A Driving Evaluation Program for Individuals with Traumatic Brain Injury

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A Driving Evaluation Program for Individuals with Traumatic Brain Injury

Description
Research has shown that traumatic brain injury (TBI) is a common condition that affects numerous individuals within the United States. Driving is a coveted occupation that gives identity and independence to many. Determining an individual’s capacity to drive is crucial to the rehabilitative process for an individual after a traumatic brain injury. Unfortunately, there is not a standard method for determining fitness to drive and it is left to the evaluator’s discretion. Therapists may use assessments that have been commonly used but do not yield the appropriate information for accurate assessment. This project reviewed the standardized assessments and recommendations geared to evaluate driving capabilities for this particular population with the goal of developing a comprehensive, evidence-based driving evaluation program for individuals with traumatic brain injuries. By having a program that allows for a trained professional (DRS) to determine a person's fitness to drive, the burden is taken off loved ones and physicians.

Disciplines
Occupational Therapy | Rehabilitation and Therapy

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Traumatic brain injury (TBI) causes significant cognitive, physical, emotional, social and economic impairments for roughly 1.4 million people living in the United States each year. This common condition and the impairments acquired, disrupt an individual's ability to participate in activities of daily living (ADL's) and other related activities such as driving (Crooks, Zumsteg, & Bell, 2007; Heegaard & Biros, 2007). Traumatic brain injury is defined as "a nondegenerative, noncongenital insult to the brain from an external mechanical force, possibly leading to permanent or temporary impairment of cognitive, physical, and psychosocial functions, with an associated diminished or altered state of consciousness" according to Dawodu (2009).

With a traumatic brain injury, the Glasgow coma scale (GCS) is the typical measurement used to determine an individual's level of consciousness within 48 hours after an injury. This scale determines the severity of the brain injury with a numerical assignment in the areas of eye opening, motor responses and verbal responses. Based on the scores given, the brain injury can be categorized into severe (a score of 3-8), moderate (a score of 9-12) or mild (a score of 13-15). The Ranchos Los Amigos Scale is also used to determine the severity of deficit in cognitive functioning. Levels are assigned based on the individuals responsiveness ranging from level I - no response grading up to level VIII - purposeful appropriate (Dawodu, 2009). Mild TBI's account for 80% of all head injuries (Lezak et al., 2004) with the typical person experiencing head injury being males 15-19 years in age at time of onset (Langlois, Rutland-Brown & Thomas, 2004). Many people who sustain mild TBI's do not receive medical attention and therefore gathering statistical information on this population is difficult.

Brain injury can be defined in two ways: primary injury and secondary injury. Primary injuries can be broken down into direct injury, which occurs when the head is struck by an object or its motion is arrested by another object, and indirect injury which occurs with acceleration and
deceleration such as whiplash. Secondary injury refers to a disruption in the brain's normal homeostasis such as increased intracranial pressure and decreased cerebral perfusion leading to ischemia (Crooks et al., 2007; Ghajar, 2000; Heegaard & Biros, 2007). Functional consequences of TBI are determined by the extent and location of the injury. Factors such as premorbid health, personality, intelligence, age, societal, economic status and psychological characteristics can affect the prognosis for an individual with TBI (Classen et al., 2009).

Individuals TBI can experience a myriad of symptoms which include, but are not limited to: headaches, dizziness (vertigo), poor balance, forgetfulness, slowed thinking, impaired concentration, decreased executive function, fatigue, forgetfulness, irritability, visual impairment, or sensitivity to light or noise, any of which can adversely affect the ability to drive (Crooks et al., 2007; Heegaard & Biros, 2007).

**Driving and TBI**

Driving allows people to participate in various life activities, including basic activities of daily living (ADL's), instrumental activities of daily living (IADL's), work, education, and other preferred activities within the community (American Occupational Therapy Association [AOTA], 2002). Driving is a role that many take pride in and allows for freedom to explore and experience their environment. It enables occupation within the community and provides the opportunity for mobility and participation in desired and expected activities. The ability to drive allows a person to feel connected to their community, gives feelings of familiarity and acceptance as well as to provide knowledge of social rules (Rapport, Bryer, & Hanks, 2008). Lack of transportation adversely affects one's ability to participate in desired occupations and can lead to social isolation. According to Hopewell (2002), "40%-60% of survivors who cease driving after a TBI are especially challenged with respect to taking care of basic needs and for
community integration." Cesation of driving has adverse affects on one's quality of life even when alternative transportation is available (Legh-Smith et al., 1986; Liddle & McKenna, 2003). The inability to drive can come abruptly with no time to plan for alternative transportation.

Driving is a complex task requiring the integration of visual-perceptual stimuli, information processing, good judgement and decision making, and the performance of appropriate motor responses (Classen et al., 2009). An individual with TBI may have difficulty discriminating among simultaneous inputs and anticipating danger, both critical to the skill of driving (Van Zomeran, Brouwer, & Minderhoud, 1987). According to Michon (1979, 1981) who proposed a hierarchical model of driving which include: strategic, tactical and operational levels, driving after a TBI can disrupt the interconnectedness of the skills required to perform each level, which in turn results in unsafe driving. Due to the fact that individuals with TBI can have difficulty with cognitive, sensory and motor actions, driving becomes difficult and potentially dangerous and may limit their ability to return to driving safely (Fisk, Novack, Mennemeier, & Roenker, 2002; Innes et al., 2005, 2007). There is controversy within the research reviewed regarding neuronal systems stimulated during the task of driving.

The inability of one to drive can be difficult for family members and caregivers and most believe that the physician is responsible to determine fitness to drive. Most states by law, mandate medical professionals to report unsafe drivers when there has been a change in cognitive functioning that render them unsafe to drive. With this mandate, drivers licenses are suspended until the individual is deemed safe to drive by a medical professional and/or the Department of Motor Vehicles. Unfortunately, many physicians lack specialized training in driving assessments and do not have the time to complete thorough assessments (Marshall & Gilbert, 1999). Some are cleared to continue driving but may have hesitations or anxiety about
engaging in the task based on symptoms experienced and feelings of inadequacy. Individuals with TBI often lack insight into their deficits and therefore are unable to make appropriate and safe decisions regarding their fitness to drive.

**Driving Simulation**

On-the-road testing has been accepted as the “gold standard” for determining fitness to drive. This has been thought to be the most valid instrument due to it taking place and evaluating real life situations. However, in reviewing accident statistics it is proven that drivers do not always drive as they did on their licensing tests (Fox, Bowden, Smith, 1998). In addition, on-the-road testing can be expensive, lead to dangerous driving, and is time consuming. Therefore, this type of testing can risk the safety of not on the individual being evaluated, but also the community. On-the-road testing also is unable to put a driver into various contexts including, weather, traffic, amount of pedestrians, and light (Schectman, Classen, Awadzi and Mann, 2007).

Driving simulation can be a reliable and valid alternative to on-the-road testing. Driving simulation can emulate a wide range of situations at one time, as well as providing potentially dangerous situations in which the driver must react as in a real-life situation. Numerous weather conditions commonly seen can be introduced as well as adjusting the occurrence of pedestrians and traffic on the road. Consequently, the risk for crashes can be assessed in a safe manner without resulting in physical injury or damage to property (Schectman, Classen, Awadzi and Mann, 2007). In addition, with using a driver simulator, results can be assessed objectively and accurately in a standardized manner (de Winter et al, 2009).

Driver simulators have been around for many years. Nearly every driving simulator in use today originated from research simulators within the military, government, academia, and
automotive industries. They were initially developed to examine public transit operators in the early 1910’s. Simulator use rose in the United States due to concerns about automobile safety and an increase in collision rates. The improvement of simulators increased when, in the 1980’s, video games and personal computer usage became popular. The improvements from this time period resulted in a more realistic simulation of the driving environment including, traffic, imagery, as well as real-time features (Straus, 2005).

Validity of driving simulation verse on-the-road assessment was examined by Lee in 2005. This study consisted of 129 older adults aged 60-90 years with a valid driver’s license and not having incurred the maximum demerit points per state law. Driving ability was assessed by both behind-the-wheel assessment, and with a PC-based SITSIM driver simulator. Each assessment included a 30 minute initial interview and a 45 minute driving session. Factors that were assessed during testing included, vehicle speed, lane position, divided attention, observation of traffic rules, using the rear mirror, stopping distance, and indicator usage. All participants in this study used their own vehicles for the behind-the-wheel portion of the assessment. Results showed a significant positive correlation (r=0.716) from the driver simulation testing with the road testing results. Consequently, this high positive relationship validates using a driving simulator as a cost-effective alternative to behind-the-wheel testing (Lee, 2005).

Simulator-based assessments were found to be valid and in some instances even more sensitive than behind-the-wheel testing to predict long-term driving performance in this study by Lew, et al. (2005). This was a prospective study involving 11 participants who had experienced a severe traumatic brain injury within two to 25 months, and 16 healthy participants (used for normative values). Each group was assessed using a driver simulator (STI version 8.16) and a
behind-the-wheel assessment. In addition, a Driver Performance Inventory was used to rate driving skills on both assessment methods. Data was taken at baseline, and again 10 months later. Results confirmed that the simulator significantly predicted aspects observed during driver performance at the 10 month follow-up. When reviewing the results of data at baseline, and data at follow-up, the predictive efficiency of 82% provided evidence that failing the simulator at baseline correlated to failing the driving evaluation at follow-up. It was also found that participants road test scores showed no significant relation to their driving performance at follow-up (Lew et al., 2005).

Comparing driving errors between on-the-road and simulated driving assessments were studied by Shectman, Classen, Awadzi, and Mann (2009). The study was comprised of 20 younger (25-45 years) and 19 older (65-85 years) drivers. The STISIM M500W simulator was used as well as a vehicle for behind-the-wheel testing. They assessed the number and type of driving errors committed in addition to negotiating a right and left turn. No significant differences were found between the two assessment methods (simulator vs. road testing) in the type of turn made and driving errors. For instance, a left turn in the simulator had a mean driving error of .74 as compared to .76 on the road testing. This indicates that the same trends exist when making errors on the road and in the simulator. Also in examining adjustment to stimuli, lane maintenance and visual scanning, no significant differences were found. Therefore, this data indicates that the results of driving simulator testing can be generalized to actual road testing (Shectman et al., 2009).

Schultheis, Roseman, Rebimbas, Mourant, and Millis (2007) conducted a study examining the relationship between virtual reality driving simulator (VRDS) and cognitive demands of driving after bring injury. This study consisted of 28 participants, 10 healthy
individuals, and 18 individuals with an acquired brain injury. Cognitive testing was assessed for relevancy in determining fitness to drive as well as performance on a behind-the-wheel (BTW) evaluation compared to simulated driving evaluation. Results show that no significant relationship between the VRDS and BTW globally (pass/fail), but did show significant relationship between the subcomponents of the tests. VRDS speed control was related to BTW speed control (p<.05), and BTW testing correlated (p<.05) to VRDS testing in respect to lane deviation, head turning standard deviation, average distance from stop sign, and deceleration. In regards to cognitive testing, the only test found to be related to driving performance was the Paced Auditory Serial Addition Test (PASAT). However, this test is uncommon to use with this population due to the difficulty of the tasks. In summary, these findings suggest that driving simulators provide the sensitivity required to assess driving ability following a brain injury (Schultheis et al., 2007).

Off Road Assessments

Off-the-road assessments are commonly used to assess cognitive, physical, and motor ability. These assessments test the skills that are essential to safely driving a vehicle and can detect problematic behavior prior to BTW, or simulated driving. According to Winerman (2004), a significant correlation exists between driving skill and cognitive assessments. They found that visuospatial skills had the best correlation to driving skill. Other factors associated with driving such as, attention and concentration, executive functions, general cognition and memory, were also found to have a high correlation to driving (Winerman, 2004). There are currently a multitude of assessments that can address similar issues and it is imperative to know what each assessment can uniquely offer, and how that information will move your client forward.
Occupational therapy is a great fit for administering the battery of assessments as well as aiding in the decision making process of determining one’s ability to return to driving. Driving evaluation and rehabilitation compliments the scope of occupational therapy because driving and community mobility is an important component of one's daily living and sense of autonomy. Individuals who choose driving evaluation as a profession gain the certification of Driver Rehabilitation Specialist (DRS). A DRS certification enables a professional to plan, develop, coordinate, and implement driver rehabilitation services for individuals in need (ADED, 2010).

Below is a list of assessments that would help gain a more detailed picture of a particular client. These assessments will add valuable data for determining the clients ability to drive. The following assessments capture the individual’s cognitive status, motor ability, visual perceptual skills, visual acuity, and executive functioning. All of these assessments will be given prior to the BTW or simulation experience in the event that results of the assessments deem them unfit to drive.

The Behavioral Assessment of Dysexecutive Syndrome (BADS) is set of six standardized performance tasks and a behavioral questionnaire that measures executive function skills. The measured skills include organization and planning, problem solving, and decision making. It also assesses the client’s awareness of behavioral problems that impact their daily living situations. The BADS is used with adults who have experienced an acquired brain injury or individuals experiencing mental health conditions. The zoo test takes approximately 20 minutes to administer. There are six subtests, with the zoo map being the subtest that would be utilized in a driving evaluation. The BADS has an internal consistency of .60, test-retest reliability of -0.08 to 0.71 and interrater reliability of >.88. Construct validity is 74%, concurrent validity was
based on significant correlations between subtest and other measures of executive functioning (Norris & Tate, 2000).

The Trail Making Test (TMT) is a neuropsychological instrument that is commonly used. The test consists of two parts, A and B. Time and efficiency are imperative in this test since it is a test of speed. Part B would be the only part used in testing for fitness to drive. Part B tests cognitive demands such as visual scanning, visual-motor coordination, and visual-spatial ability. Part B is more complex and the individual must connect numbers and letters in an alternating pattern as fast as they can. This test is thought to be a good predictor of brain impairment. TMT B has been more closely associated with visual, non-verbal intelligence than with attention, information processing (Alsworth, 1997).

The Motor-Free Visual Perception Test (MVPT) is a norm-referenced, standardized test of visual perception. It measures visual perception independent of motor ability. This test takes approximately 25 minutes to administer. Scoring is user friendly as there are no basals or ceiling required. Optional response time data identifies whether an individual’s responses are significantly delayed (Zeltzer, 2010).

The Snellen eye chart is a widely used, accepted tool to assess an individual’s visual acuity. Visual acuity measures only the smallest detail we can see, it does not represent the quality of vision in general. The chart has a series of letters or letters and numbers with the largest being located at the top. The Snellen fractions are measures of sharpness of sight. Legal blindness is considered to be 20/200 or worse (Watt, 2003).

The Traffic Sign Recognition Test is a 20 question, multiple choice test commonly administered to determine fitness to drive. This test determines an individual’s ability to identify common traffic signs (MacGregor, Freeman, & Zhang, 2001).
The Short Orientation-Memory-Concentration Test is a valid and reliable measure of cognitive impairment. The test is a 6-item questionnaire. The test has predicted the scores on a validated 26-item mental status questionnaire. There was a positive correlation between scores on the 6-item test and plaque counts obtained from the cerebral cortex of 38 subject at autopsy. It can discriminate between mild, moderate, and severe cognitive deficits (Katzman, 1983).

The RoadWise Review is a computer-based and performance-based battery of tests that would be used to prepare a client for their driving evaluation. This software contains the Driving Health Inventory and is available from any local American Automobile Association (AAA, 2010).

Along with driving history, general physical status, sensation, coordination, balance, ambulation, endurance and transferring ability would all be assessed to determine the individual’s ability to drive. These skills are essential in developing an overall occupational profile for each client.

Conclusion

Research has shown that TBI is a common condition that affects numerous individuals within the United States. Driving is a coveted occupation that gives identity and independence to many. Determining an individual's capacity to drive is crucial to the rehabilitative process for an individual after a traumatic brain injury. Unfortunately, there is not a standard method for determining fitness to drive and is left to the evaluator’s discretion. Therapists may use assessments that have been commonly used but do not yield the appropriate information for accurate assessment. Presented in this literature review is a compilation of standardized assessments and recommendations geared to evaluate driving capabilities for this particular population. With this overall occupational profile of an individual's ability to drive, or lack
thereof, occupational therapists are in a good position to make recommendations based on performance outcomes. Recommendations may include return to driving through rehabilitation, to address skills deficits or discontinue driving with alternative community mobility for those deemed unsafe to drive. Adaptations and car modifications can also be made to allow individuals to continue the occupation of driving. Education to family members and caregivers play an important role and can provide essential support for those facing the possibility of the abrupt end of occupational identity. By having a program that allows for a trained professional (DRS) to determine a person's fitness to drive, the burden is taken off loved ones and physicians.

Limitations of this literature review are confined to the population of individuals with brain injuries, although it can be strongly argued that the information presented can be generalized to other populations with cognitive and motor deficits. Research is limited in the area of assessing the predictive validity of driving simulators as this is a relatively new concept in determining fitness to drive. Further research needs to be done to determine the validity and reliability of a standard protocol for driving evaluations and rehabilitation.
References


Program Development:  
A Driving Evaluation Program for Individuals with Traumatic Brain Injury  

Sarah Buchanan, OTS and Kiley Wall, OTS  
May 27, 2010
Our Community Partner

• **Progressive Rehabilitation Associates, Portland, OR**

• Specializes in the areas of chronic pain, work hardening, acquired and traumatic brain injuries

• **Day Treatment Program:**
  – The **Brain Injury Rehabilitation Center (BIRC)**
    • Provides comprehensive rehabilitation for adults with acquired brain injuries
    • Leading provider of rehabilitation services for adults with brain injuries since 1986
    • Multidisciplinary and offers a wide range of services.
Project Objective

To develop a comprehensive, evidence-based driving evaluation program for individuals with traumatic brain injuries.
Met with PRA OT Advisor and Director of BIRC
Began Research Process
Interviewed local driving programs: DRIVEABLE, Alpine Rehab
Adapted & Administered Driving Questionnaire to BIRC Alumni
Held a focus group with clients currently in the BIRC program
Developed a comprehensive, evidence-based literature review
Presented findings to PRA

PROJECT TIMELINE

August 2009

May 2010
Anonymous individual with brain injury

“MY OWN SENSE OF MY ABILITY IS LESS THAN REALITY.”
Determining the Need

• **Driving Questionnaire**

• Administered to 7 BIRC alumni

• Age range 22-61, mean age 41.3 years
  – 5 male, 2 female

• **Results**
  – 1 medically unfit to drive
  – 5 stated they are currently driving, but felt nervous about skills and would pay for OT based evaluation
  – 1 indicated no need for evaluation
Determining the Need Continued

• **Semi-structured Interview**
• Interviewed 7 participants in the BIRC program at PRA
• 10-15 minutes in length
• **All participants:**
  – Male
  – Currently have drivers licenses but strongly encouraged not to drive by physician
  – Have other means of transportation, but have a strong desire to return to driving
  – Interested in driving evaluation program geared towards individuals with brain injuries
  – Would pay out of pocket for this specialized service
Qualitative Data to Support Driving Program

I don’t trust myself.

It feels like a burden to have my family drive me places.

I don’t want to endanger my family.

I would love to go through driving rehab.

I want a professional to be comfortable with my driving, not just myself.

I could pass a driver DMV test.
Driving and TBI
Statistics: Traumatic Brain Injury (TBI)

• Roughly 1.4 million people in the U.S. have experienced a TBI
• Mild TBI's account for 80% of all head injuries
• Typical person experiencing head injury
  – Males - 65 years and older
  – 15-19 years
• Disrupts an individual's ability to participate in activities of daily living (ADL) and other related activities such as driving
The Occupation of Driving

• Allows participation in a variety of life activities within the community
  – Activities of Daily Living (ADL)
  – Instrumental Activities of Daily Living (IADL)
  – Work
  – Leisure
  – Education

• Allows for freedom to explore and experience the environment

• Provides connection to the community

• Gives feelings of familiarity and acceptance

• Provides knowledge of social rules
Lack of Transportation

• Adversely affects participation in desired occupations
• Leads to social isolation
• Decreased quality of life
• Can come abruptly with no time to plan for alternative transportation
Skills Required for Driving

- Visual-perceptual skills
- Visual acuity
- Information processing
- Judgment
- Decision making
- Performance of appropriate motor responses
- Sequencing

- Cognition
- Executive functioning skills
- Memory
- Attention to detail
Oregon: Mandatory Reporting State

- Medical professionals mandated by law to report unsafe drivers

- Many physicians lack time needed and the specialized training
Assessments
Comprehensive Assessments

- Behavioral Assessment of Dysexecutive Syndrome (BADS)
  - Zoo Map
- Trail Making Test (TMT)
  - Part B
- Short Blessed
- Traffic Sign Recognition Test (TSRT)
- Motor-Free Visual Perception Test (MVPT)
- Snellen Eye Chart
- Various neuromotor assessments
Driving Simulation Compared to Behind-the-Wheel Assessment
## Comparing the options

**Behind-the-wheel**
- Accepted as the “gold standard” for determining fitness to drive
- Accident statistics prove that drivers do not always drive as they did on their licensing tests
- Expensive
- Limiting contextually
- Dangerous driving

**Simulation**
- Provide potentially dangerous situations
- Numerous weather conditions
- Adjusts the occurrence of pedestrians and traffic on the road
- No physical injury or damage to property
- Objective assessment of driving performance
Validity of Driving Simulators

Lee et al., 2005

- Results showed a significant positive correlation ($r=0.716$) from the driver simulation testing with the road testing results.

Lew et al., 2005

- Comparing data at baseline, and at a 10 month follow-up
  - Predictive efficiency of 82% provided evidence that failing the simulator at baseline correlated to failing the driving evaluation at follow-up.
  - Participants road test scores showed no significant relation to their driving performance at follow-up.
Validity of Driving Simulators Cont.

Comparison of Driving Errors

- No significant differences were found between the two assessment methods (simulator vs. road testing)
  - Ex.) The simulator had a mean driving error of .74 as compared to .76 on the road testing

D.S. and Cognitive Demands

- DS speed control was related to BTW speed control ($p<.05$) as well as lane deviation, head turning standard deviation, average distance from stop sign, and deceleration ($p<.05$)
S-2300 Cockpit Simulator

S-4350D STARS Desktop

S-3300 STARS Modular

Simulation
Clinical Process

Administer assessments

Yes → Driving Simulator

Yes → Continue Driving

No → Alt. mobility options

No → Rec. discont. driving

No → Driver Rehab Training

No → Alt. mobility options

Test at later date
Multifactor Older Dementia/Driver Evaluation Model (MODEM)

Informant Data

Ethics

Client Factors

Cognitive Assessments

Road Test

Professional Reasoning
Scientific – Diagnostic – Narrative—Procedural—Pragmatic—Ethical—Interactive—Conditional
(Schell & Schell, 2008)

Ultimate Decision

(Hunt, 2010)
# Financial Benefits

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- Cost-Benefit Ratio: 1.46
- Based on $300/evaluation including simulation
- Includes hiring 1 PT OT year one, 1 FT OT year 2, and 1 PT and 1 FT OT year 3
- Also includes operating costs such as:
  - Simulator
  - Assessments
  - Marketing costs
  - Office equipment
  - Driving Rehabilitation Certification
SPECIAL THANKS TO:

Progressive Rehabilitation Associates
Julie Allen, OTR/L
Andrew Ellis, PhD
Linda Hunt, PhD, OTR/L
Questions?