a scale of 1 (POOR) to 10 (EXCELLENT) rate your performance in the virtual environment: _____

3. a. Did any unusual events occur during your exposure? *(Circle one)*   YES   NO

    b. If YES, please describe:

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