VISUAL REACTION TIME DIFFERENCES BETWEEN MEDICALLY-AT-RISK ADULT DRIVERS AND HEALTHY CONTROLS

By

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December, 2021

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Rationale: Visual and cognitive abilities are crucial to the performance of driving and decreased visual processing speed is considered one of the strongest risk factors for poor driving capacity in older adults. Individuals with deficits in visual perceptual skills, specifically scanning or processing speed, will likely have difficulty with judgement and reaction to on-road events. Currently, there are limited assessments of visual processing speed beyond pencil/paper tasks. **Purpose:** This study examined visual processing speed using the Vision Coach™, a visual light board with established normative data for community living adults. Specifically, the research study compared visual reaction times between previous collected data and medically at-risk older drivers with three research questions: (1) is there a statistically significant difference in performance time between medically at-risk individuals and the controls, (2) does the type of medical condition (e.g., neurological, cognition, complex medical conditions) differentiate performance, and (3) does the Vision Coach™ differentiate between drivers based on fitness to drive. **Design:** Data collection was part of a comprehensive driving evaluation with a fitness to drive outcome. The Vision Coach™ "Full Field 60" task was used to collect the reaction times used to compare between the two groups, three diagnostic categories, and fitness to drive outcome. **Results:** Independent t-tests showed a significant difference ($p < .001$) in trial times between healthy controls and medically-at-risk adults. No significant difference ($p = .141$) was found between diagnoses groups. The Vision Coach™ was able to differentiate ($p < .001$) between those who "passed" and those who "failed" a driving evaluation. **Conclusion:** Results of this study indicate that being medically-at-risk for driving impacts an individual's ability to quickly react to a visual stimulus. However, diagnosis type does not significantly impact trial time. Lastly, the Vision Coach™ was shown to be an effective screening tool for determining fitness to drive.

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A Thesis

Presented to the Faculty of the Department of Occupational Therapy

East Carolina University

In Partial Fulfillment of the Requirements for the Degree

Master of Science in Occupational Therapy

By

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December, 2021

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Chapter 1: Introduction

Occupational therapy practitioners emphasize the importance of using occupations to better a client's health, well-being, and participation (American Occupational Therapy Association [AOTA], 2020). Occupations include activities of daily living (ADLs), instrumental activities of daily living (IADLs), health management, work, education, play, leisure, rest and sleep, and social participation (AOTA, 2020). Within the activities that fall under IADLs is driving and community mobility. This IADL focuses on a client's ability to appropriately plan and move around in the community through transportation, such as driving, walking, biking, or through use of public transportation (AOTA, 2020). Research shows that driving was selected as one of the most important IADLs by older adults with a chronic illness and their care givers (Dickerson et al., 2013). After completing individual surveys on 11 different IADL tasks, driving was found to be the most meaningful after being identified by 26 of the 30 older adult participants. Additionally, it was found to be one of the most affected IADLs, along with cooking, community participation, home management, and yard work (Dickerson et al., 2013). The health condition impacting the individual was considered by both the older adult and their caregiver to be the main factor affecting IADL performance. In a similar study in which typical older adults were surveyed on importance of IADLs, it was found that transportation and driving were ranked as the highest and most important out of the 19 IADL tasks provided (Fricke & Unsworth, 2001).

Driving is essential for participation in other occupations since it is the main source of transportation for those living in the United States (NationMaster, 2011). Currently, 89% of adults 65 or older use driving or riding as a passenger in a private vehicle as the main source of transportation (Coughlin & Cobb, 2000; ICF Consulting, 2006). When an individual is required to cease driving, it impacts their ability to engage in their community, such as being able to go to the store, getting to/from work, attending doctor's visits, and participating socially (Marotolli et al., 2000). Along with decreased participation, previous drivers have reported higher instances of depressive symptoms than their current driver counterparts (Fonda & Herzog, 2001; Ragland et al., 2005). Additionally, individuals who have restricted driving distances have shown a higher chance of developing depressive symptoms, but this risk is still less than those who are required to cease driving altogether (Fonda & Herzog, 2001). A possible explanation for experience of these depressive symptoms could be related to the overall loss of mobility and independence that comes with the loss (or restriction) on the ability to drive (Marotolli et al., 2000; Ragland et al., 2005). The reduced engagement level that results from driving cessation has negative impacts that can affect an older adult's quality of life (Dickerson et al., 2019). Unfortunately, in most parts of the country, the revocation of a license and the aftermath that occurs is not a problem that can easily be corrected by use of public transportation. Only 49% of Americans have access to public transportation, with only 41% or rural counties having any form of public transportation available (Bailey, 2004). Thus, it is critical for the assessment tools and process for determining fitness to drive be supported with sufficient evidence and clinical judgement. Accordingly, occupational therapists play a critical role as the "go to" professional for evaluation for driving fitness (Pomidor, 2019) which includes appropriate and evidence based tools in order to make accurate judgements regarding an older adult's fitness to drive since the decision will have considerable ramifications.

According to data from 2016, there were almost 42 million drivers over the age of 65 (Center for Disease Control and Prevention Injury Center [CDC Injury Center], 2019). Additionally, the CDC reports there were around 7,400 older adults who were killed in a motor vehicle crash and over 290,000 who had to be treated for emergency injuries. The risk for involvement in a fatal crash increases around ages 70 to 74 and is highest in individuals 85 and up (CDC Injury Center, 2019). According to the current census data, by 2060 the number of adults ages 85 and up will triple and almost one in four Americans will be 65 years and older (Nasser, 2019). Based on this current outlook, it is safe to say that the amount of licensed older adult drivers is only going to increase as the years go on and the average life span increases. While age does not mean that a person who is older is medically-at-risk for driving (i.e. has a diagnosis that may impair driving ability), as one ages, there is an increase in the number of medical conditions that influence driving risk (i.e., risk of crash), such as dementia, mild cognitive impairment, Parkinson's disease, stroke, heart failure, glaucoma, diabetes, hip fracture, and arthritis (Croston et al., 2009; Dugan & Lee, 2013; Kowalski et al., 2012; Lafont et al., 2008; Marottoli et al., 1997; Marottoli et al., 2000; Sims et al., 2011; Van Landingham et al., 2013). Due to this higher likelihood of developing a medical condition that can impact driving, it is more common for older adults to be the individuals determined medically-at-risk for driving and requiring a comprehensive driving evaluation.

Due to the increase in crash rates, as well as overall increase in the aging population, it is important that appropriate assessment tools are established to evaluate fitness to drive. Fitness to drive is determined by assessing physical, cognitive, and visual abilities. When an individual has an impairment in any of these areas, their ability to drive safely may be put at risk. Physical abilities are needed for an individual to properly control their vehicle, visual skills are needed to accurately observe their surroundings, and cognitive abilities are required for processing, executing decisions, problem solving, and overall executive functioning. Additionally, visual perception should be examined since it is encompassed by both visual and cognitive abilities.

Visual perception includes an individual's visual processing speed and allows them to react quickly to their environment while driving (Dickerson & Niewoehner, 2012). Processing speeds decline as an individual ages but there are limited options for assessing visual processing speed for individuals who have a cogntive impairment. To help determine an appropriate assessment in identifying decline in driving ability, this study will use the Vision Coach™ to analyze how adults with medical conditions compare to healthy, community living (controls) adults when it comes to visual processing speeds.

The Vision Coach™ is an interactive lightboard that measures visual processing speed and reaction time. The device is a large screen that is mounted to the wall and can be adjusted up or down based on a participant's height. The screen has 120 light up dots imbedded within it and these dots are disguised by a black overlay. Almost all parameters surrounding the Vision Coach™ can be adjusted. Previous research by Miller (2017) and Register (2016) used the Vision Coach™ to establish normative data for healthy individuals across adulthood. The present study will utilize this data to analyze if there is a difference in visual reaction times between healthy adult drivers and medically at-risk drivers.

Chapter 2: Literature Review

Capabilities of Driving

Physical

Physical, cognitive, and visual abilities are necessary to safely perform the task of driving. Physical abilities that are necessary for driving include the following: adequate range of motion, strength, coordination, static and dynamic balance, postural control, proprioception, stereognosis, and kinesthesia (Classen & Lanford, 2012). These are all functional skills needed to properly maneuver and execute control over a vehicle effectively. For instance, drivers must be able to reach the pedals, steering wheel, and gear shift, and the appropriate amount of force is needed to operate the pedals and turn the steering wheel. Motor and praxis skills are also vital to operating the vehicle and are used to organize, sequence, and carry out the movement plans of an entire motor activity, as opposed to a singular motion (Dickerson & Niewoehner, 2012). These skills are utilized with an individual's procedural memory and their visual skills, such as through scanning the environment. Accordingly, these specific physical skills are required of individuals completing tasks on the Vision Coach™. They include hand-eye coordination, adequate upper extremity range of motion, the ability to apply force to activate the button, and the motor and praxis skills needed to integrate what is being seen and what action needs to be carried out.

Cognitive

Cognition includes three main domains: attention, memory, and executive functioning. Attention is considered the foundation for all other cognitive functioning and information processing (Barco et al., 2012; Gillen, 2009). Driving involves all types of attention (i.e., selective, sustained, alternating, and divided) due to the vast number of components that need to be focused on during the task. Memory is also a component that has many different categories, all of which are used throughout the driving process. However, the most necessary form of memory used to complete the complex task of driving is visual memory (Barco et al., 2012). Drivers have to be able to refer to the mental image of their driving route and be able to manipulate this image when wayfinding or having to return to a previous destination (Barco et al., 2012). Procedural memory is also important in that it allows individuals to simply perform that act of driving without having to consciously process through all the necessary steps involved (Barco et al., 2012).

Executive functioning is the supervisor over the rest of the cognitive processes. Executive functioning is higher level organization and integrates the many discrete components of cognition including judgement, problem solving, impulse control, initiation, planning, anticipating, decision making, organizing, and sequencing of actions (Barco et al., 2012). These components are all utilized when operating a vehicle, but emphasis is placed upon the decision-making aspect due to impairment in this area being a primary cause of crashes (Van Zomeran et al., 1987). A driver has to be able to quickly make appropriate decisions and judgments at all times while on the road. For instance, if a car begins to drift into the driver's lane, they need to be able to consider options (i.e., use of a horn, braking, changing lanes) and be able to act upon one of these decisions in a timely and efficient manner. All of these processes are necessary for driving and for handling emergency safety situations that occur while on the road.

The relationship between cognition and driving has been studied to try to determine if a there is a cognitive assessment or combination of assessments that could accurately predict an individual's ability to drive (Barco et al., 2012). However, most current cognitive tests are limited to verbal or paper/pencil examination. They are only able to identify individuals who are considered at-risk for driving (i.e., screening) and further evaluation is needed to determine driving ability, which requires higher levels of cognitive performance. The cognitive processes primarily addressed with the Vision Coach™ consist of the individual's ability to initiate movement, anticipate a new visual stimulus, and organize and sequence oculomotor and physical movements in timely response to the visual stimuli.

Visual

Driving is a task that requires many visual demands and skills, such as visual acuity, contrast sensitivity, light sensitivity, peripheral vision, motion perception, and scanning (Elgin et al., 2012). All of these capacities are important in order to properly detect, discriminate, and recognize objects and potential events taking place. Visual impairment caused by medical conditions or disease can greatly impact one's ability to drive. The most common types of impairments seen in older adults are cataracts, macular degeneration, glaucoma, diabetic retinopathy, and brain injury due to a cerebral vascular accident or stroke (Elgin et al., 2012). With almost all conditions that impact vision, there are usually several types of deficits occurring, such as how cataracts cause glare problems, decreased light sensitivity, decreased acuity, and decreased contrast sensitivity (Elgin et al., 2012). Due to the significance of vision itself and the visual skills necessary in the task of driving, it is imperative that proper assessments and evaluations be conducted to ensure a driver has the ability to properly perform in these areas.

In performance of tasks on the Vision Coach™, participants require adequate functioning of all of these abilities in order to properly complete the task in a timely fashion. However, scanning and peripheral vision will be the skills most directly involved since the participants will be required to quickly scan all areas of the board, with stimuli potentially falling on the outer edges of their visual field.

Visual Perception

Visual perception is a performance skill with components of both cognition and vision. The process involves taking the visual information from the environment and interpreting it in order to react (Kohlmeyer, 2003). The steps include receiving the visual stimuli in the environment, organizing the information and integrating it into understanding the environment, and then responding to the stimuli itself, usually through hand-eye coordination (Zoltan, 2007). Some of the skills required to complete this process are depth perception, spatial relations, right-left discrimination, topographical orientation, and figure-ground discrimination (Barco et al., 2012). Visual perception is needed in order to recognize objects in the driving environment, such as traffic lights, road signs, pedestrians, other vehicles, and so forth. These skills are also needed in understanding information being received from mirrors on the vehicle, judging the driver's distance from other vehicles (depth perception), and remaining oriented to the destination and previous location (topographical orientation) (Baker, 2006; Barco et al., 2012).

Processing speed is also imperative to driving and is related to vision and cognition – one has to see it, perceive it, cognitively recognize what they see, and then respond. Processing speed is dependent on working memory and refers to how quickly an individual is able to integrate the new information that has been presented (Dickerson & Niewoehner, 2012; Levy, 2005). This speed of processing is important because it relates to how quickly a driver can performance an action when a stimulus has been presented (Bryer et al., 2006). If processing speed is too slow while driving, the individual is at risk.

Two significant risk factors associated with crash involvement in older adults are decreased visual processing speed and divided attention. Deficits in these areas are frequently observed with difficulty maintaining vehicle control and poor on-road driving performance

(Elgin et al., 2012). Visual processing speed is needed to respond to the environment in a timely manner and appropriately react to hazards that may occur while driving (Dickerson & Niewoehner, 2012). For example, if a driver sees brake lights in front of them, but their visual processing speed is impaired, they may not begin to brake in time which may result in a crash. Drivers who have impaired processing speed are likely to have difficulty judging the distance and speed of other cars and reacting quickly to on-road events, such as responding to brake lights, traffic lights, and changes in traffic.

Unfortunately, processing speeds decline as indviduals age due to dendrite branches decreasing in neurons which can affect how quickly information is transferred in the brain (Levy, 2005). Visual processing speeds can be analyzed by assessing an individual's reaction time, and reaction time has been found to corelate with driving performance (McKnight & McKnight, 2000; Warshawsky-Livne & Shinar, 2002). Thus, tools that can assess an individuals' speed of processing may contribute to determining fitness to drive.

One such tool is the Useful Field of View (UFOV™) , developed by Karlene Ball and Daniel Roenker (brainHQ, 2021). The UFOV consists of three subtests that increase in the complexity of task demands and has been used in multiple studies (Amick et al., 2007; Bédard et al., 2008; Carr et al., 2011; Classen et al., 2009; Edwards et al., 2010). For example, Classen et al. (2011) conducted research on predicting driving performance of individudals with Parkinson's disease using the UFOV as a clinical assessment. Two participant groups were used, one with Parkinson's disease (PD) (ages 65-85, n = 41) and the other with healthy community-living older adults (ages 65-85, n = 41). Participants in this study completed clinical evaluations, as well as comprehensive driving evaluations. The two on-road outcomes used were the global rating score (GRS) (pass-fail) and Sum of Maneuvers Score (SMS), which is a weighted error score determined by the assistance required to safely perform 91 maneuvers on the road (Classen et al., 2011). The UFOV Subtest 2 was found to have the highest correlation with the GRS ($r = -.607$, $p <.001$) and SMS ($r = -.699$, $p <.001$). The UFOV was able to correctly classify driving outcomes (pass or fail) for 81% of the participants with PD. Individuals with PD who did poorly on the UFOV were more likely to fail the on-road portion. This is consistent with previous knowledge of slower visual processing speed being related to poorer on-road driving performance. However, it is important to recognise the UFOV as a screening tool, as there were four false positives and four false negatives in this study.

Additionally, although the UFOV has significant research evidence for its use as a screening tool (Dickerson, et al., 2014), there are some limitations in its use. This test is administered via computer so the visual field is limited to the size of a standard computer monitor. This is a smaller spacial area when compared to the visual field of a driver when on the road. The UFOV is also costly to complete since it is pay per assessment use. Having this additional expensive for each patient may impact the availablity and likelihood of having the assessment in the clinic.

The Vision Coach™ is another tool used to analyze visual processing speed. While there are a variety of potential methods of assessment, the basic task evaluates how quickly an individual can visualize, process, and respond to the stimuli that is presented. Based on the time needed to complete the visual processing task, it has the potenial to assess an individuals processing and reaction time which is important for driving performance.

Evaluation of Fitness to Drive

Occupational therapists are qualified to evaluate driving because the activity of driving falls within the occupational domains of the profession (AOTA, 2020). Visual, perceptual, physical, and cognitive abilities are all regularly assessed by occupational therapists within the home and are also capabilities required while driving (Dickerson et al., 2011). Fitness to drive is a term used to describe a driver's ability fully control a vehicle, and obey rules of the road and traffic laws, without any functional impairment that could significantly increase their risk of a crash (Transportation Research Board, 2016). All capabilities required for driving influence an individual's fitness to drive. Driving competency is achieved when an individual has shown that they have met fitness to drive criteria to a recognized body that is responsible for driver licensing (Transportation Research Board, 2016). An individual may have impairments but still meet the driving competency required to maintain their licensure (Transportation Research Board, 2016). Adaptive equipment, driving restrictions, or assistive technology may be provided to an individual in order for them to meet this driving competency and maintain their license.

Driving assessments for the abilities required of driving can be conducted to evaluate an individual's capacity to drive but there is no single evaluation tool that can accurately determine an individual's fitness to drive (Dickerson et al., 2014; Dickerson et al., 2019). Currently, in addition to off-road assessments, a behind the wheel (BTW) evaluation is needed in order to completely evaluate a participant's driving capabilities (Dickerson et al., 2011; Langford, 2008).

A BTW evaluation is the best way to get a true gauge of how someone controls the vehicle and performs on the road. However, BTW evaluations are more expensive to conduct and include an element of risk to the individual being tested and the evaluators in the vehicle (Dickerson, 2014). Although the behind the wheel assessment is the most ecological assessment of driving, there are several other forms of equipment and tests that can be used in help aiding the decision of whether a client should cease or continue driving. These driving assessments typically examine one area of the complex task of driving so multiple tests are usually needed in order to properly assess the fitness to drive of an individual. Due to the need of multiple tests, and the lack of a variety of visual reaction time assessments, it is important to research to expand the number of evidenced based assessment tools such as the Vision Coach™.

Visual-Perceptual Tools

Dynavision™

The Dynavision™ is a large light board tool that can be used in addressing motor and praxis skills and sensory perceptual skills (Dynavision, 2010). The newest version of Dynavision™ is from 2010 and is called the Dynavision D2™. The board weighs 125 pounds and contains 64 buttons that light up either red or green. The buttons of the Dynavision D2™ are visible against the screen, as the screen itself is black with the lights themselves being white. It has a height adjustment function that has a range of 28 inches, making it easy to use with a variety of patients (Dynavision, 2010). The Dynavision™ can be programmed by the therapist in a variety of ways, with options for the modes, light speeds, working areas, and speed and number of digits displayed in the center of the panel (Dynavision, 2010). When completing a Visual and Motor Reaction Times Test on the Dynavision™, individuals are asked to, "hit the red buttons as quickly as you can." This measures the individual's overall visual processing speed and associated reaction time. The Dynavision™ Company states the tool can be used for interventions to assist with impairments related to visual field loss, visual hemi-attention, alternate visual attention, divided visual attention, sustained visual attention, visual-processing, visuomotor reaction time, eye-hand coordination, dynamic standing/sitting balance with reaching, range of motion, weakness, and endurance (Dynavision, 2010).

The Dynavision™ D2 has shown to be a reliable tool in assessing reaction times (Wells et al., 2014). In a study completed by Wells et al. (2014), 42 young active men and women completed six sessions on the Dynavision D2™. In each session, participants performed three visuomotor tasks of increasing difficulty. Specific results found that visual reaction times and reactive ability demonstrated a moderate to strong reliability, whereas motor reaction times showed a fair reliability (Wells et al., 2014). These results showed that the Dynavision D2™ is a reliable means to assess reaction time within active young adults.

There have been mixed results in evaluating Dyanvision's retraining capabilities. An early preliminary evaluation using Dynavision™ for training on stroke patients suggested that there were improvements in the participants driving capabilities and response times (Crotty & George, 2009). However, when a randomized control trial was conducted, results did not support this evidence. During the randomized control trial, participants completed a 60 minute on road assessment, *Abilities in Response Time Measures Assessment* (Kirby & Nettelbeck, 1991), and a *Visual Scanning Analyzer* assessment (Berndt et al., 2008). Participants were then assigned to either the control group (n = 13) or intervention group (n = 13). Intervention consisted of 18 Dynavision™ training sessions that lasted for 40 minutes each. Results showed that a higher proportion of intervention participants passed the on-road assessment portion than in the control group, but these differences were not statistically significant. Additionally, Dynavision™ was not shown to improve on the impairment level skills of response time and visual scanning (Crotty & George, 2009).

Thus, while the Dynavision™ has shown to be a reliable tool in measuring reaction times in younger active adults, there have been no studies conducted on the reliability of assessing medically at-risk adults' reaction times. Regarding the Dynavision™ retraining potential, although there was not a statistical significance in improving driving, there were a higher percentage of intervention participants who passed the on-road test. With further studies, the

Dynavision™ may be able to improve driving performance in combination with other intervention measures.

Vision Coach™

The Vision Coach™ is similar to the Dynavision™ in that it is an interactive light board that can be used as an evaluation and rehabilitation tool in a range of fields, such as occupational therapy, physical therapy, vision therapy, speech and language therapy, vestibular rehabilitation, post concussive rehabilitation, and driver rehabilitation (Vision Coach, n.d.). This tool is reported to be used for the assessment and intervention of a multitude of impairments. Typically, it is used for issues related to balance and coordination, divided attention, eye-hand-body coordination, fixation and location, fine and gross motor skills, visual field deficits, visual attention and stamina, visual recognition, reaction time, visual scanning and tracking, and sensory integration (Vision Coach, n.d.).

The Vision Coach™ is a "non-invasive, patient specific, perceptual learning program based on visual stimulation" (Vision Coach, 2011). The board itself is 50" x 34" and is contains a counterweight slider that is mounted to the wall allowing for it to adjust to varying heights (Xi et al., 2014). The board contains 120 target light dots with some dots containing letters or numbers. In contrast to the Dynavision D2™, these lights are fixed into the board and located behind the black screen, ensuring that the lights are not visible until illuminated. There is also a fixator light located in the center of the screen that can be turned on or off depending on the task (Xi et al., 2014). Similar to the Dynavision D2, the Vision Coach has a control panel allowing for the therapist to adjust the visual field, speed of the lights, number of lights displayed, and color of the lights (red, green, or red/green). Regardless of the settings or test being completed, an individual completes a Vision Coach™ task by touching the dots that appear on the board as quickly as possible. The Vision Coach™ can be paired with a tablet to sync data in real time. The data provides a visual of the lightboard and numbers the dots in the order they appeared during the trial. Data provided includes: the type of task completed, the length of time between each individual stimulus provided, the amount of time it took overall to complete the task, and a breakdown of how successes versus misses occurred.

Validity and Reliability

The Vision Coach™ has demonstrated to be a reliable tool for occupational therapists (Xi et al., 2014). In a study designed to evaluate the test-retest reliability of the Vision Coach™, 242 healthy older and younger adults completed six trials of the Full Field 120 Vision Coach™ task. There were four classifications of participants: older female, older male, younger female, and younger male. Participants had to visually find and physically press 120 different dots presented on the screen as quickly as possible. Test-retest reliability ranged from 0.962 to 0.987, with the lowest reliability being found among young male participants and highest among older female participants (Xi et al., 2014).

This same study also demonstrated a significant positive correlation related to age and task performance amongst the older participants. As age increased, the time to complete the task also increased (Xi et al., 2014). Lastly, it was found that completing two initial practice trials helped to decrease learning effects on the Vision Coach™, and reliability and task performance became acceptably stable after this point (i.e., two practice trials) (Xi et al., 2014). Thus, it appears that the Vision Coach™ is shown to be a reliable tool in working with healthy adults and that as individuals age, visual processing speed and reaction time slows.

In a relatively recent study examining reaction times on the Vision Coach™, it was determined that the position the participant was in, either sitting or standing, did not affect the participant's reaction time (Miller, 2017). In this study, participants consisted of 121 healthy, cognitively intact, participants, ranging from 21 to 79 years old. Fifty-two participants were in the young adult age group (21 to 45 years old) and 60 participants were in the older adult age group (60 to 79 years old). The older adult participant group was recruited from a larger study requiring participants to engage in a variety of driving assessments during a two to three hour session. All participants completed a total of eight trials (four sitting, four standing) on the Vision Coach™. The Vision Coach™ task used was the Full Field 60, which required participants to visually scan, find, and press 60 lights that would illuminate individually on the Vision Coach™ board. In data analyzation, results from the first two trials in both the sitting and standing conditions were eliminated due to learning of the task causing significant differences unrelated to the sitting or standing conditions. Results also showed that height, wingspan, and gender did not significantly impact a participant's reaction time. Overall results showed no difference regarding body position in the healthy population (Miller, 2017).

Further research on reaction times with Vision Coach™ has shown that the average trial time significantly decreases between younger and older adults (Register, 2016). This research study was conducted in conjunction with the study by Miller (2017). Therefore, the same participants and data were utilized, but the overall purpose and data analyses focused on the difference between the age groups. Results from the younger adult group showed a 35 second average minimum score and a 50 second average maximum score. In the older adult group, the average minimum score was 46 seconds and the average maximum score was 78 seconds (Register, 2016). Between the young and older adult groups, a statistically significant difference ($p \leq 0.001$) was found in the average trial time with overall results showing that as individuals age, reaction times begin to slow.

The studies conducted by Miller (2017) and Register (2016) serve as the building blocks for the present study. Both research investigations provided information on how the Vision Coach™ can be used as an assessment tool and provided normative data on the Full Field 60 Vision Coach™ task that can be used for comparison in future research. The present study will be conducted within the same environment, using the same tool, and under the same testing guidelines. Using the normative data already gathered, this study can examine if significant differences in visual reaction times exist between healthy controls and medically at-risk drivers.

Summary

Visual and cognitive abilities are crucial to the performance of driving and decreased visual processing speed is linked with being a strong risk factor for poor driving capacity in older adults. Those who have slower processing speed have difficulty with judgement and reaction to on-road events. Currently, there are limited assessment options for visual processing speed, but the Vision Coach™ has shown to be an appropriate and reliable tool for analyzing this process in healthy individuals. Both Miller (2017) and Register (2016) provided information on how the Vision Coach™ can be used as an assessment tool and established normative data for the current proposal to build upon to examine if significant differences in visual reaction times exist between cognitively intact and at-risk older adult drivers.

Since the Vision Coach™ has the potential to be an accurate assessment tool for visual processing skills, it may prove to be an appropriate addition to the many tools used by occupational therapists in assessing driving. However, there has only been research conducted on typical functioning adults regarding the Full Field 60 Vision Coach™ task. Therefore, the purpose of this study is to see if there are statistically significant differences identified on the Full Field 60 Vision Coach™ task in individuals who are considered at-risk for driving compared to typical healthy adults. The null hypothesis states that there will not be a significant difference in visual processing skills for the at-risk adults compared to the healthy controls. In addition, this exploratory study will also examine if there are significant differences in performance between individuals with different impairments (e.g., stroke, dementia, mild cognitive impairment). Finally, the study will provide preliminary data in the effectiveness of the Vision Coach™ as a tool for assessment of visual perception in determining fitness to drive. Therefore, the specific questions are:

1. Is there a difference in Vision Coach™ performance (time) between individuals who are medically at-risk for driving compared to community living healthy adults (healthy controls)?
2. Does a participant's specific diagnosis have an influence on amount of time taken to complete the Vision Coach™ task?
3. Is the Vision Coach™ an effective tool for determining fitness to drive? Specifically, is there a relationship between the time taken to complete the Vision Coach™ task and the driving evaluation outcome? Exploratory analysis will be done to answer the third question.

Chapter 3: Methods

Design

A cross sectional quasi-experimental design was used to compare the Vision Coach™ reaction times between at-risk adult drivers and healthy controls. Since this study focuses on a pre-existing variable of the drivers being classified as either at-risk or a healthy control, no randomization can be utilized. Instead, the study provides a comparison between two separate groups. The primary independent variable is the drivers risk level (at-risk or control) and the dependent level is the time required to complete the Vision Coach™ "Full Field 60" task. Variables of age, gender and diagnosis are also examined. The outcome of the comprehensive driving evaluation (e.g., pass, fail, restrictions) is used to determine the potential for use as a tool for determining driving fitness.

Participants

Participants were drivers who were considered to be medically-at-risk. Considered medically-at-risk means the participant has a medical condition that may impair their driving. In this study, a primary care provider or the state licensing agency has identified the participant as medically at risk and is requiring the participant complete a comprehensive driving evaluation with a driving rehabilitation specialist/occupational therapist. Thus, the participants were part of a current UMCIRB study (18-002080) which uses the assessment data from the comprehensive driving evaluation completed by appropriate clients of Vidant Medical Center in Greenville, NC and East Carolina University. The data in this study includes demographic data and the overall outcome of the on-road assessment to determine fitness to drive.

Signed consent was obtained by a member of the research team for UMCIRB study (18-002080).

Instrumentation

The Vision Coach™ was the instrument used to gather data in the present study. The Vision Coach™ is an interactive light board that can be used as an evaluation and rehabilitation tool (see Appendix C) and is fully described in the literature review. The validity of the Vision Coach™ has yet to be fully evaluated. However, there has been a study addressing the test-retest reliability of the tool and the Vision Coach™ was found to have good reliability, with the intraclass reliability coefficients for all participant groups being at or above 0.96 (Xi et al., 2014).

Studies have also shown that there is no significant difference between Vision Coach™ performance and gender, height, or wingspan (Register, 2016; Miller, 2017). Additionally, Miller (2017) found that the position of the participant, sitting versus standing, did not impact an individual's performance on the Vision Coach™. However, results do support that as a participant's age increases, their performance on the Vision Coach™ slows (Register, 2016).

Procedure

This study is part of a larger on-going study analyzing various assessment tools used to determine driving fitness for cognitive, visual, and physical components. The participants took part in the Vision Coach™ "Full Field 60" task during the clinical assessment of comprehensive driving evaluation and prior to completing the on road component. Since it was an additional task to the comprehensive driving evaluation and voluntary for the participants to complete, they were offered a gift card of $25 to complete the tasks on the Vision Coach.

Researchers were trained on how to program and use the Vision Coach™. The established data collection methods (see Appendix D) were used by all of the research team to collect the data. Researchers followed an adapted version of Register's (2016) Vision Coach™

Protocol. This task required participants to tap 60 red dots that would randomly illuminate on the board. The dots appeared one at a time and would not disappear until the participant had tapped the dot. The participants were encouraged to select the dots as quickly as possible. Four trials were conducted, with the first trial acting as a practice round.

The participants completed the "Full Field 30" task as the practice trial. Participants could ask any clarifying questions at the end of this trial. After the practice round was complete, three more rounds were completed, with up to a 1-minute break allotted between each to control for fatigue. Participants were able to complete the Vision Coach™ trials while seated or standing as previous research showed there was no significant difference in reaction times (Miller, 2016). Researchers made note of any errors that occurred during testing or any mistakes that happened regarding data collection. Data was privately stored on a Samsung Tablet that was paired to the Vision Coach™ (see Appendix E & F). At the end of the three testing trials, participants were dismissed and continued with their driving evaluation.

Data Analysis

Data analysis compared participants' reaction times against Vision Coach™ data that was previously collected based on a cognitively intact group of adult drivers. Data was analyzed by averaging the three trial times together. A propensity score method based on age and gender was used to weight the participants from the two studies for a fair comparison.

Independent t tests were used to compare the two groups (at-risk drivers & controls) to identify if there were any differences regarding reaction times. In addition, a general linear model was used to analyze the differences adjusted by age and gender. Finally, differences among the three diagnosis groups and among the three final outcome groups in the current study were analyzed using one-way ANOVA. Data analysis was conducted on the Statistical

Packaging for the Social Sciences (SPSS Version 27). Analysis was reviewed by a statistics specialist from East Carolina University.

Chapter 4: Results

Demographic Data for Controls and Medically-at-Risk

Table 1 illustrates the demographic data between the two groups with the original data and cases weighted using the propensity scores. The healthy controls group had an original mean age of 49.98 with 76% being female and 24% being male participants. The medically-at-risk group had an original mean age of 60.49 with 40% being female and 60% being male participants. After weighting the cases, the healthy controls had a mean age of 51.33 with 71.5% being female and 28.5% being male participants. The medically-at-risk group had a weighted mean age of 54.20 with 71.4% being female and 28.6% being male participants. Although there is a large difference in number of participants, the average age and proportion of male to female participants is relatively equal between the two studies after weighting of the cases.

Table 1

Demographics Between Groups

	Healthy Controls N = 242	Medically-at-Risk N = 35	Chi-Square P-value	T-test P-value
Age Range (yrs.)	21-79	28-89		
Original Mean Age (yrs.) (SD)	49.98 (21.96)	60.49 (15.74)		<.001
Original Female (%)	184 (76.0%)	14 (40.0%)	<.001	
Original Male (%)	58 (24.0%)	21 (60.0%)		
Weighted Mean Age (yrs.) (SD)	51.33 (21.76)	54.20 (16.58)		0.365
Weighted Female (%)	173 (71.5%)	25 (71.4%)	0.994	
Weighted Male (%)	69 (28.5%)	10 (28.6%)		

Differences in Reaction Time

Graphical analysis of the data revealed a marked distinction between the medically-at-risk and control groups (see Figure 1). Table 2 illustrates the descriptive analysis of both groups' trial times, as well as the results of the independent t-tests that were conducted to compare trial times. The original average trial time of the healthy controls was 53.02 seconds, and the medically-at-risk adults had an original average trial time of 75.97 seconds. After weighting the participants, the average trial time of the healthy controls was 53.52 seconds, and the average trial time of the medically-at-risk adults was 72.54 seconds. Figure 1 identifies two potential outliers within the medically-at-risk group. These outliers consisted of a participant (age 47 with a neurological condition) with an average trial time of 138 seconds and another participant (age 76 with a neurological condition) with an average trial time of 117 seconds.

With the original data, there was a significant difference in the trial times for the controls (M= 53.02, SD = 10.85) and medically-at-risk participants (M = 75.97, SD =19.18); t (275) = -6.92, p = <.001. With the weighted cases, there was also a significant difference in the trial times for the controls (M = 53.52, SD = 10.82) and medically-at-risk participants (M = 72.54, SD = 17.04); t (275) = -6.42, p = <.001. These results suggest that being medically-at-risk impacts an individual's ability to quickly react to a visual stimulus. This means that individuals who have an impactful medical diagnosis may react slower to stimuli when driving, such as taking longer to hit the brake when seeing a pedestrian crossing the street.

Sensitivity analyses were conducted by removing the two identified outliers in the medically-at-risk group and repeating the t-test analyses with both original and weighted data. Using the original data, there was a significant difference in trial times for the controls (M = 53.02, SD = 10.85) and medically-at-risk participants (outliers removed) (M=72.84, SD 14.42); t

(273) = -7.61, p = <.001, 95% CI [-25.10, -14.54]. Using the weighted data, there was a still a significant difference in trial times for the controls (M = 53.52, SD 10.82) and medically-at-risk participants (outliers removed) (M = 70.92, SD 14.04); t (274) = -8.44, p =<.001, 95% CI [-21.45, -13.34].

Table 2

Comparison of the Differences in Trial Time

	Healthy Controls	Medically-at-Risk	C. I.	P-value
Trial Time Range (sec.)	35.00-81.25	49.33-138.00		
Original Average Trial Time (sec.) (SD)	53.02 (10.85)	75.97 (19.18)	(-29.7, -16.2)	<.001
Weighted Average Trial Time (sec.) (SD)	53.52 (10.82)	72.54 (17.04)	(-25.0, -13.0)	<.001

A univariate general linear model was performed to further adjust for age and gender. Results from that model showed that the average reaction time was still significantly different (p = <.001) between the two studies. The original data was significant at p = <.001, 95% CI [15.58, 21.99]. The weighted data was significant at p = <.001, 95% CI [15.2, 21.3]. The original data with outliers removed was significant at p =<.001, 95% CI [13.18, 18.66]. The weighted data with outliers removed was significant at p = <.001, 95% [13.27, 18.67].

Table 3

Univariate General Linear Regression Model Adjusted for Gender and Age

	Healthy Controls Average Trial time	Medically-at-Risk Average Trial Time	C. I.	P-value
Original Average Trial Time (sec.) (SE)	53.47 (0.63)	72.26 (1.48)	(15.58, 21.99)	<.001

	Healthy Controls Average Trial time	Medically-at-Risk Average Trial Time	C. I.	P-value
Weighted Average Trial Time (sec.) (SE)	53.01 (.61)	71.28 (1.49)	(15.2, 21.3)	<.001

Differences Across Diagnoses

In the current study data, three groups were created based on diagnostic categories: 1) primarily cognitive diagnoses (e.g., memory impairment, mild cognitive impairment (MCI), dementia, Alzheimer's disease; 2) neurological diagnoses (e.g., stroke, traumatic brain injury, brain tumor/cancer, Parkinson's disease); and 3) complex medical conditions that affect driving or a combination of conditions (e.g., diabetes, arthritis, orthopedic conditions.) Graphical analysis of the data revealed it was appropriate for an ANOVA to be conducted (Figure 2). Table 4 illustrates the descriptive analysis of the three groups' trial times.

Table 4

Average Trial Times Across Diagnoses

	N	Mean	SD	P-value
Cognition	7	75.38	15.06	0.141
Neurological	20	80.65	21.63	
Complex Medical	8	64.77	10.86	

A one-way between subjects ANOVA was completed to compare the effect of the diagnosis category on the trial time. There was no significant effect of diagnosis level on the trial time at the $p<.05$ level for the three conditions [$F(2, 32) = 2.087$, $p = 0.141$]. Post hoc comparisons using the Tukey HSD showed there was no statistical difference between any of the diagnosis conditions. The mean score for the cognition group ($M = 75.38$, $SD = 15.06$), the mean for the neurological group ($M = 80.65$, $SD = 21.63$), and the mean for the medical diagnosis group (M = 64.77, SD = 10.86) did not significantly differ. These results show that the specific type of medical condition did not influence the trial times of the participants.

Differences Across Driving Outcome

After conducting graphical analysis (Figure 3), a one-way between subjects ANOVA was conducted to compare the effect of the time it took to complete the Vision Coach™ task to the driving outcome. The driving outcome was divided between three outcomes: driving cessation, driving with restrictions, or driving without restrictions (Table 5). There was a significant effect of trial time on driving outcome at the $p<0.01$ level for the three conditions [$F(2, 32) = 8.282$, $p = 0.001$]. The Tukey HSD post hoc test was conducted (Table 6). The mean score for the driving with no restrictions condition (M = 53.64, SD = 5.71) was significantly different than the driving with restrictions (M=76.62, SD = 7.81) and driving cessation (M = 78.54, SD = 21.50) conditions. However, there was no significant difference found between the driving with restrictions and driving cessation conditions. These results suggest that the time to complete a scanning task on the Vision Coach™ can differentiate between individuals who "pass" a driving evaluation and individuals who "fail" (i.e., cease driving) or require driving restrictions. Specifically, the results show that when adults had a faster trial time, their evaluation outcome resulted in them driving without restrictions.

Table 5

Average Trial Times Across Driving Outcomes

	N	Mean	SD	P-value
Cessation	14	84.10	23.13	.001
No Restrictions	13	79.49	8.94	
Driving with Restrictions	8	56.02	6.86	

Table 6

Post Hoc Tests Comparison for Driving Outcomes

Driving Outcome		Mean Difference	Std. Error	Sig.	95% Confidence Level Lower Bound	95% Confidence Level Upper Bound
Cessation	Restrictions	4.608	6.183	0.739	-10.586	19.802
	Driving no restrictions	28.074	7.115	.001	10.590	45.558
Restrictions	Cessation	-4.608	6.183	.739	-19.803	10.586
	Driving no restrictions	23.466	7.214	.007	5.740	41.193
Driving No Restriction	Cessation	-28.074	7.115	.001	-45.558	-10.590
	Restrictions	-23.466	7.214	.007	-41.193	-5.740

Chapter 5: Discussion

The overall purpose of this study was to explore the use of the Vision Coach™ as an assessment tool for examining scanning and visual processing speed. This work expands on the previous work of Register (2016) and Miller (2017) who established normative data for healthy adult controls and found that scores were not affected by gender or physical position for the collection of data. Results from their research also demonstrated an aging effect, specifically as one ages, processing speed decreases. In this study, the results clearly demonstrated that the Vision Coach™ can differentiate between healthy community-living adults and individuals considered medically-at-risk or individuals who have medical conditions that affect their visual processing speed. The task used in this study especially focused on scanning and processing speed and it is important to note that the individuals who were medically-at-risk did not have specific visual impairments, but a range of conditions such as dementia, stroke, arthritis, and diabetes. However, as such, the medical conditions were significant enough to warrant a referral for a driving evaluation due to impaired visual scanning and/or processing speed.

In regard to diagnoses impacting performance on the Vision Coach™, analysis indicated that there was no significant difference in processing speed when comparing the trial times of those with different diagnoses. Although there were subtle differences noticed amongst all three categories of medical conditions (e.g., cognition, neurological, complex medical), the analysis indicated that processing speed was the independent factor that determined fitness, not the specific diagnosis. These findings support the importance of testing processing speed, regardless of diagnosis, as individuals vary in their presentation of symptoms and having a specific diagnosis is not predictive of visual processing performance. Moreover, it suggests that the Vision Coach™ should, and could, be used as a universal assessment tool for visual processing.

The third research question specifically used the data to determine if the Vision Coach™ could be used as an assessment tool for determining fitness to drive, to which it identified differences in those who "passed" or "failed" a driving evaluation. These results were statistically supported and suggest that the Vision Coach™ may be appropriate to utilize as a screening tool for examining fitness to drive as individuals who had a shorter trial time were more likely to pass the comprehensive driving evaluation.

Previous research has shown that individuals who have decreased visual processing speed had a higher likelihood of being involved in a motor vehicle crash (Elgin et al., 2012). Additionally, Classen et al. (2011) found that the UFOV Subtest 2, which analyzes visual processing speed, found that individuals who had poorer test performance were more likely to fail the overall driving evaluation. The current results support these outcomes, as individuals who were considered medically-at-risk for driving demonstrated increased time to visually scan, find, and press the lights on the Vision Coach™ task (i.e., less responsive visual processing speeds) were more likely to require driving restrictions or a recommendation to cease driving. These findings suggest that analyzing visual processing speed is appropriate when conducting a driving evaluation or using the Vision Coach™ as a screening tool, as a measurable difference has been identified in those at-risk compared to controls.

Expanding the number of tools able to assess for fitness to drive is necessary as there is no single evaluation tool that can accurately determine an individual's ability to drive (Dickerson et al., 2014; Dickerson et al., 2019). Being able to assess for specific deficits related to driving performance, such as visual processing speed, is necessary for identifying areas of concern in those who are medically-at-risk for driving. Having functional tools (i.e., not pencil and paper) that can screen and identify areas of concern in physical, cognitive, and visual performance can lead to more appropriate recommendations for comprehensive driving evaluations.

Application to Occupational Therapy Practice

In this study, the evidence supports using the Vision Coach™ as an appropriate screening tool to conduct prior to a driving evaluation. Having access to multiple assessment options within a driving evaluation is important is all clients have individual needs and deficits that can impact their ability to drive. Although the Vision Coach™ provides explicit data on visual processing, the physical and cognitive capabilities record for driving can also be observed when conducting a screening assessment. Physical abilities necessary for driving and utilized during the Vision Coach™ task include range of motion, strength, coordination, static and dynamic balance, postural control, and praxis skills (Classen & Lanford, 2012; Dickerson & Niewoehner, 2012). Clinical observation during the Vision Coach™ task provides insight into these physical abilities of clients. Observing a client's functional movement when reaching a dot on the screen can be related to how they would be able to operate the components of a car. For instance, a client may be able to quickly see a dot appear and recognize where it is on the screen, however, poor coordination and reduced upper extremity strength may prevent them from being able to respond to the dot in a timely manner. This can be related to on the road as they may be able to see a car pull out in front of them but may not have the strength and hand-eye coordination to turn the wheel to merge into the neighboring lane. Cognition can also be assessed in how the client is able to attend to the visual stimulus and organize and sequence the oculomotor and physical stimuli with the vision stimulus. Attention is the foundation for cognition and this Vision Coach™ task requires sustained attention (Barco et al., 2012; Gillen, 2009). If a client is unable to maintain the attention required for the brief period required to complete the task, then they will be unfit for driving. The physical and cognitive abilities required to complete the task can only be analyzed using clinical observation and clinical judgement. However, the Vision Coach™ task provides a basic screening for making these observations as all participants are being asked to perform the same level of task.

It would be beneficial for the Vision Coach™ to become standardized as it is able to collect quantitative data that can be used to analyze an individual's visual motor and processing capabilities. Completion of standardized assessments is necessary to ensure that evidence based research is being utilized to appropriately influence a clinician's reasoning related to patient driving status and outcomes. The findings of this study provide emerging evidence that there is a visual reaction time difference between medically-at-risk adults compared to healthy counterparts on the administration of the Full Field 60 light task. This may be of assistance to occupational therapists in general practice who can potentially use the Vision Coach for screening for fitness to drive.

Intervention Tool

Along with the Vision Coach™ being an appropriate tool to assist in determining driving fitness, it has the potential to be an intervention tool in practice to improve visual scanning and processing speed. The Vision Coach™ has a variety of settings that can be used to customize an intervention trial. Settings are provided to select different areas of the board, such as individual quadrants, right/left sides of the board, and top/bottom of the board. These settings could be utilized to address specific areas in the visual field that a client may be experiencing deficits in, such as visual scanning or processing speed. For instance, if a client is neglecting their peripheral visual field, the Vision Coach™ tasks could first begin by having the participant utilize the reduced field that is in the center of the screen. However, with improvement the visual field on the board can be expanded to the full field to encourage the client to utilize their peripheral vision and expand their overall visual field. The visual field of the Vision Coach™ could also be adjusted to appear on only one side for client's that may have a deficit to one area of the visual field, such as a patient who had stroke and is now experiencing left neglect or right/left inattention. The client could stand in the center of the board and only have dots that appear on the side with the neglect/attention deficit so that they are required to practice scanning on that particular side. Once they begin to improve, the full field of the board could be utilized so that they are required to look to both sides of the screen.

Cognitive components can be added to Vision Coach™ interventions by having individuals call out the numbers and letters that appear on the dots on the board. For example, a therapist can adjust the speed of the Vision Coach™ to be turned on to an appropriate level for the client and then the therapist can instruct the client to press the dots but call out each letter and/or number that appears. This specific intervention may be beneficial for an individual who has suffered a TBI and now has difficulty with divided attention or multi-tasking. This intervention would provide the client with a visual processing task that incorporates a higher level of cognition. The therapist could also have the individual incorporate discrimination by having them only call out numbers versus letter (or vice versa). Practitioners can also have clients press only the dots that have numbers and ignore dots that have letters or are blank. The Vision Coach™ possesses a great range in possible intervention options as tasks can be graded up and down according to a patient's current level. Simple tasks (i.e., utilizing one color, reduced field, one task, no/slow speed) can be easily built upon to increase the visual motor complexity of the task (i.e., utilizing two colors, full field, increased speed, letters and numbers). Additionally, this tool should be considered by therapists as it can objectively collect quantitative data on reaction time and quadrant success rates. This quantitative data can be used to monitor patient progress in conjunction with the subjective observations documented by the therapist.

Subjective observation when utilizing this tool is necessary to include in documentation as the Vision Coach™ randomizes the appearance of dots. As discussed in the limitations, reaction times can appear to decrease due to the randomization of the lights as opposed to actual improvement in client function. For example, a participant who perseverated on whichever side she was facing showed a drastic decrease in the time taken to complete two back-to-back trials. This was not due to learning of the system, but rather during one trial the dots shifted from right to left more frequently than in the following trial where several dots would appear on one side at a time. This resulted in the participant having to recognize and switch between sides less often and decreasing her time as a result. The Vision Coach™ does show the order of the dots presented on the board and individual time break downs between each press of the dot so it provided the evidential backing of the observations made. This situation is a great highlight of why clinical observation is important during assessment of performance and in data analysis.

The Vision Coach™ versus Dynavision

As discussed in the literature review, the Dynavision is a similar tool that looks at motor, praxis, and sensory perceptual skills (Dynavision, 2010). However, the primary difference between the Vision Coach™ and the original Dynavision/Dynavision D2™ is that the Vision Coach™ disguises the dots within the board, whereas participants can see the dots on the Dynavision boards so they are able to anticipate where the stimulus will appear. Due this aspect of the design of the boards, there is a need for a similar study to be conducted on the Dynavision D2™ to see if it would also be determined to be used as a screening tool in assessing driving fitness. This is a necessary area of research as many clinics and hospitals may have the

Dynavision tool, as opposed to the Vision Coach™. Ensuring that both tools were able to determine individuals at-risk for driving versus healthy adults would allow for more practitioners to have access to a tool that screens for a participant's driving ability.

Future Research

Future research topics regarding the Vision Coach™ should expand outside of the Full Field 60 light task and include larger sample sizes of multiple diagnoses to allow for a more representative comparison. Studies focusing on young adults and middle aged adults who are medically-at-risk should be conducted to gather a more accurate portrayal of reaction times with those who experiencing occupational challenge. Additional studies should be conducted to compare specific diagnoses to see if differences occur on an individual diagnosis level as opposed to a category of diagnoses.

Limitations

Prior to the COVID-19 pandemic, the inclusion criteria was individuals over the age of 65 with a medical condition. Due to pause in the research, the parameters of the study were adjusted to include all individuals who were considered medically at-risk and participating in a driving evaluation through Vidant Medical Center in Greenville, NC and East Carolina University. In recognition that medically-at-drivers can be of any age, this was more reflective of the medically at-risk population. However, because of the pandemic, the number of participants was relatively smaller than expected.

With any study, there are potential limitations. To avoid any limitations, the protocol of the prior studies using controls were used. While fatigue might be a factor, the control participants did not show fatigue in previous studies (Register, 2016; Miller, 2017). In addition, any "slowness" should be considered, as part of the symptoms related to participants being medically-at-risk, since fatigue was not an issue with the normal controls, even after performing additional trials.

A potential limitation may have been whether one practice trial was sufficient. The previous Vision Coach™ studies did not have official practice trials (Register, 2016; Miller, 2017). However, the first two trials of their eight test trials were excluded as there were statistical differences found in the length of trial times. These unofficial practice rounds amounted to two rounds of the Full Field 60 task. The practice round for the current study was kept to one practice trial using the Full Field 30 task to account for timing of the remaining driving evaluation. It is possible that having these differences in practice trials may have impacted the medically-at-risk participants' performance during the task.

As part of a larger study, fatigue was a consideration, as the on-road component followed shortly after this data collection. Conversely, learning effects may have also occurred since participants were asked to complete multiple trials on the same Vision Coach™ task. Both these issues were accounted for by averaging the three trial times during data analysis. A unique potential limitation could be that participants may have experienced performance anxiety as this is a novel test for many individuals and the data was also being used towards their driving evaluation. This is a factor that cannot be specifically established, but researchers explained to participants that the Vision Coach™ task was being conducted as part of a research study with their results having a limited impact on the final decision.

Another limitation was the difference in sample sizes between the control group and medically-at-risk group. The control group had significantly more study participants as volunteers were able to be utilized. The medically-at-risk group consisted of participants who were required to be referred for a driving evaluation at the ECU clinic. This limitation was accounted for in data analysis by weighting the statistical influence of each participant and by placing them into diagnosis categories, as opposed to separating them out by their specific diagnosis. Additionally, since participants were medically-at-risk, some participants may have had multiple different diagnoses that impacted their function. There is no way to fully control for this limitation, however, participants were classified into their diagnosis group by their primary diagnosis according to their medical record.

Lastly, the Vision Coach™ randomizes the appearance of the dots during the Full Field 60 task. Due to this, there is the possibility that reaction times may appear to improve due to the ordering of the lights (i.e., several dots appearing back-to-back in one area of the board), as opposed to learning effects or improvement in client function. This was accounted for during the averaging of trial times during data analysis.

Summary

The purpose of this study was to identify if there was a difference in visual processing speed between individuals deemed medically-at-risk for driving and healthy counterparts. The results showed that being medically-at-risk impacts an individual's ability to quickly react to visual stimulus. Although, there was no significant evidence to show a difference in trial time between difference diagnostic groups, the Vision Coach™ trial times did support that medically-at-risk individuals who had a slower trial time resulted in a poorer driving outcome (restrictions or driving cessation). Additionally, since the Vision Coach™ is able to identify differences between processing speeds for those who "pass" vs "fail" their driving evaluation, it can be an appropriate screening tool used in general practice.

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Appendix A

IRB Approval Letter

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board
4N-64 Brody Medical Sciences Building· Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** ·
rede.ecu.edu/umcirb/

Notification of Amendment Approval

From: Social/Behavioral IRB
To: Anne Dickerson
CC:
Date: 12/8/2020
Re: Ame5_UMCIRB 18-002080
UMCIRB 18-002080
OT-DRIVE

Your Amendment has been reviewed and approved using expedited review on 12/8/2020. It was the determination of the UMCIRB Chairperson (or designee) that this revision does not impact the overall risk/benefit ratio of the study and is appropriate for the population and procedures proposed.

Please note that any further changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a Final Report application to the UMCIRB prior to the Expected End Date provided in the IRB application. If the study is not completed by this date, an Amendment will need to be submitted to extend the Expected End Date. The investigator must adhere to all reporting requirements for this study.

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

The approval includes the following items:

Description
Expected study end date extended to 12/30/2021

For research studies where a waiver or alteration of HIPAA Authorization has been approved, the IRB states that each of the waiver criteria in 45 CFR 164.512(i)(1)(i)(A) and (2)(i) through (v) have been met. Additionally, the elements of PHI to be collected as described in items 1 and 2 of the Application for Waiver of Authorization have been determined to be the minimal necessary for the specified research.

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

Appendix B

IRB Study Identification Information

Go to forms menu Print Help

You Are Here: OT-DRIVE

Reading: UMCIRB 18-002080

Study Identification Information

This is the first step in your Human Research Application. You will automatically be guided to the appropriate page views needed to complete your submission. If a question is not applicable to your study, you may state this as your response. Please read the help text located on the right side of the page throughout this application.

1.0 * **Study Name (Short):**
OT-DRIVE

The short study name is limited to 255 characters.

2.0 **Study Name (Long):**
Determining the efficacy of the OT-DRIVE model for addressing the IADL of driving and community mobility.

Most other text boxes do not have any limits on number of characters.

3.0 * **Summary of Research in Lay Terms:**
This study will explore and examine the usefulness or efficacy of using the OT-DRIVE model for addressing driving and community mobility. The OT-DRIVE model supports occupational therapy generalists as the primary resource for determining driving risk for adults who want to return to driving after a medical event or illness. The model then extends to when the occupational therapist refers to a driver rehabilitation specialist (DRS), what is the outcome of that evaluation.

The intention of this study is to examine data being collected and determine if clinical decision making is appropriate, based on whether screening, evaluation and treatment implementation.

The occupational therapy generalist will screen vision, motor, perception, and cognition skills and abilities and determine if they are: "red" high risk for driving, "green" low risk for driving, or "yellow" needs further evaluation.
Those clients who are "red" should receive driving retirement information and/or intervention to promote needed skills.
Those clients who are "green" will receive education and safety information.
Those who are "yellow" will receive further evaluation to a DRS which may include an on road assessment.

The lay summary should be no more than 400 words and should include the following:
Background/Purpose of Study
Description of Subjects/Participants
Research Methods/Procedures

4.0 * **Principal Investigator:**
Anne Dickerson

Use the "select" or "add" button to choose from a list of individuals for each applicable role.

5.0 **Faculty Investigator** (Serving as the responsible individual in the oversight of the research study when the PI is a student, resident, fellow or visiting faculty.)

Faculty Investigator IRB Certification Renewal Deadline:

6.0 **Study Coordinator or Contact Individual:**

7.0 **Contact Individual(s) (if different from Study Coordinator or Principal Investigator):**

Last Name	First Name	Organization	Profile	IRB Certification Renewal Deadline

There are no items to display

*People added here **will** be able to **edit** the study.*

Clicking the "Add" button allows you to choose individuals that are already registered within ePIRATE. This function will not add individuals that have not registered in ePIRATE yet.

8.0 **Sub-Investigators:**

Last Name	First Name	Organization	Profile	IRB Certification Renewal Deadline
Cassidy	Terri	Other Organization/Institution	Terri Cassidy's Profile	9/30/2021
Earley	Elizabeth	Occupational Therapy, Department of	Elizabeth Earley's Profile	1/19/2022
Mitchum	Emily	Occupational Therapy, Department of	Emily Mitchum's Profile	8/13/2023
Penna	Victoria	Occupational Therapy, Department of	Victoria Penna's Profile	8/17/2022
Poythress	Haley	Occupational Therapy, Department of	Haley Poythress's Profile	8/19/2023
Romer	Sydney	Occupational Therapy, Department of	Sydney Romer's Profile	1/6/2022
Touchinsky	Susie	Other Organization/Institution	Susie Touchinsky's Profile	11/20/2021

9.0

Other Study Staff - (Read-Only):

Last Name	First Name	Organization	Profile	IRB Certification Renewal Deadline

There are no items to display

*Other study staff may include graduate assistants, statisticians or others that may only have a very limited and specific role in the study. People added here will be able to **read** the study.*

Appendix C

Vision Coach™ Board

Appendix D

Vision Coach™ Protocols

Initial Setup

1. Press 'Color' button until 'Red' flashes in upper right hand corner
2. Press 'Area' button until 'Full Fld' appears in upper right hand corner
3. Participant will complete three trials.

Information

This tool is called Vision Coach™. It has been developed to evaluate visual fields and train individuals to process information faster. We will be using it to measure your scanning ability, which you know is important for driving. The outcome will be used for your driving evaluation today. I am also collecting this data for my thesis, so I can determine how effective it really is.

If they do not do well/are concerned, reassure them that it is just a small piece of the evaluation. Don't be concerned if you feel like you did poorly, this is just one small piece of the overall driving evaluation.

Board Setup

4. Have participant face the board in standing position.
5. Press 'Fixator' button
    a. 'Fix on' should flash in upper right corner
6. Press 'Start'
    a. White fixator light should appear in center of board
7. Adjust height of board so that fixator light is at chin level
    a. Pull out tabs at bottom of board to adjust board height

b. Participant should be able to reach the top and bottom of the board

8. Close tabs at the bottom of the board
9. Have the participant practice pressing the red dot that appears so that they can understand how hard to press.
10. Press ‘Fixator’ button until ‘Fix Off’ appears in upper right corner.

Practice Trial

11. Start participant in comfortable position where they can reach the top and bottom of the board.

12. **Press ‘Mode’ button until ‘FF 30’ appears** in upper right-hand corner.

    a. Ask participant if they feel comfortable and are ready to begin. Instruct participant, say: “We are now going to complete the practice trial. Scan the board and press all red dots on the screen as quickly as possible. You may use both hands.”

13. Press ‘Start’ button.

    a. After the practice trial, the participant will be given a minimum of a 1-minute break to rest or get water. Data does not need to be saved for the practice trial.

Testing Trials

16. Start participant in comfortable position where they can reach the top and bottom of the board.

17. **Press ‘Mode’ button until ‘FF 60’ appears** in upper right-hand corner.

    a. Ask participant if they feel comfortable and are ready to begin. Instruct participant, say:

i. First trial: “We are now going to complete the first trial. This will take longer than the practice trial. Scan the board and press all red dots on the screen as quickly as possible. You may use both hands.”

ii. Second & third trial: “We are now going to complete the next/last trial. Scan the board and press all red dots on the screen as quickly as possible. You may use both hands.”

18. Press ‘Start’ button.

19. After each trial, the participant will be given a maximum of a 1-minute break to rest or get water. **Make sure you save the data during this time.**

20. Repeat steps 16 to 19 once more.

Appendix E

Vision Coach™ Data Transfer for Samsung Tablet

1. Open the settings application on the tablet and make sure that the tablet is connected to the wifi titled "vcoach." When the tablet is connected to this wifi it will now pair with the Vision Coach™ and you will be able to save data to the device.
2. Open your internet browser (i.e. google chrome) and enter the IP address into the web address/search bar area.

Appendix F

Saving Data and Renaming Documents on Samsung Tablet

While still on the google chrome webpage:

1) Select print web page once data appears. Instead of printing, click save as PDF.
2) The PDF will save to the app “My Files”.
3) Click on Device Storage within the app.
4) Click on the folder labeled “My Documents.” The Vision Coach Data should appear.
5) To Rename - click “More” in upper right corner, click edit, select document, click “More” again, select rename.
6) Name the document using the participant ID.

Figure 1

Trial Times Between Groups

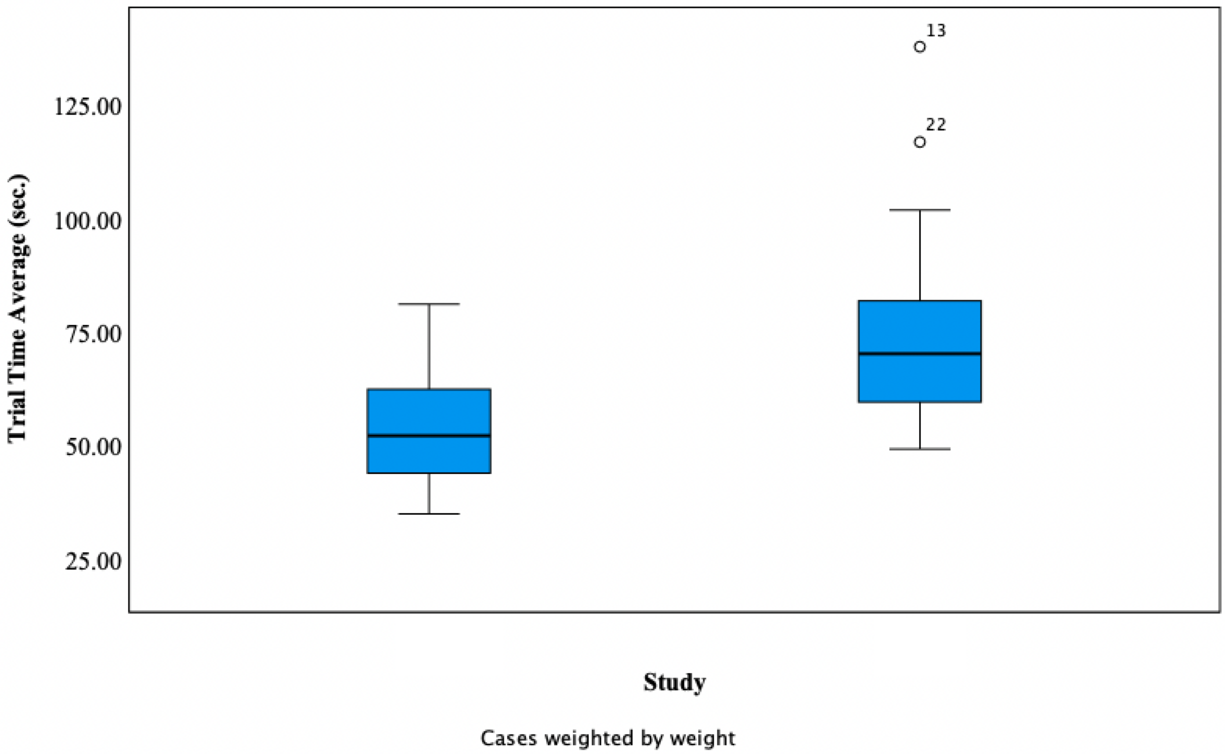

Figure 2

Trial Times for Diagnostic Conditions

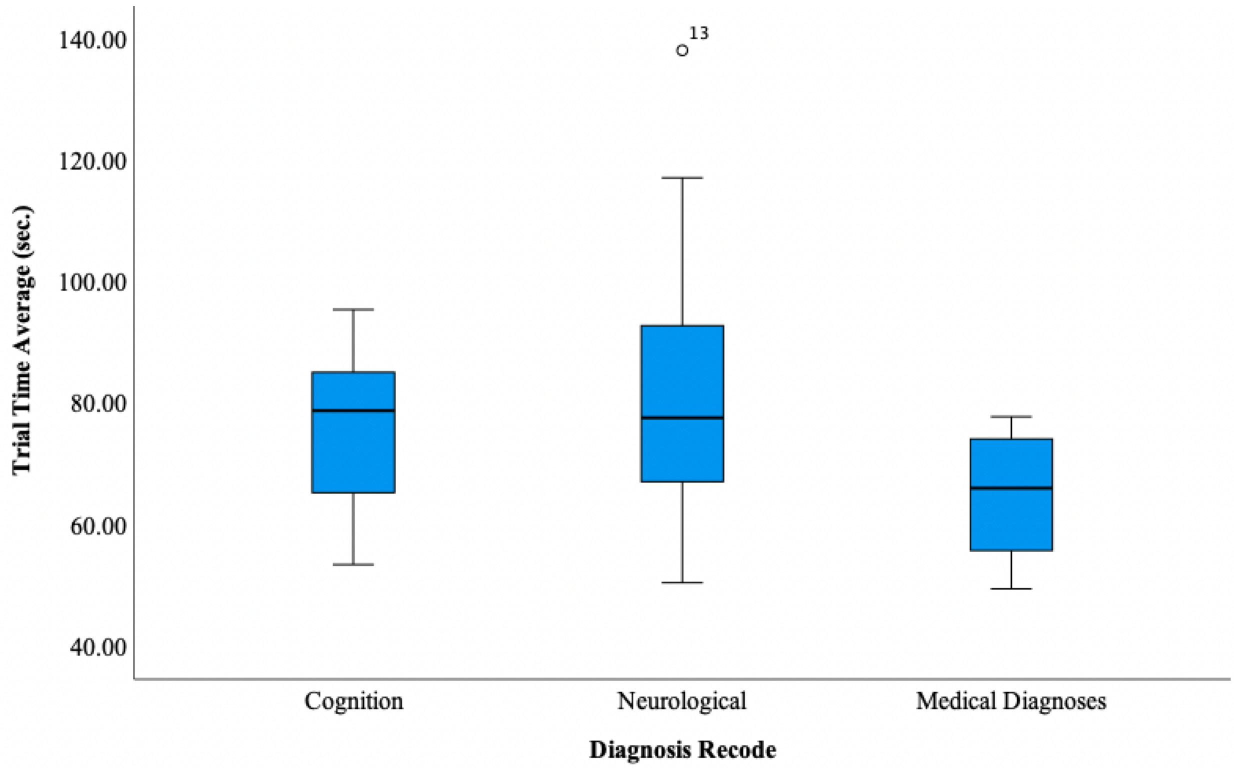

Figure 3

Trial Times for Driving Outcome Groups