THE EFFECTIVENESS OF USING AN INTERACTIVE DRIVING SIMULATOR TO IMPROVE DRIVING SKILLS AND ABILITIES FOR TEENS AND YOUNG ADULTS WITH AUTISM SPECTRUM DISORDER WITHIN THE CONTEXT OF A DRIVING BOOTCAMP

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Purpose: The purpose of this study was to determine the effectiveness of the interactive driving simulator as an intervention tool for teens and young adults with Autism Spectrum Disorder.

Method: A pretest/post-test design was used on an assessment drive on the interactive driving simulator which took place within the context of a *Driving Bootcamp*. Eight participants with self-reported Autism Spectrum Disorder completed pretesting on the interactive driving simulator on day two of the camp. This was followed by the intervention periods on the interactive driving simulator including: three consecutive days of 30 minutes and six weeks of follow-up sessions two times a week for 30 minutes. Individualized intervention sessions were used to target client-centered driving deficits. Post-testing was completed on the last day of the follow-up sessions. Drives were scored using both the performance measures from the simulator output data and a standardized observational assessment tool (*P-Drive).*

Results: Simulator output data revealed a significant difference between pre and post testing on one measure, total collisions. No significant differences were found between pre and post testing on measures related to: object collisions, pedestrian collisions, sign tickets, times over speed, percentage of time out of lane, and percentage of pedal reaction time. *P-Drive* average raw scores and calibrated scores demonstrated significant differences between pre and post testing among the participants and had very good interrater reliable between four trained raters.

Conclusions: With limited significant differences, simulator output data may not be an effective measure of overall driving performance, although it may be due to the low number of participants. Significant differences on the *P-Drive* average raw score and calibrated scores suggests the interactive driving simulator to be an effective intervention tool for teens and young adults with Autism Spectrum Disorder. Further, the *P-Drive* proved to be a useful observational assessment tool to use when examining performance on the interactive driving simulator.

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CHAPTER I: INTRODUCTION

Driving is an important instrumental activity of daily living (IADL) which facilitates independence in daily life. Social, vocational, and educational opportunities are enhanced with this independence (Cox, Reeve, Cox, & Cox, 2012). It is one of the first occupations that teens engage in which require adult-like responsibilities. Driving can also allow one to maintain jobs, relationships, and other individually identified important activities (Monahan, 2012). Independence in driving increases an individual's ability to go shopping, attend health care appointments, and engage in social activities (Ackerman, Edwards, Ross, Ball, & Lunsman, 2008). Not being able to obtain one's license can have a serious impact not only on one's ability to complete daily occupations, but can also have a negative impact on mental health. Specifically, not obtaining one's license can very much compromise one's sense of autonomy (Daigneault, Joly, & Frigon, 2002).

Safe operation and maneuvering of a car is critical to modern society, not only for general safety reasons, but for financial reasons as well. Financial issues come into play considering the cost of medical and car/environmental costs when one is involved in an accident (Tyson, Yang, Leve, & Harold, 2012). Therefore, the decision for whether a person with executive functioning impairments possess fitness to drive needs to be considered carefully. People with these impairments are often hard to identify and assess because they often have normal intelligence levels and therefore perform very well on structured tasks, such as intelligence quotient tests (Tyson et al., 2012). Unfortunately, real world situations involving unstructured activities, such as driving, prove to be difficult for this population. Common executive functioning tests include assessments of complex attention, fluency, problem solving (especially in novel situations), and decision-making. When considering fitness-to-drive, there are clear cut, legally defined minimal requirements for sensory impairments (such as vision), but requirements for cognitive functioning are less defined (Tyson et al., 2012). Although interesting, Ackerman et al. (2008) provided evidence that processing speed and functional performance better predict driving cessation in older adults when compared to physical impairments such as poor health or vision. While all of these smaller aspects, such as vision, relate and can impact driving, it is the integration of these factors through executive functioning processing that better predicts driving outcomes (Ackerman et al., 2008; Barkley, 2012)

In 2009, an increase in referrals to assess fitness to drive for people with executive functioning impairments was reported in Norway (Alexandersen, Dalen, & Brønnick, 2009). One reason mentioned for this increase is due to research pertaining to the amount of cognitive functioning needed to drive safely. Another reason listed for this increase is the number of people with executive functioning impairments who show an interest in engaging in the IADL of driving. Because of this, the public has looked to health professionals to help to determine fitness to drive among individuals with cognitive deficits (Alexandersen et al., 2009). Fortunately, executive functioning abilities can improve. In some instances, providing a person with executive functioning impairments a way to learn strategies and compensatory skills, through occupational therapy intervention, can enable safe driving (Tyson et al., 2012).

By studying the relationship between executive functioning impairments and driving ability, families, occupational therapists, and researchers will be able to gain insight into the problems preventing people with executive functioning impairments from driving safely. Because driving increases mobility and independence, which in turn positively affects physical, social, and emotional health, it is occupational therapists' ethical responsibility to address these deficits and further help these individuals engage in this important occupation.

CHAPTER II: REVIEW OF THE LITERATURE

Skills Used During Driving

Both cognitive and physical skills are used during driving. Cognitive components commonly cited in literature used during driving include attention, memory, processing speed, visual-perceptual skills, and executive functioning (Barco, Stav, Arnold, & Carr, 2012). Safe driving requires the cooperation of all these skills (Tyson et al., 2012). Executive functioning is an umbrella term which describes one's ability to "plan, organize, sequence, shift, strategize, execute, inhibit response, form goals, reason abstractly, monitor thought processes and behaviors, perform searcher, and allocate resources" (Tyson et al., 2012). Additionally, executive functioning skills are involved in the initiation of an activity, during problem solving, in judgement during decision-making, in impulsivity, in flexible thinking, during organization, and during sequencing complex actions. All of these skills come together to achieve a common goal (Barco et al., 2012). Because executive functioning plays such a large role in processing, these skills are a crucial factor in driving ability and driving safety.

Executive Functioning

Executive function is an umbrella term used to describe a group of complex, higher-order cognitive processes that are used throughout daily life (Barkley, 2012). These functions "enable a person to engage successfully in independent, purposive, self-serving behaviors" (Gillen, 2013 p. 669). These skills are used in adapting to new situations and achieving goals. Although the exact processes grouped under this umbrella term have been long debated, executive functions generally include: decision making, problem-solving, planning, organizing, sequencing, anticipating, strategizing, and flexible thinking (Barkley, 2012; Gillen, 2013; Tyson et al., 2012).

These skills develop throughout the lifespan. "Spurts" of growth in executive function begin as young as 12 months and continuing until the majority of these functions are developed by age eight. Refinement of these skills continue on through the second decade of life where specific growth spurts are seen between ages 15-19 and 20-29 years of age (De Luca, et. al., 2013).

Executive functioning allows one to successfully engage in many daily life activities and participate within their environment (Barkley, 2012; Gillen, 2013). Thus, deficits in executive functioning can affect numerous areas of one's life. Specifically, these deficits cause safety concerns when engaging in the IADLs (Blumenfeld, 2009; Solhberg & Mateer, 2001; Tyson et al., 2012). Because of this, executive functioning has been noted to be the most important predictor for successful independent living and therefore impacting one's ability to feel fully integrated into the community (Blumenfeld, 2009; Solhberg & Mateer, 2001). When compared to other IADLs, the IADL of driving requires a higher level of function and a more skillful integration of executive function processes. This is due to the fact that these cognitive processes are highlighted most during "new, nonroutine, complex, and unstructured situations," which occurs during driving (Gillen, 2013, p.669; Tyson et al., 2012). Specific studies have noted the link between executive functioning deficits and driving. For instance, people with cognitive impairments have shown to perform significantly worse on driving assessments when compared to a control group (Tyson et al., 2012). Additionally, vehicle crashes and injury increase with the severity of cognitive impairment (Tyson et al., 2012).

Components of Executive Functioning

Problem Solving and Decision Making. Problem solving is the cognitive process used when faced with a novel or difficult situations whereas decision making is the outcome of this process (Gillen, 2013; Barco et al., 2012). The transitive relationship between these two processes maintain that if problem solving is impaired then decision making will also be impaired. Deficits in these areas are linked to driving efficiency. For instance, impaired decision making has shown to be directly tied to driver errors and vehicle crashes (Tyson et al., 2012). These skills are used during driving when deciding: way-finding, what to do if a road is closed on a familiar route, what to if a light turns yellow, how to get a car out of a tight parking space or garage, and what to do during an emergency situation (Barco et al., 2012).

Planning. Planning involves one's ability to map out steps to reach a goal (Barco et al., 2012; Barkley, 2012). Simple planning can be seen when planning a route (Barco et al., 2012). To change lanes one must not only cognitively plan the steps of putting on the turn signal, looking to make sure there are no cars coming, and then moving the car into the other lane, but also must translate these steps to the motor planning needed. Deficits in planning can be noted during driving when someone slams on their brakes when they see a red light instead of beginning to slow down when they see a yellow light. Deficits in planning can also be seen when someone quickly swerves to get onto an exit ramp instead of planning this move and merging into the lane in a safe manner (Barco et al., 2012).

Sequencing. Sequencing is one's ability to put steps in the correct order to achieve a desired outcome (Barco et al., 2012; Barkley, 2012). Sequencing is used not only while driving, but also when preparing to drive. For instance, one needs to sequence the steps of getting into the car, putting on one's seatbelt, and turning on the car. Furthermore, sequencing is also used during way-finding and direction-following (Barco et al., 2012).

Anticipating. Anticipation allows one to determine possible outcomes in a given situation (Barco et al., 2012; Barkley, 2012). For example, this skill can be noted in driving when anticipating when to break or accelerate in traffic. Also, when another road user puts on their turn signal most drivers will anticipate that this driver is going to turn and thus adjusts their driving accordingly. Anticipating also comes into play during merging situations. When a lane is ending, drivers in other lanes anticipate that the cars in the ending lane are going to merge to their lane and thus drive accordingly (Barco et al., 2012).

Flexible Thinking. Flexibility in thinking allows someone to change their way of thinking when an unexpected event occurs (Barco et al., 2012; Barkley, 2012; Roger & Ziviani, 2012). Outcomes of on-road driving assessments have been shown to be directly related to cognitive flexibility; specifically, as deficits in cognitive flexibility increase a decrease is observed in driving performance (Alexandersen et al., 2009). Flexible thinking can be observed during driving when there is a change in a route due to an unexpected road closure of when having to decide what to do when one misses a turn (Barco et al., 2012).

Impulsivity. Impulsivity is demonstrated during decision-making and entails making decisions before gathering all the relevant data or making decisions without thinking of the potential consequences (Barco et al., 2012; Barkley, 2012). Signs of impulsivity include thrill seeking and aggression, which can translate to unsafe driving (Tyson et al., 2012). Impulsivity can be observed when a driver merges without looking, turns into oncoming traffic without looking, or changes lanes without looking (Barco et al., 2012).

Combining of Component Skills

The executive functioning skills listed above are most often observed in combination with one another during driving. For example, deficits in initiation and planning are noted when difficulty occurs initiating the movement of the foot from the gas to brake or vice versa. Deficits in planning and sequencing are noted during the process of making a lane change for turning

(Barco, et al., 2012). Also, poor impulse control directly affects decision-making behaviors and can be manifested into risky driving behaviors such as speeding, engaging in road rage behaviors, and engaging overall aggressive driving (Tyson et al., 2012).

Executive functioning skills are most challenged in novel situations (Barco et al., 2012; Corbett, Constantine, Hendren, Rocke, & Ozonoff, 2009). Novel situations often involve decision-making and impairments in decision-making have shown to be a main predictor in vehicle crashes (Barco et al., 2012). Although some skills used during driving are learned and practiced, the environment in which we drive in includes pedestrians, weather, other drivers, road conditions, and speed, which are constantly changing and thus creating novel situations/environments each time one drives a car.

Some studies have examined overall executive functioning deficits related to driving (Mäntylä, Karlsson, & Marklund, 2009). In one study, researchers determined that individual and developmental difference in executive functioning among people have shown to contribute to driving accidents. Specifically, teens with lower executive functioning scores correlated with more errors made during a simulated drive (Mäntylä et al., 2009).

Use of Strategies to Compensate for Deficits in Executive Functioning

While it may be debated if executive skills are malleable, it certainly is clear there are techniques can be used to increase these skills or compensate for deficits (Sohlberg & Mateer, 2001). Compensatory strategies can include environmental modifications (e.g., manipulating amount of distractions present, ensuring organization of environment, ensuring rest, etc.) and compensatory strategies (e.g., external cueing systems such as checklists or reminder systems) (Gillen, 2013; Lowenstein & Acevedo, 2010). Cognitive rehabilitation has shown to produce positive results in improving strategies to support executive functioning during IADL performance (Solhberg & Mateer, 2001; Tyson et al., 2012). Examples of these compensatory training techniques include: problem-solving training, goal management training, and metacognitive training. The aim of the problem-solving training is to replace a person's impulsive decision-making technique. This is done by replacing the person's technique with verbally mediated analysis of a proposed goal along with the development of a systematic way to achieve the goal (Gillen, 2013; Von Cramon, Von Cramon, & Main, 1991). The aim of goal management training is to encourage people to maintain their focus on goal-directed behaviors (Gillen, 2013; Levine, 2000). Lastly, the aim of metacognitive training is to increase the participant's metacognitive aspects through a structured process (Birnboim, 1995; Birnboim & Miller, 2004; Gillen, 2013). Other strategies, such as speed processing training, have also demonstrated the ability to decrease unsafe driving behaviors (Tyson et al., 2012). Further, interventions have also shown to be successful in improving executive functions with specific populations. Some of these include: integrative mind-body training, computer training (e.g. *Luminosity*), non-computerized games, aerobics, martial arts, and yoga (Diamond & Lee, 2011; Tang, Yang, Leve, & Harold, 2012).

Enriquez-Geppert, Huster, and Herrmann (2013) went on to further divide executive function improvement training into two broad categories: computerized behavior trainings and interventions targeted at direct neuromodulation (e.g. neurofeedback, transcranial electrostimulation) (Enriquez-Geppert et al., 2013, p.1). These two training techniques have both shown to be successful in improving executive functioning. Additionally, these improvements in executive functioning generalized to other "untrained tasks aiming at the same cognitive process, as well as across cognitive domains within executive control" (Enriquez-Geppert et al., 2013 p. 1).

Autism Spectrum Disorder

The diagnosis rate of Autism Spectrum Disorder (ASD) has increased from 1 in 150 in 2000 to 1 in 68 in 2012 (Centers for Disease Control and Preventions, 2016). ASD is characterized by impaired social communication and interaction. These impairments along with patterns of behavior that are repetitive and/or restrictive decrease one's ability to actively and effectively engage in social and occupational environments (Centers for Disease Control and Prevention, 2015). Moreover, deficits in executive functioning frequently accompany the diagnosis of ASD (Corbett et al., 2009).

Executive functioning deficits can be some of the most debilitating aspects of this disorder (Corbett et al., 2009). Due to this population increase and the executive functioning deficits associated with this disorder, it is beneficial to society and to this large group of people to determine effective compensatory strategies to help these individuals drive safely and effectively. Although deficits associated with ASD have been demonstrated to affect driving abilities, little research had been conducted with behind the wheel practicality. No study to date has assessed actual on-road driving behaviors in drivers with ASD (Reimer et al., 2013).

Driving with Autism Spectrum Disorder. A recent survey demonstrated that 24% of adults with ASD identified themselves as independent drivers (O'Neil 2012; Freeley 2010). In fact, a survey of 297 parents of children with ASD revealed that 63% of respondents noted that their daughter or son are already driving or plan to drive in the future (Huang, Kao, Curry, & Durbin, 2012). Although a large number of people with ASD obtain their driver's licenses, they do so significantly later than non-ASD drivers (Daly, Nicholls, Patrick, Brinckman, & Schultheis, 2014). Drivers with ASD also drive significantly fewer days a week, acquire significantly more traffic violations when compared to non-ASD drivers, and do not drive in specific conditions, such as at night or during rush hours (Daly et al., 2014). These driving habits can negatively affect the driver's social and occupational life. Regarding driving safety, drivers with ASD have shown to be involved in more crashes and receive more driving citations then non-ASD drivers (Daly et al., 2014). These statistics and demographics regarding drivers with ASD demonstrate the importance for researching driving abilities of this population and further driving interventions which can be used with this population.

One survey of parents and/or caregivers of teens with ASD revealed that the majority (70%) of respondents believed that ASD "moderately" or "extremely" negatively impacted their son's or daughter's ability to drive (Cox, Reeve, Cox, & Cox, 2012). Although drivers with ASD have many pre-driving deficits which may impede their ability to drive safely and therefore requires a driving rehabilitation specialist (DRS) to assess fitness-to-drive, no formal guideline exists to assess fitness-to-drive for this specific population (Daly et al., 2014; Monahan, Classen, & Helsel, 2013). Because of this, occupational therapists who are working with this population have little to no resources or evidence on which to base their decisions of fitness-to-drive (Classen, Monahan, Brown, & Hernandez 2013). Additionally, many *Individualized Education Plans* of teens with ASD do not even include any driving skill goals (Huang et al., 2012).

Evaluation. It is critical to recognize that many of the assessments tools presently used to screen and evaluate driving have been norm referenced on older drivers or drivers with specific medical conditions. Because of the unique characteristics of individuals with ASD, one cannot assume that the same assessments tools will be valid. For example, Classen (2013) found that the Useful Field of Vision® (UFOV) had a ceiling effect in her study of teens with ASD and ADHD. The UFOV is an assessment which determines one's processing speed and ability to divide attention (Visual Awareness, n.d.). Conditions such as poor vision, difficulty with divided-attention, and slower processing can affect these skills (Visual Awareness, n.d.). Although in one study teens with ASD performed more poorly on one of the UFOV tests regarding selective attention, other subtests on the UFOV did not show a difference between teens with ASD and a control group. Because of these results, the UFOV may not be sensitive enough to be used with this population (Classen et al., 2013).

Impairments associated with ASD that affect driving abilities. The visual, cognitive (executive functions), and motor deficits associated with ASD have demonstrated to affect many different occupations, including driving. Although, cognitive deficits have often proven the most difficult to overcome. All skills of driving can be affected in people with ASD including: problem-solving, decision-making, planning, sequencing, anticipating, flexible thinking, and impulsivity (Barco et al., 2012; Classen et al., 2013). Evaluations by DRSs have noted differences with ASD divers and non-ASD divers. In one study (Classen et al., 2013) when evaluated by a DRS, teens with ASD made more driving errors than both ADHD drivers and non- ASD/ADHD drivers. Drivers with ASD made errors in all categories of the study except for two: vehicle positioning and gap acceptance. The other categories in which drivers with ASD made errors included: visual scanning, speed regulation, lane maintenance, signaling, and adjustment to stimuli. These errors could in part be attributed to certain deficits related to ASD, specifically prioritizing and attention-shifting. Drivers with ASD tend to inefficiently prioritize important information and demonstrate delays in attention shifting when presented with multi-stimuli environments (Classen et al., 2013). Both information prioritizing and attention-shifting are skills used frequently in driving, thus deficits in these areas may partly explain why the previously mentioned driving errors occurred. Another impairment associated to ASD that may affect driving is difficulty in responding to the increased cognitive demands of increased stimulation. Reimer et al. (2013) examined driving behavior and visual attention between a group of young adults with ASD and a control group. All the young adults with ASD had an IQ of 85 or higher, a valid driver's license, and no major sensorimotor handicaps. Using an interactive driving simulator, the young adults with ASD displayed a higher, unvaried heart rate and a gaze pattern avoiding high stimulus areas and towards less complex portions of the scene. These observed patterns in the teens with ASD deviate from what is considered to be ideal driving behaviors (Reimer et al., 2013).

Hazard perception has also shown to be a barrier to safe driving for people with ASD. Given their issues with processing social stimuli, Sheppard, Ropar, Underwood, and van Loon (2010) found that participants with ASD had more difficulties identifying social hazards (those containing people) than a control group. Interestingly enough, there was no difference between the participants with ASD and the control group when identifying non-social hazards (those not containing people). Motor planning issues were also demonstrated in this study. This was showcased through the drivers with ASD's slower reaction time when responding to hazards when compared to the control group. Furthermore, reaction time related to detecting hazards is associated with future accident rates (Sheppard et al., 2010).

Parents and/or caretakers of children with ASD were surveyed regarding their perception of their son's or daughter's driving. Parents and/or caretakers reported issues with multitasking while driving, such as merging into traffic or other combinations of skills, proved to be the most problematic (Cox et al., 2012). Based on the outcomes of the study, Cox et al. (2012) noted three main issues that caretakers and/or parents and driving instructors need to be aware of when interacting with drivers with ASD: 1.) interpreting the actions of others (social), 2.) managing unexpected changes in the driving environment, and 3.) sustaining attention through an extended drive.

Intervention Strategies for Driving

Although there is research related to the deficits associated with ASD that may impact driving ability, there is very little research regarding effective compensatory intervention strategies to use with this population to help improve driving skills. Through a survey, parents and/or caretakers of children with ASD who taught their children to drive were asked to indicate the least helpful and most helpful strategies regarding helping their teens to drive. The least helpful strategies mentioned included: emotionality (not helpful to show emotion), talking too much/ giving too many instructions at once, and inconsistency. The most helpful strategies included: practice and repetition (regular driving), teaching in small steps, using video games or other driving like experiences to increase exposure before getting behind the wheel, giving directions before starting a drive, and showing emotional stability through calmness and patience (Cox et al., 2012). Although this survey sheds light on some practical techniques to use when helping a person with ASD learning to drive, these techniques are very general. There is a clinical need for specific interventions that can be used with the specific deficits related to ASD.

Interactive Driving Simulator. While there is limited research regarding specific interventions, driving technologies, such as the interactive driving simulator, have been given credence in being a potential intervention to enable driving safety (Akinwuntan et al., 2005; Devos et al., 2009; Devos et al., 2010; Hoffman & McDowd, 2010; Lee, Lee, & Camerson, 2003; Reimer et al., 2013). Reimer et al. (2013) regarded the interactive driving simulator as a way to provide clinicians and researchers a “reproducibly, control, efficiency, and ease of use” way to assess fit-to-drive (p. 2212). An interactive driving simulator not only provides a realistic driving experience, but it also involves the simultaneous use of multiple skills used during driving. Additionally, the use of a simulator provides therapists with a safe learning environment where errors do not risk physical or emotional well-being (Classen, Dickerson, Justiss, 2012). Furthermore, 67% of parents and/or caregivers of children with ASD believed driving technologies, such as using an interactive driving simulator, could be very useful tool in teaching teens with ASD to drive (Cox et al., 2012).

The interactive driving simulator has shown to improve people’s driving performance who suffer from executive functioning deficits due to strokes. Many of these studies compared cognitive re-training to the use of a simulator-based driving training (Devos et al., 2009; Devos et al., 2010; Akinwuntan et al., 2005). A study completed by Akinwuntan et al. (2005), randomly assigned eighty-three stroke patients to receive either driving-related cognitive tasks or simulator-based training. On-road pre and post tests were used to determine overall driving performance. Results indicated that individuals who received the simulator-based training showed improved driving abilities in the post-test on-road driving assessment. Seventy-three percent of the individuals in the simulator-based training passed an official pre-driving assessment, which legally gave them the right to drive, compared to the 43% of individuals in the driving-related cognitive tasks group (Akinwuntan et. al., 2005). Devos et al. (2009) also compared simulator-based training to cognitive training program and determined that although both groups improved significantly on on-road tests, the simulator-based training group achieved higher scores overall when compared to the cognitive training group. Lastly, results from a five year follow up study demonstrated the long-lasting effects of simulator-based training when compared to cognitive training. Five years after the original training occurred, results of the study indicated 60% of participants who were in the stimulator-based training group were considered fit-to-drive when compared to the 48% of participants in the cognitive training group (Devos, et al., 2010). Although no studies have been found which implement the use of an interactive driving simulator to improve driving skills specifically with people with ASD, the research noting improvement in other individuals with executive functioning impairments with the use of an interactive driving simulator give credence in using this tool with people with ASD.

Driving Programs. Driving programs have been used to many years to assist novice drivers to increase safe and effective driving. Many of these programs use both preparatory teaching activities combined with on-road driving experiences. These range from standard driver's education programs to more involved programs such as video feedback systems and Steering Teens Safe (STS)©. General driver's education programs usually include classroom hours and behind the wheel experience. For instance, in the state of North Carolina, driver's education courses are offered through all high schools by a contracted agency named North Carolina Driving School. This particular agency requires at least 30 classroom hours and at least 6 behind the wheel hours to complete their driver's education program (North Carolina Driving School, 2016). Unfortunately, basic driver's education courses have not shown to be effective in reducing number of teen collisions (Mayhew, 2007). Additionally, many of the instructors of these types of programs do not have medical knowledge to assist individuals with medical conditions (Dickerson, Stressel, Justiss, & Luther-Krug, 2012). As discussed, there are additional programs available to teach novice drivers how to drive safely and effectively. Both video feedback (the use of visual feedback to notify a teen driver of a driving error) and STS (program focusing on increasing quality and quantity of parent-teen communication regarding face driving) have both proven to be effective (Peek-Asa, Hamann, Reyes, & McGehee, 2016). Although, as with regular driver's education programs, these programs have not shown to be an effective way to address driving skills specifically with the ASD population. Therefore, overall, there are a lack of driving programs which focus specifically on teaching the growing population of ASD drivers how to safely and effectively engage in this ever important IADL.

Summary

The important IADL of driving provides people with independent mobility linked to important occupations such as maintaining relationships or employment. This link further strengthens the tie between the ability to drive independently and health and well-being. Because of these health benefits, driving is an important occupation for occupational therapists to focus on with their clients. Individuals with executive functioning impairment frequently demonstrate issues interfering with safe driving. Because of this, people with executive functioning impairments need to be taken under special consideration when assessing fitness-to-drive.

One specific population, people with ASD, have shown significant deficits in driving related specifically to executive functioning. The rate of people with ASD has continued to rise. Therefore, the rate of drivers with ASD has risen which increases the importance of teaching compensatory driving strategies to ensure safe driving (Reimer et al., 2013). Drivers with ASD are involved in more crashes, receive more citations, and make more driving errors overall than non-ASD drivers (Classen et al., 2013 & Daly et al., 2014). Furthermore, drivers with ASD have difficulty recognizing hazards containing social stimuli (Sheppard et al., 2010). Although there is a lack of evidence-based driving interventions which can be used to help drivers with ASD, interactive driving simulators have been given some credence in its' ability to help drivers with

ASD learn to drive more efficiently and safely (Reimer et al., 2013). Therefore, the purpose of this study is to explore whether an intervention consisting of a five-day *Driving Bootcamp* with six-week follow-up sessions will demonstrate any differences in driving performance, skills needed for driving, and in particular demonstrate improved performance in executive functioning measures. The specific research question for this pilot study was to explore whether the occupational therapy intervention strategy of using an interactive driving simulator within the context of a driving program for individuals with ASD can compensate for executive functioning impairment as evidenced by improved driving ability on a specific drive scenario on an interactive driving simulator.

CHAPTER III: METHODS

Design

A pretest/post-test design was used to address the specific research question: Does the outcome measures of the driving simulator and an observational tool demonstrated a significant difference (i.e., improved driving ability on a specific drive scenario on an interactive driving simulator) on the post-test compared to a pretest after the participants receive occupational therapy intervention using an interactive driving simulator within the context of a driving program for individuals with ASD. The dependent measures were the outcomes measures of both the simulator and a standardized evaluation tool. Due to the small number of participants and the nature of the intervention was individualized, participants were used as their own controls. The intervention (IV) was the use of the different interventions (Table 1) on various drive scenarios on the interactive driving simulator.

Program. The use of the interactive driving simulator occurred during a *Driving Bootcamp*, which took place in Health Science's Building on East Carolina University's west campus. The *Driving Bootcamp* aimed to increase the use of compensatory strategies to improve efficacy and safety in driving. The *Driving Bootcamp* focused on improving driving and community mobility skills for teens and young adults with ASD. The program consisted of a week intensive involving 5 consecutive days for 6 hours a days of structured interventions in both group and individual formats. Subsequently, follow-up sessions were held two times a week for six weeks. One participant only completed follow-up sessions one time a week due to distance from the *Driving Bootcamp*. During follow-up sessions, participants completing 90 minutes of individualized interventions consisting of: 30 minutes of driving/community mobility activities, 30 minutes of the driving simulator, and 30 minutes of visual motor activities. The activities were based on previous research findings to target specific driving deficits associations with drivers with ASD (description of *Driving Bootcamp* Appendix A). Many of the activities used during the *Driving Bootcamp* were used as preparatory activities for the interactive driving simulator. For instance, skills such as hazard detection and road sign detection were activities completed outside of the interactive driving simulator, but the skills learned during these activities directly translated to skills required to be a safe and effective driver on the interactive driving simulator.

Participants

Participants were recruited throughout the area of Greenville, North Carolina and surrounding areas. Organizations in which participants were recruited from included the *Greenville Autism Society* and private local private doctor's office who serve clients with ASD. This study consisted of seven male participants who completed the entire *Driving Bootcamp* process. One additional participant only completed the week-long intensive and not the six weeks of follow-up appointments and was thus not included in data analysis. All participants were between the ages of 15-19, had self-reported Autism Spectrum Disorder, and had the ability to speak and understand English. None of the participants had other major sensorimotor handicaps (e.g. deafness, blindness, aphasia, visuospatial neglect), diagnosis of severe psychiatric conditions, nor physical conditions which impact driving (e.g. missing limbs, delayed motor reactions). Demographics are displayed in Table 2.

Instruments

P- Drive.

The *P-Drive* (Patomella, 2014) was used to score simulator driving during the pretest drive and post-test drive. The *P-Drive* is an on-road driving assessment tool that consists of 27 items related to driving which are scored based on a four-point rating scale. The rating scale is used to assess both driving safety and quality of performance. Rating scale interpretation is as follows: "4= competent performance facilitating safe driving", "3= questionable and hesitant performance", "2= ineffective performance hindering driving and leading to risky situations", and "1= incompetent performance leading to repeated or serious mistakes during the driving test and/or the instructor intervenes to secure the situation" (Patomella, 2014, p. 5). Although never used in practice or research in the U.S., the *P-Drive* has demonstrated to be both internally valid (coefficient= 0.6) and reliable (coefficient= 0.90) by "producing a linear measure of driving ability" when used with people who suffer or have suffered from strokes, dementia, and mild cognitive impairments in Sweden (Patomella, Tham, Johansson, & Kottorp, 2010, p. 92). Furthermore, after training a short half-day training session, *P-Drive* has shown to have good between-rater reliability (ICC =0.950, 95% CO 0.889 to 0.978) (Vaucher et al., 2015).

Modifications to the evaluation tool were made to the *P-Drive* to better represent driving behaviors and road rules of the United States. After the modifications, training was arranged and completed by two professors and seven occupational therapy students at East Carolina University on the use the *P-Drive* by the developer of this assessment, Anne-Hellen Patomella. After training, review of the assessment was done to adapt the assessment to better fit U.S. drivers. This review included careful examination of scoring criteria along with scoring a recorded drives that were completed in United States. Further, edits were made to fit simulator driving because some specific behaviors are unable to be performed on the interactive driving simulator. The specific items of changing gears, reversing, way-finding, and focusing would be included on on-road assessment, but these are not assessed on the interactive driving simulator due to restrictions of the software (See appendix B for adapted score sheet). Therefore, with some edits made to better fit U.S. driving and simulator driving, research has shown this assessment to be sensitive enough to use as a pre and post driving assessment for people with executive functioning impairments (Patomella & Bundy, 2015).

Equipment and Software

As seen in Appendix C, the interactive driving simulator hardware used in this study was a steel framed apparatus which allows for individual adjustments including: seat position, steering column position, seat belts, shoulder straps, etc. Additionally, the interactive driving simulator allows for real-life transference through usable doors enabling entrance and exit of the simulator, real-time steering, and real-time acceleration and braking pedals. Accompanying the simulator apparatus, is the *STISIM-OT Drive* software (Systems Technology, 2013). This software enables realistic drives which can be programmed to include a focus on different driving skills including: reaction time, vehicle control, car following, divided attention, memory/planning/navigation, passing, gap judgments, merging, and hazard perceptions. Further, there are three difficulty levels (easy, medium, or hard) which can be selected under each of the categories. Drives are framed in different environments including: rural, urban, and suburban. Performance measures summarizing driving behaviors are collected throughout the drive. These include accident counts, brake and accelerator behaviors, steering and handling behaviors, and driver compliance/attention behaviors. Accident counts describe the variables involved in the accidents whether these be vehicle, pedestrian, other obstacles, or off-road. Braking and accelerating behaviors are broken down into speeding behaviors, reaction time, time to collision, and tailgating. Steering and handling behaviors assess lane positioning, deviation along the centerline, and edge crossings. Lastly, driver compliance/attention measures describe compliance with signal lights, signs, and turning rules along with divided attention. After the completion of a drive, the *STISIM-OT Drive* software produces overall frequencies of the driving behaviors, including statistical rates of the behaviors previously mentioned (Systems Technology, 2013).

Procedure

After IRB approval (Appendix D), participants began the study by completing an informed consent. For those under 18 years of age (n=4), one of the parents signed a consent form to allow their teens to participate in the study. The participants over 18 years of age, signed for themselves. The risks of the study were explained to both the parents and the participants. Participants received a unique identification number prior to collecting any confidential or identifying information. The identification numbers (IDs) were used on the simulator instead of the participant's name. While there are other intervention in the Bootcamp, this procedure will only address the driving simulator procedures, data analysis and outcomes.

Pretest. For the simulator pretest, the facilitator read scripted directions regarding simulator precautions (simulator sickness) and overall driving regulations on the interactive driving simulator to the participants (see Appendix E). Participants were then oriented to the interactive driving simulator and given the opportunity to complete up to three practice drives, although all participants chose only to complete one practice drive during both pre and post testing. The practice drives consisted of a 2.5 mile drive taking approximately 5 minutes. Before this pretest drive began, driving regulations on the simulator were reviewed with the participants again to ensure understanding of these regulations (Appendix E). After being read the regulations, participants were asked to complete the standardized drive (pretest) on the simulator. (See Appendix F is a description of the standardized drive). The standardized route entailed a progressively complex course, starting with simple traffic maneuvers and progressing to complex maneuvers. As noted in previous research, the standardized drive entailed important variables which assist in determining fitness to drive including: “varying speeds, types of roadways, intersections with varied traffic signals, and situations necessitating knowledge of rules of the road and right-of way” (Dickerson et al., 2012, p. 354). Also, turn by turn directions were used throughout the drive, which again was shown in previous research to be an important predictor in fitness to drive (Dickerson et al., 2012). Because the standardized drive included all these driving variables found significant in determining fitness to drive in previous research, it is believed that this standardized drive encompasses all important and necessary driving habits to allow for a comprehensive driving assessment. The assessment drive was scored using the *P-Drive* by 2-3 trained raters. Up to three additional trained raters watched the recorded pretest and scored the drives on the *P-Drive* assessment at a later date. Therefore, each pretest drives were scored either in person or from a recording of the drive by four trained raters.

Intervention. During the next week and additional six week follow up appointments, the participants participated in the *Driving Bootcamp*. As described, different tasks, skills and abilities were used during driving was be a focus during the camp. During the time the simulator was used as an intervention tool, researchers took detailed notes on each intervention session the participants completed on the interactive driving simulator. These notes would include observations such as what interventions did the researcher use with the participant when on the simulator (Table 1), what goal the research identified for the participant on a drive and if the participant met/ did not meet the goal, what specifically caused the client difficulty, or what driving tendencies did the research observe (both positive and negative). These notes were used to assist with producing a full picture of each participant’s use of the simulator.

Post-test. At the end of the six-weeks participants completed post-testing on the interactive driving simulator following the same procedure as the pretest. Scripted driving rules and regulations on the simulator were again review with the participants (Appendix E), participants completed the one five-minute warm-up drive as completed in pretesting, and then participants completed the standardized assessment drive on the interactive driving while being rated using the *P-Drive* by 2-3 trained raters. Again, up to three additional trained raters watched the recorded post-test and scored the drive using the *P-Drive* assessment at a later date. Thus, resulting in the post-test drives being scored by a total of four trained raters. Pretest and post-test data was analyzed along with the demographic data.

Data Analysis

All data was entered into an Excel document to be coded and checked for both outliers and errors. Performance measures from simulator output data were analyzed both individually and as a group using a paired t-test to determine significance between pre and post driving behaviors. Next, *P-Drive* raw scores were calculated by adding total points scored on the assessment for each participant by rater. Average raw scores were then calculated by adding all the raters' scores of a participant's drive and dividing by the total number of raters (four). These scores were then compared using a t-test to determine differences between pre and post testing of the participants as a group. *P-Drive* average raw scores were further examined using Spearman's rho to determine interrater reliability.

Using Winsteps software, Rasch partial credit analysis was used to calibrate each *P-Drive* rater and item. From this calibration, interval-level measures were produced for each rater and item. Then, rater and item data were compared to the Rasch measurement's model of unidimensionality to determine the extent to which the data fits this model. From this comparison, logit scores were determined for each participant's pre and post test score. These logit scores were then compared using a paired t-test. Because the *P-Drive* assessment was scored in different fashions (in-person scoring and play-back scoring), a t-test was used to determine if differing scoring methods had an effect on driving performance. This was done by analyzing both average raw scores and logit scores of in-person scoring and play-back scoring.

Lastly, descriptive statistics were then used to analyze the demographic data, including measures of central tendency. The demographic information was compared to outcome measures produced both by the *P-Drive* (raw and calibrated scores) and the performance measures derived from the *STISIM-OT drive* software. These comparisons were analyzed using paired t-test.

CHAPTER IV: RESULTS

Performance Measures from Simulator Output Data

All simulator performance outcome measure data (dependent variables) were visualized and analyzed. For the group, only one of the stimulator outcomes measures was significantly different. Comparison between pre and post test number of collisions was significant ($t(6)= 3.12$, $p=.021$) suggesting an improvement in performance. Figure 1 illustrates this the number of collisions pre and post for each client. All clients decreased the number of crashes, except for Participant 1 who had one additional crash during post-testing. Other data that was number of occurrences (e.g., number of tickets) as a group is illustrated in Figures 2 and 3, with none reaching significance. Figure 3, shows the simulator outcomes that are percentage of time (e.g., out of lane, pedal reaction), comparing pre and post as a group with neither significant.

Although, there were no significant differences, likely due to the small sample, there were changes observed. Figures 4-9 illustrates each pre and post simulator outcome measure for each participant. Specifically, all participants either decreased or maintained their number of objects collisions from pre to post testing, except for Participant 1 who have one additional object collision during post-testing (see Figure 4). All participants either decreased or maintained their total number of pedestrian collisions from pre and post testing (see Figure 5). Also all participants, except for Participant 1, either decreased or maintained the number of stop sign tickets received if they did not come to a complete stop or stop at least one car length from the stop sign from pre to post testing (see Figure 6). All participants either decreased or maintained the total number of occurrences in which they were over the speed limit from pre to post testing (see Figure 7). This figure also demonstrates that this driving behavior did not prove to be a concern for many of the individuals in that only two of the seven participants were noted to be speeding at any time during testing. Participants demonstrated inconsistent performances on the total percentage of time outside of their lane with three participants decreasing this percentage and four participants increasing this percentage from pre to post testing (see Figure 8). Again, inconsistent performances were observed for total response time between the onset of a stimuli and gas pedal release by the driver with three participants decreasing this time and four participants increasing this time from pre to post testing (see Figure 9).

P-Drive Assessment

Using *the P-Drive*'s four raters' average raw scores for the seven participants, there is a significant difference between pre and post testing (t(6)= -5.36, p=.002). Since higher scores indicate improvement, these results suggest participants gained driving skills and abilities as a result of the simulator intervention. Figure 10 is an illustration of the pre and post *P-Drive* scores (averaged of the four raters) for each participant. Interrater reliability was calculated for the four raters for the *P-Drive*, and would be considered very good correlation (See Table 5).

Using the *P-Driv*e's four raters' logic scores, there is a difference between pre and post testing (t(5)= -4.22, p=.008). Figure 11 is an illustration of the pre and post *P-Drive* logic scores. The significant difference in logic scores suggests improved driving between pre and post testing. In this analysis one of the participant's data was not analyzed due to missing data. Both analyses (raw and calibrated scores) showing significant difference suggest that the participants, as a group, improved driving abilities and skills on the interactive driving simulator from pretest to post-test.

Scoring of P-Drive

Because 56% of the drives were scored in-person by raters (raters scoring while the participant completed the drive) and 44% were scored by raters watching play-backs (re-watching the drives completed by the participants which were recorded through the simulator software), statistics were used to determine if in-person rating vs play-back rating had an effect on outcome scores. Additionally, it is important to note that when scoring a drive in playback, the raters are unable to score steering, pedal usage, and attending/acting to mirrors because these items need to be observed behaviorally in person. Using a paired samples t-tests, no significant difference was found between the different scoring methods ($p>0.05$).

Demographics

Statistics were used to determine if demographics had an effect on driving performance. Analysis examined demographics' effect on both raw score and logic scores from the *P-Drive* assessment. Paired t-test results of the demographics showed no significant differences ($p>0.05$).

Chapter V: DISCUSSION

The purpose of this study was to examine the use of the interactive driving simulator as an effective intervention and training tool to improve safe and effective driving for teens and young adults with Autism Spectrum Disorder. The results were essentially three-fold; 1) the collection of formal data through the use of the simulator output data, 2) results of a standardized assessment, the *P-Drive*, and 3) examining objective data extracted from the researchers' observations and interactions with the participants while on the interactive driving simulator. A caveat of the results is that the participants were also addressing driving skills during the participation in the *Driving Bootcamp*. Other interventions implemented during the *Driving Bootcamp* included Visions Coach (Vision Coach, n.d.), The Interactive Metronome (Interactive Metronome, n.d.), IPad games, hazard detection activities, modified CarFit, and other activities. While it is impossible to determine how the other activities contributed to the results of this study, experientially, the interactive driving simulator was probably the most significant intervention in terms of time and perceived value (investment of energy) by the participants.

Simulator Output Data

After examining the simulator output data, the only significant difference between pre and post testing was total number of collisions, decreased from a total of twenty collisions to a total of nine among the participants. This suggests an improvement in scanning abilities and hazard detection skills. Accordingly, many of the participants were observed to independently alter their driving patterns when potential hazards were more likely to occur. For instance, many participants would drive slower and increase scanning when in an urban environment.

Previous research indicated different driving errors consistently made by drivers with ASD including: decreased overall reaction time, decreased reaction time specifically to social stimuli, decreased ability to shift attention, decreased visual scanning, speed regulation errors, and lane maintenance errors (Classed et al., 2013; Sheppard et al., 2010). These same driving errors were noted in many of the participants' driving performance on the interactive driving simulator. In fact, some participants demonstrated inconsistent performance and/or no improvement in some of these driving behaviors (e.g., total time out of lane and pedestrian collisions) from pre to post testing. This may suggest that occupational therapists need to develop and frequently implement interventions focusing on improving these deficits when working with drivers with ASD. However, there were also some improvements in other noted characteristics of drivers with ASD. These included such behaviors as total collisions and times over speed. Because improvements were noted in some of these errors during post-testing, the present study also highlights the interactive driving simulator as beneficial intervention too.

The simulator output data suggests that the driving behaviors of speeding may not be a significant issue for this population. In fact, during the *Driving Bootcamp*, many of the participants required interventions that focused on increasing/maintaining speed because they often drove too slowly. This observation is supported by previous research that individuals with ASD have difficulty when responding to the increased cognitive demands of increased stimulation (Reimer et al., 2013). Because it took a longer time to process what was going on within the driving environment for many of the participants, many compensated by driving slower.

Interestingly, the simulator output data had limited significant differences, which was not necessarily expected. However, previous research also noted that a driving simulator's output measures may not be sensitive enough to capture overall driving behaviors (Classen et al., 2012). Further, the simulator measures may also entail too specific of criteria to score well on certain measures. For instance, when approaching a stop sign on the interactive driving simulator, the driver must come to a complete stop right at the white line on the road and if the driver fails to do so the interactive driving simulator will count this as a stop sign error. This is an important outcome of this study for practitioners in that a skilled practitioner needs to be observing the participation in this type of intervention and not depend on simulator outcomes.

P-Drive

Although the simulator output data had limited significant differences between pre and post testing, both *P-Drive* raw scores and *P-Drive* calibrated scores demonstrated improved driving behaviors from pre to post testing, therefore suggesting that the use of an interactive driving simulator within the context of a *Driving Bootcamp* as an effective intervention for teens and young adults with ASD. Although participants were unable to complete on-road driving, studies have demonstrated the ability of learning which occurred through simulation to be transferred to on-road driving (Akinwuntan et al., 2005; Devos et al., 2009; Devos et al., 2010). Further studies have demonstrated the link between simulator performance and on-road driving performance, noting the simulator to be an effective evaluation tool and intervention tool to address on-road driving (Casutt, Martin, Keller, & Jäncke, 2014; De Winter et al., 2009; Lee, 2003; Meulener & Fraser, 2015; Yan, Abdel-Aty, Radwan, Wang. & Chilakapati, P, 2008). This research demonstrates the link between simulator driving performance and on-road driving performance, thus supporting the potential use of the interactive driving simulator as a safe and effective intervention tool that could be used as a precursor or in combination with to on-road driving instruction.

Assessment

This study also expands upon previous research citing the interactive driving simulator as a controlled and consistent assessment tool (Dickerson, 2013). As noted in previous research, there exists no formal guidelines to determine fitness-to-drive for this drivers with ASD, but the present study points to the benefits of the use of an interactive stimulator as one way to assist in determining fitness for drive for this population (Daly et al., 2014; Monahan et al., 2013). The interactive driving simulator not only allows for testing to be done within a controlled and safe environment with no physical consequences, it also allows clinicians to develop a range of observations that can be consistent across clients and evaluations.

Considering there were limited significant differences on simulator output data from pre to post testing and significant differences on *P-Drive* data (both raw and calibrated), it suggests that using a standardized observational assessment tool when evaluating driving performance on the interactive driving simulator is critical. The present study supports the use of the *P-Drive* as an effective assessment tool to be used on the interactive driving simulator. Previous research and the present study indicate the importance of spending time to train raters on the use of the *P-Drive* to assure valid scores and also strong interrater reliability as noted in the present study (Patomella & Bundy, 2015; Patomella et al., 2010). Further, because the results of the raw score align with the calibrated score, this supports the findings of Patomella and Bundy (2015) that P-Drive raw scores can be an effective way to determine fitness to drive. This is beneficial to note because practitioners need not to complete complicated statistics to determine significant changes in driving behaviors but can instead use raw scores (Patomella & Bundy, 2015).

Individual Participants

Because the participants varied tremendously both individually and in regard to functional level of their Autism Spectrum Disorder, it was beneficial to split the participants into three groups when discussing their individual performance based on the three functional levels of Autism Spectrum Disorder according to the *Diagnostic and Statistical Manual of Mental Disorders* (American Psychiatric Association, 2013). It is important to note that the individuals were divided into the three groups based on their functional driving ability, not on overall functioning.

Level 1: Requiring Support. Participant 7 already had his permit and was driving daily when the camp started, therefore interventions that proved most beneficial focused on more complex driving tasks such as night driving, highway driving, divided-attention drives, long drives (30 minutes), and wayfinding drives. His driving deficits related mostly to focusing attention and reaction time. The majority of drives which Participant 7 drove were considered difficult on the interactive driving simulator difficulty rating scale. Per simulator output data, between pre and post testing Participant 7 decreased total number of collisions and pedestrian collisions, while increasing his percentage out of his lane (slightly) and pedal reaction time. He maintained zero object collisions, sign tickets, and percentage of time over speed during both pre and post testing. His *P-Drive* raw score increased from 51.25 to 78.

Participant 8 also had his driving permit but was only driving on average one day per week when the camp started. His driving deficits related mostly to impairments in: decreased scanning ability and overall lack of insight into his deficits. Interestingly, Participant 8 was not invested in the camp in the beginning and did not understand why he was there. Through watching play-backs of his drive, he began to see the mistakes he was making and soon became invested in the intervention activities, especially the interactive driving simulator. One of the most beneficial interventions for Participant 8 was watching recordings of his drives. He frequently asked to re-watch drives and would point out mistakes he made, which further assisted with increasing his insight. Other interventions focused on increasing scanning abilities through identifying potential hazards. Additionally, because he did demonstrate a number of positive driving behaviors, researchers challenged Participant 8 with many of the same interventions used with Participant 7. This included the use of difficult drives and by using interventions that focused on more complex driving tasks such as night driving, highway driving, divided-attention drives, long drives (30 minutes), and wayfinding drives. Per simulator output data, between pre and post testing he decreased the number of total collisions, pedestrian collisions, and reaction time while slightly increasing the percentage of time outside of his lane. He maintained zero object collisions, sign tickets, and percentage of time over speed during both pre and post testing. His *P-Drive* raw score increased from 61.7 to 74.2. A few weeks after the intervention ended, Participant 8 successfully obtained his licensee.

At first, Participant 4 was very invested in the camp, but as the camp progressed into the six weeks of follow-up sessions, he demonstrated decreased interest and active participating. Participant 4's driving deficits related to impairments in: sustained attention, reaction time, scanning, and inconsistent appropriate and safe reactions to hazards. Therefore, the focus of interventions was on sustained attention (longer drives, distractions) and increasing scanning by having him identify potential hazards with Participant 4 making better progress. The most beneficial interventions for Participant 4 were interventions similarly used with participants 7 and 8 in that researchers focused on more complex driving tasks such as night driving, highway driving, divided-attention drives, long drives (30 minutes), and wayfinding drives. Additionally, difficult drives were used frequently to as a way challenge multiple driving behaviors at once.

Although Participant 4's interested/active engagement decreased, his results were very promising. Per simulator output data, Participant 4 demonstrated the most improvement among all the participants in that he decreased total collisions, object collisions, pedestrian collisions, percentage outside of lane, and pedal reaction time while not increasing any measures between pre and post testing. He also maintained zero sign tickets and times over speed both during pre and post testing. He improved his *P-Drive* raw score from 60.75 to 78.25 between pre and post testing

Level 2: Requiring Substantial Support. Participant 2's significant driving deficits were related to his self-reported ADHD in that his impairments related to: impulsivity, distractibility, and sustained attention. Interventions that proved beneficial were related to pausing the drive before a critical driving decision needed to be made and discussing with the Participant what the safest decision would be and why. Researchers also frequently prompted Participant 2 to identify driving actions and potential hazard to assist him in surveying his driving environment before he made diving decisions. As Participant 2 progressed with these interventions, distractions were increased during driving (such as listening to a podcast) to assist Participant 2 with ways to decrease attention to these distractions. For this participant, one significant outcome of the intervention for him was the insight he gained into the importance of taking his ADHD medication before completing complex tasks such as driving. In terms of pre and post simulator output data, Participant 2 decreased total collisions, object collisions, sign tickets, and times over speed while he increased percentage of time out of lane and pedal reaction time. He maintained the same number of pedestrian collisions (one) from pre to post testing. He also improved his *P-Drive* raw score from 38.25 to 65.75 between pre and post testing.

Although Participant 3 did demonstrate some characteristics related to ASD (e.g., decreased ability to shift attention and decreased reaction time) his motor-ticks and anxiety negatively impacting his ability to drive more than these other deficits. Moreover, as the participant's anxiety increased, the frequency of his motor ticks also increased. Thus, the identified strategy was to first focus on improving basic driving skills which in turn increased his confidence while also decreasing his anxiety. Although his anxiety still impacted his driving, especially after he made a mistake, a strategy was developed to have him verbalize that he was feeling increased anxiety and practice finding a safe place to pull-over on the simulated drive to take a break and relax. His steering grip ("ten and two") was also changed (to "five and seven") to assist with increased stabilization of his arms to decrease the amount of impact his ticks had on his steering. Researchers also used many other interventions such as hazard detection, lane maintenance, speed maintenance, identification of driving actions, and so forth but the previously mentioned interventions proved to have the biggest impact on Participant 3's driving ability. Per simulator output data, from pre to post testing he decreased his total number of collisions, object collisions, and sign tickets while he increased slightly the percentage of time out of his lane and pedal reaction time. He maintained the number of pedestrian collisions (1) from pre to post testing. Speeding did not prove to be difficult for Participant 3 as observed by the fact that he had zero times over speed during both pre and post testing. He also improved his *P-Drive* raw score from 54.25 to 66.25 between pre and post testing.

Level 3: Requiring Very Substantial Support. Participant 6 demonstrated many different characteristics associated with ASD that affected his driving performance. These impairments related to: sensory processing, reaction time, motor planning, attention, ability to divide attention, and ability to process complex stimuli. Because of his deficits and overall level of functional performance, intervention was focused more on basic driving control such as the calibration of the gas and brake pedals, accelerating and breaking appropriately, and steering control. The majority of his drive were rated as “easy” on the interactive driving simulator difficulty scale. Per simulator output data, between pre and post testing he significantly decreased total collisions (from six to two), object collisions (from four to one), pedestrian collisions, sign tickets, percentage of time over speed, and his percentage of time outside his lane. He increased his pedal reaction time between pre and post testing. Although Participant 6 had the lowest pretest *P-Drive* raw score, he demonstrated the most overall improvement from his base-line. He increased his *P-Drive* raw score from 28.25 on his pretest to 58.75 on his post-test (a difference of 30.5 points). However, although he showed improvement, he did not demonstrate the ability to perform the necessary driving skills to transition to on-road driving at this time.

Lastly, Participant 1 presented with some similar characteristics as Participant 6. He demonstrated many ASD characteristics that affected his driving ability including impairment in: attention, divided attention, ability to process complex stimuli, reaction time, and flexible thinking. The focus for Participant 1 was on basic driving control such as the calibration of the gas and brake pedals, accelerating and breaking appropriately, and steering control. The majority of his drives were “easy” among the difficulty scale of the interactive driving simulator. In regard to the simulator output data, he performed worse on measures related to total collisions, object collisions, and sign tickers. He performed the same on measures related to pedestrian collisions and times over speed. However, he did perform better on measures related to percentage of time out of lane and pedal reaction time, although these were very small increases. Further, when examining the different between pre and post *P-Drive* raw scores he improved only slightly (pre= 37.5, post=43.5). In comparison to the other participants, he demonstrated the least improvement on *P-Drive* raw scores between pre and post testing. There appeared to be several reasons for this. First, immaturity may have played a part in that he was one of the youngest participants (only 15 years old), he did not have his permit, nor completed any driver's education classes. Thus, it is not surprising he would not make gains on something that was so new to him. Second, when examining this participant's performance, he did demonstrate improvement, especially when he was able to ask questions and receive immediate feedback. During the post-test drive, per protocol there was no talking or reassurance, which appeared to cause Participant 1 increased anxiety, which ultimately affected his driving performance. Therefore, Participant 1 did not demonstrate the driving skills to transition to on-road driving at this time.

Future Research

The advantages of the use of the interactive driving simulator as both an intervention tool and assessment tool were noted throughout the study. These advantages of using the interactive driving simulator as an intervention tool include: varying difficultly levels of drives, drives focusing on specific driving behaviors, varying lengths of drives, the ability to re-watch the drives. The advantages of using the interactive driving simulator as an assessment tool include: the ability to complete driving in a safe and controlled environment and the ability to re-create the same driving environment to more easily determine changes in driving behaviors. Because this study focused on providing individualized interventions on the interactive driving simulator and comparison of the effectiveness of different interventions is impossible, thus, it will be beneficial for future research to determine which interventions are most effective for this population as a whole. This would assist with providing practitioners with concrete evidence-based interventions to use with driver with ASD. Also, it would be beneficial to complete future research studies containing larger sample sizes. This will enable results to be more easily generalized to the population of ASD drives. Additionally, although previous research has demonstrated the link between performance on the interactive driving simulator and on-road driving performance, it is imperative to continue to build this research (Akinwuntan et al., 2005; Devos et al., 2009; Devos et al., 2010; Hoffman & McDowd, 2010; Lee et al., 2003). Lastly, while there is previous research related to the effectiveness of simulator training with certain diagnoses, i.e. stroke, there are no studies determining the effectiveness of simulator training with drivers with ASD (Akinwuntan et al., 2005; Devos et al., 2009; Devos et al., 2010). Therefore, it would be beneficial to continue research related to the use of simulator training specifically for those with ASD.

Limitations

Being a pilot study, the small number of participants will decrease the result's ability to be generalized. Additionally, because the participants were a convenience sample of volunteers from the Greenville area of North Carolina, generalizability of the results to the target population of drivers with ASD is further be reduced.

Also, events occurring before the research begins, such as driver education courses, could also have had an effect on the outcome of the study. Although statistics determined these variables did not have an effect on performance, one could argue that these statistics might change if the sample size was larger. Further, although the assessment drive was only used during pre and post testing, elements of these drives were present in other drive scenarios which were used as intervention drives during the *Driving Bootcamp*. Thus one could argue that the participants did not actually improve driving performance but learned how to respond to specific stimuli on the interactive driving simulator.

The instrumentation and equipment used in the study also causes limitations. Although the *P-Drive* has shown to be reliable and valid, edits had to be made to the assessment to better represent United States driving and further edits were made to enable the assessment to be used on the interactive driving simulator (Patomella & Bundy, 2015; Patomella et al., 2010). These edits could jeopardize the reliability and validity of this assessment. Also, because the interactive driving simulator is a representation of reality and therefore has questionable ecological validity, it could be argued that skills learned on the interactive driving simulator will not be able to be transferred to on-road driving.

Summary

The purpose of this study was to examine the use of the interactive driving simulator as an effective intervention and training tool to improve safe and effective driving for teens and young adults with Autism Spectrum Disorder. Results from *P-Drive* data (both raw and calibrated) signify overall improved driving performance from pre to post testing for the group of participants. While statistical differences were only found with one of the simulator outcome measures, individual participants did improve in most measures. This result indicates and supports the importance of occupational therapy practitioners using their observation skills and as well as standardized assessment tools for driving simulator intervention and evaluation. This study also provides evidence for the use of the interactive driving simulator as a way to determine fitness-to-drive for individuals with ASD. Further, the study established the *P-Drive* assessment as an effective way to evaluate driving performance on an interactive driving simulator.

Lastly, this study reveals the effects of varying functional levels of ASD on the ability to implement compensatory strategies to enable safer and more effective driving. Some participants were very successful in implementing strategies while other participants, who presented as lower level with more ASD characteristics, demonstrated increased difficulty in progressing towards becoming a safe and effective driver. This study aims to further research related to drivers with ASD, the use of an interactive driving simulator as an intervention tool and assessment tool, and the use of the *P-Drive* as an effective way to assess driving performance on the interactive driving simulator.

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Table 1. Interventions

Variety of Drives	Drive variables were selected to challenge certain driving behaviors: length, level of complexity, environments, speeds, hazards, weather/road conditions.
Identification of Driving Actions	Participants were asked to identify needed driving behaviors for weather conditions, specific objects, road characteristics, hazards, road signs and pedestrians.
Active Passenger	Participants sat in the passenger seat and engaged in active passenger activities either verbally or through a worksheet when another participant was driving.
Review Performance	Participants re-watched drives they had completed to examine and analyze their driving behaviors in terms of risks and positive improvement.
Wayfinding	Participants were given a map, prompted to plan out a route to a certain location, and then completed their planned route on the simulator. This task was used to improve their ability to way find and to learn how to manage wayfinding without putting their driving at risk for collision.
Divided Attention	During these drives, arrows appeared on the lower portion of the screen signaling the participants to push a button. This task challenged participants' ability to divide attention and to carry out a motor task during driving.
Distraction	Use of conversation or other distractors were used during drives to challenge participants' ability to divide attention.

Table 2. Demographics

Participant	Age	Education Level	License Status	Driving Experience	Average of Days per Week Driving	Frequency of Simulated Games during Summer	Parent's expectation of Driving Simulator Performance
1	15	8th grade	None	No experience	0	6-9 hours per day	Very good
2	18	Enrolled in college	Driving permit	Drives occasionally with supervision	1	Over 12 hours per day	Very good
3	19	12th grade/ completed high school	Driving permit	Does not drive	0	Over 12 hours per day	Good
4	17	11th grade	Driving permit	Only taken driver's education	0	Over 12 hours per day	Good
6	16	10th grade	None	Only taken driver's education	0	Never	Poor
7	16	10th grade	Driving permit	Drives regularly with supervision	5	1-3 hours per day	Good
8	18	Enrolled in college	Driving permit	Drives occasionally with supervision	1	6-9 hours per day	Excellent

Table 3. Definitions of Simulator Performance Measures Data Used for Outcome Measures

Object collision	total number of collisions with vehicles and roadway objects by driver's vehicle. Roadway objects include barriers and cones.
Pedestrian collision	Total number of collisions with pedestrians by driver's vehicle.
Total collision	Total number of collisions involving off road crashes, vehicles, other roadway objects, and pedestrians.
Sign ticket	Stop sign tickets issued if driver does not come to a complete stop at least one car length from the stop sign.
Times over speed	Total number of speeding tickets given to the driver's vehicle. All posted speed limits are given 3mph leeway to allow for reasonable speedometer adjustment.
Out of lane	Percentage of time total drive time the driver's vehicle was out of the driving lanes. Includes whenever a portion of the vehicle's body is over the roadway centerline or off the roadway.
Pedal react	Response time between the onset of the stimulus event and gas pedal release by driver

Table 4. Average Raw Scores of P-Drive by Rater

	Participants													
	1		**2**		**3**		**4**		**6**		**7**		**8**	
Rater	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	38	34	40	66	53	61	62	82	27	51	58	80	63	77
2	39	53	48	75	58	72	59	81	24	61	39	81		80
3	30	48	30	60	58	67	60	75	29	66	56	77	65	68
4	43	39	35	62	48	65	62	75	33	57	52	74	57	72
Average Raw Score	**37.5**	**43.5**	**38.25**	**65.75**	**54.25**	**66.25**	**60.75**	**78.25**	**28.25**	**58.75**	**51.25**	**78**	**61.7**	**74.25**

Table 5. Interrater Reliability Scores

Correlation between rater 1 and 2	.879
Correlation between rater 1 and 3	.863
Correlation between rater 1 and 4	.930
Correlation between rater 2 and 3	.949
Correlation between rater 2 and 4	.916
Correlation between rater 3 and 4	.947

Figure 1. Simulator Data: Number of Total Collisions Among Participants

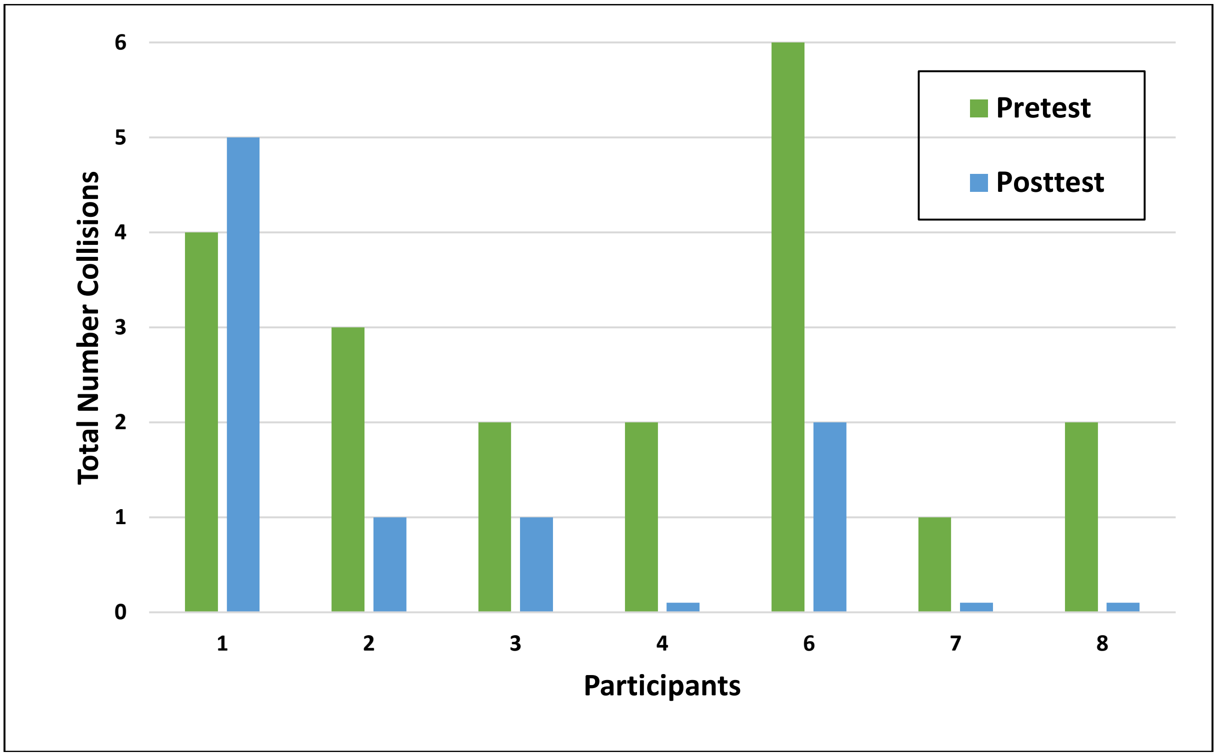


Figure 2. The Mean of All Participants (n=7) Simulator Performance Data

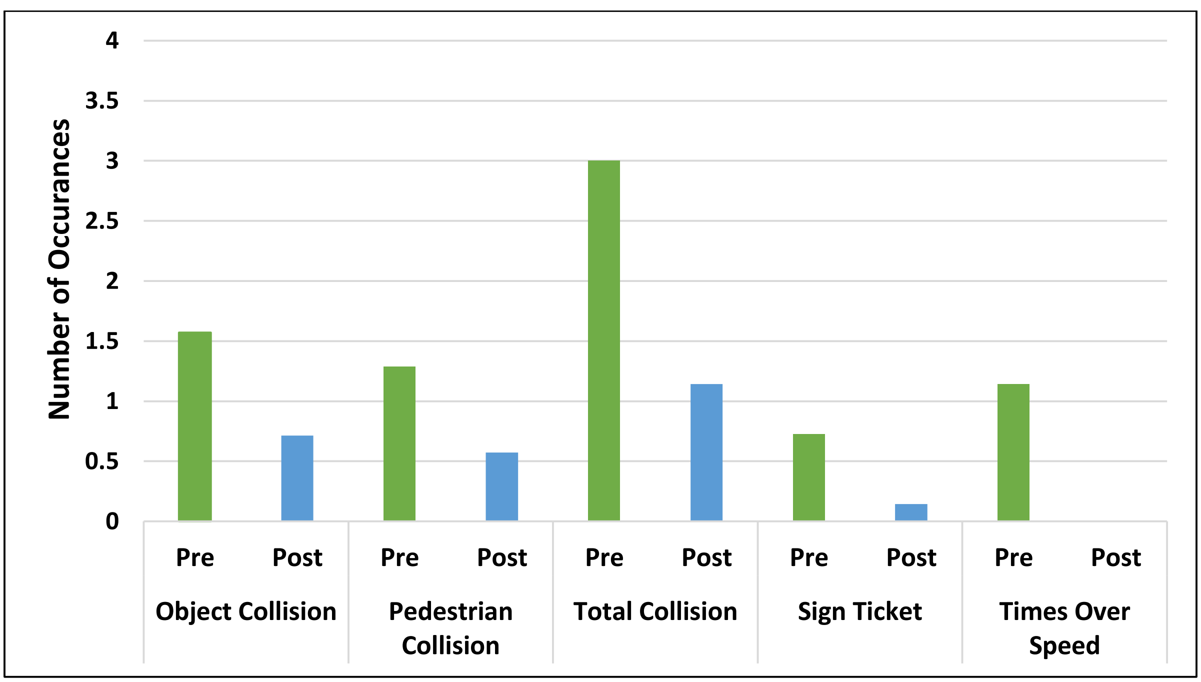
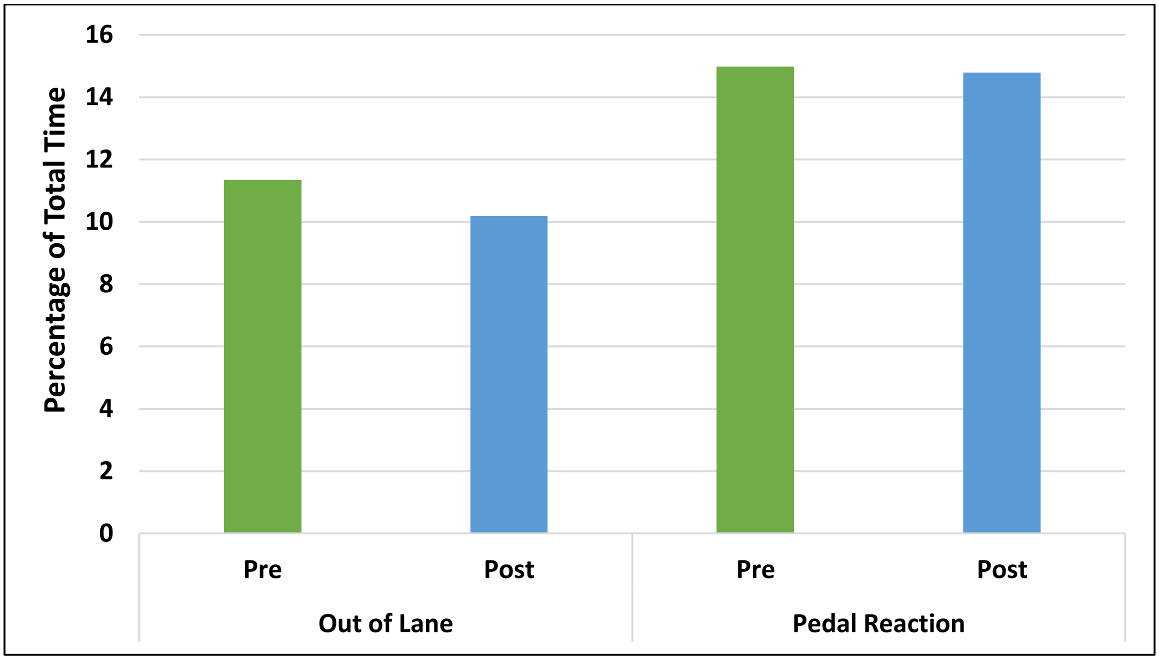


Figure 3. The Percentage Mean of All Participants (n=7) Simulator Performance Data



Notes: chart signifies percentage of total time out of lane and percentage of total time between the onset of a stimulus and when the participant released the gas pedal (pedal reaction)

Figure 4. Simulator Data: Number of Object Collisions Among Participants

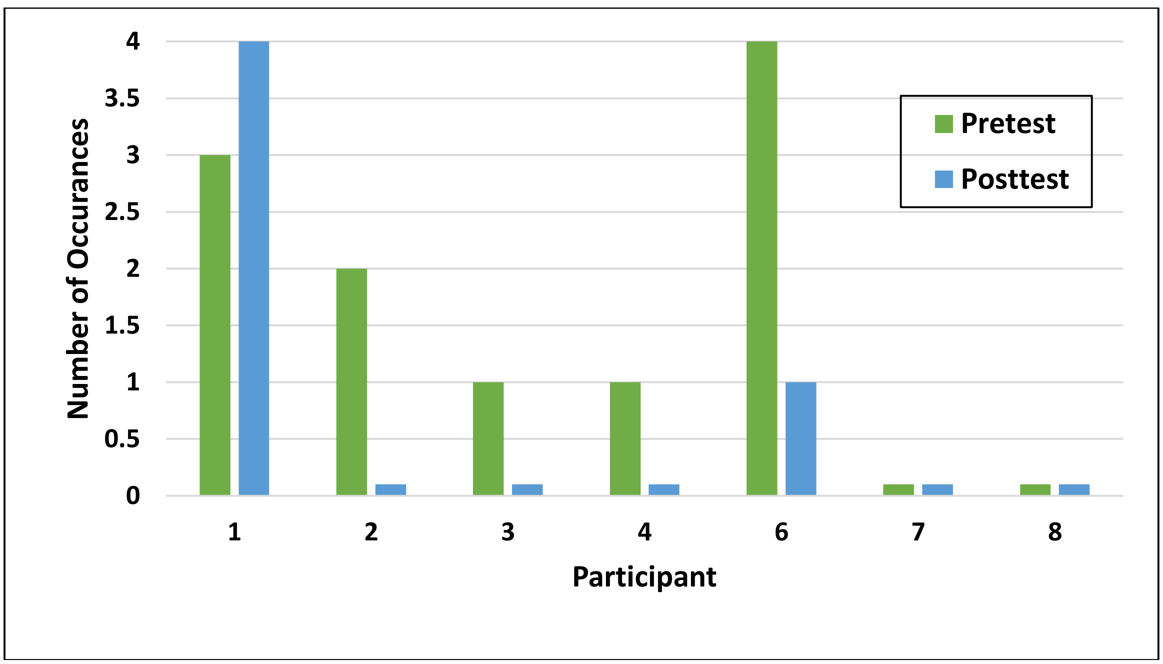


Figure 5. Simulator Data: Number of Pedestrian Collisions Among Participants

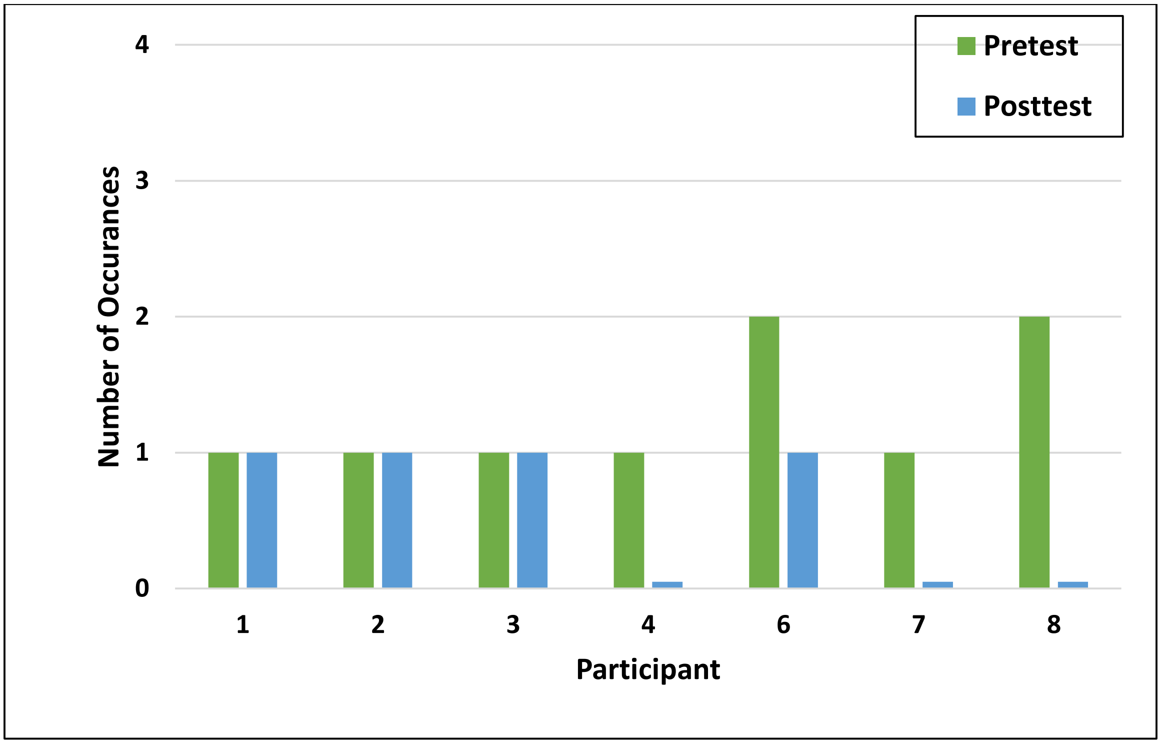


Figure 6. Simulator Data: Number of Sign Tickets Among Participants

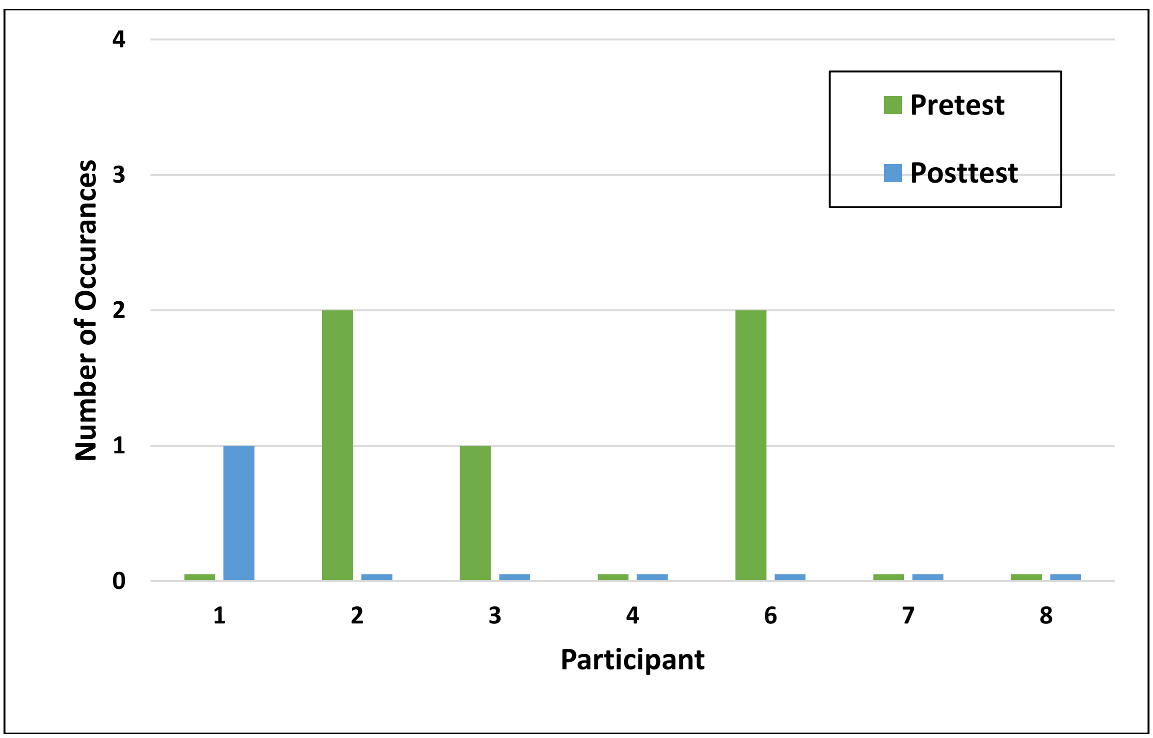


Figure 7. Simulator Data: Number of Times Over Speed Among Participants

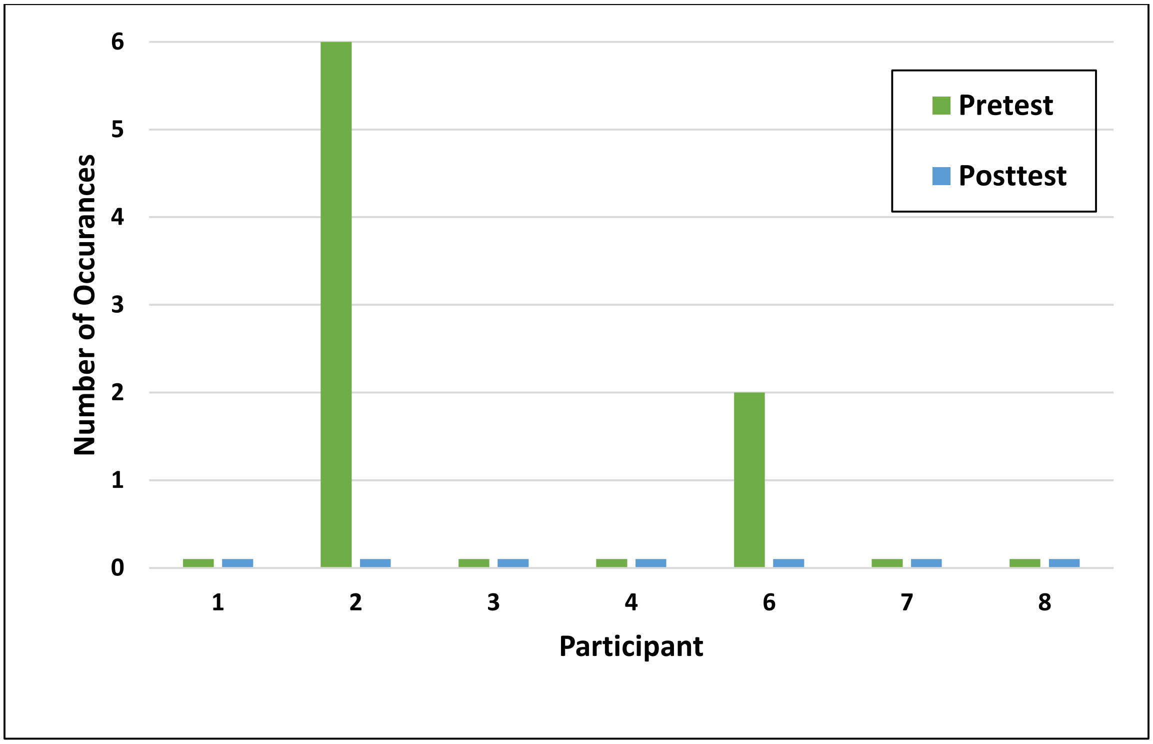


Figure 8. Simulator Data: Total Percentage Out of Lane Among Participants

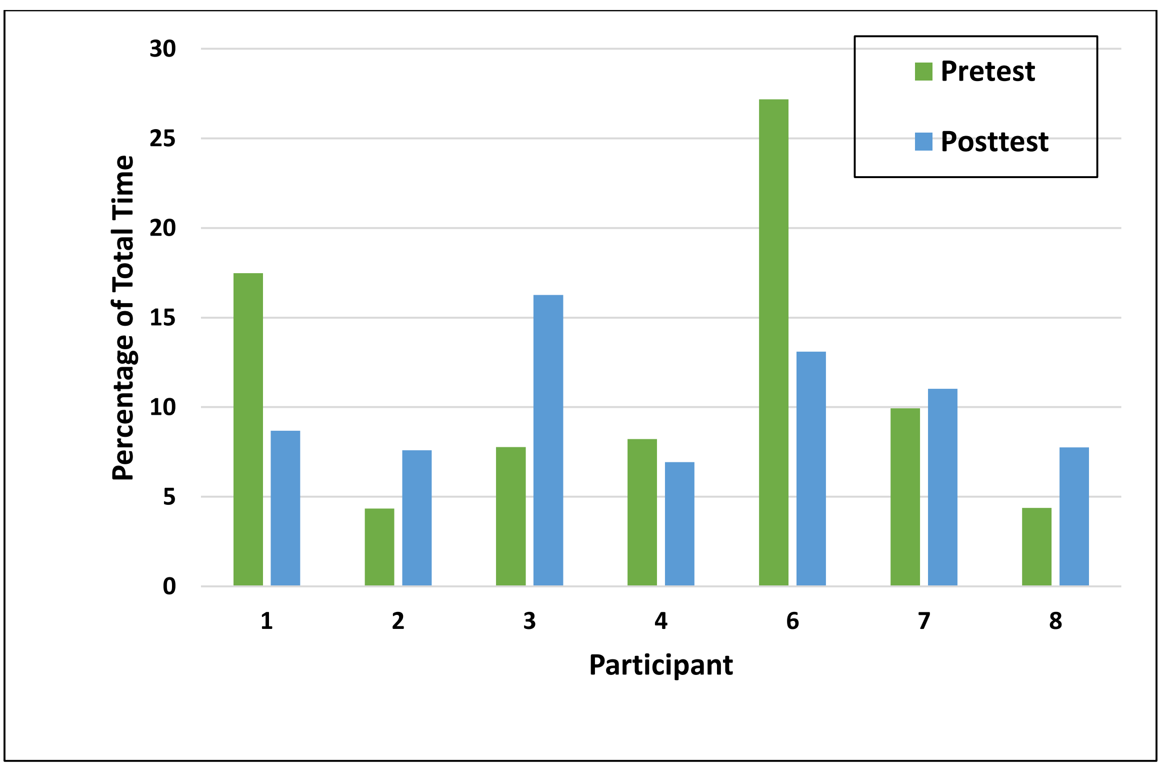


Figure 9. Simulator Data: Total Percentage of Pedal Reaction Time Among Participants

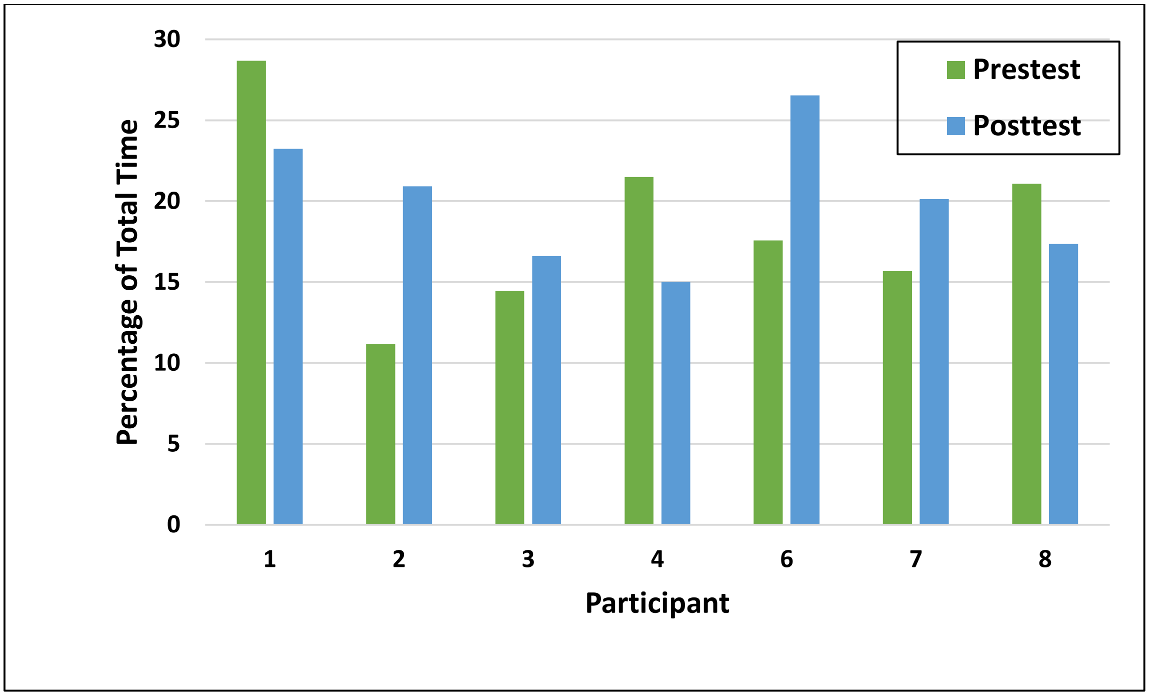


Figure 10. Each Participants' Pre and Post P-Drive Average Sum Scores (Mean of Four Raters)

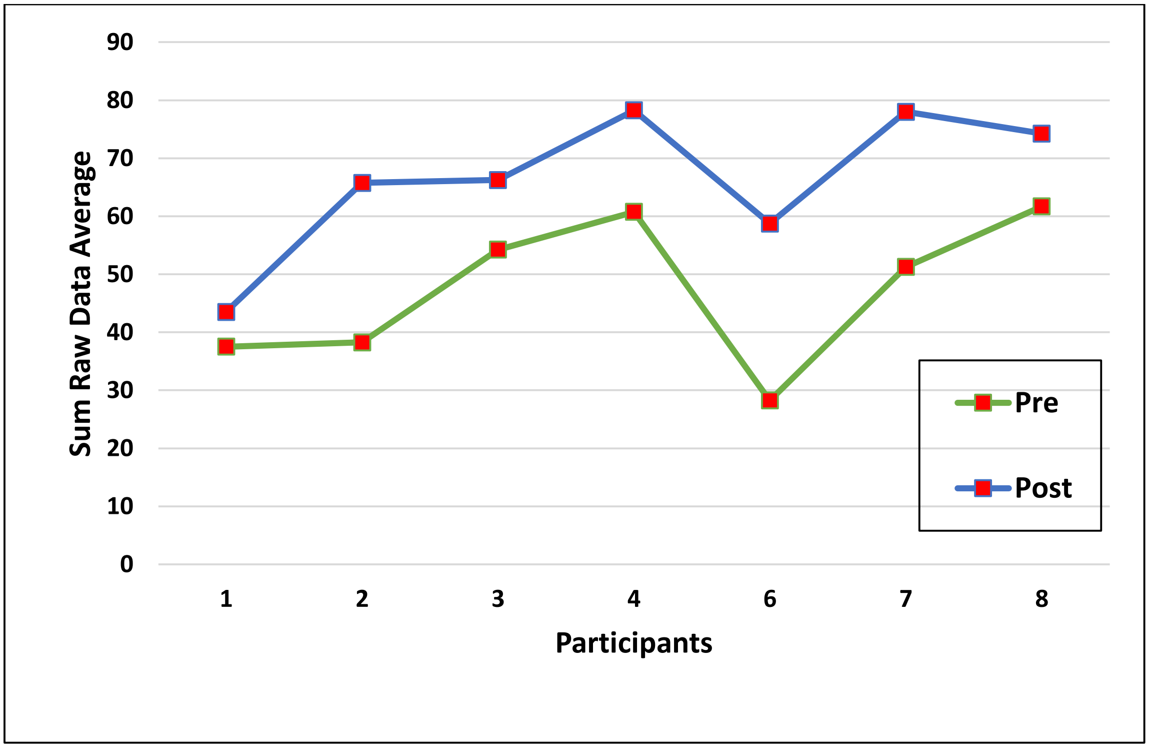
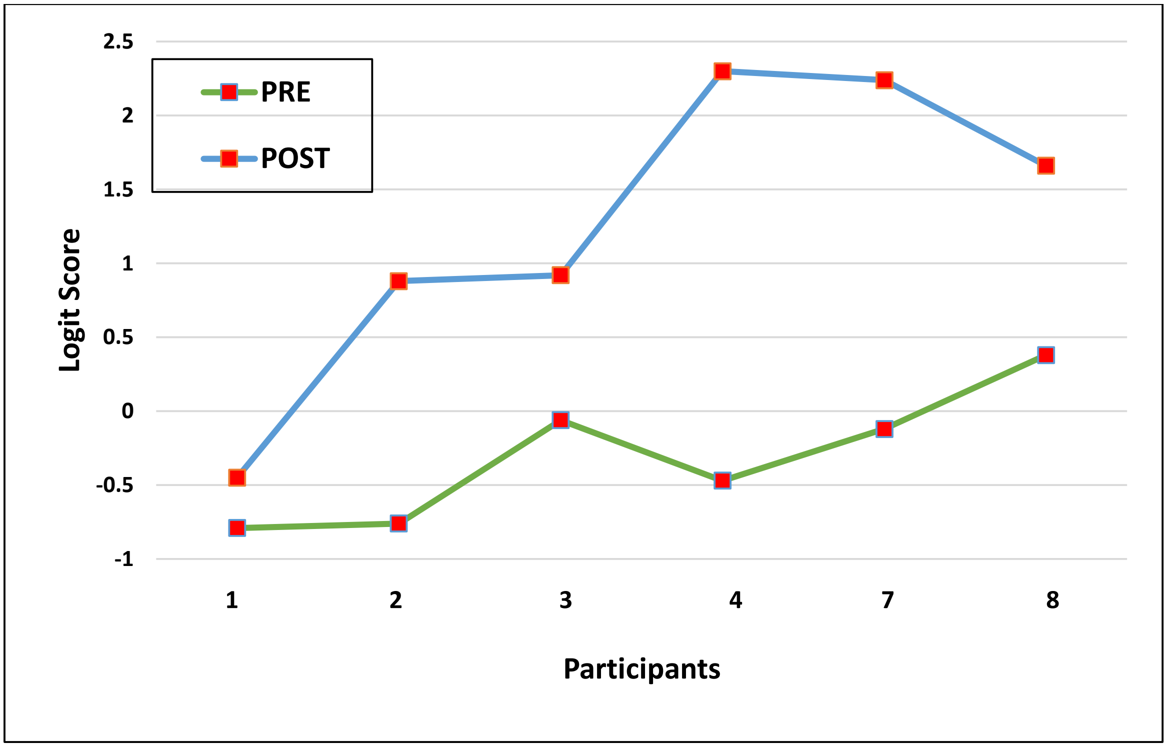


Figure 11. Each Participants' Pre and Post Logit Scores



Appendix A. *Driving Bootcamp* Description

The *Driving Bootcamp* focused on improving driving and community mobility skills for teens and young adults with ASD. The program consisted of a week intensive involving 5 consecutive days for 6 hours a days of structured interventions in both group and individual formats. Subsequently, follow-up sessions were held two times a week for six weeks. One participant only completed follow-up sessions one time a week due to distance from the *Driving Bootcamp*. During follow-up sessions, participants completing 90 minutes of individualized interventions consisting of: 30 minutes of driving/community mobility activities, 30 minutes of the driving simulator, and 30 minutes of visual motor activities. The activities were based on previous research findings to target specific driving deficits associations with drivers with ASD.

Week Intensive Schedule- Monday-Friday 9am-3pm

- Day 1- Administered pre-evaluations and determined individualized intervention plans
- Days 2-5- Six hours of structured, individualized interventions following the table below. Interventions were led by graduate students in group, paired, and individual formats based on each client's needs based on assessment results.

Follow-up Sessions for 6 Weeks for 90 minutes each

- 30 minutes- Driving/Community mobility activities. These were individually designed to expand on activities implemented during the week intensive along with additional new activities listed below. Activities which individuals displayed difficulty in will be repeated as needed.

- 30-minutes- Driving simulator was continued to be used to address client's driving deficits.
- 30 minutes- The Interactive Metronome or Vision Coach was selected for each participant to target scanning, attention, and hand-eye coordination deficits.

Week Intensive Activities		
Activity	**Description**	**Amount of Time**
iPad Games	iPad parking and mind games used to assist in improving visual perception and executive functioning.	30 minutes per day x 4 days
Vision Coach	Interactive board used to improve tracking, visual reaction time, eye-hand-body coordination intervention.	30 minutes per day x 4 days
Interactive Metronome	Interactive computer-based training tool used to improve attention, memory, and coordination intervention.	30 minutes per day x 4 days
Interactive Driving Simulator	Interactive driving simulator used to address the client's' needs and deficits through individualized feedback consisting of different cuing and instructions, different drives, and levels of drives. This was used to allow participants to practice their driving skills in a safe environment.	30 minutes per day x 4 days
Road Signs Scavenger Hunt	Interactive game used to improve participants understanding of different road signs and their meanings.	30 minutes x 2 days
Driving Hazard Activity	YouTube driving videos were used for participants to practice identifying social and non-social driving hazards	40 minutes x 2 days
Introduction to Mapping	Facilitators taught participants how to read both paper and online maps	40 minutes x 1 day
Modified CarFit	Facilitators educated participants in each of the 12 safety points.	40 minutes x 1 day
What Do You Do If?- General Questions	Participants problem-solved potential conflicts they may encounter with community mobility such as what you would do if -*It starts raining when you are driving? You get lost?*	40 minutes x 1 day
What Do You Do If? -Policer Officer Pulls You Over Simulation	Facilitators demonstrated how to respond if pulled over according to the DMV handbook. Participants sat in the driver's seat and acted out their response if pulled over.	40 minutes x 1 day
Plan a Trip-Washington D.C.	Participants worked in small groups with a facilitator to plan a trip to Washington D.C. without driving or flying. Participants practiced finding alternate forms of	40 minutes x 1 day

	community mobility and budgeting while planning the hotel stay and attractions.	
Local Bus System	Participants were given the local bus system and ride guide. Participants mapped out the routes they would take between locations they frequently visit and the timing and cost of the trip.	40 minutes x 1 day
Q&A with Driver with ASD	Driver shared driving experiences including two accidents and what he learned from those encounters	40 minutes x 1 day

Additional Interventions Used During Follow-up Weeks	
DMV Permit Practice Tests	Online permit, signs and signals, and rules of the road practice quizzes.
Review/Quiz of Road Signs	Facilitators used copies of common traffic signs like flash cards and then quizzed the participants on what they do when encountering each sign.
How to Use a Taxi	Facilitators guided the participants in learning how to arrange a ride, get in the taxi, what to do while riding and exiting the taxi.
Mapping	How to navigate with a map of the building, university medical campus and local bus systems
Navigating to Most Visited Places in the Community	Participants will map out several areas in the community and use a map to problem-solve an efficient way to navigate to each location.
Organizing Your Day	Builds off the navigation activity to challenge participants to identify the most efficient methods to effectively complete their daily responsibilities

Appendix B. P-Drive Assessment

P -Drive

Performance Analysis of Driving Ability

Name (not to be written for research)		Name of rater	
Id.no.	Age	Date for assessment	
Diagnosis		Date of onset	Time since diagnosis (months)
Cognitive tests done		Advised not to drive (y/n)	Driving anyway (y/n)

☐ **Manual** ☐ **Automatic** ☐ **Modification/s**___________

Actions (1-25):

Maneuvers

1. steering	4	3	2	1
~~2. changing gears~~	~~4~~	~~3~~	~~2~~	~~1~~
3. using pedals	4	3	2	1
4. contr speed, slow	4	3	2	1
5. contr speed, fast	4	3	2	1
6. using indicator	4	3	2	1
~~7. reversing~~	~~4~~	~~3~~	~~2~~	~~1~~

Orientate

8. following instruct	4	3	2	1
~~9. finding the way~~	~~4~~	~~3~~	~~2~~	~~1~~
10. positioning on road	4	3	2	1
11. keeping distance	4	3	2	1
12. planning	4	3	2	1

Follow regulations

13. Yielding	4	3	2	1
14. obeying stop	4	3	2	1
15. follow speed reg	4	3	2	1

Attending and acting (heeding)

16. straight ahead	4	3	2	1
17. to the right	4	3	2	1
18. to the left	4	3	2	1
19. to mirrors	4	3	2	1
20. to regulatory sign	4	3	2	1
21. to advisory sign	4	3	2	1
22. to fellow road users	4	3	2	1
23. reacting	4	3	2	1
~~24. focusing~~	~~4~~	~~3~~	~~2~~	~~1~~
25. problem solving	4	3	2	1

Rating scale	**Quality of performance**	**Impact on the activity**
4	Good **Competent performance**	Positive, facilitating
3	Questionable **Hesitant performance**	Causing insecurity (asking questions)
2	**Ineffective Performance**	Causing risky situation
1	**Incompetent performance**	Causing repeated risky or dangerous situations. Interruption

Other information:

Standard route ☐ Special route ☐

Signed consent form ☐

Time on-road (min):_________

OUTCOME: ☐ Pass ☐ Fail

☐ Fail with lessons

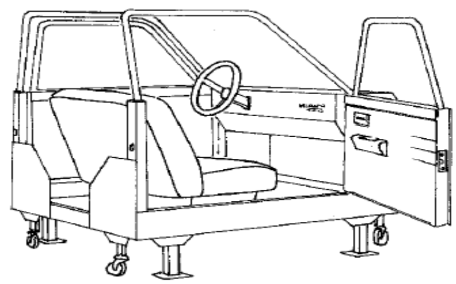
☐ Other____________

Appendix C. Interactive Driving Simulator Hardware

Spec Sheet Model WT-960

Model WT-960
Car Transfer Simulator

The WT-960 Tran-Sit ® Car Transfer Simulator is designed to provide a safe and convenient alternative to "parking lot" transfer training sessions. It is an attractive and functional addition to any rehab program and its life-like appearance adds to the realism of training activities.



Product Description

- All-Steel Construction
- Stationary Feet and Retractable Casters
- Steering Wheel with Tilt-Column
- Dashboard Instrument Cluster Decal
- Fully Functional Passenger and Driver Doors with Arm Rests, Handles, Locks, Keys
- Vinyl Covered Fixed-Back Bench Seat with Seat Tracks
- Seat Belts and Shoulder Straps
- Open Back For Easy Access By Therapist
- Dimensions: 48" x 60" x 56" ht
- Weight: 500 lbs.

Available Options

- Reclining Bench Seat Upgrade
- Reclining Bucket Seats
- Gas/Brake Pedal Module
- Reaction Time Tester
- Handicapped-Driver Hand Controls
- Height-Adjustment System
- Computer-Based Interactive Driving Simulation
- Factory Delivery Available

ATP

Advanced Therapy Products, Inc. • P.O. Box 3420 • Glen Allen, VA 23058-3420
1-800-548-4550 E-Mail: Atpwork@aol.com
Website: www.atpwork.com

Appendix D. IRB Approval

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building- Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office 252-744-2914 · Fax 252-744-2284 · www.ecu.edu/irb

Notification of Initial Approval: Expedited

From: Biomedical IRB
To: Jennifer Radloff
CC:

Date: 7/21/2015
Re: UMCIRB 15-001027
Community Mobility Skills Boot Camp

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 7/21/2015 to 7/20/2016. The research study is eligible for review under expedited category # 6, 7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
AMPS	Standardized/Non-Standardized Instruments/Measures
BADS	Standardized/Non-Standardized Instruments/Measures
Child Assent (15-17)	Consent Forms
Consent (age 18-22)	Consent Forms
CTMT	Standardized/Non-Standardized Instruments/Measures
Drive Safe Drive Aware	Standardized/Non-Standardized Instruments/Measures
Expert Search and Scanning Skills	Standardized/Non-Standardized Instruments/Measures
IM	Standardized/Non-Standardized Instruments/Measures
Mazes	Standardized/Non-Standardized Instruments/Measures
OPTEC	Standardized/Non-Standardized Instruments/Measures
Parent Consent	Consent Forms
P-Drive US Version 2014	Standardized/Non-Standardized Instruments/Measures

Appendix E. Directions for the Interactive Driving Simulator

Simulator sickness or motion sickness is always a possibility. It occurs because you are "driving" and your eyes seem movement and your body should feel the movement, by you are not moving. Thus, there is an incongruence between your senses that may result in discomfort. It happens with a small percentage of people. You will feel different. Let us know immediately if you feel nausea, full headedness, dizzy, sweaty, headache, or "just not feeling right." We will stop immediately.

Directions for Driving:

1. The simulator will give you directions of when you need to turn, otherwise, go straight through the intersection, observing and obeying to the traffic signs or traffic signals.
2. Please adhere to standard traffic laws and regulations
3. When stopping at stop signs and traffic lights, stop AT the intersection, not too far back and not past the sign—if there is a white crossing line, get up as close as you can to the line
4. Come to a COMPLETE stop at red lights and stop signs.
5. Always is the right lane as your travel lane when it is available to you, you may use the left lane as needed, for example, to pass a vehicle or yield to merging traffic. Just make sure it is safe to change lanes and use your mirrors.
6. Use your directional or turn signal for all lane changes and turn.
7. You may drive off of the road to avoid hitting something.

Appendix F. Description of Assessment Drive on Interactive Driving Simulator

The drive consists of a four-mile route which takes approximately ten minutes. Drivers are told which turns to make by an automated voice. Speed limits vary throughout the drive from 25-70 mph. The driver will share the road with other cars, buses, pedestrians, and bicyclists.

- Environments included: metro, rural, farmland, school zone, and residential
- Road advisory signs include: school zone, pedestrian crossing, stop signs, stop lights, and construction work
- Hazards included: pedestrians crossing the road, cars and busses pulling out in front of the driver, bicyclists, congested traffic conditions, avoiding a head on collision