BRAIN INJURY professional
vol. 17 issue 1

Driving After Brain Injury

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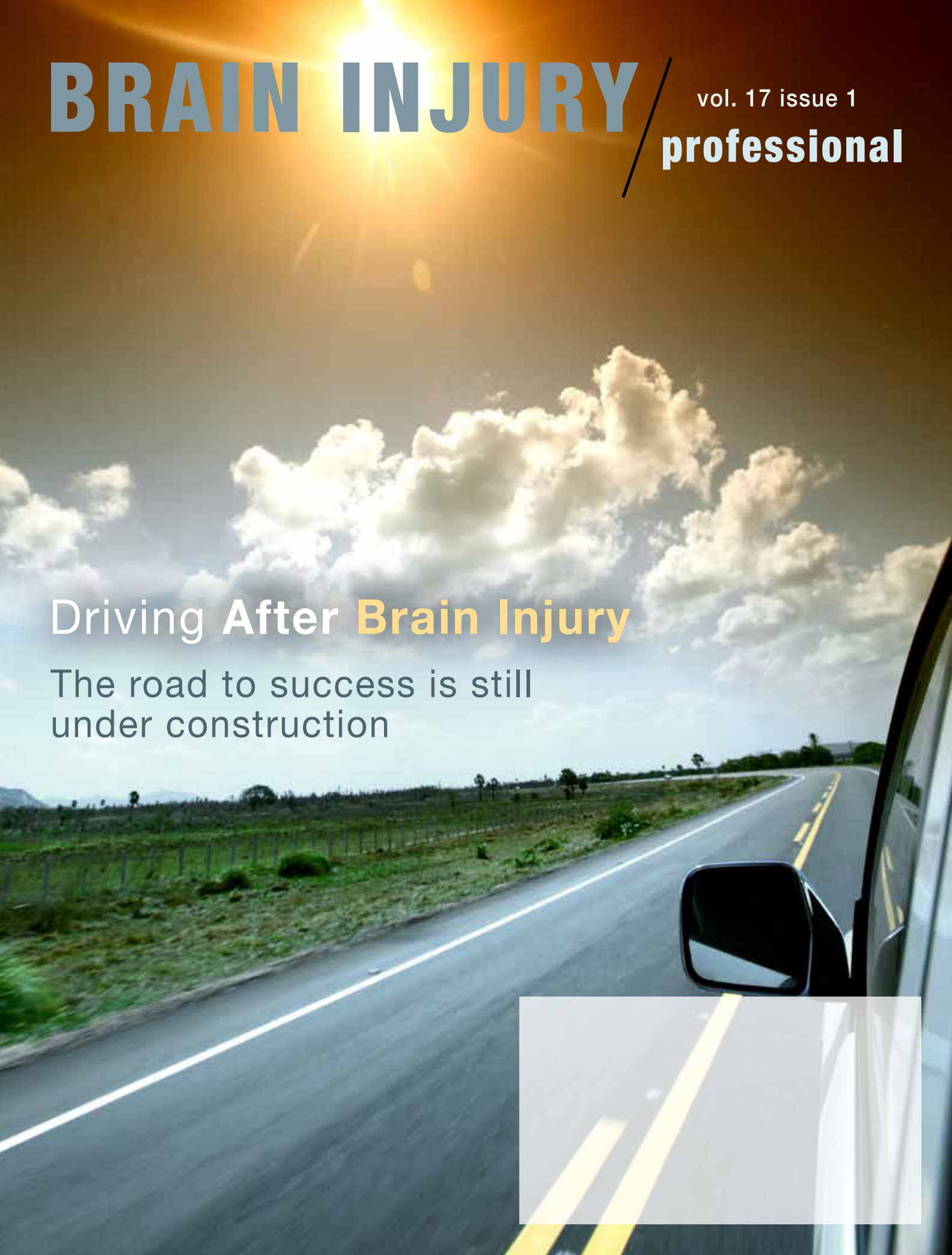

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Nathan D. Zasler, MD, DABPM&R, FAAPM&R, FACRM, BIM-C, CBIST

from the editor in chief

I was very pleased when Dr. Schultheis accepted the guest editorship for this issue of *Brain Injury Professional* given her work in clinical neuropsychology and driving neurorehabilitation after ABI.

Dr. Schultheis has assembled an excellent group of authors and topics for this issue. The lead article by Dr. Schultheis delineates relevant factors in the determination of driving capacity following acquired brain injury. Other articles in this issue address clinical issues and considerations for older adult drivers with a history of TBI, aspects of community reentry and integration relative to driving clearance and participation as well as the role of driving simulation in the context of driver assessment after brain injury.

This special issue is further complemented by two briefer articles looking at both research and clinical perspectives as germane to the factors associated with successful driving after brain injury. There are also two very interesting albeit contrasting interviews in this issue. The first dealing with survivor perspectives and clinical considerations regarding return to driving with Ms. Janine Kirby who sustained a traumatic brain injury in 2012. The second interview is with Ms. Beth Roland, OTR, CDRS, CBIS President-elect of the Association for Driver Rehabilitation Specialists (ADED).

We round out this issue with our technology column which addresses cutting edge technology germane to an immersive virtual reality driving simulator called NeuroDRIVE.

We hope this issue provides important and cutting-edge information on driving assessment and rehabilitation to those clinicians involved with community integration.

Editor Bio

Nathan Zasler, MD, is an internationally respected physician specialist in acquired brain injury (ABI) care and rehabilitation. He is CEO and Medical Director of the Concussion Care Centre of Virginia, an outpatient neurorehabilitation practice, as well as, Tree of Life, a living assistance and transitional neurorehabilitation program for persons with acquired brain injury in Richmond, Virginia. He is board certified in Physical Medicine and Rehabilitation and fellowship trained in brain injury, as well as, Brain Injury Medicine certified.

Dr. Zasler is an Adjunct Professor of PM&R at VCU in Richmond, Virginia, as well as, an Adjunct Associate Professor of PM&R at the University of Virginia, Charlottesville, Virginia. He is a fellow of the American Academy of Disability Evaluating Physicians, and a diplomat of the American Academy of Pain Management.

Dr. Zasler has lectured and written extensively on neurorehabilitation issues in ABI. He is active in national and international organizations dealing with acquired brain injury and neurodisability, serving in numerous consultant and board member roles including currently serving as Vice-Chairperson of IBIA.

from the guest editor

Maria Teresa Schultheis, PhD

Editor Bio

Maria Teresa Schultheis, PhD, is the Vice Provost of Research, within the Office of Research and Innovation at Drexel University in Philadelphia, PA. Dr. Schultheis is a tenured full professor in the Department of Psychology and she is a Clinical Neuropsychologist who received her PhD in Clinical Psychology in 1998.

Dr. Schulthies' clinical and research experience have been focused on the rehabilitation of cognitively impaired populations, including traumatic brain injury, stroke and multiple sclerosis. Specifically, she has specialized in 1) the application of technologies to improve clinical assessment and intervention and 2) studying the demands (physical, cognitive and behavioral) of driving following neurological compromise. This includes research focusing on the application of Virtual Reality (VR) technology and the development of VR as a tool for ecologically valid assessment and rehabilitation. Dr. Schultheis' approach is interdisciplinary and her work intersects psychology, biomedical engineering, transportation, and rehabilitation medicine.

As a researcher, Dr. Schultheis' work has been supported by more than $5.8 million in public and private grants. She has consulted with the National Institutes of Health and the National Multiple Sclerosis Society, along with various international research agencies. She has published over 100 peer-reviewed articles, presentations and book chapters. In 2008, she published the "Handbook on Driving Assessment" a comprehensive resource for professionals involved in determining the driving capacity of individuals with neurological involvement and integrates clinical work on assessing driving capacity for different clinical populations and conditions.

The rapid evolution of technology has resulted in significant changes to our everyday life activities – including driving an automobile. Computing, communication, and sensor technologies are just some examples of technologies that have already been integrated into automobiles to create new benefits and assistance for drivers. These advances can allow individuals to remain behind the wheel and continue to experience the personal sense of autonomy and independent lifestyle that is often associated with being a driver.

For an individual with a neurological compromise, and specifically brain injury, the ability to drive can be compromised by lingering cognitive, physical, sensory or behavioral difficulties resulting from the brain injury. However, many of these individuals retain the desire to maintain the driving privilege. And studies have demonstrated the significant negative impact on their ability to return to work, how they socialize and for many how they define their autonomy. And while the reasons for driving may vary throughout an individual's lifetime, the importance of maintaining this privilege typically remains.

For clinicians working with these individuals, the task of determining whether they are ready to return to driving can be daunting. This critical decision requires a balance of understanding the potential risk (both to the individual and others) and the impact to that individual's quality of life. It is this clinical dilemma that has personally fueled over 20+ years of conducting research to understand the very complex behavior. Along the way, it became clear to me that while the literature on examining driving capacity following brain injury continues to evolve, there remains limited sources that weave together the findings from the research literature with direct clinical implications. As such, this special issue of *Brain Injury Professional* aims to provide a resource for clinicians faced with this challenging clinical dilemma by providing a review of current topics related to driving after brain injury.

Driving is one of the most complex behaviors that individuals perform – not only does it require the integration of multiple skills and abilities, but the act of driving is performed within an ever-changing environment and context that is often too difficult to predict or anticipate. That being said, it would be impossible to cover all of the relevant aspects of driving, but we aim to highlight some of the most clinical relevant research related to driving.

The issue begins with a clinician's "cheat sheet" to provide clinicians with summary of key areas that have been addressed in the driving research literature and offers guidance on domains most relevant to assessment and determining capacity to drive. This is followed by articles addressing three top areas of driving research: aging, community integration and future driving assessment tools. The first of these introduces an important but often overlooked challenge of evaluating individuals who are aging with a brain injury. The issue presents consideration for the concomitant limitations and provides guidance for clinical recommendations. The second article, provides a review of the current literature examining the relationship between driving and community re-integration and provide guidance for the role of professionals in assisting individuals with brain injury in navigating these changes. Finally, the third article, provides a glimpse into the future of driving assessment. Specifically sharing a summary of existing research that has focused on the development of clinically relevant driving simulators. These promising tools may provide clinicians with novel approaches to improve both our assessment and rehabilitation of driving related skills. The special issue also includes an interview with both a clinical and an expert interview to provide insights into the importance of driving after brain injury.

The current issue is designed to synthesize information from the research driving literature, assist the clinician in the translation of current research and provide guidance for clinicians. But most important, it is just one step in the long term objective of developing evidence-based tools to help inform clinical decision making about driving capacity…because ***"The road to success is still under construction."***

Driving After Brain Injury: A Clinician's Cheat Sheet

Maria T. Schultheis, PhD • **Elizabeth Whipple**, PhD

Driving is a complex task that requires the successful integration of perceptual, physical, cognitive, and emotional systems. Individuals with brain injury (BI), along with their families and care providers, are often faced with the determination about an individual's capacity to return to driving post-BI. This brief report offers a synopsis of primary areas of assessment relevant to determining driving capacity following BI.

Relevant Factors of Driving Capacity

To date, there is no one unified and standardized and accepted clinical driving evaluation process. This is further complicated by the lack of federal guidelines and/or mandates to provide overarching directions to clinicians charged with the task of determining capacity to returning to driving post-BI. Therefore, clinicians (which can include physicians, occupational therapists, physical therapist and neuropsychologists) often rely on the assessment of various factors that have been identified as relevant to driving. Across the literature, the areas consistently identified include vision, motor/physical and cognitive performance.

Vision

- Although vision is the primary sensory related to safe driving and is the only sensory domain evaluated legally, there is a dearth of studies that have examined it specifically following BI.
- Existing legal visual requirements primarily focus on visual acuity (i.e., 20/20, or the ability to resolve detail at 20 feet), but these requirements are highly variable from state to state (see American Association of Motor Vehicle Administrators)
- Visual field is the second most commonly evaluated visual ability in relation to driving, and like acuity, the requirements for visual field vary on a state-by-state basis. Unlike visual acuity, which has clear metrics, the definition of visual field differs across studies (Owsley, C. & McGwin, 2010)
- Conflicting findings result from these murky operational definitions. Taken together findings from this research suggest that individuals with visual field impairments may be compromised on some aspects of driving performance (e.g., identification of signage) but unaffected in other areas (e.g., speed estimation).
- Studies with other neurological populations have demonstrated that other visual domains warrant consideration when determining driving risk (Schultheis et al, 2010), for example contrast sensitivity and visual processing speed. In older drivers, impaired contrast sensitivity is associated with a recent history of crash involvement and with driving modification and difficulty (Owsley et al 2010). Similarly, in older drivers slowed visual processing speed and visual inattention have been linked to number of crashes (Owsley et al 1998) and problems with vehicle control (wood et al, 2009).

Conclusion: Overall, driving is a highly complex visual task, and each aspect of visual functioning must work within an integrated system in order to successfully navigate the driving environment. Therefore, it is recommended that the standard visual acuity test be supplemented with other assessments of visual functioning (e.g., contrast sensitivity, visual field, processing speed, and divided attention).

Motor

Physical domains, including strength, coordination, grip, and reflexes in both the upper and lower extremities are basic requirements for managing automobile control devices (e.g., steering wheel, pedals). Following BI, these motor skills may be compromised due to residual difficulties with weakness, hemi-paralysis, ataxia or rigidity.

- Physical fitness should be evaluated in clinic prior to on-the-road assessment.

- Physical assessment should include range of motion, muscle tone, strength and endurance, coordination, balance, proprioception and mobility.
- Even minor impairments in a person's ability to integrate information from the sensory, motor programming, and muscular-skeletal systems can lead to significant disability.
- While motor and physical capacity is commonly evaluated by physical therapists, many driver specialists commonly incorporate gross motor measures of upper and lower extremity to determine the need for adaptive driving equipment

Cognition

The majority of existing literature on driving post-BI has focused on defining the relationship between cognitive impairment and driving performance. In general, the main areas of cognition identified as relevant are consistent with findings from other neurologically compromised populations

- Deficits in selective and divided attention, memory, and information processing speed all negatively impact driving safety (Ortoleva et al 2012).
- Attentional impairments are particularly concerning in an on-road environment, as BI survivors are often easily distracted, unable to recognize hazards, or unable to multi-task successfully.
- However, patients with mild to moderate deficits who appreciate their own cognitive limitations have been found to pass an on-the-road evaluation more successfully than patients with a similar neuropsychological profile who also display anosognosia (Schanke et al, 2000)

An important consideration, regarding cognition is the varying utility of formal cognitive testing dependent on the level of cognitive compromise. For example, cognitive testing maybe useful for detecting severe deficits in clients who may be unsafe behind the wheel prior to an on the road assessment and thereby help ensure the safety of both the driver and the evaluator. By contrast, the relationship between mild cognitive impairment and driving performance is less defined.

Unfortunately, to date there is limited empirical evidence to inform the specific cognitive aspects of driving and the consistency of predictive validity of these tests. However, integrating findings from across the various neurological populations has yielded some robust findings, including the identification of key cognitive domains. (see TABLE 1 for summary).

Summary: Although neuropsychological testing alone is not sufficient to predict driving fitness, it can discriminate among groups with differing skill levels and provide useful information to supplement an on-the-road test. However, caution is warranted regarding generalization, as some studies have found that around 60% of patients with neuropsychological scores that suggest driving difficulties are deemed to be safe drivers following an on-road assessment (Schanke et al 2000).

Table 1. Tests of key cognitive domains for assessment of driving capacity

Cognitive Domain	Terms used to describe this domain	Tests commonly used in literature
Attention	Divided attention Sustained attention Choice reaction time Selective attention Distractability Visual attention	WAIS Digit Span Trail Making A Conners Performance Test UFOV
Visual Spatial	Perception Spatial perception Visual problem-solving	WAIS Block Design Raven Progressive Matrices Rey Figure
Processing Speed	Information processing speed Visual scanning	Symbol Digit Modality Trailing Making Test A & B PASAT
Executive Functioning	Judgment Disinhibition Decision Making	Stroop Wisconsin Card Sort Tower of Hanoi WAIS-Comprehension WAIS- Abstract Reasoning

- Similarly, a slower processing speed means a slower reaction time, slower driving, and slower decision-making.
- Executive functioning impairments, particularly in the areas of inhibition, planning, abstract reasoning skills, and self-awareness, can also affect driving performance (Ortoleva et al 2012). As judgment and insight are can be impaired after BI, drivers may be prone to more risk-taking behaviors, demonstrate poor awareness of driving problems or accidents, or be unable to recognize driving errors.

Other Factors

Other factors to be considered in an assessment of driving capacity include the patient's premorbid driving history, as personality and risk-taking behaviors pre-injury may have implications for driving safety post-recovery. Lowered self-awareness and lack of insight into deficits is often a symptom of BI, however, some studies have found that drivers with BI are capable of recognizing changes in their driving skills, and often self-limit their own driving (i.e., avoid driving at rush hour or at night). Finally, other consequences of BI such as fatigue, the inability to appreciate consequences, and emotional lability (e.g., impulsivity, anxiety, irritability, apathy) may also lead to dangerous situations on the road (Bivono et al, 2012).

Finally, an important consideration that is commonly overlooked or not addressed clinically is the need for repeated driving evaluations. Unlike the legal process, which requires some aspect of licensure renewal for all drivers, among clinical populations, a formal driving evaluation process is typically seen as a one-time requirement. More specifically, the driver evaluation focuses on the readiness of the individuals to pass the legal driver examination. This is because clinical driver specialists do not have the authority to approve or decline legal driving status. Given this, after most individuals have received and passed a clinical driving evaluation, they go on to receive their state licensure.

This license is then subject only to required legal renewals-- that are typically minimal and do not take medical aspects into consideration.

What is most concerning about this process is the compiling evidence that the sequelae of BI can change over time and with the aging process32. BI residual symptoms may be experienced years after the injury, and can include a variety of difficulties (e.g., daytime sleepiness; fatigue; risk of seizures; cognitive, motor, and sensory deficits) (Brenner et al, 2008). More importantly, the aging process likely compounds these symptoms. As a result, aging adults with a positive history of BI may be at higher risk of driving accidents than their aging cohort (Brenner et al, 2008).

Conclusions: Taken together, the determination of the ability to return to driving post-TBI is best supported by a multi-level, multi-domain evaluation. Clinicians should incorporate the expertise of vision, physical/motor, cognition and driver rehabilitation specialists.

Resources

American Congress of Rehabilitation Medicine-Brain Injury Long Term Issues Task Force. Brain injury, aging, and health: Conducting large scale survey research. *Rehabil.* Outlook 8, (2001).

Association ofr Driver Rehabilitation Specialists: www.aded.net

American Medical Association: Clinician's Guide to Assessing and Counseling older Drivers: https://www.nhtsa.gov/sites/nhtsa.dot.gov/files/812228_cliniciansguidetoolderdrivers.pdf

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Author Bios

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Dr. Schulthies' clinical and research experience have been focused on the rehabilitation of cognitively impaired populations, including traumatic brain injury, stroke and multiple sclerosis.

Navy Lt. (Dr.) Elizabeth Whipple was commissioned as a lieutenant in the fourth year of her Ph.D. program in clinical psychology at Drexel University. She completed her internship at Naval Medical Center San Diego in 2017 and completed her first tour at US Naval Hospital Guam. She currently serves as an embedded psychologist with Naval Special Warfare Command in Coronado, CA. Dr. Whipple's research interests include TBI, combat stress, and driving behaviors of post-9/11 combat veterans.

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Clinical Considerations for Older Adult Drivers with a History of Traumatic Brain Injury

Kayci L. Vickers, PhD

An estimated 40% of adults have sustained a traumatic brain injury (TBI) during their lifetime and the rates of TBI in the older adult age group have been steadily rising in recent decades – with numbers exceeding U.S. population growth statistics (Gardner, Dams-O'Connor, Morrissey, & Manley, 2018). As a greater number of individuals survive TBI due to medical advancements, the population of persons aging with brain injury also continues to grow (Felicetti, Trudel, & Mozzoni, 2005). Driving is an instrumental activity of daily living that supports emotional and physical health among older adults (Pietrapiana, Tamietto, Torrini, Mezzanato, Rago, & Perino, 2005; Anstey, Li, Hosking, & Eramudugolla, 2017). Unsurprisingly, up to 85% of adults who sustain a TBI eventually return to driving (Pietrapiana et al. 2005; Rapport et al., 2006; Schultheis, Matheis, Nead, & DeLuca, 2002), and older adults who return to driving after brain injury experience lower rates of depression, better social integration, and an overall better health compared to individuals who cease driving (e.g., Donorfio, D'Ambrosio, Coughlin, & Mohyde, 2009; Edwards, Lunsman, Perkins, Rebok, & Roth, 2009).
Despite the psychosocial benefits of driving, older adults are overrepresented in crashes per distance travelled, and represent the group with the highest rates of serious injury or death resulting from crash involvement (Li, Braver, & Chen, 2003). This article highlights and discusses key clinical considerations for driving among older adults with a history of TBI.

Driving is a complex task which requires a combination of different functional and operational activities for low level control of a vehicle guided by more complex maneuvers and strategic decision making (Michon, 1989). Although there is no gold-standard for identifying individuals who are safe drivers, Brouwer and Withaar (1997) proposed a conceptual framework for safe driving that is especially applicable to clinical contexts. This model includes three primary criteria. First, individuals must have a low probability of sudden and unpredictable lapses in control over their behavior. They must also have sufficient perceptual, cognitive, and motor abilities to apply important driving skills. Finally, social judgment and responsibility must be intact. Across these three criteria, there are many TBI sequelae which could impair one's ability to safely operate a vehicle, most of which are likely to be further exacerbated by the effects of aging (Brenner, Homaifar, and Schultheis, 2008).

Medical Status

Medical conditions which occur secondary to TBI can greatly impact one's ability to safely operate a vehicle, particularly as these relate to increased seizure risk and changes in arousal (i.e., sleep). Following TBI, individuals are at increased risk for seizures, both acutely and in the years post-injury (Agrawal, Timothy, Pandit, & Manju, 2006). It is estimated that up to 30% of brain injury survivors experience a "late seizure," that is a seizure that occurs after their first week post-injury, with the risk of occurrence being greater with increasing TBI severity (Annegers, Hauser, Coan, & Rocca, 1998; Frey, 2003). Individuals aged 65 and older confer additionally increased risk for partial seizures due to the increased prevalence of comorbid medical

conditions (e.g., cerebrovascular disease; Hauser, 1992; Sirven, 2001). Seizures that occur while driving are particularly dangerous as these render the driver unable to engage in or apply any of the necessary components of safe driving. Although accidents due to seizures only account for about 0.2% of motor vehicle accidents overall (Sheth, Krauss, Krumholz, & Li, 2004), they account for 30% of medically-related accidents (Drazkowski et al., 2003). Additionally, a significant number of individuals experience sleep disturbance and increased fatigue following TBI. Sleep disturbance (e.g., hypersomnia, insomnia, daytime fatigue, etc.) affects nearly half of TBI survivors (e.g., Clinchot, Bogner, Mysiw, Fugate, & Corrigan, 1998; Chaudhuri & Behan, 2004, Oullet & Morin, 2006). Among older adults, these changes may compound with typical changes in sleep and fatigue due to increased rates of sleep disorders, neuroendocrine abnormalities, and mood disorders among older adults (Gulia & Kumar, 2018; Rodriguez, Dzierzewski, & Alessi, 2015). With regard to driving, sleep or fatigue-related motor vehicle crashes are generally more severe than other crashes (Sagberg, Jackson, Kruger, Muzet, & Williams, 2004), and past studies have found that poor sleep is a risk factor for cognitive decline among older adults (e.g., Yaffe, Falvey, & Hoange, 2014).

Sensorimotor Deficits

In addition to changes in medical status that occur after TBI, individuals also frequently experience sensorimotor impairments, including visual and motor deficits (Arlinghaus, Shoaib, & Price, 2005). As individuals age, these skills also naturally decline. With regard to vision, declines in acuity, visual field size, and night vision are typical with aging as are increased rates of eye disease (Brouwer & Ponds, 1994; Messinger-Rapport & Rader, 2000). These changes may result in increased need for compensatory behavior when driving. Where there is not guidance for "minimal" levels of physical functioning required for safe driving, motor abilities such as strength and coordination are utilized during driving maneuvers and may be impacted post-injury. In many cases, these changes can be ameliorated with adaptive equipment, and research generally indicates that driving problems post-injury do not relate to physical limitations (VanZomeren, Brouwer, & Minderhoud, 1987). However, it is important to consider these changes in the context of cognitive impairment, as one may have difficulty learning or utilizing compensatory mechanisms.

Cognitive Functioning

Individuals who have experienced a brain injury are twice as likely to be involved in a motor vehicle accident as those who have not, which has been posited to be primarily due to the reduced cognitive capacity post-injury (Bivona et al., 2012; Vickers, Schultheis, & Manning, 2018). Most commonly, TBI survivors experience declines in memory, executive functioning, self-regulation, and information processing speed (e.g., Draper & Ponsford, 2008; Rike, Johansen, Ulleberg, Lundqvist, & Schanke, 2019); however, there is significant heterogeneity in cognitive profiles reflecting the variety of factors that can impact TBI severity and recovery (e.g., injury mechanism, age at time of injury, psychosocial factors). While all of these cognitive domains have been shown to impact driving performance, information processing speed in particular is consistently cited as critical to safe driving as declines in this domain can slow reaction time on-road resulting in elevated risk for driving errors and accidents (Ball, Owsley, Stalvey, Roenker, Sloane, & Graves, 1998; Anstey, Windsor, Luszcz, & Andrews, 2006).

Cognitive changes post-TBI compound with typical age-related changes, particularly in the domain of information processing speed which typically declines with age. Age-related brain changes include decreased grey and white matter volume, reduced synaptic density, declines in neurotransmitter level, increased amyloid burden, and increased cerebrovascular burden (Raz & Rodriguez, 2006; Terry & Katzman, 2001; Hedden et al., 2012). When combined with post-injury cognitive impairments, these age-typical brain changes are more likely to result in functional decline (Senathi-Raja, Ponsford, & Schonberger, 2010). Moreover, individuals with a history of head injury are at greater risk for developing dementia during their lifetime, though the etiology of this remains unknown (Kokiko-Cochran & Godbout, 2018). Taken together, the effects of aging are likely to exacerbate any residual cognitive deficits from TBI.

With regard to driving performance, neuropsychological tests have been widely explored as a means of predicting driving fitness after brain injury (Marshall et al., 2007; Tamietto et al., 2006). Cognitive impairments can impair one's ability to engage in all aspects of Brouwer and Withaar's model, including reducing one's capacity for vigilance and consistency in their vehicle control and in some cases can impair one's judgment and decision-making capacity. In line with this, many studies have identified multiple cognitive domains important to driving, such as attention, executive function, visual perception, and information processing speed (e.g., Hannold, Classen, Winter, Lanford, & Levy, 2013; Ross, Ponsford, Di Stefano, & Spitz, 2015), and a majority of crashes among older adult drivers have been found to relate to inattention and slowed visual processing (Eberhard, 1996). Although these domains of cognitive function have been found to relate to simulated driving and on-road driving test performance (Bliokas, Taylor, Leunge, & Deane, 2011; Schanke & Sundet, 2000), the ability of these measures to predict real-world driving performance has been mixed (Rapport, Bryer, & Hanks, 2008).

Conclusions

It is critical to consider the impact of TBI on driving performance and safety in older adult populations. At this time, there is a lack of national consensus regarding standard driving evaluation methods, and only a handful of studies exist which address driver remediation and retraining. While there remains no heuristic that can reliably indicate driver risk, healthcare teams should carefully consider the combined impact of TBI and aging when determining which recommendations to make to a patient and family about driving. Therefore, as clinicians we must work to construct recommendations which convey clinical concern based on the best available data, while also respecting the autonomy of our patient and their support system.

While there is still work to be done in this area, the American Geriatics Society and National Highway Traffic Safety Administration (NHTSA) have identified a Plan for Older Drivers' Safety (American Geriatrics Society, 2016) which provides guidance for clinical team members who are in a position to assess and counsel older adults about driving fitness. Clinicians are encouraged to follow these 5 general steps:

1. **Screen** for medical conditions or medications that may impact driving as well as recent adverse driving events or behaviors.
2. **Assess** driving-related functional skills in older adults at increased risk for unsafe driving.

3. **Evaluate and Treat** at-risk older adult drivers for conditions that may impair functional skills related to driving and intervene with the goals of:

   a. Optimizing treatment of medical and functional contributors to driving impairment.

   b. Referring older adult drivers with persistent deficits to driving rehabilitation specialists for further evaluation and training related to driving.

4. **Counsel** older adults and their caregivers about safe driving behaviors, potential driving cessation, and alternative options for maintaining independent mobility (e.g., through ride-share apps or public transportation).

5. **Re-evaluate.** Specifically, if an individual continues to drive, follow-up should include re-evaluation of the risk factors discussed here and it should be determined if they have made suggested changes to their driving. If they have discontinued driving, they should be monitored for signs of declining mood due to depression or social isolation.

In general, it is critical that these conversations occur before a major incident happens so that there is time to identify a workable plan for discontinuing driving, and to allow time for the psychological and practical adjustment to driving cessation. In all cases, it's important to maintain an open and respectful line of communication about discontinuing driving with patients and to work with them to find solutions which balance autonomy and safety.

In summary, driving is a complex activity that requires reliable cognitive and physical skills, and which can be impacted by a number of medical conditions. It is also an activity which is important to maintaining independence into older adulthood. For individuals with a history of TBI, it is important to consider the compounding effects of post-injury deficits and age. When making recommendations, it is critical to carefully consider the emotional and social impact of driving cessation while also working to support patient safety.

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Driving, TBI and Community Integration

Monica L. De Iorio, MS • **Lisa J. Rapport**, PhD

Driving After Brain Injury

Driving a motor vehicle is an essential aspect of functional independence, because it is the most common way that adults access activities such as shopping, health care, and social interactions. After TBI, driving privileges are often suspended during recovery and rehabilitation to ensure safety of the driver and the public. Only 40 to 60% of individuals who sustain moderate to severe TBI return to driving (Novack et al., 2010). In general, people who sustain less severe injuries return to driving more quickly than those with severe TBI. Similarly, younger age, higher education, and having been employed at the time of the TBI predict faster return to driving than is typically observed among older adults, people with low education, and people who were not working prior to their injuries (Fleming, Liddle, Nalder, Weir, & Cornwell, 2014; Novack et al., 2010). However, because driving is a complex skill that involves many abilities, predicting who is safe to return to driving can be difficult, especially early in recovery. The topic of return to driving is typically an important focus of people with TBI, their family members, and health professionals with important implications for personal identity, independent functioning, and community integration.

A Sense of Independence

Driving is strongly associated with personal identity of independence in adulthood. Additionally, cars often have implications for social status and self-esteem.

Understandably, people with TBI have identified return to driving as a major marker of returning to "normal" (Liddle et al., 2012). Consistent with the symbolism of driving within American culture in general, return to driving following TBI has been associated with increased feelings of connectedness. Driving cessation is often linked to a sense of loss, and a change in social identity and relationships (Pachana, Jetten, Gustafsson, & Liddle, 2016). Healthy aging drivers are compelled to consider their skills changing over time, and many older adults gradually curtail their driving before deciding to stop entirely (Jouk et al., 2016). In contrast, driving cession after TBI occurs quite suddenly, often followed by an ambiguous recovery period in which the person is unsure of whether or when they may return to driving. Considering the acute onset of cognitive problems following brain injury, it is understandable that a person might have difficulty adjusting to the notion that they might need to stop driving.

Effects of Driving on Community Integration after Brain Injury

Residual impairment from brain injury can lead to decreased participation in social activities and employment, and contribute to reduced engagement. One of the main goals of rehabilitation after injury is *community integration*, which is a multifaceted concept including both subjective and objective domains (Minnes et al., 2003; Williams, Rapport, Millis, & Hanks, 2014).

Objective components of community integration include counts of activities experienced outside of the home and participation in work and social events. *Subjective* components of community integration include personal beliefs regarding one's connection to the community, regardless of the quantified episodes of interaction. For example, one person may feel a strong connection to their community with weekly get-togethers with friends, whereas another person may struggle to feel connected if not working full-time and attending multiple social events per week.

Community integration involves multiple domains of independent living, social activity, and productive activity (Prigatano, 1989; Sander, Clark, & Pappadis, 2010). Individual and cultural differences affect specific types of engagement activities that are priorities for people. What is a valued activity that fosters a feeling of connectedness in one person may be unimportant to another person. Thus, providing individualized interventions promoting community integration is essential. Driving after TBI is one potential target of intervention that cuts across a wide variety of priorities and can influence most aspects of community integration. Driving is an important symbol of independence for most adults, as well as a critical element of practical transportation concerns.

Not surprising, driving is strongly related to subjective community integration after TBI. Veterans with TBI who endorsed driving difficulty were more likely to have poorer psychological well-being and limitations in their social roles than veterans who did not endorse driving difficulty (Winter, Moriarty, & Short, 2017). The effect of driving on perceptions of connectedness may be mitigated by social support (Rapport, Bryer, & Hanks, 2008). However, if the primary source of social support is from family caregivers, it is important to monitor strain experienced by caregivers in this regard. Family caregivers of individuals who have stopped driving following brain injury report experiencing emotional distress that may have reciprocal effects upon the person they are caring for (Liang, Fleming, Gustafsson, Griffin, & Liddle, 2017).

Driving cessation also has substantial repercussions for objective aspects of community integration. On a practical level, driving independently allows for ease of transportation to support objective community integration, including essential activities such as shopping and access to health care (Winter et al., 2017). Driving is strongly related to obtaining and maintaining stable employment following brain injury (Forslund, Roe, Arango-Lasprilla, Sigurdardottir, & Andelic, 2013; Kreutzer et al., 2003; Ponsford & Spitz, 2015). People with brain injury report that difficulties associated with lack of transportation are among the key barriers to finding a job (McRae, Hallab, & Simpson, 2016).

Even five years after injury, driving status predicted social and occupational participation beyond measures of cognition, motor behavior, and depression (Erler et al., 2018). Other aspects of objective community integration, including participation in unpaid vocations and social interactions, are also affected by ability to drive (Rapport et al., 2008). Unfortunately, people who cease driving after TBI experience diminished objective community integration, even if they report using alternate forms of transportation, like public transportation, private services, or help from family and friends (Rapport et al., 2008; Rapport, Hanks, & Bryer, 2006).

Roles of Brain Injury Professionals

Professionals working with people with brain injury play critical roles in providing guidance through the emotional process of waiting to return to drive, or accepting and adjusting to driving cessation. Professionals provide information and support in response to worries about return to driving, and they can identify options for alternative transportation. Plans for alternate transportation must be individualized and reevaluated over time, because there may be difficulties in utilizing transportation based on financial status, accessibility, and availability. Further, supporting independent use of alternate transportation may help mitigate the adverse outcomes associated with driving cessation by decreasing dependence on caregiver availability and willingness.

Unfortunately, individuals may resist exploring alternative transportation due to ambiguity surrounding return to driving. When someone is focused on returning to driving, they put off engaging in activities outside of the home, assuming that these aspects of life will fall into place once they resume driving (Liddle et al., 2011). Community integration is adversely affected during these delays and hiatuses. Therefore, professionals working with people after brain injury should work to provide clear communication about the expectations for recovery and the steps required for safe return to driving.

Evaluation of fitness to drive following brain injury can involve formal and informal assessment. Research shows that caregivers "hold the keys to the car" and have the most influence on whether and when a person with TBI returns to driving. However, it is important to note that caregivers' subjective opinions about a person's fitness to drive are only modestly related to objective predictors of driving (Coleman et al., 2002). Therefore, referrals to neuropsychologists and occupational therapists for formal assessments of fitness to drive can be very helpful in ensuring that accurate decisions are made about who returns to driving, as well as avoiding blame placed on family members when driving privileges are suspended or terminated.

In sum, whether a professional is tasked with helping a person return to driving or adapt to life after driving cessation, it is important to monitor its effects on community integration.

- Driving following brain injury has important links to both subjective feelings of connectedness and objective engagement in social and occupational activity.
- Difficulty adjusting to loss of driving privileges is likely compounded by the abrupt nature of brain injury, as well as the ambiguity surrounding recovery of driving ability.
- Professionals can support community integration regardless of driving status by engaging in discussions about the role of driving on personal identity, and aspects of community integration that are most valued.
- Provide clear psychoeducation about the requirements for safe return to driving while promoting exploration of alternate modes of transportation.
- It can be helpful to take a "hope for the best, plan for the now" approach in encouraging individuals to find ways to build and maintain connections in their community while a decision about return to driving is determined.

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Successful Driving After Brain Injury: A Research Perspective

Luke Miller, BS

From a research perspective driving is defined as a complex, cognitively taxing task requiring self-awareness, behavioral and emotional regulation, visual scanning, and motor skills necessary for safe on-road navigation.

A review of the literature indicates a focus on defining factors that lead to motor vehicles crashes (MVC):

- Researchers prioritize identifying deficits that compromise driver safety.
- Researchers measure driving performance metrics related to vehicle control and positioning, intersection negotiation, traffic law compliance, and reaction to changing road conditions in relation standard neuropsychological assessments to identify unsafe driving behaviors attributed to cognitive deficits.

Some examples of driving behaviors and cognition after brain injury:

- Reckless behaviors are associated with speeding and failure to comply with traffic laws are often attributed to lapses in behavioral and emotional regulation
- Distracted behaviors defined as the failure to respond to signals in the driver's visual field are attributed to deficits in attention and decision-making

Ultimately, these findings suggest targets for improving driver safety intervention, however research driving performance metrics have not been consistently integrated into clinical practice. Clinicians remain challenged to make the important determination of return to driving. because for individuals with brain injury, returning to driving is a major rehabilitation goal for promoting life satisfaction, independence, and community and occupational integration.

Author Bio

Luke Miller is currently working on his Bachelor's Degree of Pscyhology at Drexel University. He is a Research assistant at Center for Injury Research and Prevention at Drexel University.

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7 - 10: *World Congress for Neurorehabilitation*, October 7 – 10, Lyon, France. For more information, visit wfnr.co.uk.

9 - 10: *20th IARP Annual Conference*, October 9 -10, Fort Worth, TX. For more information, visit rehabpro.org.

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2021

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3 - 6: *14th IBIA World Congress on Brain Injury*, March 3 - 6, Dublin, Ireland. For more information, visit ibia2021.org.

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6 - 9: *Fourth International Conference on Pediatric Brain Injury*, October 6 - 9, New York City, NY. For more information, visit ipbis2021.org.

27 – 29: DOC SIG Meeting 2021, October 27 -29, Valencia, Spain. For information on the meeting, please visit internationalbrain.org.

Driving Simulation and the Future of Driving Assessment

Kevin J. Manning, PhD

The determination of driving capacity following brain injury is a long-standing challenge clinicians and family members often face. While clinical behind the wheel/on-road assessments remain the most widely accepted measure of driving competency, new technologies – such as driving simulation offer a standardized approach to expose drivers to potentially dangerous situations in a safe and controlled environment, something not easily accomplished with an on-road exam. As a result, clinicians may increasingly find themselves utilizing driving simulators as a way to augment traditional methods of assessment given: 1) technological advances have greatly increased the usability and realism of driving simulation as well as decreased the cost Classen et al, 2014), and 2) simulation can be useful for both assessment and as a medium to implement driving rehabilitation (Campos et al., 2017). A review of the most leading findings derived from the simulation literature, inclusive of various cognitively compromised populations demonstrates the potential clinical applications.

Simulation Can Detect Subtle Changes in Driving Performance

Driving simulation proves a useful tool to elucidate errors that occur under challenging driving conditions. Due to obvious safety concerns, the on-road driving examination does not allow for the assessment of potentially dangerous driving experiments. But, as detailed in a series of early studies by Rizzo and colleagues, the use of simulated driving challenges delineates clear performance differences in patients with and without cognitive impairment. In an early study, Rizzo et al. (Rizzo, McGehee, Dawson, & Anderson, 2001) studied 18 participants with mild Alzheimer's disease and 12 healthy older adults. Each participant drove an uneventful simulated route for 15 min before reaching a final intersection that triggered an illegal incursion by another vehicle that required an optimal response to avert a crash. Notably, findings revealed that no participants committed a safety error while driving on uneventful segments of the virtual environment. However, six of the 18 subjects with dementia crashed as a result of intersection incursion vehicle compared to zero control participants. Likewise, Lew and colleagues found automated measures of driving simulation were more sensitive and accurate than behavioral observations of simulated driving in predicting on-road driving in a small sample of patients with TBI (Lew et al., 2005). While more research still remains in this area, simulated driving may detect driving errors in patients with only mild or subtle cognitive and functional impairments; such individuals may drive without error in uneventful traffic conditions but exhibit poor vehicle control or decision making under more cognitively demanding situations.

Driving Simulation and Measures of Cognition

Driving simulation can also illuminate the association between complex driving behaviors and in-office behavioral assessments. Clearly, driving errors produce accidents, and certain patient characteristics (e.g., cognition, vision) are associated with accidents and driving errors. Increased understanding of how driver characteristics contribute to driving errors may aid clinicians in detecting individuals who may be at greater risk for driving difficulties and clarify the association between behavioral assessments and specific driving errors. Using simulation, driving errors during complex behaviors can be deconstructed and separately analyzed at each step. For example, simulation during intersection navigation can allow us to understand whether errors are a result of a breakdown in intersection approach speed, gap estimation and judgement when to turn, or vehicle and speed control in maneuvering the turn. Following up their earlier work, Uc, Rizzo, et al. (2006) studied 61 drivers with Alzheimer's disease and 115 healthy older adults who underwent a crash simulation; after a segment of uneventful driving, the driver encountered a lead vehicle stopped at an intersection, creating the potential for a collision with the lead vehicle or another vehicle following closely behind the driver. While gross crash rates did not differ between individuals with AD (5%) and healthy older adults (3%), simulation allowed the investigators to understand that individuals with AD were more likely to engage in sudden vehicle slowing at the intersection, which significantly increased the risk of being struck from behind. Furthermore, sudden slowing was associated with multiple cognitive abilities, but a brief measure of executive functioning (Trail Making Part B) was associated with the greatest increase in risk of unsafe behavior. Specifically, the authors were able to demonstrate that with each 30-s prolongation on Trail Making Part B, the risk of abrupt slowing increased by 31%. More recently, in adults with acquired brain injury, Vickers and colleagues (2018) found that simulated measures of driving performance completed under a dual-task (e.g.,, coin sorting) were strongly correlated (e.g. r = -.78) with cognitive measures. Simulation can therefore enhance our knowledge of the specific cognitive processes underlying driving errors that contribute to accidents.

Driving Simulation and the On-road Assessment

Driving simulation will likely never replace the on-road test. Instead, driving simulation is better situated to help augment in-office assessments in order to aid in the determination of who will require an on-road exam (Campos et al., 2017). Together with in-office assessments, low-cost driving simulation may be useful in classifying patients into levels of driving risk (Classen, Monahan, Canonizado, & Winter, 2014). For example, Piersma and colleagues (2016) used a combination of structured clinical interviews, neuropsychological tests, and driving simulation to predict on-road test performances in older adults with and without Alzheimer's disease. The sample included 35 (43.2%) patients who passed the on-road assessment and 46 (56.8%) patients who were rated either as marginal or unsafe drivers. Using a dementia rating scale, several cognitive measures of processing speed, executive functioning, visuospatial abilities, and general cognition, as well as driving simulation performance metrics, the authors reported that they were able to classify 87% of subjects as either safe or unsafe on a subsequent road-test. While these researchers relied upon a binary classification of safe or unsafe, "trichotimization" of patients into categories - the approach may be especially helpful in identifying those patients who are marginal for further on-road evaluations (Campos et al., 2017). Further investigation with other populations in the use of simulation and behavioral assessments to predict on-road exams is needed.

Simulation and Driving Rehabilitation

Simulators could be used as a safe and controlled medium from which to help rehabilitate driving abilities. This could particularly be beneficial to adults who have experienced a brain injury. Close to 80% of individuals with a history of brain injury return to driving post-injury, (Schultheis et al., 2002) a concerning figure when considering evidence suggesting drivers who have experienced a brain injury are at least twice as likely to be involved in a crash as those who have not (Bivona et al., 2012). Following identification of specific driving errors, one could use the simulator towards task-specific training. Using intersection navigation as an example, a rehabilitation session might begin with a patient attempting to turn left at an intersection without traffic. With success in this maneuver, greater complexity is gradually added that increases cognitive demands, e.g., turning left with oncoming traffic, requiring judging opposing vehicle speed and estimating the gap from which the driver can turn. Following success at this higher-order scenario, one could then add unexpected or distracting events, such as pedestrians crossing at the crosswalk or vehicles impatiently honking from behind. The objective metrics generated by driving simulation - combined with the potential for controlled and systematic addition of challenges can provide a mechanism for quantifying changes in performance and progress in driver rehabilitation.

There is increasing empirical support for the use of driving simulators in the rehabilitation of veterans with traumatic brain injury and/or posttraumatic stress disorder (Imhoff, Lavalliere, Teasdale, & Fait, 2016). Classen and colleagues have used a three-session rehabilitation program consisting of individual coaching to increase self-awareness of driving errors, visual attention training, and verbal feedback during a simulated drive. A case study to determine the feasibility of this program found that the overall driving errors were reduced post-intervention from 33 to 9 (Classen, Monahan, et al., 2014). A follow-up study demonstrated a significant decrease in lane maintenance errors and the total number of driving errors (Classen, Cormack, et al., 2014).

Similar types of driving focused rehabilitation programs have been used with adults with Parkinson's disease (Uc et al., 2011) and multiple sclerosis (Akinwuntan et al., 2014), and these studies represent a promising clinical application of driving simulation.

In summary, clinicians are increasingly called upon to comment on the driving abilities of their patients. The recommendation to cease or continue driving entails significant responsibility, both to the patient and society. As reviewed above, there is a rich history whereby the controlled environment of driving simulation has helped clarify how cognitive and perceptual limitations increase crash risk. More recently, simulation has been shown to help augment the traditional driving assessment process by alerting clinicians to patients who need additional on-road evaluations. This is particularly important as it remains challenging for clinicians to translate the statistically significant relationships between in-office assessments and driving into clinically meaningful outcomes for their patients. Finally, simulation is also increasingly being used towards driving rehabilitation in a variety of patients with neurological injury or disease.

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Author Bio

Kevin Manning, PhD, is a clinical neuropsychologist and Assistant Professor of Psychiatry at the University of Connecticut School of Medicine, where he provides neuropsychological evaluations to a wide range of patients. Dr. Manning's clinical research aims to better understand the functional performance of adults with mild cognitive weaknesses as a result of injury or disease. He currently holds funding from the National Institute of Health to investigate whether cognitive remediation can improve cognition and functional performance in older adults. Dr. Manning has published in numerous professional journals and has contributed chapters on cognition and driving.

Successful Driving after TBI: A Clinical Perspective

Maya Showell

Clinically, the ability to drive has been identified as an important rehabilitation goal for individuals who have a sustained a traumatic brain injury (TBI). The goal to return to driving is often subjective and commonly a result of either a request of the individual with TBI or concerns of a family member and/or significant other.

Driving assessment and rehabilitation are inherently individualized and can range from goals of driving more frequently or longer distances to driving at nighttime and reducing driving.

The Behind the wheel (BTW)/on-road assessment is the most common clinical tool for driving assessments post-TBI.

- The BTW can measure the operational aspects of driving such as handling a vehicle and can include some cognitive aspects such as decision making. However, safety for the driver and evaluator limits the level of driving challenges that can be presented in a BTW.
- The BTW and driver rehabilitation can include setting goals, achievement of those goals, and learning compensatory strategies.

Follow-up studies have attempted to define the patterns and/or changes in driving among drivers post-TBI – but the findings are conflicting—with some studies reporting no significant difference between the frequency of motor vehicle crashes pre-and-post injury and others reporting increased risk for unsafe driving behaviors and motor vehicle accidents. Others have reported that relevant individual factors—such as motivation, emotion and experience have not been well integrated into empirical studies.

A closer integration of the detail driving metrics of the research and the wholistic metrics of clinical studies may serve to provide a more comprehensive understanding of the complex behavior of driving.

Author Bio

Maya Showell is currently working her Bachelor's Degree and Master's Degree in Psychology at Drexel University. She is a Research Assistant at the Drexel University's Department of Psychology's Applied Neuro-Technologies Lab.

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Driving: A Client's Perspective

Interviewed by **Rebecca Williams**, MS

About the Interviewee: *The following is an interview with Janine Kirby, an independent community-dwelling adult female who survived a traumatic brain injury (BI) in December 2012, after being hit by a steel bar on the right side of her head. She was diagnosed with a seizure disorder years later, and underwent a lobectomy, which resulted in the resection of her anterior right temporal lobe. The questions and her responses are accompanied by empirically-supported commentary for clinical context.*

Pictured: Kirby

Why is driving important for you?

It's a sense of independence- to be able to get to where I want to go when I want to get there. Also, driving was always very therapeutic to me; You know, you have no destination, you put on a good song and you just drive. Driving and being on the road, in your own thoughts, was always a very good stress-buster for me. Driving was also a big part of my identity - I always drove pick-up trucks, as a little skinny girl in the construction business. Pulling up in my F150, I would pop out as this little fiery redhead who's the boss. I never thought about that before- it was a big part of my identity: Kirby and her truck.

Clinical Considerations:

- Reliable transportation access has been found to be the greatest environmental barrier experienced by individuals who have survived BI (Whiteneck, Gerhart & Cusick, 2004).
- Return to driving following BI can lift self-esteem to premorbid levels and elevates overall life satisfaction (Novack, et al., 2010).

Why is driving important for your lifestyle?

It is relevant to my volunteer work. Even though I can't work anymore, I like to volunteer and not being able to drive keeps me from doing as many things as I want to do. Socialization - I always balk at asking people to pick me up, take me here, take me there. And, I'm single. I don't want a chaperone to have to take me on a date. And, when someone wants to meet you somewhere you have to keep in mind 'oh, I can't get myself there'. And, when you're not ready to tell them that you have a disability, because you want them to meet you in person first to see that you're 'normal', just a little different. It always comes up in the driving conversation, because you have to tell them why you can't drive. It's the holidays right now, and even though I can't go into a store and go shopping anymore, I would like to go to the dollar store and pick out wrapping paper for myself and not have to bother a neighbor to take me. And, a sense of security. There's been several times over the last five years I've had to go to the hospital in the middle of the night. It's frightening when you can't take yourself to the hospital, and you wonder 'will somebody answer their phone right now'. You don't want to have to call 9-1-1, because you don't want to have to pay that bill.

Clinical Considerations:

Objective community integration outcomes following BI are related to driving status, and social mobility is only modestly improved by access to alternative transportation. Notably, occupational integration has not been found to be improved by alternative means of transportation (Rapport, Hanks & Bryer, 2006).

Are you familiar with return-to-drive process?

Clinical Consideration:

- BI survivors report that the most important functional deficit following their injury is inability to drive (Hopewell, 2002).
- Up to 70% of individuals who have sustained a BI return to driving (Fisk, Schneider & Novack, 1998).

When my license first got taken away it was for seizures, which I understood. The DMV sent me information about how to get back to driving about a year later.

Did anyone in a rehabilitation setting talk to you about the return-to-drive process?

I was highly suggested not to drive. Even if I stopped having seizures, they said, I would most likely be a danger to myself and others driving. No one talked about returning to drive.

Do you think it would have been helpful if they had?

Clinical Consideration: Individuals who have sustained a TBI and undergo a comprehensive driving evaluation are not at increased risk for accidents nor traffic violations. Retraining driving behaviors in the TBI population has been shown to be effective in reducing risk reduction on the road (Schultheis, Matheis, Nead & DeLuca, 2002; Katz, et al., 1990; Haselkorn, Mueller & Rivara, 1998; Mazer, et al., 2003; Sivak, Olson, Kewman, Won & Henson, 1981).

I'm sure if I asked my therapists they would have. But, it would give us hope- like, if you stick with therapy and work hard, and be patient with yourself and your brain, you could drive one day. Mentioning it would be a good thing, absolutely.

Do you think that your ability to drive has changed since your injury, beyond seizure risk?

Even before I started having seizures again, which was about two years after my initial accident, I knew that because of significant right-sided weakness my reaction time would be compromised. That had me frightened. My vision is completely messed-up, still.
I had a lot of visual processing problems. I can't walk and turn my head at the same time- I get dizzy. I tried driving in a parking lot my first couple years, and I got sick.

I get sick sometimes when someone else is driving, but something about me being the person turning the car was very strange. And, looking in the mirrors- my brain couldn't flip the image in my own head and I got confused and would overthink it.

Clinical Considerations:

Driving necessitates complex and overlapping skills encompassing visual, motor and cognitive abilities, which are often impacted by BI. While those who have survived BI estimate their driving abilities to be above average, they are also capable of insight into these deficits, and often adjust their driving behaviors to accommodate these changes (Schultheis, et al., 2002).

Is there anything else you think would be important for clinicians to know about the patient perspective on returning to drive?

It would be good to encourage patients to do things like taking driving lessons, or help them get hooked up with a driving center that doesn't just serve teens learning to drive. Find people who are more patient in teaching people how to drive. Maybe with driving, all some of us need is a boost to get our confidence back.

Clinical Considerations:

Greater than 94% of those who cease driving after BI do not obtain a formal driving evaluation, and do not receive professional input specifically regarding their fitness to drive. Moreover, of those who do return to driving, roughly half are formally evaluated before doing so (Rapport, Hanks & Bryer, 2006).

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About the Interviewer

Rebecca Williams, MS, is a PhD candidate at Drexel University's Clinical Psychology program, as a student under the mentorship of Dr. Schultheis in the Applied Neurotechnologies laboratory. Her research has focused largely on the psychosocial and neuropsychological outcomes of acquired brain injury.

Specifically, her interests lie in investigating novel approaches to exploring and understanding functional deficits following acute brain injury rehabilitation. Much of Rebecca's clinical training has taken place in rehabilitation settings, most recently as an extern at Good Shepherd Penn Partners Brain Injury Rehabilitation Center in Philadelphia, PA.

BIP expert interview

with Beth Rolland, OTR, CDRS, CBIS

Beth Rolland, OTR, CDRS, CBIS, is a senior occupational therapists at Upstate University Medical Center. She is the President-elect of the Association for Driver Rehabilitation Specialists (ADED). She is has taught at Seton Hall, Columbia University and Kean University. Additionally, she is a lecturer at La Moyne College, Utica College, Cayuga College. She frequently speaks on the topic of Driving Rehabilitation.

Beth, first of all, I want to thank you for taking the time to have this interview with "Brain Injury Professional". I am Dr. Nathan Zasler, one of the co-editors of the publication as well as Vice Chair of the International Brain Injury Association. Welcome.

Thank you.

My first question for you Beth is can you give our readers a brief summary of your experience in the realm of driver evaluation and acquired brain injury and where you started and where it has taken you?

Yes, absolutely. I graduated with my degree in Occupational Therapy from Columbia University in 1997 and began working at Kessler Institute for Rehabilitation in northern New Jersey. I learned quite a bit about how to evaluate and treat vision deficits, cognitive deficits and physical deficits that often accompany brain injury. In 2000, I started a satellite driving program in Saddle Brook, New Jersey. I ran that program for 16 years before I moved to Syracuse, New York where I live now. Currently my facility does not have a vehicle, but I am performing clinical pre-driving evaluations. I have been involved with driving rehabilitation on a national level for quite a few years. I have sat on the Board of Directors twice, first as a Member at Large and now as President Elect. I have also served on and chaired several committees, including the research committee, which I formed as an ad hoc in 2010. I realized there was a need for the national organization to start looking more at evidence-based practice, and to integrate research into our process. The committee was recently upgraded to a standing board committee three years ago. Many of our members would love to be involved with research but are not supported by their place of employment. It is a goal to connect these practitioners with academic researchers to collaborate on projects. It will be benefit all of us if we work together. I am currently spearheading an ad hoc committee that is working on gathering education, resources and research in the field of driving rehabilitation to look at what we have and what we are missing.

Congratulations on that! For those readers who are not familiar with ADED, can you tell us a bit about the organization, what the acronym stands for and what the goals of the organization are, please?

The acronym ADED is a bit misleading. The organization's initial name was the Association of Driver Educators for the Disabled. At some point the name was changed to the Association for Driving Rehabilitation Specialists, which more accurately reflects our clientele, but the acronym remains. ADED was established in 1977 to support professionals working in the field of driver education, driver training and transportation equipment modifications for persons with disabilities and persons experiencing the aging process. It supports therapists who are working in driver rehabilitation, manufacturers of adaptive equipment, and mobility equipment dealers who install adaptive equipment in vehicles through education, information dissemination and a certification program for professionals. ADED has been building its base of educational offerings. Every year there is a conference providing up to 30 hours of continuing education on a wide variety of topics as well as an exhibit hall full of the latest adaptive vehicles, equipment, and tools of the trade. It's a great opportunity to see how things work and learn about the latest techniques and research, as well as network with other professionals in the field. ADED also offers two-day courses that are given around the country apart from the conference, as well as online education.

Let me shift to a different question regarding ADED. From a mission standpoint I know one of the goals is to establish some basic parameters for how these evaluations are done. Can you tell us a little bit about what ADED has done in that direction?

ADED has both a Code of Ethics and a Best Practices document, which outline the standards expected for providing driver rehabilitation services. The Best Practices document outlines the entire process of working with a client, including what should be included in an evaluation in both the clinic and in the vehicle. These documents help to guide practice and are updated regularly to reflect the best, evidence-based information.

Good and is there a revision planned or is that an ongoing evolution process?

There is a revision every few years on a regular cycle. Best Practices is almost due for another revision.

Great and how does that compare with the activities of AOTA relative to driving assessment?

While the majority of Certified Driving Rehabilitation Specialists (CDRS) through ADED are Occupational Therapists, ADED has a diverse membership that includes other healthcare professionals and driver educators as well. AOTA's certification in Driving and Community Mobility is open only to Occupational Therapists and has a broader focus encompassing clinical interventions not specifically related to driving. AOTA's certification is portfolio based rather than exam based. They have made a concerted effort to empower generalist OT's who are not specializing in driving to address a client's mobility needs and determine who would best benefit from a referral to a driving specialist in order to make use of limited resources. There are not enough of us out there to meet the need.

One of the greatest challenges is that we don't have a clinical tool to assess cognition that will definitively tell you who will be safe to drive and who will not. As of now, there is no test or group of tests that has a high enough degree of confidence based on research to make a decision without putting someone behind the wheel.

Let me shift gears a bit and ask you as a therapist who does this sort of work, what do you see as the major challenges with assessing people with acquired brain injury?

One of the greatest challenges is that we don't have a clinical tool to assess cognition that will definitively tell you who will be safe to drive and who will not. As of now, there is no test or group of tests that has a high enough degree of confidence based on research to make a decision without putting someone behind the wheel. It is fairly easy for a driver rehabilitation specialist to determine who will need adaptive equipment to compensate for physical deficits, but with cognition it can be very difficult to assess that adequately outside the vehicle. This is one of the problems with not having enough evaluators with behind the wheel programs. One of ADED's goals has been to move practitioners away from some of the older tests that research has shown NOT to have correlation to behind the wheel predictability and towards the ones that do. There are members who are striving to find that research and to do that research. Eventually, we may see a standardized assessment, but there are some researchers who believe that we may need to use a different cognitive battery with different populations in order to achieve the best validity.

My concern as a brain injury medicine subspecialist is the absence of a more standardized evaluation process whether off road or on road for people with brain injury related impairments. Any thoughts on this issue?

Yes. It is also difficult to standardize a behind the wheel evaluation. Driving in Manhattan, for instance, is very different from driving in the farmlands of Oklahoma, or in the Rocky Mountains in the snow. Even if you have the same route for everyone, traffic is different every single time you drive it. Pedestrians and bicycles are different every time. Traffic lights are different. Road conditions are different based on the weather. Drivers around you are making different good and bad choices. A driver needs to be able to handle the challenges unique to the roads on which they drive, so a standardized route is not necessarily the best scenario. There are recommendations for setting up a route in your particular area which include having a certain number of left turns, and including stretches of highway and also unstructured driving, which can be particularly challenging for some patients who have had brain injuries.

Researchers have been moving towards using simulators to provide the same route every time and provide some standardization. I think simulators are a terrific tool for research and training. They are not yet at the level they need to be to replace the behind the wheel evaluation, but they offer the opportunity to make a drive uniform for everybody. You can also manipulate variables such as weather, or number of left turns, or number of hazards and when they appear.

You don't however get the forces you feel when you go around turns, or when you brake. This is part of what you use as a driver to adjust your performance.

My last question for you is what do you see as the future for virtual reality applications in the context of driver assessment?

I think there is some really great potential in that area, and I have seen the technology come a long way. Current VR is far more realistic, and there are richer and more detailed environments in which to be immersed. I think that one of the challenges that still remains is the motion sickness. Simulator sickness is a similar barrier. I think the technology has tremendous potential if we can figure out a way to get around that.

Great, and let me thank you again for doing this interview. We really appreciate your time and the information you provided to our readers.

You are so welcome.

About the Interviewer

Nathan Zasler, MD, is CEO & Medical Director for Concussion Care Centre of Virginia, Ltd., as well as CEO & Medical Director for Tree of Life Services, Inc. Dr. Zasler is board certified in PM&R, fellowship trained in brain injury and subspecialty certified in Brain Injury Medicine. He is an affiliate professor in the VCU Department of Physical Medicine and Rehabilitation, Richmond, VA, and an adjunct associate professor in the Department of Physical Medicine and Rehabilitation at the University of Virginia, Charlottesville. He is Chairperson Emeritus of IBIA and currently serves as Vice-Chairperson. He is co-chief editor of *Brain Injury*, *NeuroRehabilitation* and *Brain Injury Professional*. Dr. Zasler is an advocate, educator, clinical researcher, inventor, entrepreneur and busy practicing clinician who is involved with community-based neurorehabilitation, chronic pain management, and health care consultation, both clinical and medicolegal.

Technology: NeuroDRIVE

Stephen K. Trapp, PhD

Objective (non-advertorial) review of product(s) or technology platforms designed to improve the rehabilitation, long-term care, or the quality of life of persons with brain injury.

Driving following traumatic brain injury (TBI) is a highly valued functional skill linked to a range of important life outcomes. In fact, driving difficulties post-TBI are highly predictive of community participation and over all well-being (Erler et al., 2018; Winter, Moriarty, & Short, 2017). Even with alternative modes of transportation, individuals interested in driving following brain injury report a diminished sense of community integration in social and occupational domains when driving is restricted (Rapport, Bryer, & Hanks, 2008). These domains are well-established predictors of a number of health-related quality of life indices. Accordingly, there is a need to examine the range of rehabilitative opportunities to remediate driving skills.

Simulator technology is an encouraging direction for driving assessment and rehabilitation (Imhoff, Lavallière, Teasdale, & Fait, 2016). Simulators offer a direct functional approach to rehabilitation in which the targeted performance is addressed with practice of pertinent activities, like driving (Giles, 2010). Further, simulators offer opportunities for objective assessment and ecologically relevant content. This approach is growing in value as digital technology becomes increasingly more cost-effective and easily adoptable by a range of end-users.

A recent advance in driving simulation interventions is the NeuroDRIVE (Ettenhofer et al., 2019). NeuroDRIVE is an immersive virtual reality (VR) intervention using a driving simulator to assess driving skills while an individual practice driving in a virtual environment. Virtual environments are often digitally constructed contexts that provide an immersive experience for an individual. Additionally, a virtual environment provides a safe opportunity to practice driving skills before on-road testing.

Dr. Mark Ettenhofer, a neuropsychologist and Director of Research Operations at the Defense and Veterans Brain Injury Center (DVBIC) at the Naval Medical Center San Diego (NMCSD), leads the team that developed NeuroDRIVE. The NeuroDRIVE system was initially designed from the perspective of assessment. Dr. Ettenhofer explained that although "the immersive aspect of the simulator itself added to the engagement for the patient," he wanted a VR system to validly quantify driving skills. Further, he sought to "offer real life cognitive challenges," that could "expand (an individual's) driving skill capacity and expand their bandwidth to respond to unexpected events." The latter being critical for driving safety, as numerous unforeseen events can occur while driving and tax the cognitive responsivity of individuals with brain injuries.

The NeuroDRIVE intervention involves six 90-minute sessions including a review of performance progress and virtual driving practice. Virtual driving practice includes performing component cognitive skills pertinent to driving (e.g., dual processing, response inhibition, working memory), performing composite driving skills featuring customary driving practices (e.g., road hazards, yielding), and an unassisted race-track course. The simulation apparatus used is the General Simulation Driver Guidance System (MBFARR, LLC; Moncrief, Behensky, Harkins, & Fuller, 2015), which both provides the virtual reality experience and objectively assesses performance.

Like many rehabilitation technologies, NeuroDRIVE is a product of science and industry partnerships. In this case, Dr. Ettenhofer's intervention was propelled by technology development by Rick Moncrief (MBFARR, LLC), a video game developer who pioneered arcade driving simulator games. "Being able to draw on video game experience, was helpful even though this was very different application," commented Dr. Ettenhofer.

Pilot data indicate promising directions for this intervention with regard to cognitive performance (Ettenhofer et al., 2019). Although no changes were found in VR driving performance within the small sample, an intervention group demonstrated significant improvements in working memory and selective attention / visual search. Pilot data ready the project for larger demonstration research and wider implications for VR simulator use in driving rehabilitation.

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Author Bio

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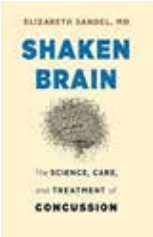

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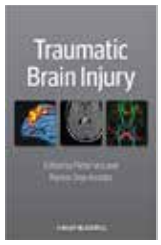

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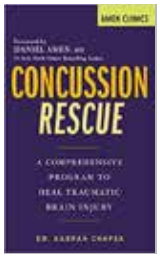

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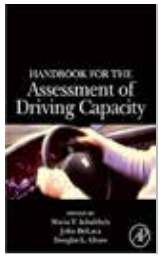

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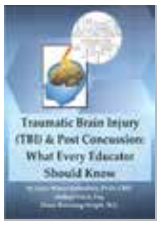

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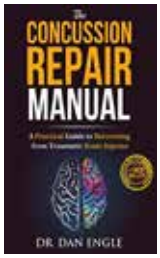

The Concussion Repair Manual: A Practical Guide to Recovering from Traumatic Brain Injuries

Author: Dr. Dan Engle

Publisher: Lifestyle Entrepreneurs Press
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SCARLETT LAW GROUP

Scarlett Law Group is a premier California personal injury law firm that in two decades has become one of the state's go-to practices for large-scale personal injury and wrongful death cases, particularly those involving traumatic brain injuries.

With his experienced team of attorneys and support staff, founder Randall Scarlett has built a highly selective plaintiffs' firm that is dedicated to improving the quality of life of its injured clients. "I live to assist people who have sustained traumatic brain injury or other catastrophic harms," Scarlett says. "There is simply no greater calling than being able to work in a field where you can help people obtain the treatment they so desperately need."

To that end, Scarlett and his firm strive to achieve maximum recovery for their clients, while also providing them with the best medical experts available. "As a firm, we ensure that our clients receive both the litigation support they need and the cutting-edge medical treatments that can help them regain independence," Scarlett notes.

Scarlett's record-setting verdicts for clients with traumatic brain injuries include $10.6 million for a 31-year-old man, $49 million for a 23-year-old man, $26 million for a 7-year-old, and $22.8 million for a 52-year-old woman. In addition, his firm regularly obtains eight-figure verdicts for clients who have endured spinal cord injuries, automobile accidents, big rig trucking accidents, birth injuries, and wrongful death.

Most recently, Scarlett secured an $18.6 million consolidated case jury verdict in February 2014 on behalf of the family of a woman who died as a result of the negligence of a trucking company and the dangerous condition of a roadway in Monterey, Calif. The jury awarded $9.4 million to Scarlett's clients, which ranks as one of the highest wrongful death verdicts rendered in recent years in the Monterey County Superior Court.

"Having successfully tried and resolved cases for decades, we're prepared and willing to take cases to trial when offers of settlement are inadequate, and I think that's ultimately what sets us apart from many other personal injury law firms," observes Scarlett, who is a Diplomate of the American Board of Professional Liability Attorneys.

In 2015, Mr. Scarlett obtained a $13 million jury verdict for the family of a one year old baby who suffered permanent injuries when a North Carolina Hospital failed to diagnose and properly treat bacterial meningitis that left the child with severe neurological damage. Then, just a month later, Scarlett secured an $11 million settlement for a 28-year-old Iraq War veteran who was struck by a vehicle in a crosswalk, rendering her brain damaged.

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