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Driving anxiety in young people with autism spectrum disorder : a driving simulator pilot study

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Driving Anxiety in Young People with Autism Spectrum Disorder:

A Driving Simulator Pilot Study

by

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Abstract

Objective: The goal of this project was to investigate how driving anxiety changes over time in young people with autism spectrum disorder (ASD) when using a driving simulator technology. Additional exploratory measures were collected on duration of participation, stopping distance and reaction time. ***Methods:*** Six young adults with developmental disabilities (DD) and eight typically developing teenagers (TD) were recruited from the Faison Center and Richmond community to participate in an ongoing driving simulator pilot study. All participants (N = 14) completed a four part protocol consisting of driving simulator exercises and coursework modeled from the Virginia DMV's learner's permit prep materials. A self-report driving anxiety questionnaire was delivered to parents and clients at baseline and after completion of the study (TD n = 6; DD n = 3). ***Results:*** Overall trends in means were used to assess driving anxiety from pre to post. Self-report anxiety measures for the participants revealed a decrease in anxious feelings about driving and an increase in worry about losing control behind the wheel over time, compared to parents who self-reported an increase in anxiety for both. DD participants required a greater mean number of sessions ($t(12) = -5.36$, $p < .001$) and a greater mean session duration in minutes ($t(12) = -4.38$, $p = .001$) to complete training, compared to the TD participants. Stopping distances, at three different speeds, revealed no significant differences between groups. Reaction time, using pedals versus steering, also revealed no significant differences between groups. ***Conclusions:*** Although the multi-item self-report driving anxiety scale had poor psychometric properties, for example low internal consistency, the overall trends in mean reported anxiety revealed that participants showed an increase and decrease in driving anxiety (for the items analyzed) compared to parents who reported increased driving anxiety. These results have

implications for training people with DD to drive and reduce driving anxiety, which may improve driving performance.

Driving Anxiety in Young People with Autism Spectrum Disorder:

A Driving Simulator Pilot Study

The goal of this investigation was to better understand anxious driving behavior in teenagers with and without autism spectrum disorder (ASD). First, it is important to describe both anxiety and driving behaviors in novice drivers. The two groups, typically developing teenagers and teenagers with developmental disabilities (DD), were selected for this study based on the shared comorbidity of ASD and anxiety. It is hypothesized that both groups, developmental disabilities and typically developing, will report initial levels of driving anxiety, but the DD group will show no change from pre to post compared to the TD group who will show decreased anxiety. However, it is important to understand ASD and the characteristics that may affect a person learning to drive. Other exploratory questions are included to assess group differences in (1) pre assessment skills, (2) duration of participation, (3) stopping distance, and (4) reaction time.

I first provide a general overview of generalized anxiety disorder and how anxiety can be expressed in various ways. Driving related anxiety and fears are of greatest interest here. Next, research using driving simulator technologies will be reviewed to show the gap in the literature surrounding driving and driver's related anxiety--particularly the gap in driving research among the autism population. Comorbidities with anxiety will be reviewed, with an emphasis on ASD and the characteristics that accompany people on the spectrum. This information will transition into the present study, which is aimed at filling the gap in analyzing the intersection between driving anxiety, simulated driving research and the autism population.

Generalized Anxiety Disorder

Occasional anxiety is an expected part of life. It is normal to feel anxious in response to dangerous or new situations. However, those who are plagued with constant worry and nervousness that does not go away and worsens over time suffer from something greater. Anxiety disorders can present themselves as five major types. The most common, as defined by the current Diagnostic Statistical Manual (*DSM-5*), is generalized anxiety disorder (GAD), or excessive and hindering worry, occurring more days than not for at least 6 months, accompanied by a variety of physical or cognitive symptoms (Agrawl, Heath, & Lynskey, 2011; American Psychiatric Association, 2013). Individuals with GAD often express their anxiety in different ways.

Environmental stressors, emotional changes, and social situations are leading causes of teenage anxiety, with 25% of 13-18 year olds having an anxiety disorder, according to the National Institute of Mental Health (The National Institute of Mental Health, 2017). Behavioral and emotional avoidance are common among people diagnosed with anxiety (Cooper, Miranda & Mennin, 2013). Some examples of behavioral effects associated with anxiety are observed bodily agitation or discomfort, distressed facial expressions and poor social interaction (Katz et al., 1993). Individuals who experience fear behaviorally and emotionally, all engage in some type of avoidant behavior. However, the origin of the fear and what causes panic is often difficult to determine (Taylor, Deane & Podd, 2000). Individuals struggle to know why they avoid certain situations or what causes feelings of uneasiness to begin with. To help with this, self-report items that ask individuals to describe their fear result in a detailed chain of events leading up to the fear, without stating the feared stimulus or situation that provoked the anxiety.

Driving Related Anxiety and Fears

Driving is a symbol of freedom as individuals mature through adolescence and into adulthood. However, the presence of anxiety in earlier years and in different domains has the potential to restrict driving freedom due to driving related fear. Driving related fear is categorized by the *DSM-5* as a specific phobia that results in situational panic attack-like episodes (American Psychiatric Association, 2013; Taylor, Deane & Podd, 2000). Driving phobia is the active choice to reduce or eliminate all driving to avoid the panic attack-like episodes (Taylor, Deane & Podd, 2002). This strict criteria makes it difficult for drivers to qualify as having this disorder, although many express some symptoms. According to a survey from a leading car insurance search engine, 1 in 4 teenagers (47% females compared to 33% males) who are of age to receive their license put off learning to drive due to worry and fear (Beck, 2018).

While there is a lack of evidence surrounding what causes driving related fear, driving related behavior can be examined to better understand anxious driving tendencies. Driving anxiety and driving aggression are similar because they both involve hyperarousal and emotional responses (Zinzow & Jeffirs, 2017). The physiological symptoms that result from these two characteristics have a direct effect on risky driving behavior. Where there is perceived risk, aggression and anxiety can be conceptualized in terms of the “fight or flight response”. Aggression is linked to “fight” and anxiety to “flight” (Zinzow & Jeffirs, 2017). Novice drivers can become aroused easily while driving and thus perceive the environment or road conditions around them as threatening. In this case, the driver will become physiologically aroused and may engage in aggressive or risky driving behavior.

The literature on driving anxiety has identified three domains of anxious driving behavior: exaggerated safety and caution, anxiety based performance deficits, and hostile driving behaviors (Clapp et al., 2011). These domains were identified through examining associations between anxious behavior and self reported stress history. Ultimately, accident distress, from past driving experiences, poses a severe vulnerability for developing anxious driving behaviors (Clapp et al., 2011). However, fear of driving can exist in the absence of motor vehicle accidents, which can also limit an individual's freedom to drive. Taylor, Deane and Podd (2000) focused on driving related fears in general. Researchers recruited 190 fearful drivers through social media, online websites and flyers, and intentionally used no formal diagnostic criteria in attempt to conceptualize what constitutes driving related fears. No difference was found in self report measures of the physiological and cognitive components of fear or measures of anxiety in those who have experienced a motor vehicle accident compared to those who have not (Taylor, Deane & Podd, 2000). These results suggest that a history of motor vehicle accidents is not necessary to produce driving anxiety or fear. Therefore, more research is needed to understand what causes higher levels of driving anxiety in some people.

Research shows that arousal and anxiety influence novice driver's decisions to reduce speed while driving (Schmidt-Daffy, 2013). Anxiety arises when task demands on the road exceed the driver's typical capability. Anxiety is based on evaluating the relationship between threat and the individual's perceived goals, which reflects a top-down emotional bias (Schmidt-Daffy, 2013). The individual has to assess whether the action goal will result in a desirable or undesirable consequence. If the consequence is undesirable then the individual will experience an increase of attention, arousal, and subsequent anxiety. The increase in each of these domains results in the driver's decision to reduce speed and promote safety. Despite this, research analyzing driving anxiety and the resultant effect on driving behavior suggests higher self-reports of anxiety correlate with dangerous driving behavior outcomes (Dula, Adams, Miesner & Leonard, 2010). Safe driving requires cognitive awareness and sustained attention, both of which are consumed by the driver's anxiety. Individuals with greater anxiety are more likely to engage in driving under the influence (DUI) and are held accountable for at-fault car crashes (Dula et al., 2010). To teach individuals to practice safe driving, anxiety levels must be assessed and reduced to account for potentially dangerous driving situations. Exposure to driving in safe environments may reduce driving anxiety overtime and prepare drivers for driving situations that were previously anxiety provoking.

Driving Simulator Research

Road safety research reports that novice drivers under the age of 25 years old have higher crash involvement, because of inexperience and distracted driving (Beanland, Goode, Salmon & Lenne, 2013; Klauer et al., 2014). Distracted driving occurs when drivers engage in a secondary task that shifts attention away from the road, resulting in unsafe driving. Additionally, the age of young novice drivers influences their cognitive and emotional development, both of which play an important role in learning driving skills and practicing driving safety (Steinberg, 2007). In the first three months of licensed driving, young drivers are eight times more likely to be involved in a collision compared to drivers with experience over three months ("Release: Teen crash risk highest…", n.d.). Driving simulators have been implemented as a safe alternative to training, practicing, and measuring road driving skills. The simulators provide novice and adult drivers with the opportunity to train motor skills in a controlled environment with visual imagery display. Research shows that simulators are still effective for driver training and motor training despite the fact that they are not actual motorized vehicles.

Driving simulators have a series of broad applications, rendering them useful for many empirical studies. They assess skills such as speed management, hazard anticipation, sustained attention, reaction time, performance based deficits, and many others (Wang, Zhang, Wu & Guo, 2007). A comprehensive driver's training program, developed for road hazard handling training, shows increased performance in the novice driver's ability to recognize and respond to hazardous situations in the simulator (Yanbin, Wei & Salvendy, 2010). Simulator training may also prevent fatigue related accidents during training by offering a safe limit to extended period highway driving. Driving for extended periods of time has been shown to increase fatigue, disrupt driver alertness and result in unsafe driving and quantitative analyses, measuring reaction time to assess impairment of driver alertness, reveal increased reaction times and unstable performance as length of time driving increases (Ting, Hwang, Doong, & Jeng, 2008). Simulated driving programs are designed to train specific skill sets and the goal is for the skills to transfer to real world driving. However, driving simulator results are not to be used as a replacement for on-road driving practices or tests.

Driving simulator training programs are still being developed to better address the population of drivers who have driver's anxiety or driving related fear. Driving simulator research identifies other interventions that serve as supplementary training for people with driving related fears. Virtual reality exposure therapy to treat driving phobia reveals reductions in driving phobia over an 8 week period of treatment sessions (Wald, 2004). Similarly, virtual reality and cognitive behavioral therapy have been used to treat driving anxiety and aggression in veteran populations. After 8 weeks of intervention sessions, the virtual reality driving scenarios presented through a driving simulator resulted in significant self-reported decreases in driving phobia, hyperarousal induced by driving fears, and risky driving of veterans (Zinzow et al., 2018). By understanding behaviors associated with anxiety and the supplementary treatment interventions that target these behaviors, the bridge between driving anxiety and simulated driving programs will become more clear.

Comorbidities with Anxiety

Anxiety disorders are extremely prevalent in the adolescent population, making it probable that some novice drivers also suffer from anxiety disorders. However, anxiety disorders also share a high comorbidity with other disorders. The current study focused on driving related anxiety in young people with autism spectrum disorders. The high comorbidity rate, specifically with Autism Spectrum Disorders (ASD) requires a more thorough understanding of anxiety symptoms and related impairments. Comorbid disorders must be accounted for when assessing patients with a variety of symptoms and impairments.

ASD is a neurodevelopmental disorder characterized by pervasive impairments in social communication and the presence of restricted interests and repetitive motor behaviors (American Psychiatric Association, 2013). With an early onset age, humans are frequently diagnosed during early childhood. However, some do not show symptoms until early teenage years. While the understanding of ASD continues to grow in the field of psychology, research suggests that, because autism spectrum disorders are neurogenetic in their origins and onset is early in life, they resemble circuit disorders. Circuit disorders are neurogenetic syndromes that are governed by the connections that produce meaningful abnormalities within our material human physiology (Fein, 2016). The main brain region affected in those with ASD is the prefrontal cortex. The prefrontal cortex is involved in attention, language and working memory (Luna et al., 2002). Deficits occur in each of these domains as a result of abnormal functioning in this region.

Currently, researchers have a better understanding of ASD from a behavioral perspective, since behaviors are directly observable. A defining feature of ASD, highly relevant to this paper, that helps to differentiate it among other behavioral disorders, is repetitive motor movements (Militerni, Bravaccio, Falco & Fico, 2002). Examples include repetitive body movements such as rocking forward and back, hand flicking, and/or hand waving (Militerni et al., 2002). Repetitive motor movements may pose an issue for learning to drive as adolescents age.

Beyond observable behaviors, those diagnosed with ASD often share a second diagnosis: anxiety. Anxiety is common among those diagnosed with ASD and typically worsens during adolescence as people with ASD have a heightened awareness of their interpersonal differences (White, Oswald, Ollendick & Scahill, 2009). The prevalence of anxiety as a secondary diagnosis in youths with ASD is 40% compared to 20% of typically developing youths diagnosed with anxiety alone (Van Steensel & Heeman, 2017).

People with anxiety react to environmental stressors, but display and express anxiety differently (Kim, Szatmari, Bryson, Streiner & Wilson, 2000). Two common ways of expression are internalizing versus externalizing. Internalized anxiety occurs when a person is unaware of his/her hidden thoughts as a result of behaving in a way that aligns with his/her anxious tendencies and thoughts without realizing; whereas externalized anxiety presents itself outwardly for direct observation (Kim et al., 2000). Researchers find it more common for those with ASD to internalize their anxiety more than externalize issues (Kim et al., 2000). Internalization may be a result of withdrawal from the anxiety provoking situation before awareness of the initial anxious feelings.

ASD and Attention-Deficit Hyperactivity Disorder (ADHD), although two distinct disorders, share considerable overlap in symptomatology and share a high comorbidity (Dougherty, Evans, Myers, Moore & Michael, 2016). The shared comorbidity between ASD, ADHD, and anxiety disorders makes all three disorders relevant to driving behavior because driving requires cognitive control, sustained attention and controlled motor movements. ADHD is a brain disorder that involves a pattern of inattention and/or hyperactive impulsive behavior that disrupts daily functioning (“Attention-Deficit/Hyperactivity Disorder”, n.d.). Some people with ADHD only show signs of inattention or hyperactivity, while others may express both. While diagnoses are more likely to occur in early childhood years, diagnoses are still made throughout adulthood. Symptoms of ADHD, specifically, the hyperactivity and impulsivity piece of ADHD, may interfere with driver competence and put those at a greater risk for negative driving outcomes (Barkley & Cox, 2007). Research suggests that people with ADHD show significantly higher erratic control while driving compared to control groups (Barkley & Cox, 2007). The knowledge of symptom overlap and interaction is helpful for implementing safe driving practices.

Characteristics of Autism Spectrum Disorder

From a behavioral perspective, as people with ASD age through adolescence, impairments begin to affect adult domains of functioning. It is likely that driving, a skill that symbolizes independence, is compromised. Social, educational and work opportunities are reduced because of dependence on caregivers for transportation (Howlin, Goode, Hutton &

Rutter, 2004). Adolescents with ASD are at high risk for motor vehicle crashes because driving requires skills across various domains (Classen, Monahan & Hernandez, 2013).

In conjunction with impaired motor behavior, essential for safe driving, those diagnosed with ASD also exhibit impaired visual and cognitive skills that are critical for driving (Classen et al. 2013). The prevalence of visual impairment, particularly visual squinting known as strabismus, is 8.3% in people with autism compared to the typical child population (Butchart et al., 2017). Visual squinting results in a person directing attention away from the road, which can negatively impact driving performance. Impaired cognitive skills are typically assessed using IQ measurements in girls and boys with autism. The prevalence of cognitive impairment, based on an IQ score of less than 70, is higher in girls (72.7%) compared to boys (56.4%), however when comparing boys and girls with autism who have a high severity of autism, the prevalence of cognitive impairments did not differ (Nicholas et al., 2008). To assess the impact these and other ASD-related impairments have on driving skills, reaction time and stopping distance will serve as exploratory analyses in the current study. Classen et al (2013) examines specific driving errors that can occur. Two examples are lane deviation and adjustment to stimuli in the environment (Classen et al., 2013). These driving errors may be a result of delayed reaction time and failure to respond to visual cues on the road. Driver training programs for typically developing people are aware of such deficits and are reluctant to teach adolescents with autism. As a result, researchers have expressed interest in whether or not driving simulators could be used to train motor aspects of pre-driving skills in those with ASD (Brooks et al., 2016).

Simulated Driving in ASD

The success driving simulator training programs have with young novice drivers warrants further research in populations beyond typically developing people. While some people with ASD are able and do drive, most do not. According to a 2017 report from Children's Hospital of Pennsylvania (CHOP), 1 in 3 adolescents with autism acquire a driver's license before age 17 and 90% of individuals who receive their learner's permit go on to acquire a driver's license within two years (Curry, Yerys, Huang & Metzger, 2017). This majority suggests that parents who choose to allow their child with autism to receive a permit are comfortable with their child also obtaining a license. Results from a longitudinal study examining the experiences of young people with ASD who have a driver's license (N=21) reveal that multi-tasking is the most common difficulty when learning to drive (Ross et al., 2018). Driver's with ASD also self-report needing more time to learn compared to others, difficulty following directions and limited concentration while learning (Ross et al., 2018). These difficulties may impede the members of the autism population who have the capacity to obtain a driver's license.

In the past few years, researchers have begun to assess driving in those with ASD using alternative training protocols. Driving simulators are shown to be effective tools that provide safe learning for adults with developmental disabilities through the use of interactive exercises (Brooks et al., 2014). Studies examining high functioning ASD with increased cognitive demands result in distracted visual attention (Reimer et al., 2013). People with ASD are unable to attend to heightened stimulation in their visual field. Thus, driving simulations with high stimulus areas cause ASD participants to look away (Reimer et al., 2013).

Utilizing a different adaptive driving intervention to measure visual attention in individuals with ASD, Wade and colleagues (2017) found a significant difference in the number of turning related driving errors between subjects with and without ASD. People with ASD had a greater number of turning related errors. However, when other driving skills using the simulator were assessed (merging and speeding), results showed no difference in performance between ASD participants and typically developing participants (Wade et al., 2017). These results suggest that turning a steering wheel may be a more complex and difficult task for those with ASD (Wade et al., 2017).

Based on the current pattern of disrupted visual attention in driving simulation tasks, some individuals with ASD are at risk of practicing unsafe driving behavior. More research is necessary to understand the effect driving simulators have on teaching safe and effective driving skills in those diagnosed with ASD.

Current Study

This study serves to extend knowledge of driver's anxiety in novice drivers and how driving simulators can be used to train driving skills in young people with ASD. Currently, there is no literature that has examined the presence of driver's anxiety in those with ASD, likely because there are fewer individuals with ASD that are legally, physically, or mentally able to drive. Thus, the current understanding of each of these areas is useful in analyzing the relationship.

The present research question is whether driving related anxiety, if present, decreases with experience in a driving simulator program in those with ASD compared to typically developing teenagers. To address this research question, a driving simulator from DriveSafety with programmed training modules, was used with various driving related exercises to assess how driving performance changes over time. More importantly, this study examined changes in self report of driver's anxiety items on a pre/post questionnaire from both participants and parents.

Main effects of time and group status (DD vs TD) on anxiety are expected. As time progresses, from pre to post, there will be a decrease in anxiety levels. Between DD and typically developing groups, the expected difference is higher levels of baseline self-reported anxiety in the TD group compared to the DD group. For self report anxiety measure responses, it is hypothesized that driving related anxiety will decrease for typically developing participants and will not change for DD participants with the implementation of a driving simulator program. There is no expected change in the experimental group because DD participants are more likely to internalize their anxiety and withdraw from the anxiety provoking situation before realizing anxious behaviors (Kim et al., 2000).

Additional exploratory questions were also investigated to assess group differences between people with autism and typically developing young adults. These questions will explore the effectiveness of the driving simulator in teaching novice driver skills in both groups. The first exploratory question examines baseline pre-assessment skills between groups. The pre-assessment skills are divided into 6 different domains that assess the driver's initial strengths and weaknesses. The number of skills in each domain will be compared across groups and later used for comparison of performance throughout the study.

The second exploratory questions determines the differences in duration of participation among developmentally disabled (DD) participants versus typically developing (TD) participants. Based on comorbid attention and hyperactive behaviors in those who have developmental disabilities, it is expected that the DD group will progress at a slower rate compared to the DD group. Total number of sessions and session duration (in minutes) will be measured.

The third exploratory question involves group differences (DD vs TD) in stopping distance at different driving speeds. Stopping distance is one skill that is trained in young novice drivers in order to safely operate a vehicle. This question can be used to support the current research about driving simulators measuring skills across various domains.

The final exploratory question assesses an additional driving simulator skill required for safe driving: reaction time. Pedal and steering reaction times are recorded for both groups (DD vs TD) and analyzed for group differences. The results will provide additional information about learning important skills for driving using a simulator.

Method

Participants

Data collection took place at the Faison Center, located in Willow Lawn, in Richmond, VA. The Faison Center is an intensive Applied-Behavior-Analysis (ABA) facility that offers treatment to individuals with autism and other related developmental disabilities (DD) across the lifespan. The Faison Center is academically affiliated with The Applied Behavior Analysis Program at Teachers College, Columbia University and the Department of Behavioral Psychology at Kennedy Krieger Institute.

Data were initially obtained from 23 participants that were eligible or near-eligible to take their learner's permit exam with Virginia DMV. Two subgroups of participants DD (*n* =13) and TD (*n* =10) were included. Participants with DD are individuals that attend the Faison Center as students. Students who were asked to participate met the following criteria: basic motor skills, normal vision or corrected with glasses/contacts, ability to stay focused on a task for five minutes, referral by his/her classroom teacher, and consent by a parent/guardian. Students with developmental disabilities were excluded if their impairments were pervasive to the point of risk in the simulator, risk to the research facilitator, and/or self-imposed risk. Typically developing (TD) individuals recruited from the Richmond community were used as a comparison for the study, and offered free participation in a driver's training program to benefit the Faison Center's research. The TD participants were required to meet the same inclusion criteria.

For the purposes of analyses, participants were only included if they had completed all four parts of the study's protocol in its entirety (see Figure 1). Due to early withdrawal from the study and failure to complete all sessions, six participants were labeled "non-completers" and removed from the sample before final data collection. All six non-completers were from the DD group. Three additional participants were excluded based on never starting the study after giving consent or not meeting inclusion criteria. Two of the three participants excluded were from the DD group. Deidentified data were obtained from 14 participants who completed all parts of the study protocol (TD = 8; DD = 6). The demographics collected were gender, age, and race. Participants were both males and females (7 male, 7 female), who come from different ethnic backgrounds (78.6% White, 14.3% Hispanic, and 7.1% Indian). The overall mean age was 19.5 (SD = 3.96) years. By group, the mean ages were as follows: DD (M = 23.0; SD = 3.63) and TD (M = 16.88; SD = 1.13). An independent samples t-test revealed a significant difference between groups for age, $t(12) = -4.540$, $p < .001$). Among the final 14 participants, a subset of 9 participants (TD = 6; DD = 3) completed the pre/post anxiety measure and were used for those analyses.

Measures

The Faison Center collected a series of measures from the driving simulator (described below) including: reaction time, reaction distance, stopping distance, number of errors on time related tasks, pedal mobility, steering mobility, incorrect turns, lane deviation, failure to stay within the speed limit parameters, and following too closely behind another vehicle. Self-report measures were collected from both the participant and his or her parent immediately before and after participation in the study. The self-report questionnaires included questions that assessed parental support in regard to driving, driver's related anxiety, and past motor vehicle experience.

For the current study, the measures that were analyzed were items on the pre/post parent/client questionnaire that assessed driver's anxiety. Additionally, the study used data from the car simulator skills assessment, stopping distance, reaction time and participant duration (number of sessions) to complete the study protocol.

Client Questionnaire Pre/Post (CQPP; Faison Center). The CQPP is an 8 item self-report scale designed by the Faison Center to assess client attitudes toward driving, including driving related anxiety before and after participating in the study. It has 4 subscales: attitudes about driving (1 item), driver's anxiety (2 items), prior experience with motor vehicles (3 items) and parental support (2 items). Participants were asked to check the appropriate responses that describe them in each of the situations. Items requiring a yes/no response were assigned 1 (yes) or 2 (no). Items with descriptive responses suggesting anxiety were coded as: 1

(low anxiety), 2 (neutral response), 3 (high anxiety). In this study, the scale scores initially considered for the pre questionnaire were responses to items 1, 3 and 4 (see Appendix A). The scale scores considered for the post questionnaire were responses to items 2, 3 and 5 (see Appendix A). Unfortunately, internal consistency for the three pre items was very poor (Cronbach's $\alpha = 0.05$) and the content of the items at pre and post did not correspond. Because of low internal consistency, single item measurement scales were used versus multiple item. The items used were the client pre/post responses to item 1 (PRE: "How do you feel about driving a car?"; POST: "How do you feel about driving a car?") and item 3 (PRE: "Do you worry about losing control behind the wheel?"; POST: "Do you still worry about losing control behind the wheel after participating in the program?").

Parent Questionnaire Pre/Post (PQPP; Faison Center). The PQPP, similar to the CQPP, is a 6 item self-report scale designed to assess parent attitudes toward their son/daughter driving. The items assess second hand driving related anxiety in regard to their child learning to drive. It has 4 subscales with different items in each: attitudes about son/daughter learning to drive (2 items), anxious thoughts relating to son/daughter learning to drive (2 items), and supporting son/daughter in learning to drive (2 items). Parents were asked to check the appropriate responses that describe them in each of the situations. Items requiring a yes/no response were assigned 1 (yes) or 2 (no). Items with descriptive responses were coded as follows: 1 (low anxiety), 2 (neutral response), 3 (high anxiety). In this study, the scale scores initially considered for the pre questionnaire were responses to items 1, 3 and 5 (see Appendix B). The scale scores initially considered for the post questionnaire were responses to items 1, 2 and 4 (see Appendix B). When analyzing internal consistency for these three items on the parent questionnaire, similar to the client items, the results were not acceptable (Cronbach's $\alpha = 0.46$). Consistent with selecting the matching client items pre/post, similar items with the strongest pre/post relationship were selected from the parent questionnaire. The items used were the parent pre/post responses to item 1 (PRE: "How do you feel about your child driving a car?"; POST: "How do you feel about your child driving a car after participation in the program?") and item 3 (PRE: "Do you worry about you child losing control behind the wheel?"; POST: "Do you still worry about your child losing control behind the wheel after participating in the program?").

Car Simulator Skills Assessment (CSSA; Faison Center). The CSSA is a 39 item baseline skills assessment (see Appendix C) designed by the Faison Center to assess if the client possesses basic car simulator skills. It has 6 subscales with different items in each: left versus right (4 items), motor skills (8 items), traffic signal (6 items), major car parts (4 items), seatbelt (5 items), motor skills vehicle (11 items). The principal research investigator assessed each of these items with the participant before participation in the program based on observation. Each behavior was marked as 'in repertoire' or 'not in repertoire' depending on the skill. The total number of skills in repertoire in each subscale were recorded for participants.

Recruitment and Screening

The Faison Center's research department handled the recruitment of participants. Participants with developmental disabilities were recruited internally through Faison Center staff. The research department emailed upper level teachers with details of the program and eligibility criteria. Teachers utilized their discretion and sent this information home with students who were eligible for participation. The participants with developmental disabilities were chosen based on consent of the teacher and parents and assent of the participant (see information on selection criteria in Participants).

To recruit the control group, the Faison Center research department created flyers to be hung in the Richmond community. These flyers detailed the logistics of the study (ie. who, what when, where). Participation in the study was advertised as “Free Participation in a Driving Simulator Prep Course for Obtaining a Learner’s Permit to Aid in a Faison Center Research Study”. Participants in the Richmond community had the opportunity to volunteer to participate in a 6-8 week program to learn safe and effective driving skills.

Beyond the pre-screening inclusion criteria, participants, both TD and DD, were additionally screened before participation in the study. All participants were required to complete a vehicle skills questionnaire, car simulator skills assessment and car ingress/egress assessment. The vehicle skills questionnaire asked question regarding participant experience in a vehicle as a passenger. The car simulator skills assessment, described above, assessed the ability to differentiate between left and right, basic gross motor skills needed for operation of the simulator, color perception and meaning of traffic signals, identification of major car parts, ability to buckle and unbuckle a seatbelt, and vehicle motor skills such as turning a steering wheel. These skills were assessed by indicating whether the participant was ‘in repertoire’ or ‘not in repertoire’. The final assessment was a task analysis of car ingress and egress. If ingress and egress were not in repertoire, forward chaining was used to teach the steps involved in proper ingress and egress through the use of a ‘least to most’ hierarchy.

Apparatus

Participants utilized a driving simulator produced by DriveSafety Inc. that The Faison Center purchased from Clemson University's Research Department. DriveSafety Inc. is a company that designs and manufactures driving simulator technologies used by researchers in clinical practice and training facilities ("Car Driving Simulators…", n.d.). The simulator consisted of a body modeled after a Ford Focus sedan and three desktop screens in front of the vehicle and user's visual field. The interior of the vehicle had the exact features of a Ford Focus sedan including (most relevant to this study): steering wheel, pedals, turn signal, dashboard, stick shift. All three desktop screen monitors were turned on during simulator tasks. When real-time driving tasks were executed all screens displayed the roadway environment. Participants had a head on and peripheral view of the roadway enabling them to check surrounding lanes.

Figure 2. Driving simulator with three screen display of the user's visual perspective during a real-time driving simulator task.

The simulator collected a series of measures of driving performance through different simulator exercises. The measures that were collected by the simulator and used for analyses for the study are stopping distance and reaction time. Stopping distance (in feet) was measured in three different exercises. The first exercise was called “pedals and stopping” and assessed whether the participant stopped at the stop sign and whether the participant looked left and right before proceeding. The next exercise that measured stopping distance was through exercises that prompted the participant to turn right or left, requiring a complete stop before make the appropriate turn. The final exercise that measured stopping distance dealt with braking. At each stop sign the participant was required to come to a complete stop and look left and right before proceeding. Stopping distances were displayed on the screen at the end of each exercise that recorded this measure. Reaction time was measured by the pedals and the steering wheel. Pedals reaction time was measured by the rate in which the participant responded to a stop light using the correct pedal. For example, the middle screen of the simulator displayed a stop light and when the light changed to green the participant had to press the gas pedal as quickly as possible, likewise at a red light the participant pressed the brake pedal. The speed at which the participant responded was measured in seconds. Similarly, for steering reaction time, the participant had to turn the steering wheel in response to a left or right arrow as quickly as possible. The reaction times were presented in seconds on the screen after each exercise.

Procedure

The research department at the Faison Center partnered with Clemson University to develop a training program from driving simulator technology developed by DriveSafety Inc.

The Faison Center is engaged in an ongoing data collection process to develop simulated coursework and online tools from the Division of Motor Vehicle (DMV) to go along with the driving simulator technology.

Data collection was conducted at the Faison Center by on-site research staff and was approved by Faison's Institutional Review Board. Parents provided consent for their children to participate and participants provided assent. Participants and parents completed the CQPP and PQPP in the lobby of the Faison Center upon checking in, before the study started. The parent then waited in the lobby while the participant was escorted to the research study room. The principal research investigator discussed logistics with the participant before the study started. First, the participant was shown the driving simulator and told the purpose of the study. The participant received a handout that detailed the study in writing as well as a consent form that needed to be signed before participating. The consent form included the purpose of the research study, procedure, possible risks and benefits, confidentiality, right to withdraw at any time, and contact information of investigators. Additionally, the participant was told each session would last approximately one hour long and the expected duration of the study is 1-2 months (if the participant attended a session once a week).

The participant was then ready to begin the study. The program was divided into four parts. In part 1, participants completed various simulated tasks utilizing steering and pedal and operations. Some of the tasks are: Steering Static, Pedals Static, Steering Chase, Pedals Chase, Combined Controls, Copycat, etc. These tasks were designed to teach basic motor skills, assess reaction time, and challenge short term memory. The completion of each task and criteria to advance to the next level was predetermined. Participants were assessed on the number of errors they make on each task, with three trials allowed to pass to the next level. If the participant did not pass after three trials, they were automatically advanced to the next level.

In part 2, participants advanced beyond driving skill tasks and into new driver real-time simulated driving tasks. A calibration on the driving simulator was run at the start of each simulated driving session. Part 2 was a combination of task exercises from part 1 and new simulated driving exercises. The new exercises included lane keeping on a straight road (traveling an appropriate speed while staying in the designated lane), speed control on a straight road (maintain different target speeds that are displayed on signs while staying in the designated lane) and obstacles on a straight road (maneuvering through a series of orange traffic cones on a straight road without crashing). Similar to part 1, part 2 had goals that must be met in each exercise to advance to the next. The same criteria in part 1 was used for the task exercises that were repeated in part 2. The new simulated driving tasks were scored differently. For lane keeping on a straight road, the criteria was staying in the lane for 30 seconds within 5 mph of the speed limit. For speed control on a straight road, the criteria was maintaining speed within +/- 3.0 mph of the speed limit with no lane deviations. Finally, obstacles on a straight road required no crashes into orange traffic cones to pass. If the participant did not pass after three trials, they were automatically advanced to the next level.

Part 3 did not utilize the driving simulator. Participants worked together with the research investigator to learn the DMV Learner's Permit preparatory course work. Coursework included information about road signs and signals. The coursework necessary for obtaining a learner's permit was organized into powerpoint slides that included 20 active student responses (ASR's) embedded within to test the participant's understanding of course information. Participants must pass the learner's coursework with 80% accuracy on the ASR's (required 18 correct). If the participant scored lower than 80% on the ASR's, the research investigator reviewed the incorrect responses, went over the powerpoint slides that corresponded to the incorrect answers and allowed the participant to re-answer those questions. The participant must have completed the ASR's with 80% accuracy regardless of the number of attempts. Once a score of 80% is reached, the participant advanced to part 4.

Part 4, the final stage of participation, involved more detailed coursework from the DMV as well as simulated driving tasks using the car simulator. The coursework extended beyond road signs and signals to include safety, road caution, merging, speed, turning etc. Coursework was integrated into a powerpoint with embedded ASR's similar to part 3. The difference between part 3 and part 4 was that part 4's powerpoint also had embedded car simulator task instructions. The participant completed part of this section at a table and the other part in the car simulator. The simulated driving tasks were used to supplement the coursework information to allow the participant to practice learned skills directly on the simulator. Some simulated driving tasks included: turning right, turning left, lane switching with no cars in the roadway, lane switching using mirrors, stopping distance, etc. The passing criteria in part 4 was the same at part 3 (criteria for ASR's) and part 2 (simulated driving task passing criteria measuring errors). Both the ASR's and simulated driving tasks must meet passing criteria to complete level 4.

Part 4 culminated the active participation of designed coursework and simulated driving. To receive a certificate for completion, the participant took a multiple choice cumulative test from the coursework information learned in part 3 and 4. This information consisted of material that came directly from the DMV manual for learner's permit prep work. The participant had time to study the material from part 3 and part 4 powerpoints. This test was independent and could be taken as many times necessary to achieve a 100% score. After the first attempt, participants obtained feedback on the incorrect responses. A score of 100% must be achieved to receive a certificate.

A post survey, the CQPP and PQPP, was given to both the parent and participant.

Plan of Analysis

To answer this study's research questions, de-identified data were obtained from the Faison Center. All data had been collected during the tasks and assessments of each part over an 8 month period. The Faison Center research staff removed participant identifying information and sent the files to the University of Richmond email address of the research investigator in their de-identified form for analysis. Because only de-identified data were used for this analysis, the chair of the University of Richmond IRB determined that the analyses presented here was not reviewable research. The measures that were received for analysis are survey responses for driver's anxiety and pre assessment skills questionnaire (CQPP and PQPP); in addition to car simulator skills assessment data, reaction time data, stopping distance, and participant demographics and duration data.

Frequencies or means were determined for demographics collected, including gender, age, and ethnicity to assess group differences. Descriptive analyses were carried out, using independent samples t-tests, to determine group differences in mean number of sessions and mean duration of sessions (in minutes) to complete the study protocol. It was expected that there would be a difference in mean number of sessions and minutes between groups, with TD participants having completed the protocol in fewer sessions and fewer minutes compared to DD participants. Additionally, independent samples t-tests were used to determine group differences in the car simulator skills assessment (mean number of skills in repertoire in each subscale), reaction time measured in seconds (pedals and steering) and stopping distance measured in feet (at three different mph). There was also an expected difference in performance between the two groups, with TD performing at a significantly higher rate than DD participants.

Before the data were received, the plan of analysis was to determine differences in reported anxiety levels pre/post participation between groups using a two by two mixed factor ANOVA with within participants (assessment at time points 1 and 2) and between participants (DD and TD) variables. However, due to the small sample size and difficulties with the anxiety items described in the Measures section, effect sizes for single item scores were used. Changes in mean scores, utilizing the two items from the CQPP and PQPP, were used to assess trends from pre to post for both parents and participants.

Results

Baseline Skills

Baseline skills differed between groups. The car simulator skills assessment revealed that both groups (TD and DD) show 100% "in repertoire" response rates for the following 4 categories: left vs right (M = 4.0 both groups), traffic signals (M = 9.0 both groups), major car parts (M = 4.0 both groups) and seat belt (M = 5.0 both groups). The TD group showed 100% "in repertoire" responses to the motor skills category (M = 8.0) compared to the DD group, some of whom had some skills "not in repertoire" (M = 7.67, SD = 0.52). An independent samples t-test revealed no significant difference between groups for motor skills, $t(12) = 1.85$, $p = .089$). The final category, motor vehicle skills, had some members with skills "not in repertoire" for both TD (M = 9.89, SD = 2.10) and DD (M = 8.83, SD = 1.72) groups. An independent samples t-test revealed no significant difference between groups for motor vehicle skills, $t(12) = .99$, $p = .343$.

Rate of Progress

Number of Sessions. The driver training program consisted of four consecutive parts that participants were required to complete chronologically in order to advance to the subsequent part. The mean number of sessions to complete each part was determined for both groups (Figure 3). In part 1, the DD group required a greater number of sessions to complete the coursework (M = 3.50, SD = 1.05) compared to the TD group (M = 1.69, SD = 0.37). A cumulative mean was calculated for part 2, part 3 and part 4, to reflect the total number of sessions up to that part. The mean number of sessions was greater for the DD group in part 2 (M = 5.0, SD = 1.67), part 3 (M

= 7.08, *SD* = 1.50) and part 4 (*M* = 14.25, *SD* = 2.89), compared to the TD group [part 2 (*M* = 3.00, *SD* = 0.65), part 3 (*M* = 4.38, *SD* = 0.83), part 4 (*M* = 7.38, *SD* = 1.92)].

An average number of sessions across all four parts was obtained for both groups to determine if there were group differences in the total number of sessions completed. On average, the DD group took a greater number of sessions to complete all four parts (*M* = 14.25, *SD* = 2.89) compared to the TD group (*M* = 7.38, *SD* = 1.92). An independent samples t-test revealed a significant difference between groups for total number of sessions, $t(12) = -5.36$, $p < .001$).

Session Duration in Minutes. In addition to total number of sessions, the duration per session was recorded in minutes. Mean duration scores were calculated for both groups (DD and TD) to complete each of the four parts (Figure 4). After part 1, a cumulative mean was calculated for the remaining three parts (part 2, part 3, part 4) to reflect the total number of minutes at each subsequent part. In part 1, the DD group had a greater mean session duration in minutes (*M* = 163.83, *SD* = 42.40) compared to the TD group (*M* = 89.0, *SD* = 22.34). The cumulative means also revealed a greater mean session duration for the DD group in part 2 (*M* = 234.50, *SD* = 45.61), part 3 (*M* = 358.50, *SD* = 60.19), and part 4 (*M* = 778.50, *SD* = 217.50), compared to the TD group [part 2 (*M* = 147.75, *SD* = 31.51), part 3 (*M* = 216.75, *SD* = 43.38), part 4 (*M* = 403.0, *SD* = 94.99)].

An average mean duration to program completion was calculated by obtaining cumulative minutes across all four parts for both groups (DD and TD). The DD group has a greater mean total number of minutes (*M* = 778.50, *SD* = 217.50) compared to the TD group (*M*

= 403.0, *SD* = 94.99). An independent samples t-test revealed a significant difference between groups for session duration in minutes, $t(12) = -4.38$, $p = .001$).

Anxiety

Client Anxiety. Results for pre-to-post anxiety collapsed across groups appear in Table 1 and results for TD vs. DD groups appear in Table 2. For item 1 ("how do you feel about driving a car?"), there was a small difference in baseline responses (pre) for the two groups, with the TD group having a larger value for anxiety than the DD group ($d = 0.21$). There was a reduction in the overall mean reported anxiety for all respondents from pre ($M = 1.33$) to post ($M = 1.11$). Results from a paired samples Cohen's *d* reveal a small negative effect, in regard to feelings about driving a car, from pre to post ($d = -0.43$). Next, differences in change over time based on group were assessed. The DD group showed a decrease in mean reported anxiety from pre ($M = 1.25$, $SD = 0.50$) to post ($M = 1.00$, $SD = 0$). The TD group also reflected a decrease in mean reported anxiety from pre ($M = 1.38$, $SD = 0.74$) to post ($M = 1.17$, $SD = 0.41$).

For item 2 ("do you worry about losing control behind the wheel?"), the same analyses were carried out. At baseline (pre), there was a small effect size for differences between mean level of reported anxiety for the DD group compared to the TD group, with the DD group having a higher self-reported level of anxiety compared to the TD group ($d = 0.24$). The overall mean reported anxiety revealed a slight increase in mean level of anxiety from pre ($M = 1.67$) to post ($M = 1.78$). Results from a paired samples *d* revealed a small effect from pre to post ($d = 0.24$). Comparing between groups, the DD group reported a decrease in mean anxiety from pre ($M =$

1.75, *SD* = 0.50) to post (*M* = 1.67, *SD* = 0.58) compared to the TD group who reported a slight increase in mean anxiety from pre (*M* = 1.63, *SD* = 0.52) to post (*M* = 1.83, *SD* = 0.41).

Parent Anxiety. Similar to client anxiety, results for pre-to-post anxiety collapsed across groups appear in Table 1 and results for TD vs. DD groups appear in Table 2. For item 1 ("how do you feel about your child driving a car?"), there were no differences in baseline anxiety responses (pre) for the two groups (*M* = 1.00, *SD* = 0). There was an increase in overall mean reported anxiety for all respondents from pre (*M* = 1.00) to post (*M* = 1.50). Given the invariance of scores at pre for parents responses to item 1, a standard Cohen's *d* was calculated using the *SD* of the post responses (*SD* = 0.55) in place of pooled *SD* (*d* = 0.91). Next, differences in changes over time based on group were assessed. The DD group showed an increase in mean reported anxiety from pre (*M* = 1.00, *SD* = 0) to post (*M* = 2.00, *SD* = n/a). The standard deviation at post could not be determined for the DD group because only one parent responded at post (*n* = 1). The TD group also showed an increase in mean reported anxiety from pre (*M* = 1.00, *SD* = 0) to post (*M* = 1.40, *SD* = 0.55).

For item 2 ("do you worry about your child losing control behind the wheel?"), the same analyses were carried out. At baseline (pre), there was a small effect size for differences between mean level of reported anxiety for the DD group compared to the TD group, with the DD group having a higher self-reported level of anxiety compared to the TD group (*d* = 0.16). The overall mean reported anxiety increased from pre (*M* = 1.43) to post (*M* = 1.67). Results from a paired samples Cohen's *d* reveal a small effect, in regard to worrying about losing control, from pre to post (*d* = 0.35). Comparing between groups, the DD group reported an increase in mean anxiety from pre (M = 1.50, SD = 0.71) to post (M = 3.00, SD = n/a) compared to the TD group who showed no change from pre to post (M = 1.40; SD = 0.55). The Cohen's d could not be determined at post due to one parent response (n = 1).

Stopping Distance

Stopping distance was calculated at three different speeds (35 mph, 45 mph, 55 mph) in feet for both groups (DD vs TD) during a pedals and stopping task (Figure 5). Negative stopping distances reflect stopping in front of the white line at a stop sign. There was not a significant difference in the mean stopping distance for DD participants (M = -9.75, SD = 11.03) and TD participants (M = -7.29, SD = 10.44) at 35 mph; $t(9)$= .37, p = 0.72). At 45 mph, there was not a significant difference in the mean stopping distance for DD participants (M = -18.25, SD = 21.87) and TD participants (M = -9.86, SD = 17.25); $t(9)$= .71, p = 0.50). At 55 mph, there was not a significant difference in the mean stopping distance for DD participants (M = -17.00, SD = 14.76) and TD participants (M = -12.00, SD = 17.24); $t(9)$= .49, p = 0.64).

Reaction Time

Reaction time was calculated in seconds for two different assessment measures (pedals and steering). Group differences (DD vs TD) were calculated for both pedals and steering (Figure 6). There was not a significant difference in pedals reaction time for DD participants (M = 0.67 sec, SD = 0.09) and TD participants (M = 0.67 sec, SD = 0.14); $t(11)$= .04, p = 0.97). For steering, there was not a significant difference in reaction time for DD participants (M = 0.54 sec, SD = 0.11) and TD participants (M = 0.55 sec, SD = 0.06); $t(11)$= .20, p = 0.89).

Discussion

The initial hypothesis of this study was that people with DD will show no change in mean level of anxiety compared to the TD group who will show a decrease in anxiety from pre to post. The items on the anxiety measure were originally intended to sum together and create a total anxiety score. This cumulative score was to be analyzed from pre to post between groups to assess whether there was a change over time. However, the three anxiety-related items in the scale (CQPP and PQPP) had very poor psychometric properties, for example low internal consistency; therefore, single items were used for analyses and the original hypothesis was inconclusive. Means were examined between groups and over time to estimate effect sizes that might be expected in future studies. The exploratory questions were analyzed in attempt to support the literature on the effectiveness of driving simulators in teaching skills across various domains and providing safe learning (Brooks et al., 2014).

Description of Findings

The initial car simulator skills assessment measured the number of “in repertoire” skills in 6 categories for both groups of participants. It was expected that the DD group would have less in repertoire skills compared to the TD group. However, the results revealed that the TD and DD groups achieved 100% of skills in repertoire in four of the six categories. These categories include: identifying left versus right, identifying traffic signals by color, identifying major car parts, and properly buckling/unbuckling a seatbelt. There were no group differences in these four domains, which suggests that the skills required did not exceed the DD participants’ capacity. The initial inclusion criteria required normal/corrected vision, color vision, and basic motor dexterity. These criteria may be one reason for similar performance between groups. The remaining two categories (motor skills and motor vehicle skills) differed in skill performance between the DD and TD groups. The DD group had fewer in repertoire motor skills and fewer in repertoire motor vehicle skills compared to the TD group. Although there was no significant difference between groups, the results show that both groups had some difficulty with certain skills. A greater number of in repertoire skills at baseline was an expected advantage for rate of progress throughout the coursework.

In terms of age, differences were observed between both groups. The TD group was significantly younger than the DD group. An older mean age was anticipated for the DD group because people with DD develop more slowly compared to TD. DD participants were required to have a teacher/faculty recommendation to be considered for inclusion. Recommendations were based on teacher confidence in the young adults ability to operate a driving simulator and desire by the participant to learn to drive. These reasons may account for the significant difference in age between DD and TD groups

Rate of progress, a measure used for exploratory analyses, was measured by the total number of sessions completed and total minutes per session in each part and overall. The four part coursework required a different number of exercises in each part. Some exercises were longer than others, which could be better explained by total minutes per session rather than total number of sessions. Overall, the DD group required nearly twice as many sessions as the TD group to finish the entire coursework protocol. For parts 1, 2 and 3, the DD group, on average, completed 2-3 more sessions in each part than the TD group. Both groups maintained steady linear progress. However, in part 4, the DD group took nearly twice as many sessions as the TD group. The increase in total number of sessions in part 4, for both groups, disrupted the linear increase (Figure 3). There are a few reasons for this abrupt increase: (1) the exercises were more challenging and required more attempts to pass, (2) part 4 was an integration of simulator exercises and DMV coursework material, which required additional time to complete active student response questions, (3) the greatest number of exercises were included in part 4 to conclude the study. Significant differences were observed between groups for total number of sessions to complete all four parts. In terms of sessions duration, sessions were estimated to last 60 minutes to follow the expected 8 week timeline for completion. Measuring each group's total number of sessions did not account for the participants who chose not to complete the full hour session on a given week. The DD group rarely completed full one hour sessions, which may be due to comorbid ADHD symptoms of inattention and hyperactivity. Some reasons for concluding sessions early were not feeling well due to simulator sickness, lack of interest, other school related activities that interfered time wise, etc. Disrupted sessions were thought to be a reason for why the DD group required a greater number of sessions in each part compared to the TD group. However, the sessions duration (in minutes) confirmed that the DD group took twice as long as the TD group, and the session total was not greatly influenced by shortened sessions. Some TD participants also completed sessions in less than an hour, but were less likely to do so than the DD group. They were encouraged to complete the full 60 minute session. For mean session duration, the DD group spent a greater number of minutes completing each of the four parts compared to the TD group. Cumulative minutes per part revealed that the DD group was about 60 minutes (one session equivalent) behind the TD group in part 1, part 2, and part 3. In part 4, there was a steep increase in mean duration for both groups, similar to total number of sessions. On average, the DD group took 2.25 times as many minutes as the TD group. The mean rate of completion in minutes confirms that a higher session total was completed due to content and difficulty of the exercises rather than failure to complete 60 minute sessions. The difference between group mean rate of completion in minutes was significant and supported the significant results between groups for mean number of sessions completed.

The anxiety analyses revealed interesting findings about client and and parent self-reported levels of worry about driving a car and fear of losing control behind the wheel. Although the intended analyses could not be carried out to test the hypothesis, examining overall means between groups and over time provides information that can guide future research. Baseline self-reported anxiety (pre) between groups was not different from one another. The effect size between groups was very small, revealing similar baseline anxiety levels. Over time, the client self-report responses revealed a slight decrease in anxiety in regard to thoughts about driving (item 1) compared to a slight increase in anxiety in regard to worry about losing control behind the wheel (item 2). The decrease in anxiety was expected as a result of becoming more comfortable with driving and increasing performance based skills after practicing with the driving simulator for 8 weeks. However, the client increase in worry of losing control was surprising. This increase could be explained by the clients acknowledgement of their performance based deficits using the simulator. For example, participants performed worse on real time driving tasks that had a greater level of difficulty compared to the basic simulator skills tasks in part 1. As exercises became more challenging participants may have become discouraged by their performance and self-reported greater anxiety. Therefore, the debriefing session needs to explain that the simulator results do not directly suggest performance on the actual roads.

The parent self-report driving anxiety responses also reveal interesting and unexpected patterns. For both item 1 and item 2, parents report an increase in driving anxiety from pre to post. There was thought to be a decrease in anxiety as parents saw their child learning to drive and practicing for an extended period of time. However, the actual results indicated an increase in parent self-reported anxiety, which may reflect parent nervousness about their child soon becoming a driver. The reality of young adults obtaining the freedom to drive likely provokes parent anxiety.

The stopping distance and reaction time exploratory measures yielded results that add a new dimension to the existing literature on driving skill domains. Stopping distances at three different speeds were analyzed between groups. While no significant differences were found between groups, the TD group appeared to stop closer to the white line at the stop sign compared to the DD group. There are a couple explanations for this finding. First, it may be the case that the TD participants approached the white line with more caution and waited to brake completely until they were as close to the line as possible compared to the DD group who braked as soon as they saw the white line in the distance. It could also be argued that the DD group displayed even more caution, as evident by the greater stopping distance. On the contrary, the DD group stopped behind the TD group at an even greater distance away from the stop sign. This finding was surprising based on the high comorbidity between ASD and ADHD. Impulsivity was expected to negatively influence the DD participants stopping distance, with a hypothesis that the DD group would stop over the white line. However, the results revealed that that the DD group stopped further behind (a greater negative stopping distance) the TD group in all three speed conditions. Additionally, as the speed increased, the stopping distance of all three groups also increased.

Reaction times between groups were based on two different simulator assessments: pedals and steering. Both assessments revealed no significant difference between groups in terms of mean reaction time, measured in seconds. The DD and TD groups had very similar reaction times. The ability to respond to stimuli in the environment is extremely important for developing safe driving habits. This finding can be used to support DD participants ability to learn critical skills for driving.

Limitations

Although the results of this study yield interesting patterns of results, the limitations make it difficult to generalize findings to a greater population. The first limitation involves the driving simulator apparatus. While driving simulators may be effective tools for providing safe learning, simulator learning is not equivalent to real time driving. Driving simulators lack the behavioral validity that real time road driving has. Behavioral validity compares the extent to which simulated driving results in the same behavioral response as on road driving (Mullen et al., 2010). Because the simulators use visual imagery to depict "real world" situations, behavioral validity is compromised and a limitation behind simulator research. The second limitation also involves the driving simulator apparatus and its inability to generalize research findings beyond the simulator. Simulated driving measures driver performance (ie. quick reaction time, speed maintenance, lane changing) rather than driver behavior (ie. gaze, mirror checking, speed adjustment with traffic), thus neglecting what the driver chooses to do in real time (Chan et al., 2010). Driving performance can vary based on the individual's experience with other simulated technologies. Some novice drivers may outperform skilled drivers when it comes to training on the simulator because they excel in video games. However, this does not necessarily mean he/she will do the same in a car on the roadway. A novice driver may possess fast reaction time to hazardous objects in the roadway during the simulated driving program, but not on actual roads. Driving simulator findings must be carefully assessed and cautiously used to make claims about real time driving.

Additional limitations exist regarding the study's protocol, including participants. First, the small sample size disrupted the initial planned analyses for the anxiety measures. Analyses were limited to observing overall patterns in means and no significance tests could be carried out. Therefore, there was no way to determine whether the results supported the original hypothesis. Second, the existing measure for driving anxiety had poor psychometric properties. The multi-item scale had low internal consistency, resulting in the decision to analyze single items from the scale. The scale responses (low, neutral, high) were also vague and did not appropriately measure anxiety levels. Third, the anxiety measures (CQPP and PQPP) were added to the study protocol a year into data collection. Because this is an ongoing pilot study, recruitment of participants and data collection has varied during the course of the pilot study. At the time these analyses were carried out for this paper, nearly half of the completed participants did not complete the pre/post measure for anxiety. As a result, the non-completer participants were excluded from the final analyses. Fourth, the DD group displayed a high drop out rate before study completion compared to the TD group. After participants were included in the study, only those who completed the pre/post questionnaire and four part protocol were used for final data collection. When assessing drop out rates, 50% of the original DD participants were dropped before final data collection compared to 0% of TD participants.

Future Research

Future research should not only correct the limitations addressed above, but extend the current study protocol to add new findings. One future research idea is to develop an improved driving anxiety measure that uses a Likert scale with multiple items to assess how participants and parents feel about driving. A broader scale will provide a more specific self-reported anxiety score that can explain anxious driving thoughts and behaviors. A second future idea in a 8 week study like this is to offer some form of compensation (ie. money, reinforcers, etc) in exchange for participation. The compensation would be contingent upon completing the entire study protocol and post assessments. Offering compensation may reduce the dropout rate for DD participants by incentivizing participants to complete all four parts. Lastly, comorbid disorders in DD participants can be assessed in future studies to see how a secondary or tertiary diagnosis influences driving performance and self-reported driving anxiety. Comorbid diagnoses can make learning to drive problematic in both DD and TD participants due to symptom and treatment interactions between diagnoses. Medical history should also be assessed to determine family history of mental health disorders and genetic risk for developing anxiety. It is likely that people who have generalized anxiety will be more at risk for displaying anxious driving thoughts or behaviors.

Conclusions

The overall purpose of this study was to extend the Faison Center’s current pilot work by explaining how driving anxiety in young people with ASD changes over the course of an 8 week driving simulator training program. Other exploratory questions extended the literature on driving simulators as effective tools for teaching safe learning and yielded some interesting findings.

The limitations of the driving anxiety measures make it difficult to draw conclusions about the effect driving simulators have on self-reported driving anxiety. However, the overall trends in self-reported anxiety reveal that clients are more likely to show decreases in anxiety from pre to post compared to parents. Parents self-report an increase in anxiety for both items on the anxiety measure from pre to post. This finding might be a result of parents coming to terms with their child's ability to begin driving and obtain a learner's permit based on performance in the driving simulator program. The additional exploratory measures support the literature on driving simulators as effective tools for training pre-motor aspects of driving and other important driving skills.

The implications of the results provide context about the challenges, both physically and mentally, that young adults face when learning to drive. Specifically, the findings support that DD participants do have important skills (ie. reaction time) that are critical for becoming a safe driver. Driving is a symbol of freedom and means of independence, especially for people with autism and other developmental disabilities. Continued research on this topic has the potential to find new ways to teach driving skills and reduce driver's anxiety, in order to help those with DD obtain a learner's permit and, someday, a driver's license.

References

Agrawal, A., Heath, A. C., & Lynskey, M. T. (2011). DSM-IV to DSM-5: The impact of proposed revisions on diagnosis of alcohol use disorders. *Addiction,106*(11), 1935-1943. doi:10.1111/j.1360-0443.2011.03517.x

American Psychiatric Association. (2013). *Diagnostic and statistical manual of mental disorders* (5th ed.). Washington, DC: Author

Attention-Deficit/Hyperactivity Disorder. (n.d.). Retrieved from https://www.nimh.nih.gov/health/topics/attention-deficit-hyperactivity-disorder-adhd/index.shtml

Barkley, R. A., & Cox, D. (2007). A review of driving risks and impairments associated with attention-deficit/hyperactivity disorder and the effects of stimulant medication on driving performance. *Journal of Safety Research*, *38*(1), 113–128. https://doi.org/10.1016/j.jsr.2006.09.004

Beanland, V., Goode, N., Salmon, P. M., & Lenné, M. G. (2013). Is there a case for driver training? A review of the efficacy of pre- and post-licence driver training. *Safety Science*, *51*(1), 127–137. https://doi.org/10.1016/j.ssci.2012.06.021

Beck, N. (2018). 1 in 4 teens too scared to drive, says survey from the zebra. Retrieved from https://www.newswire.com/news/1-in-4-teens-too-scared-to-drive-says-survey-from-the-zebra-20736722

Brooks, J. O., Mossey, M. E., Tyler, P., & Collins, J. C. (2014). An exploratory investigation: are driving simulators appropriate to teach pre-driving skills to young adults with intellectual disabilities? *British Journal of Learning Disabilities*, *42*(3), 204–213. https://doi.org/10.1111/bld.12029

Brooks, J., Kellett, J., Seeanner, J., Jenkins, C., Buchanan, C., Kinsman, A., … Pierce, S. (2016). Training the motor aspects of pre-driving skills of young adults with and without autism spectrum disorder. *Journal of Autism and Developmental Disorders*, *46*(7), 2408–2426. https://doi.org/10.1007/s10803-016-2775-8

Butchart, M., Long, J. J., Brown, M., McMillan, A., Bain, J., & Karatzias, T. (2017). Autism and visual impairment: a review of the literature. *Review Journal of Autism and Developmental Disorders*, *4*(2), 118–131. https://doi.org/10.1007/s40489-016-0101-1

Car Driving Simulators for Clinical & Research Applications. (n.d.). Retrieved from https://www.drivesafety.com/

Chan, E., Pradhan, A. K., Pollatsek, A., Knodler, M. A., & Fisher, D. L. (2010). Are driving simulators effective tools for evaluating novice drivers' hazard anticipation, speed management, and attention maintenance skills. *Transportation Research. Part F, Traffic Psychology and Behaviour*, *13*(5), 343–353. https://doi.org/10.1016/j.trf.2010.04.001

Clapp, J. D., Olsen, S. A., Danoff-Burg, S., Hagewood, J. H., Hickling, E. J., Hwang, V. S., & Beck, J. G. (2011). Factors contributing to anxious driving behavior: The role of stress history and accident severity. *Journal of Anxiety Disorders, 25*(4), 592-598. doi:10.1016/j.janxdis.2011.01.008

Classen, S., Monahan, M., & Hernandez, S. (2013). Indicators of simulated driving skills in adolescents with autism spectrum disorder. *The Open Journal of Occupational Therapy*, *1*(4). https://doi.org/10.15453/2168-6408.1051

Cooper, S. E., Miranda, R., & Mennin, D. S. (2013). Behavioral indicators of emotional avoidance and subsequent worry in generalized anxiety disorder and depression. *Journal of Experimental Psychopathology*, *4*(5), jep.033512. https://doi.org/10.5127/jep.033512

Curry, A. E., Yerys, B. E., Huang, P., & Metzger, K. B. (2017). Longitudinal study of driver licensing rates among adolescents and young adults with autism spectrum disorder. *Autism, 22*(4), 479-488. doi:10.1177/1362361317699586

Dougherty, C. C., Evans, D. W., Myers, S. M., Moore, G. J., & Michael, A. M. (2016). A comparison of structural brain imaging findings in autism spectrum disorder and attention-deficit hyperactivity disorder. *Neuropsychology Review*, *26*(1), 25–43. https://doi.org/10.1007/s11065-015-9300-2

Dula, C. S., Adams, C. L., Miesner, M. T., & Leonard, R. L. (2010). Examining relationships between anxiety and dangerous driving. *Accident Analysis & Prevention*, *42*(6), 2050–2056. https://doi.org/10.1016/j.aap.2010.06.016

Fein, E. (2016). Our circuits, ourselves: What the autism spectrum can tell us about the Research Domain Criteria Project (RDoC) and the neurogenetic transformation of diagnosis. *BioSocieties*, *11*(2), 175–198. https://doi.org/10.1057/biosoc.2015.31

Howlin, P., Goode, S., Hutton, J., & Rutter, M. (2004). Adult outcome for children with autism. *Journal of Child Psychology and Psy- chiatry, 45*(2), 212–229.

Katz, M. M., Wetzler, S., Cloitre, M., Swann, A., Secunda, S., Mendels, J., & Robins, E. (1993).

Expressive characteristics of anxiety in depressed men and women. *Journal of Affective Disorders*, *28*(4), 267–277. https://doi.org/10.1016/0165-0327(93)90062-O

Kim, J. A., Szatmari, P., Bryson, S. E., Streiner, D. L., & Wilson, F. J. (2000). The prevalence of anxiety and mood problems among children with autism and asperger syndrome. *Autism*, 4(2), 117–132. https://doi.org/10.1177/1362361300004002002

Klauer, S. G., Guo, F., Simons-Morton, B. G., Ouimet, M. C., Lee, S. E., & Dingus, T. A. (2014). Distracted driving and risk of road crashes among novice and experienced drivers. *New England Journal of Medicine*, *370*(1), 54–59. https://doi.org/10.1056/NEJMsa1204142

Luna, B., Minshew, N. J., Garver, K. E., Lazar, N. A., Thulborn, K. R., Eddy, W. F., & Sweeney, J. A. (2002). Neocortical system abnormalities in autism: An fMRI study of spatial working memory. *Neurology*, *59*(6), 834–840. https://doi.org/10.1212/WNL.59.6.834

Militerni, R., Bravaccio, C., Falco, C., & Fico, C. (2002). Repetitive behaviors in autistic disorder. *Adolescent Psychiatry*, *11*(5), 9.

Mullen, N., Charlton, J., Devlin, A., & Bedard, M. (2010, November 30). Simulator validity: behaviors observed on the simulator and on the road. Retrieved from https://trid.trb.org/view/1114738

Nicholas, J. S., Charles, J. M., Carpenter, L. A., King, L. B., Jenner, W., & Spratt, E. G. (2008). Prevalence and characteristics of children with autism-spectrum disorders. *Annals of Epidemiology*, *18*(2), 130–136. https://doi.org/10.1016/j.annepidem.2007.10.013

Reimer, B., Fried, R., Mehler, B., Joshi, G., Bolfek, A., Godfrey, K. M., … Biederman, J.

(2013). Brief report: examining driving behavior in young adults with high functioning autism spectrum disorders: A pilot study using a driving simulation paradigm. *Journal of Autism and Developmental Disorders*, *43*(9), 2211–2217. https://doi.org/10.1007/s10803-013-1764-4

Release: Teen crash risk highest during first three months after getting driver's license. (n.d.). Retrieved from https://www.nichd.nih.gov/newsroom/news/071018-teen-driving

Ross, V., Jongen, E., Vlierden, K. V., Brijs, K., Brijs, T., Hens, R., . . . Vanvuchelen, M. (2018). Process of learning to drive by young persons with autism: Experiences of the young persons themselves, parents, and driving instructors. *Transactions on Transport Sciences, 9*(2), 42-56. doi:10.5507/tots.2018.012

Schmidt-Daffy, M. (2013). Fear and anxiety while driving: Differential impact of task demands, speed and motivation. *Transportation Research Part F: Traffic Psychology and Behaviour*, *16*, 14–28. https://doi.org/10.1016/j.trf.2012.07.002

Steinberg, L. (2007). Risk taking in adolescence. *Current Directions in Psychological Science,16*(2), 55-59. doi:10.1111/j.1467-8721.2007.00475.x

Taylor, J. E., Deane, F. P., & Podd, J. V. (2000). Determining the focus of driving fears. *Journal of Anxiety Disorders*, *14*(5), 453–470. https://doi.org/10.1016/S0887-6185(00)00033-5

Taylor, J., Deane, F., & Podd, J. (2002). Driving-related fear. *Clinical Psychology Review, 22*(5), 631-645. doi:10.1016/s0272-7358(01)00114-3

The National Institute of Mental Health. (2017). Any anxiety disorder. Retrieved from https://www.nimh.nih.gov/health/statistics/any-anxiety-disorder.shtml

Ting, P.-H., Hwang, J.-R., Doong, J.-L., & Jeng, M.-C. (2008). Driver fatigue and highway driving: A simulator study. *Physiology & Behavior*, *94*(3), 448–453. https://doi.org/10.1016/j.physbeh.2008.02.015

Van Steensel, F. J. A., & Heeman, E. J. (2017). Anxiety levels in children with autism spectrum disorder: A meta-analysis. *Journal of Child and Family Studies*, *26*(7), 1753–1767. https://doi.org/10.1007/s10826-017-0687-7

Wald, J. (2004). Efficacy of virtual reality exposure therapy for driving phobia: A multiple baseline across-subjects design. *Behavior Therapy, 35*(3), 621-635. doi:10.1016/s0005-7894(04)80035-2

Wang, Y., Zhang, W., Wu, S., & Guo, Y. (2007). Simulators for driving safety study – a literature review. In R. Shumaker (Ed.), *Virtual Reality* (pp. 584–593). Springer Berlin Heidelberg.

White, S. W., Oswald, D., Ollendick, T., & Scahill, L. (2009). Anxiety in children and adolescents with autism spectrum disorders. *Clinical Psychology Review*, *29*(3), 216–229. https://doi.org/10.1016/j.cpr.2009.01.003

Yanbin, W., Wei, Z., & Salvendy, G. (2010). Effects of a simulation-based training intervention on novice drivers' hazard handling performance. *Traffic Injury Prevention*, *11*(1), 16–24. https://doi.org/10.1080/15389580903390631

Zinzow, H. M., Brooks, J. O., Rosopa, P. J., Jeffirs, S., Jenkins, C., Seeanner, J., . . . Hodges, L. F. (2018). Virtual reality and cognitive-behavioral therapy for driving anxiety and aggression in veterans: A pilot study. *Cognitive and Behavioral Practice, 25*(2), 296-309. doi:10.1016/j.cbpra.2017.09.002

Zinzow, H. M., & Jeffirs, S. M. (2017). Driving aggression and anxiety: intersections, assessment, and interventions. *Journal of Clinical Psychology*, *74*(1), 43–82. https://doi.org/10.1002/jclp.22494

Tables

Table 1

CPQQ and PQPP Anxiety Scores - Overall

	Pre	Post	Cohen's *d* paired
Child (*n*)	12	9	
Item 1 *M* (*SD*)	1.33 (0.65)	1.11 (0.33)	-0.43
Item 2 *M* (*SD*)	1.67 (0.49)	1.78 (0.44)	0.24
Parent (*n*)	7	6	
Item 1 *M* (*SD*)	1.00 (0)	1.50 (0.55)	0.91*
Item 2 *M* (*SD*)	1.43 (0.53)	1.67 (0.82)	0.35

Note. Mean scores were calculated overall anxiety score from pre to post for both items on the CQPP and PQPP. N/A means that the standard deviation of one or more groups is zero, or the sample size of one or more groups is not greater than 1. *Given the invariance of scores at Pre, this value represents a standard Cohen's *d* calculated using .55 in place of pooled *SD*.

Table 2

CPQQ and PQPP Anxiety Scores by Group

	TD		DD		Cohen's *d* between groups	
	Pre	Post	Pre	Post	Pre	Post
Child (*n*)	8	6	4	3		
Item 1 *M* (*SD*)	1.38 (0.74)	1.17 (0.41)	1.25 (0.50)	1.00 (0)	0.21 TD>DD	.41* TD>DD
Item 2 *M* (*SD*)	1.63 (0.52)	1.83 (0.41)	1.75 (0.50)	1.67 (0.58)	0.24 DD>TD	0.32 TD>DD
Parent (*n*)	5	5	2	1		
Item 1 *M* (*SD*)	1.00 (0)	1.40 (0.55)	1.00 (0)	2.00 (n/a)	0.00 TD=DD	n/a DD>TD
Item 2 *M* (*SD*)	1.40 (0.55)	1.40 (0.55)	1.50 (0.71)	3.00 (n/a)	0.16 DD>TD	n/a DD>TD

Note. Mean scores were calculated for pre and post single items by group from the CQPP and PQPP. *Given the invariance of scores for some means, these values represent Cohen's *d* calculated the *SD* of one mean in place of the pooled *SD*. N/A means that the sample size of the group is not greater than 1 and therefore no *SD* could be calculated.

Figures

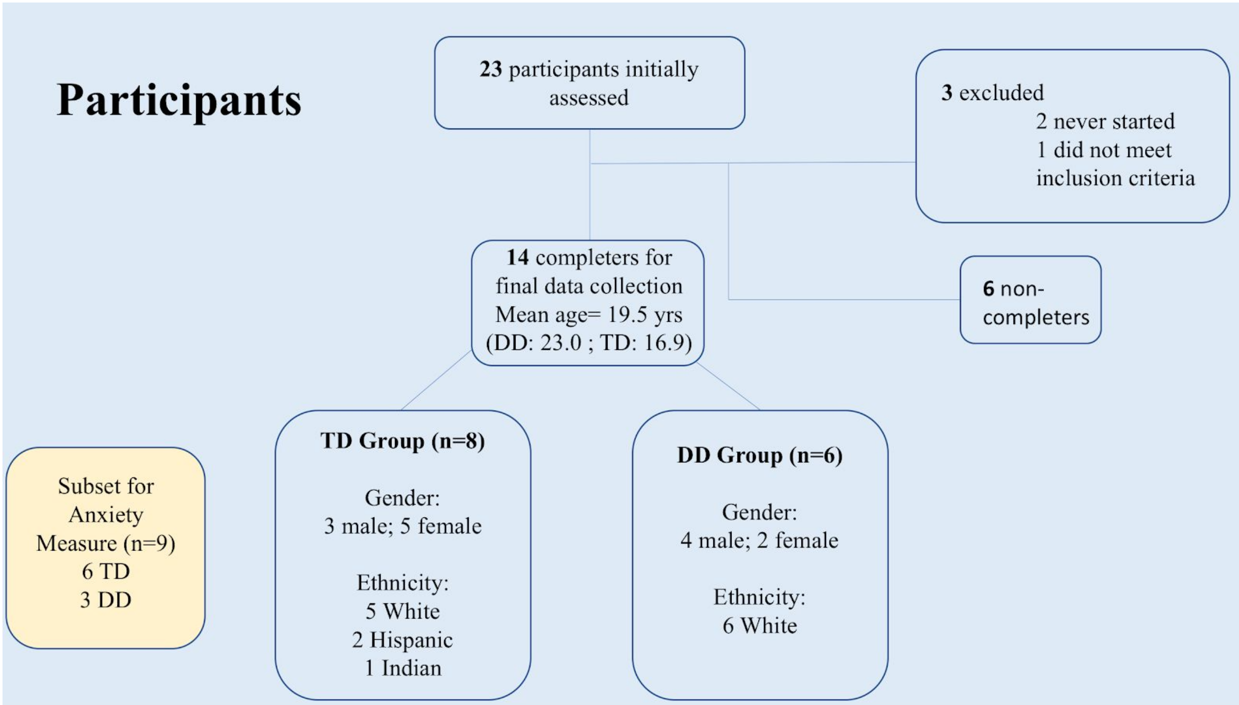

Figure 1. Description of participants from initial recruitment to final data collection. The participants used for final data collection completed all four parts of the study protocol (n = 14). A subset of the completers were used for the anxiety measure analyses (see yellow box).

Figure 2. Apparatus of car simulator utilized by participants (See page 20).

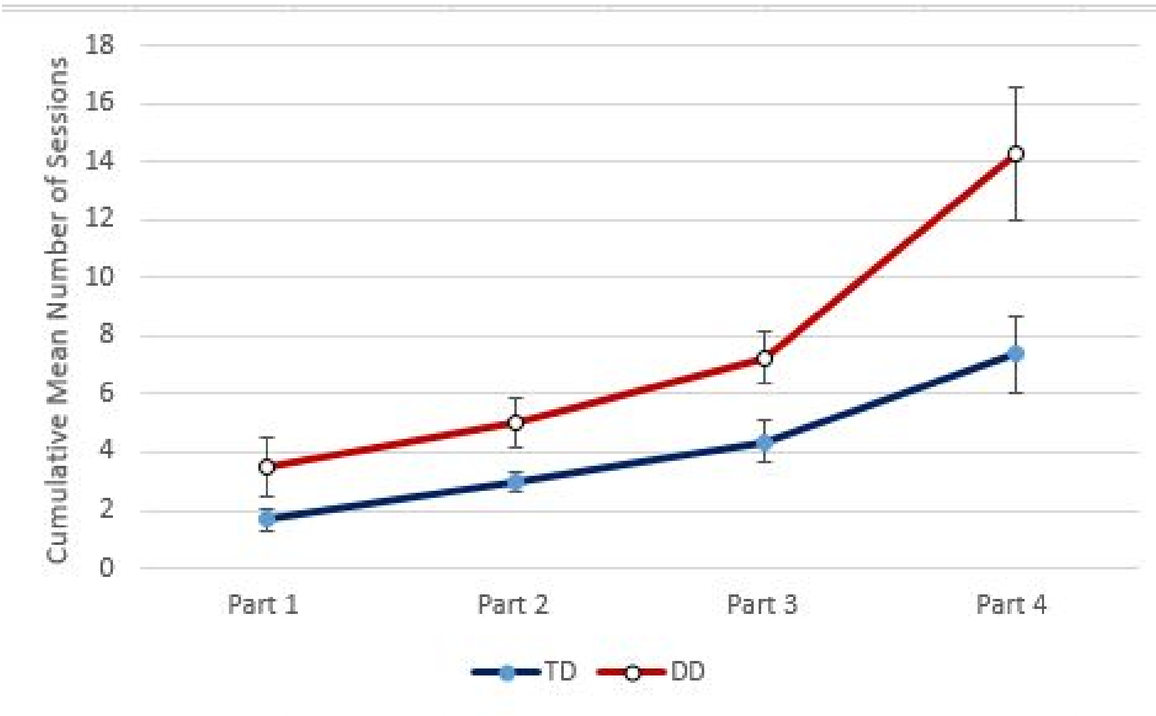

Figure 3. The cumulative mean number of sessions completed in each part of the four part coursework for both groups (DD vs TD). On average, the DD group took a greater number of sessions to complete all four parts (M = 14.25, SD = 2.89) compared to the TD group (M = 7.38, SD = 1.92). There was a statistically significant difference between groups for cumulative mean number of sessions (p = 0.000).

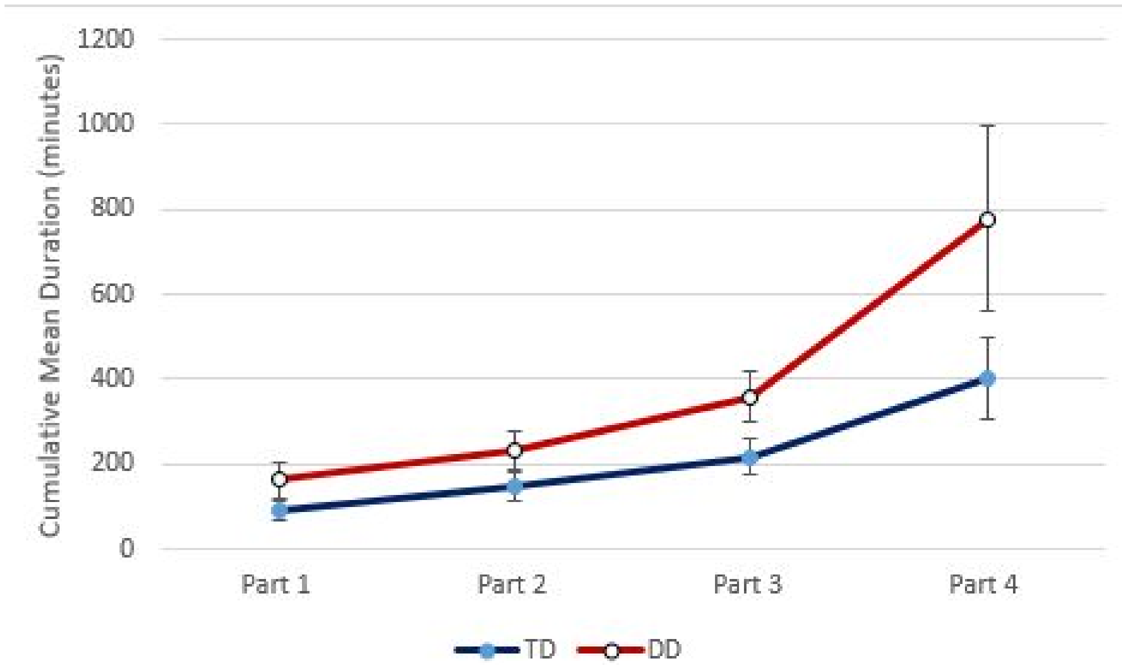

Figure 4. The cumulative mean session duration, in minutes, to complete each of the four part coursework for both groups (DD vs TD). On average, the DD group had a greater session duration (in minutes) to complete all four parts (*M* = 778.50, *SD* = 217.50) compared to the TD group (*M* = 403.0, *SD* = 94.99). There was a statistically significant difference between groups for cumulative mean session duration ($p = 0.001$).

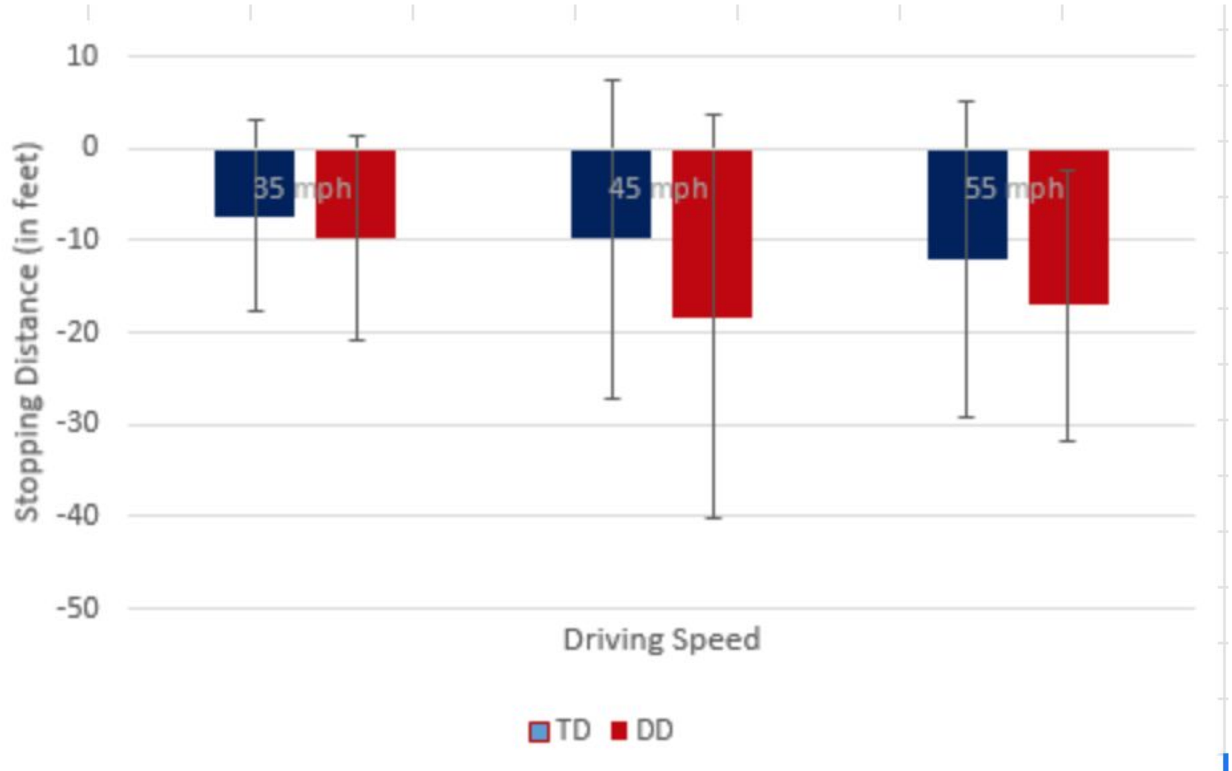

Figure 5. Stopping distance, measured in feet, at three different speeds (35 mph, 45 mph, 55 mph). Both groups (DD vs TD) had negative stopping distances, which reflect stopping a certain distance in front of the white line at a stop sign. At all three speeds the TD group stopped closer to the white line compared to the DD group. There was not a statistically significant difference between groups at 35 mph ($p = 0.72$), 45 mph ($p = 0.50$), or 55 mph ($p = 0.64$).

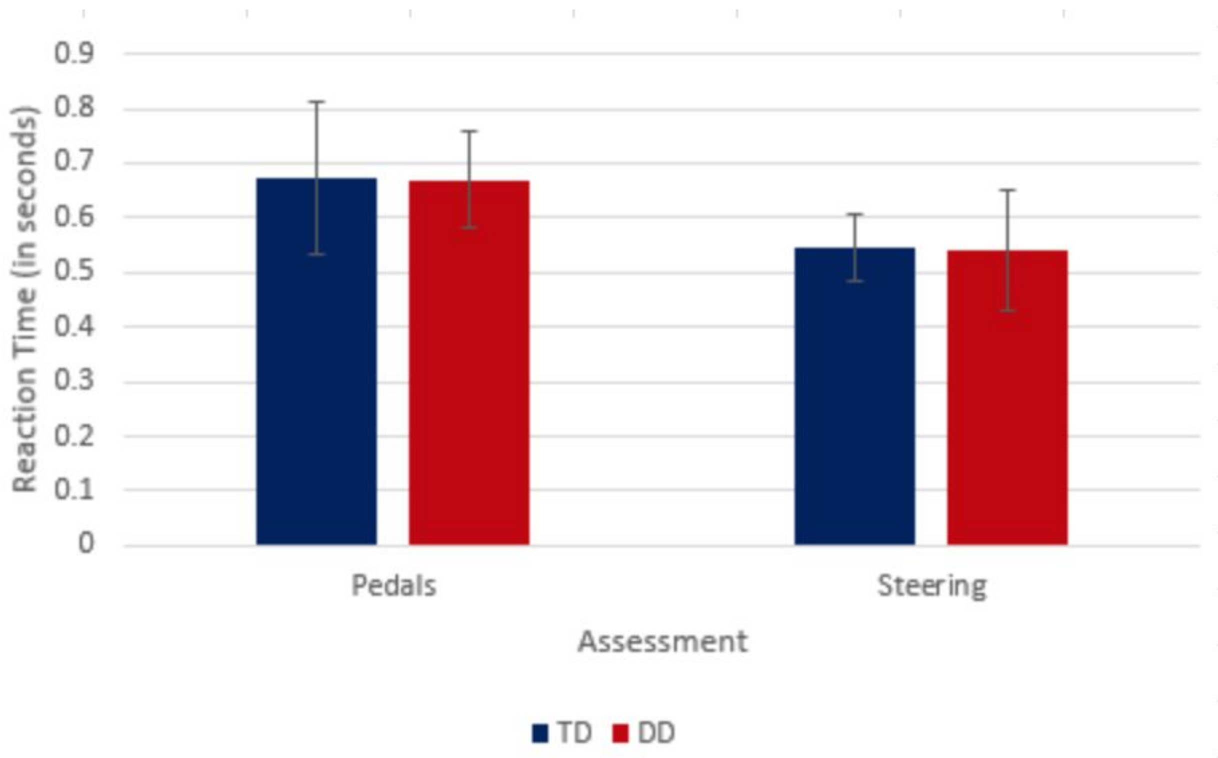

Figure 6. Reaction time was calculated (in seconds) for a pedals assessment and steering assessment. Both groups showed very similar reaction times for both assessment types. There was no statistically significant difference between groups for the pedals assessment ($p = 0.97$) or the steering assessment ($p = 0.89$).

Appendix A

Client Questionnaire Pre and Post (CQPP)

CAT Client Pre Questionnaire

Please check the appropriate response(s) that describe you in each question.

Question #1

How do you feel about driving a car?

- ◯ Great. I am excited to learn how to drive
- ◯ Fine. Let's see how I do
- ◯ Not good. I don't know if I will be a good driver

Question #2

Have you had dangerous experiences as a passenger in a vehicle or while driving?

- ◯ Yes
- ◯ No

Question #3

Do you worry about losing control behind the wheel?

- ◯ No, I think I will be a good driver
- ◯ Yes, I don't trust myself in all driving situations
- ◯ Sometimes, but with enough practice I will be okay

Question #4

While riding as a passenger in a vehicle, I feel:

- ◯ Great. I love being in the car
- ◯ Fine. Being in the car doesn't bother me
- ◯ Nervous and unable to relax

Question #5

What is your experience with driving? (Check all that applies)

- ☐ I have driven a car before
- ☐ I have played video games where I have driven
- ☐ I have driven other motorized vehicles (golf cart, go kart, lawn mower)
- ☐ I don't have experience driving

Question #6

Has anyone shown you how to operate a vehicle? (ex. shown you the gas/break pedals, how to turn on the car, turn signals, etc)

- ◯ Yes, I have been shown some things about the car
- ◯ No, I have never been shown anything related to the car

Question #7

In the past, have your parents ever spoken to you about driving someday?

- ◯ Yes. They told me I will learn to drive one day
- ◯ Yes, but they told me I probably won't be a good driver
- ◯ They told me I will not learn to drive
- ◯ No, I don't think they have ever talked to me about driving

Question #8

Do your parents support you learning to drive?

- ◯ Yes. They are happy and excited for me to learn to be a safe driver
- ◯ Sort of. They are okay with it, but worry if I can be a safe driver
- ◯ No. They are worried/scared that I will not be a good driver

CAT Client Post Questionnaire

Please check the appropriate response(s) that describe you in each question.

Question #1

On a scale of 0-10 how much did you enjoy the CAT Program and the driving simulator? (0 being not at all, 5 neutral, 10 love it)

- ☐ 0 (not at all)
- ☐ 1
- ☐ 2
- ☐ 3
- ☐ 4
- ☐ 5 (neutral)
- ☐ 6
- ☐ 7
- ☐ 8
- ☐ 9
- ☐ 10 (love it)

Question #2

How do you feel about driving a car?

- ☐ Great, I feel ready to drive a car
- ☐ I am unsure if I can drive a car
- ☐ Nervous, I do not think I feel ready yet

Question #3

After driving with the driving simulator, do you still worry about losing control behind the wheel?

- ☐ No, I think I will be a good driver on the roads
- ☐ Yes, I still do not trust myself in all driving situations
- ☐ Sometimes, but I just need more practice

Question #4

Were the lessons on the driving simulator and coursework easy to understand?

- ☐ Yes, they were very clear
- ☐ Somewhat, it was difficult at times
- ☐ No, I was confused most of the time

Question #5

Do you feel the CAT program has adequately prepared you for on-the-road driving skills and taking your permit test?

- ☐ Yes, I feel much more prepared
- ☐ Somewhat, I still have more to learn
- ☐ No, I do not feel any more prepared than when I started

Question #6

What did you enjoy most about the CAT program?

Answer:

Question #7

Please list any comments you have about the program or suggestions for improvement:

Answer:

Appendix B

Parent Questionnaire Pre and Post (PQPP)

CAT Parent Pre Questionnaire

Question #1

How do you feel about your child driving a car?

- ☐ Good. I want him/her to learn how to drive
- ☐ I don't know. Let's see how he/she does
- ☐ Worried. I am not sure if he/she will be able to drive, but I want him/her to learn about car safety

Question #2

Have you had dangerous experiences as a driver or passenger in a vehicle in the past?

- ☐ Yes
- ☐ No

Question #3

Do you worry about your child losing control behind the wheel?

- ☐ No, I think he/she will be a good driver
- ☐ Yes, I don't trust him/her in all driving situations
- ☐ Sometimes, but with enough practice I think he/she will be okay

Question #4

Have you shown your child how to operate a vehicle? (ex. shown the gas/break pedals, how to turn on the car, turn signals, etc)

- ☐ Yes, I have shown them how to operate some aspect of the car
- ☐ No, I have not shown them any operation of the car

Question #5

Do you feel your child can become a safe driver?

- ☐ Yes, I feel if he/she is taught how to safely drive, he/she can become a good driver
- ☐ Somewhat. I think there are some factors that will prevent him/her from becoming a safe driver
- ☐ No. However, I do think this course will help him/her become a better passenger and learn how to operate a car
- ☐ I am not sure

Question #6

Have you talked to your child about driving one day?

- ☐ Yes, I have indicated he/she can learn to drive someday
- ☐ Yes, I have indicated he/she may learn to drive someday, but I am worried about driver's safety
- ☐ Yes, I have indicated that he/she will probably not learn how to drive because I worry about his/her safety
- ☐ No, I have not discussed driving with my child yet

CAT Parent Post Questionnaire

Please check the appropriate response(s) that describe you in each question.

Question #1

How do you feel about your child driving after she/he has completed the CAT program training?

- ◯ Excellent, I think he/she has learned a great deal and is ready to start driving on the road
- ◯ Good, I think he/she has a learned a great deal to help with driving, but I am worried about him/her operating an actual vehicle
- ◯ Worried, I do not think he/she is ready to start driving

Question #2

After driving with the driving simulator, do you still worry about your child losing control behind the wheel?

- ◯ No, I think my child will be a good driver on the roads
- ◯ Yes, I still do not trust my child in all driving situations
- ◯ Somewhat, I think my child just needs more practice

Question #3

Do you feel the CAT program has adequately supplied your child with on-the-road driving skills and information needed for his/her permit test?

- ◯ Yes, I think my child has learned a great deal of information from this program
- ◯ Somewhat, I think this program was a good starting point for my child, but it can be better
- ◯ No, I do not think this program has taught my child properly

Question #4

Do you feel the CAT program has adequately taught your child the skills for how to be a safe driver?

- ◯ Yes, the program has done a great job and I think my child is capable of being a safe driver
- ◯ Somewhat, I feel this program can improve on preparing my child to be a safe driver
- ◯ No, I do not feel this program has adequately prepared my child to be a safe driver
- ◯ I am not sure

Question #5

Any comments or suggestions for how we can improve this program?

Answer: ____________

Appendix C

Car Simulator Skills Assessment

Car Simulator Skills Assessment

Direction: Use a different color for each time you complete this assessment. Follow instruction for each task and note response by writing your initial under "In repertoire" or "Not in repertoire" column

Client: ____

First assessment: _____/______/______ _____________
date initial

Second assessment: _____/______/______ _____________
date initial

		Left vs Right	In Repertoire	NOT in repertoire
Material		*Assess if client can distinguish between left vs right side and able to scan 45 degree on each side.*		
None	1	Ask to hold up right hand		
	2	Ask to hold up left hand		
Hands stretched to the side with identical items in each hand	3	Ask "look to the item on your left"		
	4	Ask "look to the item on your right"		

		Motor Skills	In Repertoire	NOT in repertoire
Material		*Assess if client have basic gross motor skills needed for car sim operation*		
Chair	1	Ask to sit down and stand up without the use of hands to stablize on other object or to propel the body up or down (x3)		
	2	While seated facing forward in the chair ask to pivot to each side with one foot at a time		
		pivot left foot to left, then turn and bring right foot to meet left		
		pivot right foot to center, then turn and bring left foot to meet right		
		pivot right foot to right, then turn and bring right foot to meet left		
	3	While seated, able to scoot the chair at least 4 inches forward		
		Scoot backward		
	4	While seated, able to scoot so that he/she is sitting in the front edge of the seat		
		scoot to the either side of the seat		
		Traffic signal	**In Repertoire**	**NOT in repertoire**
Material		*Assess if client can state the color and meaning of the three traffic light colors red, yellow, and green. Assess if he/she can scan in an array of three to identify each color*		
2D examplars of traffic light	1	Ask client to identify color		
		Red		
		Yellow		
		Green		
	2	Point to each color and ask what does each color mean		
		Red		
		Yellow		
		Green		

		Major car parts	**In Repertoire**	**NOT in repertoire**
Material		*Assess if client can identify parts of a car*		
Front seat of a car or the car simulator or 2D examplars	1	Ask client to find each item by pointing to it		
		Steering wheel		
		Seat		
		Seat belt		
		Pedals		
		Seat Belt	**In Repertoire**	**NOT in repertoire**
Material		*Assess if client can buckle and unbuckle seat belt*		
Front seat of a car or the car simulator	1	Ask client to sit in seat and buckle up		
		Able to pull seat belt across body		
		Able to secure buckle		
		Able to adjust seat belt so that it hits the hip-hip-clavicle points		
	2	Ask client to unbuckle		
		Able to release buckle		
		Able to return seat belt to its resting position		

		Motor Skills (vehicle)	**In Repertoire**	**NOT in repertoire**
Material		*Assess if client can hold and turn the steering wheel with a model prompt of properly turning techniques. Assess if he/she can turn the steering wheel in the direction of an arrow and with verbal instruction.*		
Steering wheel cover	1	Hold the steering wheel with both hands with appropriate grip strength?		
	2	Demonstrate turning the wheel using both hand-over-hand and shuffle techiques. Client able to imitate either?		
		Circle which technique he/she able to imitate: (H-O-H) (Shuffle)		
Steering wheel cover and printed arrow	3	Ask client to turn the steering wheel by presenting each antecedent:		
		Verbal instruction to turn left or right (x3 each side)		
		Hold arrow pointing to each side (x3 each side)		
		Assess if client can distinguish between gas and brake pedal, and imitate pressing on pedal with the ball of the feet. Assess if client can press on pedal and turn wheel simulatenously.		
Mock gas and brake pedal	4	While seated present mock pedals and ask client to put foot on gas or brake pedal		
		Able to identify the gas pedal		
		Able to identify the brake pedal		
		Does he/she press pedal with ball of right foot		
	5	Ask client what pedal to press when you want the car to go?		
	6	Ask client what pedal to press when you want the car to stop?		
	7	Ask client to press gas/brake and turn right/left (use antecedent in appropriate from Question 2) [x3]		