Close

Chapter 43

Driver Rehabilitation and Personal Transportation: The Vital Link to Independence

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In technically advanced societies, driving has become an integral part of daily living for all aspects of adult life. For people with disabilities whose mobility has become severely curtailed, driving represents the ultimate freedom, the means by which to attain their highest level of independence and autonomy over their lives.

On the other hand, medical and health professionals have a responsibility toward society as a whole, as well as toward the person with a disability, to ensure that the best advice is given regarding safe control of an automobile. Weighing the issues involved is often a difficult task for medical and health professionals. It calls for sensitivity and diplomacy and an understanding of the disability and its progression. As well as medical and functional information, knowledge of the person's level of insight and the likelihood of the person displaying responsible behavior, as a direct result of the disability or originating from his or her actual personality traits, will have a bearing on the final recommendations regarding the advisability of driving. Despite extensive research, no firm conclusions have been drawn regarding which specific cognitive deficits may constitute a barrier to driving. However, the literature shows a consensus of the need for assessment to be carried out on several levels, including medical, psychological, and functional levels, including, if deemed safe to do so, an on-road driving assessment. The difficulty of separating individual skills as predictors of actual performance was recognized by Evans (1), who nonetheless commented that "perhaps a distinction should be made between perceptual-motor skills and total performance."

In comparison to the attention given to assessing brain-injured drivers, little emphasis has been found in the literature regarding the driving safety of those with physical disabilities but without brain injuries. The studies that did focus on physical disability demonstrated that given the correct vehicle adaptations, driving safety is not compromised (2–5).

This chapter provides an introduction to the issues involved in driver assessment for a wide range of disability types. It outlines several models of driving skill theory, examines the steps to be followed when assessing driving skill, and discusses aspects of behavior and environment that impinge on the person's ability to drive safely.

FRAMES OF REFERENCE

Before approaching comprehensive driver assessment, it is necessary to have a well-formed philosophy of what is to be evaluated, what relevance it has to the task of driving, and by what process the final decision will be made. Three frames of reference, developed between 1979 and 1992, are examined here. While it appears that the first two models have evolved independently of each other, similarities are present in their approach, in which the multiple factors that comprise the complex task of driving are described. Because each model adds a different dimension to the issues involved in driver assessment, they are all worthy of consideration. The development of theoretical models in driver assessment is now addressed through these three frames of reference.

Perceptual Information Processing Model of the Driving Task

Described by Simms (6), the focus of this model is on the internal processing methods of multiple, constantly changing, incoming visual stimuli by which the driver is bombarded during the driving task. The person's driving safety will depend on the rapid interpretation and accurate responses to this information. Comprehensive visual screening, especially in regard to restriction in visual fields, is an essential first step in the assessment process.

Environmental Information

The first stage of Simms's model includes the ability to perceive traffic engineering, advisory signs, and roadway design, as well as the presence and movement of other road users.

Attentional and Perceptual Mechanisms

The second stage of the model characterizes the person's ability to gather and form the complex environmental information into a meaningful picture within a compressed time frame. Simms commented that essential visual perceptual skills at this level include "scanning, tracking and figure-ground discrimination."

Logical Analysis and Decision Making

This stage describes the ability to interpret information gathered and combine it with already existing knowledge of the driving task, in order to make the most appropriate decisions. It involves the continuous, accurate assessment of risk in a wide variety of potentially hazardous situations, which are constantly changing.

Response

The final stage of Simms's model is the time frame in which the person makes a physical response. A prerequisite is to have accurate control of the vehicle, which may require vehicle modifications as well as, in our experience, full control over at least two out of four limbs.

Hierarchical Model of Task Performance in Car Driving

This model is hierarchical in that each level impacts on the other, thus affecting the way in which the driver performs. "Dealing with Danger," an unpublished summary report by Michon of a workshop in 1979, described a three-tier model of driving skill. Michon's report was outlined by van Zomeren et al in 1987 (7).

Strategic Level

The first level of Michon's model describes the skill of planning the drive in advance. It involves making decisions about the best route to take, what time of day is preferable, anticipated traffic density, expected weather, and the level of wellness or tiredness of the driver. As the person is not yet behind the wheel, the pressure caused by the time required to make decisions on the strategic level is low. It also involves more global decision making, for example, whether to spend the extra money for antilock brakes and dual air bags—even where to live and work. Clinical experience has shown the importance of understanding the driver's ability to address the strategic level, especially among those who lack insight about their actual abilities or who do not acknowledge their failing level of health.

Tactical Level

Skills in the tactical level involve the driver's actual behavior while driving and decisions on which these are based. Examples offered by van Zomeren et al (7) include "adapting one's speed when entering a residential district, switching on the headlights when rain reduces visibility, or deciding to pass another car." The time frame in which to respond at the tactical level is moderate. In psychological terms, the tactical level is a very broad description of function. Inasmuch as the tactical level calls for prospective thinking and action, there is an emphasis on the first three levels of Simms's model (environmental information, attentional and perceptual mechanisms, logical analysis and decision making). The outcomes of faulty cognitive mechanisms have been clarified by van Zomeren et al (7), thus adding another dimension to the approaches outlined in Simms's model. Impairments on the tactical level may include "impulsivity [which] is attributed to disinhibition or reduced cognitive control." "Poor judgement" is "derived from poor estimation of risks and inadequate adaptation of speed to traffic conditions."

Operational Level

The final level of Michon's model includes the automatic decisions and practiced responses of a driver. It involves the ability to position the vehicle and steer it accurately, to use the primary and secondary driving controls, and to monitor and avoid potential hazards both in the present and a few seconds ahead. Impairments in the operational level are listed by van Zomeren et al (7) as falling "into five general categories: 1) inadequate visual scanning of traffic and environment, 2) problems in spatial perception and orientation, 3) poor tracking, 4) slowness in acting and 5) confusion when more complex actions have to be carried out." The operational level encompasses the last two levels in Simms's model (logical analysis and decision making, and response). The time frame in which to respond at the operational level is limited and an ever-present factor.

The Michon/van Zomeren model is less about skills than about the driving task and, therefore, the skills identified by Simms will find expression at both the tactical and operational levels. Further, the Michon/van Zomeren model has interesting implications for on-road assessment. First, an explicit attempt should be made to address the tactical level. For instance, one might ask the person to find a way to reverse direction ("Oops, we should have gone the other way . . .") or to find a safe way to pull off the road. Second, the strategic level needs to be addressed, but, by definition, it cannot be while driving.

A Cybernetic Model of Driving

A study in 1991 by Galski et al (8) considered elements of the earlier frames of reference and further refined them. They went one step further than developing a hypothetical model and investigated its effectiveness in clinical practice. The researchers tested the cybernetic model for its use in evaluating fitness to drive after brain injury, and reported predictive validity of the model. The cybernetic model is complex, featuring layers of skills that continuously interact with each other.

General Driving Program

This level holds knowledge of the road rules as well as learning from repeated past experiences of driving. It is not a static body of knowledge but rather a changing database of information that is constantly updated by new experiences. "It initiates and directs all driving related activities" in routine and repeated situations (8). In this sense, the general driving program is an expansion of Michon's tactical and operational levels. Impairment of the general driving program may derive from loss of memory for past learning or reduced ability to use past learning in new situations.

Executive Component

The executive component is activated by the intention to drive. It guides the preparatory activities for driving and signals the calculation and construction coprocessor to become active.

Specific Driving Program

As a decision has now been made to drive, this level organizes the elements of destination, route, and so on, as described in Michon's strategic level. In addition, the specific driving program directs four additional systems to commence operation.

Sensory Input

This involves the scanning of global information being received from the body's visual, auditory, proprioceptive, and kinesthetic sensors. Whereas routine driving requires a low demand on this level, new situations demand more precisely directed sensory monitoring. Impairment may create delays in processing.

Calculation and Construction Coprocessor

In order to interpret the ever-changing three-dimensional environment, the driver makes use of this level to "calculate, integrate and coordinate the incoming sensory information" (8). This involves visual-perceptual skills including "distance, depth, spatial relationships, velocity and gradients" (8).

Motor Output

Similar to Michon's operational level, motor output includes the physical tasks of vehicle control, such as steering, braking, and accelerating. In addition, Galski et al (8) refined the concept by considering the need to perform a single action, or a combination of actions, as well as the degree of effort required to ensure safe passage of the vehicle.

Resident Diagnostic Program

The final level checks the entire system's function. It is a generic system covering "cognitive-perceptual-physical skills, executive processes (e.g., planning, goal setting, monitoring performance, regulating behavior) and psychological factors (e.g., personality, emotions, beliefs) in all activities" (8). Impairment in this area is likely to affect insight into one's own abilities and reduce safe driving behaviors.

DISABILITIES AND CASE EXAMPLES OF DRIVER REHABILITATION

A broad spectrum of disabilities or conditions is served by driver rehabilitation and if there is any subdivision, it has to be according to the presence of 1) physical disability and 2) cognitive impairment. These are summarized in Table 43-1, together with remarks and observations based on our clinical experience. The wide scope of disabling conditions and their impact on driving often present unique challenges to persons who would be driver rehabilitation specialists. We have chosen two of our more complicated cases to illustrate what can be involved and what can be accomplished. The first, whom we shall call Patient A, was treated in New Zealand, which will account for the steering wheel positioned on the right side of the vehicle. He had physical disability secondary to spinal cord injury. The second, Patient B, was treated for cognitive and behavioral sequelae of a severe traumatic brain injury. Parts of his case have been reported elsewhere (9). Together, they represent the two broad domains of disability, physical and cognitive, which are of concern for driver rehabilitation.

Patient A: Spinal Injury with Incomplete Paraplegia and Cauda Equina Syndrome

Once his condition had stabilized, Patient A was admitted to a spinal rehabilitation facility for rehabilitation. For driver assessment, this meant that his abilities did not remain static and gradual recovery occurred over several months, making it difficult to predict his final vehicle and equipment needs with any certainty. He was referred for driver or passenger assessment near the end of his inpatient stay at the spinal unit.

Functional Ability

Patient A initially presented with patchy cutaneous sensory loss and some return of movement in all limbs, but this

Table 43-1: Disability Diagnoses Served by Driver Rehabilitation		
Disability	**Diagnosis**	**Comments**
PC	Acquired brain injury	TBI, CVA, post tumor. Check for associated physical weakness or impaired coordination. CVA: may need modifications and retraining.
PC	Parkinson disease	Caution for on-road if festinating gait is present. Later stage: medication effects may wear off quickly. Insight may be poor.
C	Dementia	Age associated and usually fit; HIV infection. Ensure support person is involved when discussing outcomes.
PC	Frail elderly	Unwell or slow recuperation following illness. Social issues weigh heavily.
P	Multiple sclerosis	Check vision, incoordination, muscle weakness. Monitor slow deterioration. May need hand controls and retraining.
P	Muscular dystrophy	Mild: driver, but keep open for review. Severe: passenger, often a child; may be disabled but growth is normal. Expect and monitor deterioration.
P	Motor neuron disease	Check driving at onset. Deterioration can be rapid. May quickly become a passenger.
PC	Cerebral palsy	Learner drivers will need extra lessons.
PC	Spina bifida—hydrocephalus	Learner drivers will need extra lessons.
C	Psychiatric (schizophrenia)	Often referred during discharge planning.
PC	Spinal injuries Complete/incomplete Paraplegia Tetraplegia (Quadriplegia) C2–C3, C3–C4, C5–C6, C6–C7	"Occult" brain injury must be suspected. Function is likely to improve dramatically. Prescribe modifications with caution. Capable of transfers and independent wheelchair stowage. Need body support for travel as passengers. Need extensive modifications for driving.
P	Children with developmental delay	Travel as passengers. Check projected changes to mobility equipment and health of principal caregiver.
P	Amputees Upper limbs Finger(s) Through wrist Above/below elbow Lower limbs Through ankle Above/below knee Bilateral/unilateral	May be hypersensitive to touch: check grip on wheel, key, hand brake, gear select. Modification to artificial limb for steering. Modify secondary driving controls. Check position of pedals. May need guides. Check vision and cognitive function if secondary to diabetes. Using artificial limbs on pedals is unsafe because there is no sensory feedback (i.e., proprioception, pressure, vibration). Add hinged left accelerator or hand controls and retrain.
P	Ankylosing spondylitis	High seat for access. Check vision and add wide-angle mirrors. Check again for blind spots as results are not always safe.
P	Arthritis Osteoarthritis Rheumatoid arthritis	May complicate other conditions. High seat for transfers. Check grip strength. Systemic involvement causes fatigue. Pace daily activities. Check shoulder range of motion and strength for steering, use of pedals, seat height and positioning, modify key and small levers and switches.
P	Brachial plexus lesions	Modify car for one-arm driving.
P	Back injury	Check seating and ergonomics; may need substantial seat reupholstery and/or change of vehicle.
P	Chronic pain	Usually cannot be of help, especially if driving exacerbates. Pace daily activities.
P	Occupational overuse syndrome	Was repetitive strain injury. Usually in upper limb. Pace and modify as for rheumatoid arthritis.
P	Postpolio syndrome	Fatigue main new factor over existing weakness in arm or leg. May have scoliosis. Review ergonomics of driving; update modifications and/or car for ease of use. Pace driving to within fatigue levels.

P = physical disability, requiring a musculoskeletal approach; C = brain insult, requiring a cognitive approach; PC = requires both musculoskeletal and cognitive approaches; TBI = traumatic brain injury; CVA = cerebrovascular accident; HIV = human immunodeficiency virus infection.

Figure 43-1. Patient A with incomplete tetraplegia uses elbow crutches for short distances and a fixed-frame wheelchair for longer journeys.

was not sufficiently functional for walking, driving, or independent transfers. He was confined to a wheelchair. At that time, it seemed his only option was to access a van via a wheelchair loader and to travel as a passenger. A further complicating factor was his large body size. This had major implications for driver assessment. It also meant that his occupational therapist and physiotherapist at the spinal unit gave special attention to equipment for daily living in all areas, especially wheelchair prescription and housing modifications. They also lobbied Patient A's funding agent to take into account not only his injury but also his ergonomic needs, a complication that hindered his rehabilitation and discharge planning.

Life Roles

Prior to his injury, Patient A was employed as an industrial chemist in a tertiary educational facility. He is married and the father of two 4-year-old boys (twins). In order to readjust their lives and to make the most of their earning capacities, Patient A and his wife decided to swap roles. His new role was to organize the care for his children during the day and to continue with distance learning by correspondence at the same time. This meant that he was determined, if possible, to drive. Traveling as a passenger simply did not fulfill his goals as a parent and a spouse.

Improvement in Function

The assessment and follow-up continued over a period of 3 months. During this time he steadily progressed to independent transfers and the use of elbow crutches. At this stage, we established that he had sufficient return of movement and upper-limb strength to enable him to use hand controls on a car with power steering. Therefore, the remaining obstacles to driving were a) how to stow an outsized fixed-frame wheelchair and b) what vehicle to choose (Fig. 43-1).

Vehicle Selection and Teamwork

With supervision from his occupational therapist at the spinal unit, Patient A quickly established that he was unable to stand up from a standard car seat. Furthermore, even with his tall height, he was unable to access the seat of four-wheel-drive vehicles, which were too high. Eventually, he discovered that the range of "people movers," a van-shaped car, seemed ideally suited to his needs. They cost more than twice the available car purchase grant. Static assessment of the first car was conducted with Patient A, his occupational therapist, the driver assessor specialist, and a vehicle modifications engineer. Although he could easily get into and out of the driver's seat, we found difficulties with seat positioning, and the potential creation of pressure areas on his thighs from the hand brake on one side and the contours of the driver's door on the other. It would require substantial modification. Another make of a similar vehicle had substantially more leg room and better seating support, and could be modified at less cost (Fig. 43-2).

Vehicle Modification and Teamwork

Patient A lives in the suburbs of a large city and would principally be driving short distances on sealed roads in relatively busy traffic. As a family, they would like to travel farther across the city on the freeway or out of town for vacations in rural areas. Both journeys require traveling at high speeds, which would affect the stability of an externally mounted, outsized fixed-frame wheelchair, which would essentially act as a large sail on top of the car. After discussions with the manufacturer of a car-top wheelchair carrier about safety risks, we decided against this modification. Instead, we agreed that although it was not ideal, Patient A should aim to stow the wheelchair in the level-access trunk, while seated safely at the opening to the trunk.

Figure 43-2. Patient A getting into the driver's seat. Weak muscles combined with heavy limbs make this a slow process.

Figure 43-3. Patient A demonstrates hand controls and steering wheel spinner. Even in the most ideal vehicle, space for equipment was limited.

The following vehicle modifications were identified at a further follow-up assessment, with an additional team member, a vehicle upholsterer.

1. Add hand controls (Fig. 43-3).
2. Add steering wheel spinner (see Fig. 43-3).
3. Hinge accelerator pedal out of range of the right foot (Fig. 43-4).
4. Remove contours on driver's door and replace with flat panel.
5. Remove seat belt stalk from side of seat and replace on floor, to eliminate pressure areas and for ease of access.
6. Remove third row of seats in rear to make room for wheelchair.

7. Add central locking system to increase security and reduce walking.
8. Extend runners to the rear on the driver's seat by 75 mm to allow more leg room when seated (Fig. 43-5).
9. Install two hand grips on driver's door opening to aid in transferring.

Figure 43-4. Foot positioning: Wearing an ankle-foot orthosis in a restricted space and weak thigh muscles make foot positioning difficult. This photograph shows the right accelerator pedal hinged out of the way for safety.

Due to his size and special needs, we had not been able to place Patient A in an adapted vehicle to test his practical driving abilities. Therefore, on collection of the vehicle, he was given driver education, concentrating on the safe use of hand controls. He quickly understood their use and within 40 minutes, was driving the vehicle as though he had had plenty of practice.

This project aided Patient A's return home and was integral in re-establishing a normal life following severe spinal injury. He regularly uses the vehicle to transport his sons to and from school and has enjoyed short weekend visits to the country. He is able to stow his wheelchair in the trunk, while maintaining his balance and has not found any difficulties achieving this on a variety of terrains. Patient A returned to the workshop on one occasion to add a further vehicle modification, which we had overlooked. On those days when he felt unwell, and needed to visit his doctor, it was difficult for him to access the front passenger seat. Therefore, the seat was also positioned 75 mm farther back to allow him sufficient leg room to travel as a passenger in addition to being a driver (see Fig. 47-5).

Patient B: Cognitive and Behavioral Sequelae of Traumatic Brain Injury

Patient B survived a head-on collision but had multiple trauma, including orbital and skull fractures and massive brain injury. He was evaluated and treated with an individualized technology-augmented cognitive rehabilitation program, in which driving was an important, but by no means the only component. By the time he was first seen a year after the accident, he was ambulatory and expressed (solo and a capella) great confidence in his ability to drive. His family did not trust his judgment to stay at home alone for anything other than short intervals and he was totally dependent on others to drive him where he needed to go. [It never ceases to amaze us how often people who are not safe in crossing the street on foot (or in a wheelchair) seek

Figure 43-5. The driver's seat was substantially repositioned to the rear to enable Patient A to sit in it. A seat belt extension, which can be seen between both seats, enables him to locate and engage the seat belt.

Figure 43-6. Patient B's use of the train was an important component of his driver rehabilitation and has continued to be part of his mobility plan.

to drive.] Initially, Patient B's obsession with driving was directed to mobility on foot and use of public transportation. With supervision and safety awareness training, he became independent on the train (Fig. 43-6). This achievement was psychologically uplifting and he has continued to use this mode of travel on longer trips, especially into urban areas.

Patient B would have angry outbursts and become easily frustrated. On each such occasion he would attest to having learned his lesson, that the problem would not occur again. He was persuaded that he had to earn the confidence and trust of others—that his own confidence was not sufficient, as his judgment was always to be "optimistic" rather than realistic. He agreed that he would have to remain outburst free for at least 3 months before he could expect others to find him sufficiently trustworthy to even consider assessment for resumption of driving. It took him 9 months to reach this goal.

Patient B had significant attentional problems (e.g., with simultaneous information processing and mental flexibility), binocular dysfunction (affecting depth and other forms of visual perception), impulsivity, and visual agnosia (failure to recognize some objects in his direct line of sight). These problems were addressed in his cognitive rehabilitation and optometric treatment programs. Some exercises were identified for their specific relevance to skills needed for safe driving, for example, visual closure. These exercises showed him concretely the standards that he needed to meet and demonstrated that others were taking his goal of driving seriously.

Throughout this time, the clinician's observations of Patient B's reasoning and behavior were complemented by information offered by family members and other professionals. It was clear that much improvement was needed before he would garner family support for his driving. Formal predriving assessment was initiated gradually and explicitly made contingent on achieving consistently acceptable behavior and judgment.

Since Patient B was under optometric care, formal vision screening was not needed; however, his binocularity problems were identified as potential issues for judgment of distances, for example, following and stopping. His visual perceptual agnosia was characterized as a "look no see" problem, regularly brought to his attention in whatever contexts it occurred, and explicitly related to driving, for example, "Gee, Officer, I didn't even see him. . . ."

Formal assessment of judgment and information-processing abilities related to driving was accomplished with the Elemental Driving Simulator (9), illustrated in Figure 43-7. On this rudimentary computer-based simulation, performance relative to a norm group of drivers is compared to self-appraisal. Patient B predicted that he would score average or better on all scales; however, it took him four attempts, separated by at least a month, to attain scores on all subscales within two standard deviations of

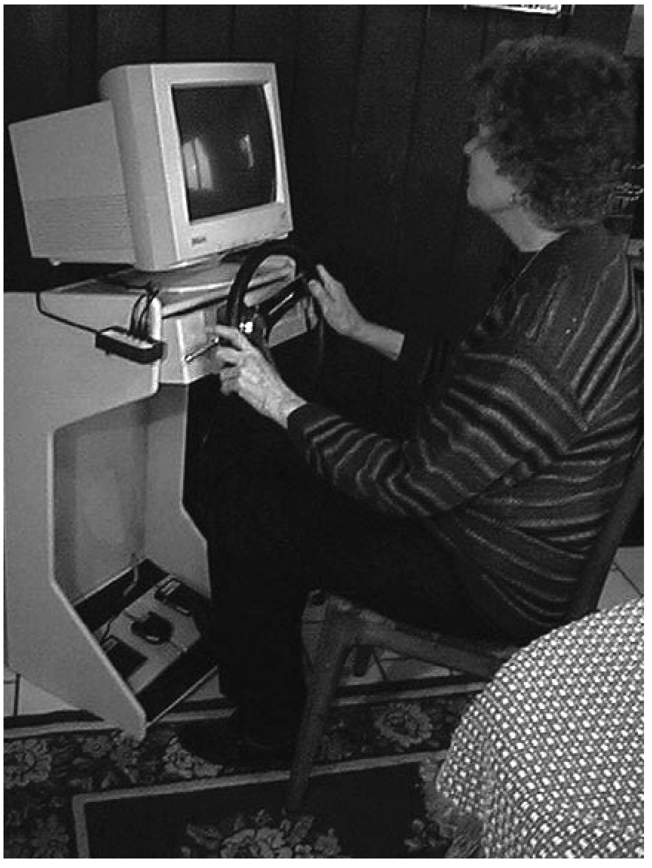


Figure 43-7. Elemental Driving Simulator (EDS) standard model. An IBM-compatible personal computer (not shown) controls a dynamic display of a schematic roadway and peripheral stimuli. The patient controls the lateral position of the "car" using the steering wheel and uses the turn signal to make responses. For hemiparetics, the foot pedals are used for responding.

the mean—a clinical cutoff corresponding to the second percentile.

An on-road behind-the-wheel assessment was then scheduled and as it happened Patient B was observed by two experienced driver rehabilitation specialists, one of whom recommended further cognitive rehabilitation and the other thought it was time to begin driving lessons. Although he had already made great progress, Patient B was still a marginal candidate for driving. Once authorized by his insurance carrier, he began lessons with a local commercial driving school instructor who was experienced with drivers with disabling conditions. The coordinating driver rehabilitation specialist observed the first lesson, which also served as an independent evaluation, and remained in close communication with the driving instructor. After 2 months of lessons, the instructor encouraged Patient B to begin practice driving. His family was not eager to work with him in this regard and Patient B was to obtain his own car and insurance and satisfy legal requirements (his license, by now, had expired and he had to notify the licensing authorities of his condition and obtain medical clearance to continue driving—see Appendix I, which details the applicable legal requirements). He obtained an oversized center-mounted rearview mirror (Fig. 43-8).

His practice and guidelines for driving now came into the direct oversight of the coordinating driver rehabilitation specialist. The following system remained in effect for approximately 1 year before Patient B achieved a modicum of meaningful independence in his driving:

1. Driving log: Patient B was to record each trip, including time, distance, objective, and observations.
2. Monthly observation drive: The itinerary for this 2-hour drive was proposed by Patient B based on where he wanted to go and felt was within his capa-

Figure 43-8. Oversized center-mounted rearview mirror.

bilities. Initially, over half the proposed routes were determined to be unsafe, usually because of traffic density and left turns. This method worked especially well as it gave the patient an opportunity to demonstrate his advancing appreciation of factors that impact on the safety of different routes. He learned how to use route planning to reduce risk. Computerized local street maps were helpful in this planning, both for Patient B and the driver rehabilitation specialist, who was not particularly familiar with Patient B's community. Over the months, the list of approved routes grew.

3. Patient B agreed to limit his driving strictly to daytime driving along approved routes. He adhered to these guidelines quite consistently, and there were no serious mishaps and only one lapse in which he drove some friends at the day center to lunch.

For a year Patient B's driving consisted of observed drives and limiting himself to approved routes. Because he showed excellent progress, he was given leeway to select his own routes within 10 miles from home. Since his depth perception continued to impact his judgments of gap and following distances at night, night driving was proscribed. A year later, a nighttime drive was scheduled and he demonstrated sufficiently improved skill that the driver rehabilitation specialist felt comfortable relaxing the night driving restriction. The patient's wife never clearly endorsed his driving, a fact that continues to frustrate him; however, she stopped objecting. He has now been driving for 3 years and has safely driven 25,000 miles locally. It has allowed him to resume part-time work and to pursue avocational and social activities.

LEVELS OF ASSESSMENT

With these examples in mind, we turn now to a systematic consideration of assessment of driving competencies and adaptive equipment needs. Specialist assessors can categorize the levels of assessment into three main sections:

1. Drivers with musculoskeletal impairment, which can be mild to severe. Mild impairment typically involves a range of adaptations to a car, or simply a change of vehicle to suit the ergonomics of the driver's disability in a more satisfactory way. These drivers can be readily evaluated using an adapted vehicle, which is essential equipment within a driver assessment program.

   Drivers with severe impairment who wish to drive from their wheelchair require a very detailed appraisal of their abilities, a precise understanding of the range of remote-controlled driving adaptations available on the market, and an understanding of which vehicles are suited to this type of adaptation. As these modifications are costly, careful prescription is needed, taking into account the person's activity tolerance, muscle strength, trunk balance, range of movement of all limbs, and potential safety while driving. In Britain and the United States, a number of companies specialize in the manufacture and installation of complex, computerized, "zero effort" driving controls into suitable vehicles.
2. Drivers with cognitive impairment, which can also range from mild to severe. The complexities of assessing the function of a driver with brain damage requires skilled attention when a return to driving is desired. Evaluation of aging drivers whose skills have deteriorated to a potentially unsafe level uncovers a whole range of social and emotional issues that they must begin to face. This aspect of driver assessment requires skilled evaluation and intervention and the support of a team to confirm and implement the assessor's findings.
3. Drivers with both musculoskeletal and cognitive impairment. This involves not only a comprehensive cognitive assessment approach but also specific evaluation for ergonomic fit of a vehicle and adaptive driving controls. It is well to be mindful of the potential for the multiplicative impact of disabilities. For example, hand controls may be easy for a cognitively intact person to learn. However, the person with mild cognitive impairments may exhibit excessive attentional constriction, hemi-inattention, or impulsivity when driving with hand controls. For drivers with variable and deteriorating conditions such as multiple sclerosis and Parkinson disease, complex issues arise involving the impact of musculoskeletal impairment on cognitive skills. Specialist assessors and close team work with the person's family or caregivers and the physician are needed to achieve an acceptable outcome. With a condition that is expected to progressively decline, the driver rehabilitation specialist should make it clear that the issue is not whether to stop driving, but when and how to do so. Along with the patient and treatment team, the driver rehabilitation specialist is to identify guidelines for making these decisions.

Although advances have been made in determining which skills affect driving safety, agreement has yet to be reached on the exact assessment battery to use. However, it is here that the multidisciplinary approach has particular value, with an on-road drive representing the final advancing vote. Essential team members include a physician, a psychologist, an occupational therapist, and a driving instructor, with other specialists such as an eye care specialist (optometrist or ophthalmologist) and vehicle modification engineer on call as needed.

While the literature focuses on providing comprehensive driver assessment services from within a large treatment facility, there is also a trend toward community-based assessment services. At this stage, the client's condition has generally stabilized and he or she has been, or is about to be, discharged from inpatient residential treatment.

Many drivers with musculoskeletal impairment who are medically stable already reside in the community and seek specialist assessment services as a further step toward independent living. A stable level of function enhances the assessment process. It enables the compilation of a realistic prescription for adaptive equipment that is suited to the individual's tested and observed abilities. Therefore, it is an advantage to see physically disabled drivers months or even years after hospital-based rehabilitation is complete.

In such a setting, the occupational therapist acts as coordinator and works closely with the client's general medical practitioner or rehabilitation team and family to obtain appropriate medical screening in preparation for driving. In community-based services, a team structure exists in different facilities, both commercial and service based, and members are called on at appropriate stages of the assessment and vehicle adaptation continuum. In New Zealand, for example, community-based, private occupational therapy services provide a focus of coordination for much of the driver assessment services. However, this may only work well in areas with a relatively low population density, such as New Zealand (population, approximately 3.5 million) (10). A significant advantage of community-based services is that they make it possible to evaluate the potential of persons with some cognitive limitations who may still be able to drive along familiar routes in their own communities.

In order to reduce the risk to the person with a disability, the assessing staff, and the public at large, efforts have concentrated on developing a screening battery prior to going on the road. The following section overviews the approaches to assessment that are commonly utilized in clinical practice and for which research has shown favorable outcomes.

Off-Road Screening Approaches

The exact range of off-road screening tools that are useful in assessing people with brain injury remain ill-defined. However, reliable results are reported in facilities where a multidisciplinary approach has been taken.

Medical Fitness

The first level of assessment is by the physician, to determine whether the person intending to drive is in a sufficiently stable condition to permit driving. If the recommended multidisciplinary driver assessment and rehabilitation services are available, the physician's emphasis should be on those medical conditions that are not apparent or intermittently produce symptoms incompatible with safe driving. These conditions include epilepsy, problems with cardiac function and circulatory efficiency, metabolic disorders including poorly controlled diabetes, and visual, neurologic, and psychiatric disorders. Essentially, the physician is being relied on to address those conditions that might not manifest themselves during clinical or behind-the-wheel assessment.

Medical screening guidelines have been developed by medical organizations and are recognized by licensing authorities. Several countries, for example, Australia (11), New Zealand, United Kingdom, Canada (12), and the United States, have manuals containing guidelines on medical fitness to drive, which usually can be obtained through the local licensing authorities or the local medical society. While these guidelines vary, in general they describe a range of medical conditions, with few guidelines on assessing cognitive function. As Gianutsos et al (13) commented, "The physician is thus placed in the difficult position of rendering an opinion both about complex cognitive functions . . . as well as driving, a domain of performance in which they have had no training or experience other than as drivers themselves." We would urge physicians in this position to seek input from other rehabilitation specialists, particularly occupational and physical therapists, and for those persons known or suspected to have cognitive/behavioral impairment, neuropsychologists. Increasing numbers of therapists are specializing in driver rehabilitation and in the United States there is a professional organization, the Association of Driver Educators for the Disabled, as well as Certified Driver Rehabilitation Specialist (CDRS) recognition (14,15). Also, in 1996, the New Zealand Association of Occupational Therapists inaugurated the first Special Interest Group in Driver and Passenger Assessment/Rehabilitation, with the aim of providing introductory and continuing education for occupational therapists in driver and passenger assessment.

Physical Skills

In the literature, no clear direction has been given in practical terms on where to place emphasis on assessing people with musculoskeletal versus cognitive impairments. In the practical setting, clinical reasoning must be used to determine the appropriateness of encompassing the whole assessment battery for people with spinal injuries and musculoskeletal impairments only. Comments on musculoskeletal impairment in this chapter are drawn from extensive clinical experience in assessing and training drivers with physical disability.

There is limited information detailing which physical skills should be measured in relation to driving and which test is to be used. In 1995 Sprigle et al (16) "surveyed 403 evaluators throughout the United States" to clarify the "methods, equipment and criteria used when assessing an individual's ability to drive." Although there was little agreement on the predictive ability of clinical evaluations, most people agreed that measurement of the following skills was important: "brake reaction time, steering reaction time, eye-hand coordination, brake force, steering force, gas force, range of motion, sensation, manual muscle strength, fine motor coordination, grip strength and pinch strength." However, not everyone used these assessments all the time. "Driving characteristics were determined most commonly by observing the task while in an evaluation vehicle, except brake reaction time . . . ," which was measured by one of three different types of equipment. Overall, simple, inexpensive techniques were used for evaluation and the majority of evaluators were satisfied with their evaluation equipment. Sprigle et al (16) concluded that "acceptable physical performance levels that could be used in driver assessment are typically unavailable to evaluators who measure driving characteristics." This was confirmed by the findings of Korner-Bitensky et al (17) who stated that "the development and testing of a standard assessment that accurately predicts driving performance will be an enormous challenge for the profession."

Throughout the assessment, the focus should be on the abilities that are relevant to the driving task from a functional perspective. In order to gauge which vehicle adaptations are most appropriate, the occupational therapist pays close attention to those actions that are difficult or impossible for the driver to perform. When considering the physical demands of driving a vehicle, in relation to any level of musculoskeletal impairment, it is useful to think of the driving compartment as a capsule, with all driving controls located on the frontal plane of the driver's body. If the capsule is divided into four segments, one for each limb, it is then easy to assign the car controls in each of the segments to each of the four limbs. This provides a convenient method of approaching functional assessment for the physical tasks involved in driving.

Upper Limbs

Physical assessment includes functional assessment of upper-limb range of movement, muscle strength, and coordination. Using the capsule concept just described, the right and left upper limbs need to be able to reach as high as the sun visor, as far laterally as the door and gear lever, and as far in front as the dashboard. These movements need to be rapid, accurate, and able to be carried out simultaneously with other tasks and without visual direction. In order to steer, one or both limbs need to be able to cross the midline in a resisted arc, which is important to be able to complete several full, resisted rotations of the steering wheel during maneuvers such as parking. Coordination and strength for steering are essential. But the exact amount of strength needed depends on the resistance from the steering wheel in the type of vehicle to be used. One older driver with Parkinson disease appeared to have adequate strength for steering the assessment vehicle: a late model car with power steering. However, his car was old and without power steering. When driving his own car, he struggled to steer the car smoothly around corners, due to his loss of muscle strength. Sharp turns at intersections were especially hazardous because of the wide arc needed to control the vehicle; he narrowly missed parked vehicles, pedestrians, and road engineering barriers.

The driver who is a "manual" wheelchair user will need sufficient arm strength and dexterity to dismantle and stow the wheelchair either inside or on top of the car. Trunk stability and upper-limb strength are also essential to enable access to the driver's seat.

Sufficient hand function and grip strength are needed to open the driver's door and to operate driving controls, which require a wide range of hand grips and dexterity. Drivers recovering from partial tetraplegia who have return of function to most of their body, but who have a completely flaccid hand, experience many problems, for instance, opening the driver's door. Unlocking can be achieved with an adapted key held between both wrists and the application of forearm movement. Alternatively a remote-controlled device eliminates this effort. However, because of the flaccid hand and absence of any muscle tone to achieve hook grip, the ability to lever up the door catch to open the car is absent. This is an important barrier. If they cannot gain access to the car, they simply will not be driving.

A range of adaptations exist for gaining control over the steering wheel when only one upper limb is functional or when arm strength is adequate but hand function is absent. Illustrated in Figure 43-9, these include a steering wheel spinner knob, tri-pin, and bi-pin. In New Zealand, a glove and pin attachment to the steering wheel results in appropriate contact with the steering wheel and a less bulky steering wheel modification. None of the devices described here cross the center of the steering wheel. In any vehicle with a driver's air bag, steering wheel adaptations that cross the center of the wheel are dangerous. On release of the air bag, the attachment will be forcibly removed and is likely to cause serious injury to the driver.

Lower Limbs

Based on the capsular driving compartment concept described earlier, there are few controls within the two segments occupied by the lower limbs: namely, the accelerator, brake, and clutch pedals and sometimes a foot-operated hand brake in the upper left segment of the lower limbs. Although relatively few in number, these controls are crucial to the safe operation of a motor vehicle and functional evaluation needs close attention.

Lower-limb range of movement is necessary to achieve a relaxed sitting position with at least 90 degrees of hip and knee flexion. Drivers who have had knee arthrodesis will need close evaluation of the suitability of their own vehicle. When they are seated in the vehicle, their foot is forced up underneath the dashboard area. The driver's seat will need to be pushed farther back, to relieve the situation. But this can result in the upper-limb controls being positioned out of reach. To relieve this situation, seating adaptations allow the affected leg to rest at a lower angle by scooping out a channel for the thigh.

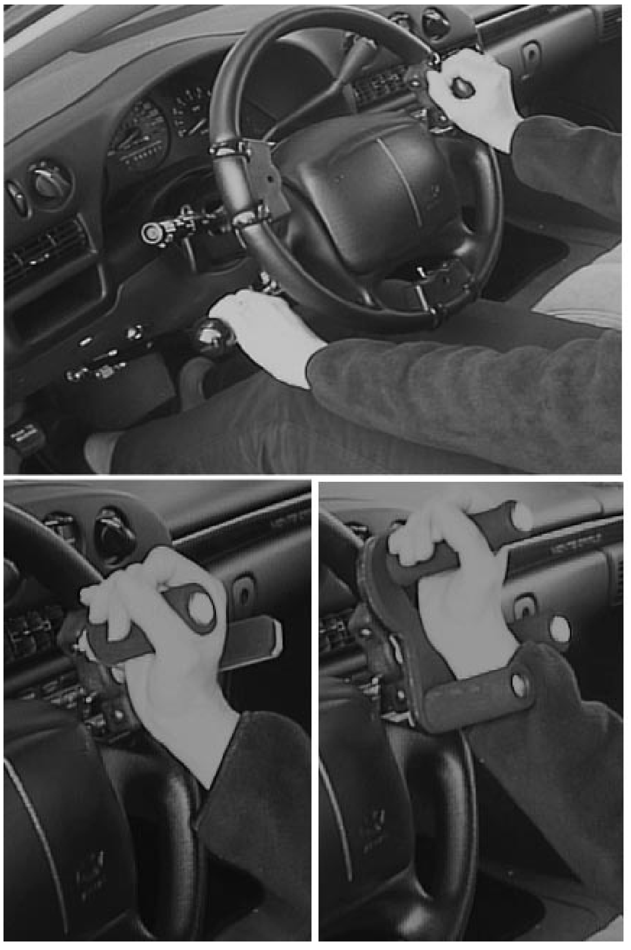


Figure 43-9. Adaptive steering wheel controls, frequently used with tetraplegic drivers, allow for a range of upper-limb abilities. *Top*. Steering wheel spinner in the right hand gives full control over the wheel, even on sharp turns. Hand controls operate the brake and accelerator pedals. *Lower left*. A bi-pin is used for those with active wrist extension. *Lower right*. Tri-pin firmly supports the wrist and stabilizes the hand of drivers with tetraplegia. Both bi-pins and tri-pins attach to the steering wheel through a pin that fits the steering wheel clamp.

Hip adduction and abduction movements are small but need to be performed with strength and accuracy. Knee extension is required for rapid, forceful braking in unexpected situations. Intact ankle plantarflexion and dorsiflexion are necessary to provide fine control over acceleration and braking. Because of the lack of ankle control, footdrop is not compatible with safe driving. Clients with footdrop who have attempted to drive report feeling puzzled that their car was constantly gathering speed. They did not relate this to their disability at the time.

Sensory feedback from proprioceptors is essential to safety. Proprioceptor impairment can result in missing the brake when stopping or confusion between the position in space of the clutch, brake, and accelerator. Causes of impaired proprioception most commonly seen in a driver assessment case load, and which can be overlooked, are trauma to nerves or joint surfaces in the lower limbs, incomplete spinal injury, mild cerebrovascular accident, multiple sclerosis, referred pain and patchy sensation from a back injury, lower-limb amputation with prosthesis, and knee-ankle-foot orthoses. Unsafe driving methods used by drivers with these disabilities may include using their hands to apply pressure to their knee for varying amounts of acceleration; achieving braking by using their hand to lift the leg from the accelerator to the brake pedal; only being able to locate the pedals in daylight as they rely on visual cues for foot movement; using their left foot on all pedals instead of using their right foot; and amputees driving with prostheses who report missing the foot pedals and accelerating instead of braking.

Lower-limb muscle endurance is another important factor in determining whether it is advisable to use the lower limbs for driving. Where there is any question of intermittent function, such as in multiple sclerosis, it is always advisable to perform the assessment during the days or activities that result in the lowest level of function. There is often a desire from drivers with intermittent leg function to use their legs on good days and hand controls on off days. Clinical experience from reports of a number of clients who have done so suggests that this can lead to involvement in crashes, probably because the person does not consistently use one driving technique.

Spinal Injury

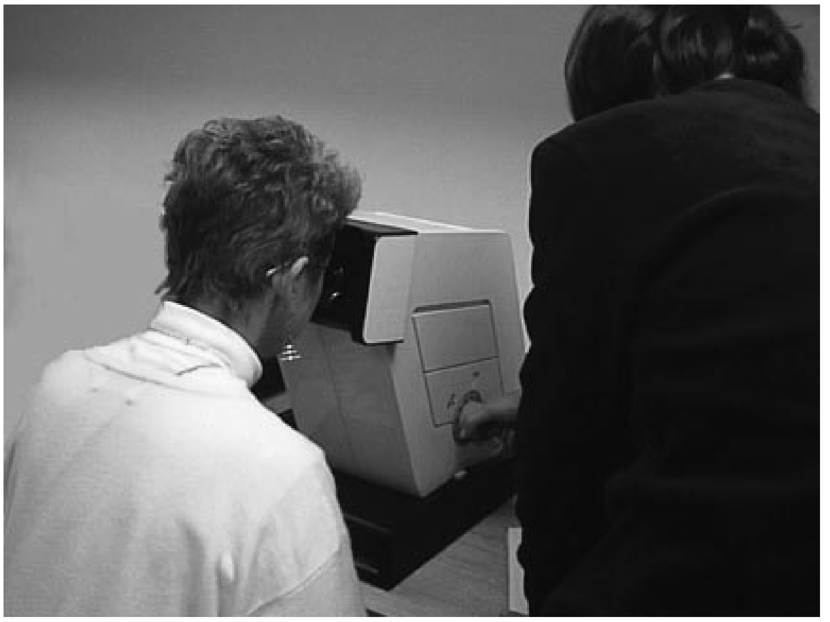
The ability to raise the head to see the roadway ahead of the vehicle and maintain this position during driving is essential. Difficulty in head rotation will indicate the need for wide-angled mirrors and retraining to use them correctly. People with rheumatoid arthritis, ankylosing spondylitis, reflex sympathetic dystrophy, and cervical injuries such as severe whiplash are frequently affected. In order to bring the reduced vision to the clients' attention, it is useful to make a "map" of the blind spots, using cones or markers on the ground around them while they are seated. Translating this to the car can help convince people of the need to compensate for the gaps with the use of mirrors and to open them to acceptance of retraining.

Following a stroke, spinal rotation can be markedly restricted, probably due to the imbalance of the muscles in the trunk and spinal regions. This results in difficulty when turning to reverse the car and may require new learning with the use of mirrors in order to achieve safe maneuvers. An estimation of sitting balance is important for people with weak trunk musculature because upper-body stability is essential to maintain full control of the vehicle when cornering.

Visual Skills

The importance of visual skills for driving cannot be overemphasized. For instance, Wylie (18) estimated that

Figure 43-10. Stereoscopic vision screening testing device at the Easter Seals Mobility Center, Meriden, CT. This model is made by Stereoptical and other models are produced by Titmus and Keystone.



approximately 90% of the information processed while driving is taken in through the visual system. Nevertheless, some have raised questions, citing the importance of higher-order attentional processing (19) and instances where persons with significant visual impairments have been able to drive safely (20,21). In attempting to resolve this apparent contradiction, Gianutsos (22) cited the multiplicative effects of combinations of disabilities, whereby substantial isolated disability can be managed, but in combination with another disability (not necessarily substantial) the resulting effect is magnified outside safe limits. So an individual might be able to compensate for isolated visual field impairment or an oculomotor problem, but not both.

Strano (23) discussed the relationship of visual acuity to road engineering signage. In brief, when visual acuity is reduced, the time available to react to visual stimuli is equally reduced. Since visual fields are neither routinely nor periodically checked, and people with visual field losses may remain unaware (24), there are drivers with visual field loss. However, in most medical guidelines, homonymous hemianopia is deemed incompatible with safe driving. Quadrantanopia is a barrier to driving in at least one Australian state (11). Strano (23) discussed the difference in quadrants and their impact on driving. In her experience, upper-quadrant hemianopia will have more serious implications on driving than lower-quadrant defects. From an international perspective, relative seriousness of left- or right-quadrant hemianopia will depend on which side of the road the person should be driving. Visual fields are rarely seen to improve over time, even with retraining. Within optometry there are new optical interventions for visual field loss that may also enable otherwise intact persons with field loss to drive safely (24–28). Strano (23) also recommended that better compensatory field of vision can be obtained by "placing the [side rearview] mirror well forward on the front fender." Wide-angle mirrors can also be helpful, although the type and placement must be considered carefully so that confusion does not substitute for increased information.

Low lighting conditions, tiredness, ill health, and stress also negatively impact mild visual defects (23). Monocular vision produces a decrease in the available visual field and impaired depth perception (23). A wing mirror fitted to the side of the missing eye may be helpful. Careful evaluation and monitoring are essential under these circumstances.

Many driver rehabilitation specialists use a stereoscopic vision testing device, such as the one illustrated in Figure 43-10. In a few minutes these devices can be used to test acuity, binocular vision and stereopsis, and color vision and to screen for responsivity in the horizontal peripheral field. Some include measures of contrast sensitivity, which has been found to correlate with at-fault crashes (29). Computerized protocols for measuring the functional visual field (24,30) or the useful field of view (19,31) have particular value, as problems in these areas have obvious and demonstrated relationships to safe driving and are often poorly recognized by the individual with impairments.

Cognitive Skills

Driving is such a complex skill, requiring efficient, integrated functioning on all levels under pressure of time, that the relative importance of the skills involved is inherently difficult to define. Some facilities have used extensive neuropsychological testing (8,32) while others have reported success with specific computer assessment of a relatively small range of cognitive skills (9,13,33).

Cognitive skills that appear to be important for a positive outcome in driver assessment are visual discrimination, nonverbal reasoning, sequencing, spatial orientation, visual scanning, figure-ground discrimination, visual tracking, and right-left orientation (6). In 1992 Galski et al (8) found "visual perception . . . visual spatial analysis and synthesis, visuomotor coordination . . . planning, organising and executing test operations . . . scanning and attention, particularly selective sustained attention, . . . to be important in the prediction of actual performance." Galski et al (8) went on to warn that "many deficits in cognition did not adversely effect safe driving and were not equally important in predicting driving performance." Over the years, we have known, for example, people with profound recent memory impairment and aphasia who have sustained safe driving records. While these factors can serve as multipliers of other disabilities, they are not per se incompatible with safe driving. Carmella Strano was heard to observe at a conference that what counts is how the person deals with such problems; for example, does he impulsively cross several lanes of traffic to make a turn for which he had forgotten to prepare?

Others may bring loss of contact with reality to the clinician's attention, if not directly observed. While the implied lack of awareness has serious implications for driving safety, fortunately, there are usually others who recognize the need to intervene at this point to dissuade or prevent the person from driving. In these cases, it may not be productive to confront the individual, but rather to advise the family to assist with alternative mobility and to avoid the issue, if necessary, by removing or disabling the vehicle.

To the list of factors that need not be emphasized in the evaluation, we should add variables, such as glare sensitivity, of which most drivers are aware and experience as barriers to driving safely.

A validated screening assessment battery, The Stroke Drivers Screening Assessment, was developed by Nouri and Lincoln in Nottingham, England (34). This assesses concentration, nonverbal reasoning, and (British) road sign recognition. It takes approximately 1 hour to administer and is intended for use by a variety of health professionals as an initial screening tool to identify those who are definitely unfit to drive a car. In the United States, the Cognitive Behavioral Driver's Inventory (CBDI) (35) was developed psychometrically [normed (36) and validated (37)]; however, it lacks face validity (does not look to the client as if he or she has a relationship to driving) and its clinical utility is thereby reduced.

Complex, but noninteractive driving simulators, such as the Doron Driver Analyzer illustrated in Figure 43-11, originally intended for learner driver education, do have face validity, but have not been shown to predict the outcome of driving performance for people with disabilities (8,13). Simulation has much potential if it offers a dynamic interactive task that has a look and feel of driving (9,38–41). For instance, the authors of two computer programs developed specifically for the detection of impairment in brain-injured drivers in Christchurch, New Zealand (4), and New York, United States, (13), reported validity when computer results were compared to on-road driving skills (9) and driver self-reported limitations (42). In using computerized assessment and on-road evaluations with 261 drivers over 62 years old, McKnight and Lange (43) reported that "cognitive deficits evidenced the strongest association with unsafe (driving) performance."

Figure 43-11. Doron Driver Analyzer at the Easter Seals Mobility Center. When performing the simulation, the patient would be viewing a video projected on a large screen directly ahead. The console is physically realistic; however, the task is not interactive (i.e., nothing that the patient does changes the display).

The success of computer-based programs is undoubtedly due to the unique ability of the computer to provide interactive, multiple information-processing tasks, at speeds similar to those of the human brain. They take less time to administer and can rapidly analyze and present results. The need to assess global skills at rapid speeds in real time may account for why pen and paper assessment processes have difficulty in predicting the outcome of driving safety. Experienced driver rehabilitation specialists, such as Amy Campbell of the Easter Seals Mobility Center (Meriden, CT), have dropped the paper and pencil procedures altogether, citing their lack of either face or empirical validity (personal communication, 1995).

Knowledge of Road Law

For people with brain impairment, additional tests examine knowledge of road law and decision making when presented with a variety of traffic situations, using road signs, slides, or videotapes (44).

Client and Family Interviews

Important information regarding premorbid driving habits, past driving experience, current license status, and general personality traits can be gained from the client and a close family member or friend. Although the information obtained is subjective, family and client interviews may add greater understanding of a wide range of lifestyle issues related to driving and place into context otherwise puzzling objective assessment findings.

It is important to remember that driving is not an end in itself, but merely a means to achieve a lifestyle goal as well as to carry out important life roles. Therefore, if one can understand the person's life roles in relation to driving, then final advice can be given in terms of which roles can be continued safely and which will need to be revised.

In-Car Static Assessment

This assessment takes place in the practical setting: in a vehicle. For people with minimal physical disabilities, it is preferable to view their needs in relation to the car that they would normally be driving. For people with cognitive impairment only and no physical disability, this stage will be carried out rapidly and with minimal detail, as part of the preparation for an on-road drive.

For most musculoskeletal driving assessments, a specially adapted vehicle with dual-control brake and accelerator will be required. The aim of this stage of assessment is to identify the actions that the person can easily perform and to develop a detailed prescription for driving adaptations. As this phase usually involves a large amount of detail, the use of a printed checklist is essential. A sample list is provided in Figure 43-12. One outcome of the static assessment may be that the current vehicle is clearly unsuited to the client's ergonomic needs and it should be replaced with another of more suitable design.

Mobility Aids

If the goal is for fully independent function, depending on the level of musculoskeletal impairment, the type of mobility aids and method of stowage inside the vehicle will need careful consideration. For instance, because of its awkward shape, a lightweight fixed-frame wheelchair, with wheels removed, is much more difficult to stow inside a car than a similar folding-frame wheelchair. This is most noticeable in a four-door vehicle, where the driver's door pillar and the steering wheel restrict the space available. Drivers with limited mobility may use a wheelchair for longer journeys outdoors (e.g., for shopping) and elbow crutches for short distances indoors. Therefore, consideration will need to be given as to how the wheelchair is to be stowed, who will accomplish this, and whether the car design allows for safe mobility when negotiating door openings.

Access

For some people, it is an accomplishment to achieve mobility as passengers. In this group are teenagers and adults with multiple handicaps, including physical and mental disabilities ranging from moderate to severe. It also includes former drivers who are no longer fit to do so. Whether in cars or vans, there are issues associated with method of access, stowage of mobility equipment, safety requirements, and caregivers.

The height of the driver's seat, width of the door opening, shape of the seat, and amount of leg room once inside may all impact on the functional ability and safety of the driver with a physical disability. The exact method of transfer into and out of the vehicle has a large impact on vehicle selection. If transfer from wheelchair to seat is not possible or contraindicated, then a van rather than a car will be required. If the driver is a permanent user of an electric wheelchair, a suitable vehicle must be selected to allow adequate head clearance when entering and exiting the vehicle, as well as when sitting in the driver's seat. As illustrated in Figure 43-13, floors of vans can be substantially lowered in order to achieve access. In addition to access to the van via a wheelchair hoist and specialist driving controls, appropriate wheelchair securing and safety belts will also be required. Assessment for people who intend to drive from their wheelchair is complex, involving specific decisions about the need for costly equipment, which this chapter does not aim to explore; detailed information should be sought from specialist driver assessors.

A variety of issues concerning access to the driver's seat of a car become a problem depending on the type of impairment. For instance, people with back injuries experience difficulty due to restricted or painful spinal flexion and rotation. This is magnified in a sports car that is low to the ground. Older people with arthritic conditions in their spine also experience this difficulty. In this respect, there is an ergonomic mismatch. On the one hand, drivers cannot reduce their body dimensions and have difficulty folding their body into a flexed position and on the other, car design has evolved to leaving a small hole in the car frame for the driver to squeeze through at the door opening.

STATIC ASSESSMENT:

DRIVER ACTIVITY ANALYSIS

Name: .... *Date:* ..../..../.... *Vehicle used:* ....

1. TRANSFERS

2. DOOR OPENING
   Key: lock & unlock

3. SEAT
   Adjust & tilt
   Seat belt

3. STEERING WHEEL
   Grip
   Turn
   Right/Left arm used to steer

4. BRAKE PEDAL Right/Left leg used for braking

5. ACCELERATOR PEDAL Right/Left leg used for accelerating

6. CLUTCH PEDAL

7. GEAR LEVER Engage through gears

8. HAND BRAKE

9. REAR VIEW MIRROR

10. SUN VISOR

11. WING MIRROR/S

12. IGNITION Insert key and start engine

13. HORN

14. WIPERS

15. TURN SIGNAL

16. LIGHTS

17. HEATER/DE-MISTER

18. TRUNK

Recommendations:

Figure 43-12. Form for static, in-car assessment.

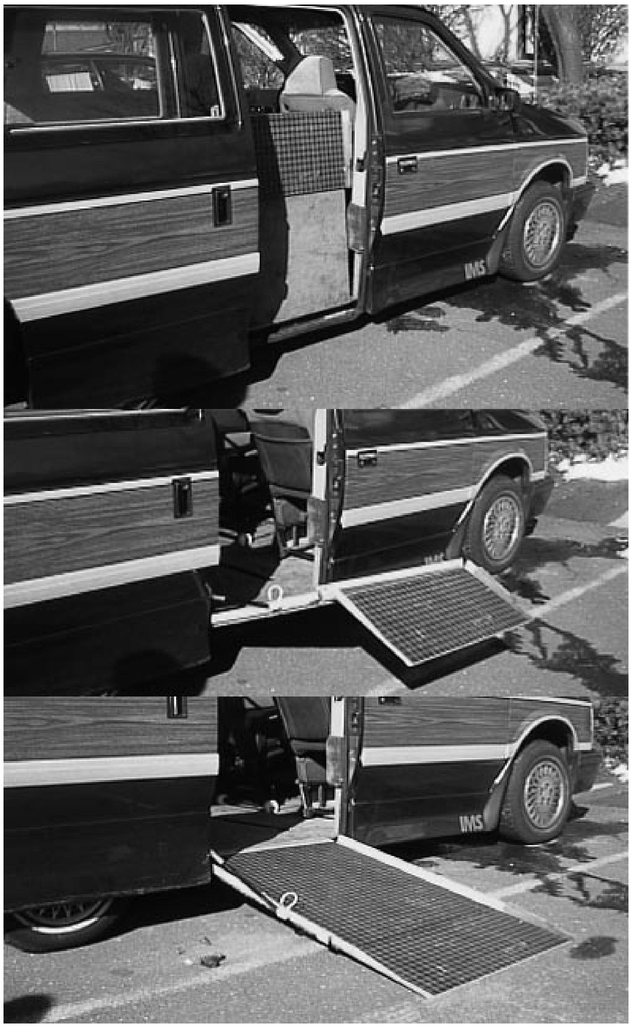


Figure 43-13. Adapted van at the Easter Seal Mobility Center. The floor has been lowered by 10 inches on this van. A side-mounted hoist installed in a van allows self-loading and driving from a wheelchair. *Top.* The door opens by remote-controlled switch. *Middle.* The hoist lowers automatically. *Bottom.* Hoist in wheelchair loading/unloading position.

Primary Driving Controls

For convenience of clinical reasoning, New Zealand occupational therapists distinguish primary and secondary driving controls. Primary controls are those essential to the driving task, that is, steering wheel, brake, accelerator, clutch, seat belt, and turn signal. They are used most frequently in optimum daylight driving conditions and therefore carry high priority in determining whether driving is possible. During in-car assessment, it is important to attend to these first.

Drivers with a spinal injury who use hand controls often need extra space to rest their legs, in order to avoid kinking the catheter tube and to maintain body balance. To enable this, the right-sided accelerator pedal can be hinged out of the way. This is also an important safety precaution when lower-limb extensor spasm is present, as a hinged accelerator ensures that unwanted acceleration is not applied during spasm. During driver training, one paraplegic client had a recurring problem of simultaneous extensor spasm in his right leg and flexor spasm in his left leg that interfered with the steering wheel. The spasms seemed to be triggered by anxiety and were noted during complex traffic situations. He was advised by the assessor to see his physician for a review of antispasmodic medication. There was a reduction in spasm sufficient to allow him to pass the practical driver's test without anxiety-produced lower-limb spasm.

In the absence of reliable function in the right leg, and when an automatic vehicle is used, a left-sided accelerator pedal can be added. Retraining is important so that the driver can use the same movement under all driving circumstances. In order for other people to also use the vehicle, it is standard practice to hinge the right accelerator so that it is out of the way but available for normal use. Reports of minor scrapes in driveways and garages caused by friends and family who attempt to drive the modified car illustrate the importance of ensuring the client is well educated in safety precautions.

Short drivers may require a range of driving adaptations including raising the height of the foot pedals. At the same time, it is necessary to reduce the length of the seat base to ensure that knee flexion is possible. A raised false floor gives the driver greater body stability when driving. Kleinberger and Summers (45) reported that severe or fatal air bag–induced injuries are more likely to occur in short female drivers (1.60 m) who do not wear a safety belt and who sit closer than 10 inches to the steering wheel. Therefore, it is imperative that satisfactory methods be found to enable the seat belt to be worn and the air bag mechanism to be turned off when it cannot be safely deployed.

Secondary Driving Controls

The remaining in-car controls represent the actions taken intermittently when driving, many of which can be adapted for easy use or operated by remote control. Frequently requested remote-control functions include adjusting headlights, controlling windshield wipers, and opening and closing windows. Special attention will need to be paid to drivers with marked hand impairment, such as that caused by rheumatoid arthritis, tetraplegia, severe hand trauma, and upper-limb amputation. In considering this list, the roles and lifestyle of the driver become important. For instance, daily use of fee-paying parking buildings means that it is essential for the driver to be able to operate the driver's window quickly; and the driver's desire for music while driving will influence what type of switches are appropriate on the radio or cassette or CD player.

On-Road Assessment

Issues

Many debates have arisen over the reliability and validity of using actual on-road driving for behavioral and cognitive assessment; nevertheless, it is an essential component of driver rehabilitation. Indeed a standard of care is evolving (46) to the effect that no one should be allowed to resume driving without an on-road assessment. This is not to say that everyone should be taken out on the road. Nor does it mean that performance on the road test overrides the outcome of the in-clinic assessment. Realistically, the aim is to determine whether persons with a disability are likely to be able to cope with driving in their locality, mostly on familiar routes, in order to pursue their goals and life roles. Whether drivers are likely to drive more than this or for extended periods outside familiar areas will have been discovered during client and family interviews. By this stage of assessment, hopefully anyone clearly unsuited for driving has been screened out of the program.

During the assessment of drivers with musculoskeletal impairment only, the on-road drive fulfills a slightly different role. Having established what range of adaptive driving equipment is likely to be suitable, the next step is to confirm in practice that drivers are actually able to use the equipment safely. There is a substantial learning curve when changing any type of driving technique, whether complex or simple. Sufficient time must be allowed for drivers to determine that they have full control over the vehicle before entering traffic flows. Essentially, they have become learner drivers again and will require competent instruction in order to feel safe in the new environment. The assessor needs to be aware of the emotional dynamics happening at this stage, and to stop and diffuse problems at any sign of unease. Drivers with low self-esteem may not feel confident in their abilities to drive; if they were injured in a motor vehicle crash, their first time back in the driver's seat may have heavy emotional significance; or they may simply have difficulty coordinating their limbs in a new way to achieve vehicle control. The use of an adapted vehicle with dual controls is essential to safety when assessing or retraining drivers who are new to driving with a disability.

Because occupational therapists (with their deep commitment to function) and most clients are impressed by the face validity of the on-road assessment, it is perhaps in order to introduce some considerations to modulate this enthusiasm, and to inspire improvements. First, "the" road test means many things to many people. Therefore, the tests actually used have no norms or established reliability and validity. In other words, the road test given to most clients does not even begin to meet the most basic standards for psychological tests and measurements (47). Interestingly enough, there have been attempts to develop a standardized road test (48,49) and substantial effort went into establishing its reliability. This "Michigan" test—unknown to most therapists in the United States—was adopted and adapted in New Zealand for evaluating advanced learner drivers (50). Implementation in each locality calls for extensive study of the level of skills accepted by the police for safe driving, establishment of a route containing a wide variety of driving conditions, and documentation during and after the 40-minute on-road drive. The documentation for each locale is several centimeters thick (about the size of a large urban telephone directory). Examiners receive 2 weeks of specialized training. Needless to say, the practical hurdles are significant, especially for community-based services. There is a major need to develop a practical on-road assessment protocol that can be implemented in different locations, with norms and acceptable levels of measurement reliability.

Then again, it would still be necessary to demonstrate that the test is a valid index of the individual's ability to drive safely. The appearance of validity, while clinically essential, is not sufficient. The vexing issue faced by all attempts to proving the validity of a given measure of driving, whether off-road or on-road, is the lack of an independent criterion. For older drivers free of overt neurologic diagnoses but with possible age-associated cognitive decline, one can attempt to use recent driving record—but even that is influenced by reporting and recording variables. A fundamental problem for measurement (but not for safety) is the fact that most older drivers limit themselves when their capabilities decline (42). Statistically, the validity coefficients shrink when poorly performing subjects maintain good driving records, because they drive very little.

Even if such a protocol were available, it would constitute a limited sample of performance, and being watched could cause the individual to be nervous, or at least, on their best behavior. Indeed, one insightful therapist looks for just this capability: Does the client recognize that the testing situation calls for one's "best behavior"? (51).

The face validity of the road test is a significant plus, but even if the psychometric limitations could be resolved, it would not be a complete assessment, its functionality notwithstanding. With off-road procedures aimed at assessing cognitive skills only, it is possible to simulate the types of crisis situations and to measure performance in precise quantitative ways. The most demanding aspects of driving can be safely condensed into a practical time frame. The more the off-road procedure simulates driving (i.e., has face validity), the more clinically effective it will be.

Many therapists have developed expertise to conduct on-road evaluations, through choosing quiet roads to minimize risk and then graduating the client to drive through increasingly busier areas. Some also become qualified driving instructors. Another approach recommended by trainers of occupational therapists as driver assessors in

Australia, and now accepted as standard practice, is for the therapist to collaborate with an experienced local driving school instructor with an interest in working with drivers with disabilities. The therapist observes and records findings from the back seat, free of the responsibility to ensure that the vehicle is operated safely. Under some circumstances, after observing the driving instructor, the therapist may feel comfortable enough to rely on the instructor's report. In uncomplicated cases where the individual has done very well on the in-clinic assessments, it may be sufficient to have a report from a local driving instructor.

If the coordinating therapist is not participating in the on-road evaluation, it is important to structure the process in such a way that the final recommendations remain in his or her hands so that all the findings and medical information are taken into account. While the on-road assessment may be the final step in the process, the results should not be the last word. For instance, off-road screening can show marked deficits in some areas of cognition that are not observed while on the road. At the least, the driver should be counseled by the therapist following the on-road drive and be made aware of what factors may constitute risky driving situations.

Finally, we must acknowledge that the state of the art in road testing is the "sweat index"—a global integration of the examiner's objective observations and subjective comfort level, signaled by his or her autonomic nervous system.

Routes

A review of published clinical practice (33,52) shows that occupational therapists, working with driving instructors, progress the client through a series of routes of increasing complexity. Fox et al (52), in Sydney, Australia, used four "standard assessment driving routes of increasing complexity . . . each requiring about 50 minutes to complete. The least complex drive is conducted within the Centre grounds, and the most complex in heavy density traffic incorporating freeway driving, road map navigation and multistorey car park manoeuvres where appropriate."

During this time, observations are recorded on a printed sheet that lists predetermined risk factors. van Zomeren et al (7) compiled an extensive list of commonly found driving faults. In New Zealand, driving instructors now use an Advanced Assessment and Training Report (53) as part of a three-tier licensing system. Occupational therapists in New Zealand are also using this same assessment approach. "The purpose of the assessment is to require drivers to demonstrate that they are skilled in the areas of Hazard Identification, Judgement, Manipulating Controls and Observing Traffic Regulations." The assessment is to last 40 minutes. The route "will, where practicable include suburban highway and motorway [freeway] conditions with at least 20 minutes of the time spent in busy city / town situations. (Medium to heavy traffic conditions should be sought)" (53).

An informal review of on-road assessment protocols in use in many driver rehabilitation programs indicates that the emphasis is on the operational level (i.e., mechanical skills). As suggested earlier, consideration should be given to incorporating the tactical level into the assessment. While examiner preparation and standardization call for a fixed route, this very fact removes the opportunity for tactical decision making regarding the route, unless the assessor specifically allows for it, for example, by asking the driver toward the end of the drive, "Can you find your way back now?"

COMMUNITY INTEGRATION

From the functional perspective of occupational therapy, besides formal assessment, it is helpful to examine the reality of the client's actual situation more fully.

Environmental Data

Terrain

Knowledge of the area in which the person with a disability intends to drive is an important aspect. Understanding the area and risks inherent for a particular disability will help to bring a practical focus for the client and family. Demonstrating a realistic understanding of the client's situation is likely to aid adherence to any recommendations made.

If the area is hilly with winding roads, then methods to maintain upper-body balance when cornering will be essential for people with weak trunk stabilizing muscles. Evaluation or prescription of the design of the driver's seat will also be necessary.

If a client with a back complaint is likely to be driving over rough ground, over poorly maintained or unsealed roads in rural areas, or over tram and railway tracks in the city, then no intervention is likely to be successful as it is the environment that is compounding the disability. If the vehicle is a light van or truck and the driver's seat is positioned over the front axle, the effect is to amplify every jolt on the road. In this instance, the vehicle and the terrain may become the prime focus of advice to the client. For instance, in the short term, the goal may be to avoid driving or to find alternative routes, and in the medium to long term to change the vehicle as well as the place of residence.

To illustrate, a client who recently had spinal surgery correctly identified the poorly maintained roads near his country home as a barrier to his return to work. However, he did not realize the importance of changing his vehicle from a four-wheel-drive vehicle with hard suspension to that of a sedan with highly absorbent suspension. He drove both vehicles over the same route. Whereas the four-wheel-drive seemed to magnify every small bump on the road, the sedan simply absorbed them.

For someone with cognitive or psychiatric impairment who is prone to concentration lapses, the monotony of driving on long, straight roads, such as on the freeway or in the Australian outback, is likely to contribute to a crash.

Climate

Weather factors specific to the driver's locality also need consideration. People with impaired contrast sensitivity may not be able to drive safely in mountainous areas where there is poor illumination during fog, drizzle, or snow. People with poor glare recovery may also be affected by oncoming headlights at night as well as environmental factors. For instance, during summer months in Auckland, New Zealand, commuters traveling west into the sun are at high risk of accidents due to what has become known as "sunstrike" (i.e., being dazzled by glare from the sun).

Behavioral

Galski et al (8) found that "behavioral measures . . . showed significant correlations to driving performance in traffic . . . it indicated that drivers who manifested specific [safety compromising] behaviors achieved poor outcomes in traffic." In his book, *Traffic Safety and the Driver*, Evans (1) devoted an entire chapter to driver behavior. Driver behavior is not what the driver can do but what the driver in fact does do. It is initially surprising to discover that in a study of the safety of racing car drivers and closely matched comparison drivers, "on a per year basis, the racing drivers had substantially more crashes and more violations, especially speeding violations." Evans provided a great deal of evidence that "we drive as we live." Evans (1) continued, "If his personal life is marked by caution, tolerance, foresight and consideration for others, then he would drive in the same way. If his personal life is devoid of these desirable characteristics then his driving will be characterized by aggressiveness. . . ." Therefore, when one is assessing drivers who lack insight, such as those with frontal lobe impairment and unresolved psychiatric conditions (the impulsiveness of hypermania, delusional thoughts or voices, unstable mood levels), assessment battery results must be interpreted with caution. During off-road assessment, additional emphasis therefore will need to be placed on safety-compromising behaviors.

Ethical and Legal Issues

Professional experience and even some data (54) reveal that many practitioners are unaware of their responsibilities to their patients regarding driving. Some useful articles are available on this subject (55,56). Gianutsos formulated a statement on "What happens to your New York State driver's license after a brain injury?" addressed to patients. She had the statement reviewed for accuracy by the New York State Department of Motor Vehicles. It is included as Appendix I and readers are encouraged to adapt it to their own jurisdictions. (They may adapt and distribute it if they acknowledge the source and send her a copy.)

Some rehabilitation specialists adopt a "don't ask, don't tell" posture regarding driving. It is safe to assume that all patients who were drivers are would-be drivers, no matter how severe their disabilities. Apprehensive about a negative decision, if there are no significant physical disabilities, they may not seek advice on the issue. However, as Antrim and Engum (57) emphasized, there is no legal safety in rehabilitation facilities' avoiding the issue of driving. Nor is ignorance of the applicable law an excuse.

In most jurisdictions there is an agency that controls licensure (e.g., the Department of Motor Vehicles in individual states in the United States, the Ministry of Transport in New Zealand, and the Roads and Traffic Authority in Australia). In some cases these agencies are national and in others, state or provincial. There is a legal code that governs this agency, as well as statutes that detail its practices. These rules include what medical and visual standards must be met for initial licensure and renewals. The most significant issue for rehabilitation professionals is whether and how the existence of a disability comes to the attention of the licensing agency. The range of possibilities includes mandatory reporting by health care providers, optional reporting with immunity (against claims of violation of confidentiality), reporting by the individual prior to resumption of driving, and reporting upon renewal of licensure. In the United States six to eight of the states have some form of mandatory reporting. British Columbia has an interesting variation with what could be called "mandatory reporting to the individual" (i.e., a mandate to raise the issue and make recommendations) followed by reporting to the licensing agency in those instances where noncompliance comes to the provider's attention. Because there is such a wide range of possibilities, it is essential for practitioners to find out from their local licensing agency what the law is.

Prior to initiation of the driving advisement process, it is important to have an explicit statement about what will be offered, individual responsibilities, and to whom the resulting information will be sent. Gianutsos uses a "Memo of Understanding" for this purpose, offered as Appendix II, which can be adapted and used to meet individual needs. It is recommended that the patient receive a written copy of the resulting report and recommendations. We have received a legal opinion that it is not sufficient to make an entry in the patient's medical record about recommendations given orally.

Helping patients return to safe independent mobility is part of our clinical mission. While the legal aspects may be daunting, we must give patients access to every resource and clinical insight we can marshal. If the outcome is not favorable, they need to know why: They may not be entitled to a license, but they are entitled to an explanation. Further, we need to offer constructive, and often creative, suggestions regarding mobility alternatives.

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APPENDIX I. WHAT HAPPENS TO YOUR NYS DRIVER'S LICENSE AFTER BRAIN INJURY?

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Dr. Gianutsos was a member of the NYS DMV's Medical Advisory Board which met in 1988–89 to review policy. She chaired the Subcommittee for the Elderly and Disabled Driver. She is not currently associated with the DMV. The information below represents her own views and, while every effort has been made to assure accuracy, not official DMV policy.

Whether you can drive safely is NOT what this is about: **If you have survived a brain injury and you want to drive again, first take the matter up with your doctors and therapists.**

What follows IS information about the NYS Department of Motor Vehicles' (DMV) rules and procedures concerning your driver's license. For the moment, we assume that you hold a valid NYS operators license to drive an ordinary private car. For trucks, buses and other commercial vehicles the rules are much stricter if you drive interstate.

Your license remains valid until it expires or DMV takes action to suspend or revoke it. Suspension and revocation actions can be taken for many reasons, including too many points for moving violations or involvement in a crash in which someone was killed. DMV can review your qualifications for licensure if they receive a complaint from another person, including a health care professional who is treating you. However, health care professionals are not encouraged to make reports as you can file a lawsuit for violation of your privacy: The law does not afford them immunity.

So the answer to the question of what happens to your license is, simply, nothing.

Well . . . not quite.

An issue may come up when you renew your license depending on your answers to the questions which DMV asks all drivers on renewal (which are similar to the questions asked applicants for new licenses). **Your answers may trigger a request for medical information and a review.** The renewal form is the MV-2M. An older form (MV-2) dated 1/89 is still being distributed. A word to the wise: **interpret these questions literally and answer them honestly**. It is in your interests to inform the DMV about your status and to keep a copy of any records of your having done so. Should you have a serious accident, no one will be able to claim that you got, or kept, your license when you were not competent and should have known better.

What are the DMV license renewal questions?

- **Since you applied for a license, or since your last renewal was issued: Have you had, or are you being treated for, any of the following, or has a previous condition gotten worse?**

- **Convulsive disorder, epilepsy, fainting or dizzy spells, or any condition which causes unconsciousness**
- **Heart ailment**
- **Hearing impairment**
- **Lost use of leg, arm, foot, hand or eye**

A review occurs if you answer "yes" to any of the questions.

What kind of health care provider can fill out the DMV forms? The form will often be quite specific. Usually a medical doctor who has treated you in the last 3 months will do; however, in cases of seizure disorders (recurring periods of unconsciousness) a neurologist or neurosurgeon will be needed. The DMV may accept a report from a neuropsychologist or other qualified individual. Such a person should be prepared to explain why they are qualified, and this may add to the time it takes to resolve the matter.

The DMV has a Medical Review Unit (Medical Review Unit Driver Improvement Bureau, New York State Department of Motor Vehicles, Empire State Plaza, Albany, NY 12228 (518 474-0774) which has a medical consultant; however, there is no standing Medical Advisory Board.

If you require a medical report, the doctor will have to sign the following statement: "***The patient's medical condition would not interfere with his/her safe operation of a motor vehicle.***"

Specific Conditions

Vision

- If you can read at **20/40 or better** on an ordinary eye chart (with or without glasses), you meet DMV's requirements. If you are aphasic (have language problems), you can have an eye doctor certify on a DMV form which the doctor usually can supply.
- If you have **lost the use of one eye**, you can still qualify to drive a car, but can not drive commercially.
- If your **acuity is between 20/40 and 20/70**, you must submit a report by an eye doctor. These are the only circumstances in which you will have to meet the DMV's requirements for **visual field**: a span of what you can normally see with one eye (140 degrees, or almost 40% of the perimeter of a circle). If you have a "**homonymous hemianopia**" (don't see one half of the field of view in each eye), you will NOT meet this standard. Strictly speaking, if your acuity is good, you could have tunnel vision and still qualify for a NYS license. This is an obvious **loophole in the regulations**. In many states and most of the rest of the world, you would not even be considered for a license with such a loss of vision. If you have a visual field problem or "neglect," you will have a difficult time compensating, especially in busy, complex or new situations, or when you are tired or distracted. Most important, you are probably under-aware of your loss—you literally may not see any problem! . . . not because you deny or neglect it. The human nervous system normally fills in the gaps (which is only a problem when there are substantial gaps in the field of vision).

Any Condition Which Causes Unconsciousness

- This item used to be "loss of consciousness" and is the one which often leads to medical review for people who were unconscious for a period of time following a head injury. Unless you have a seizure condition (see below), you may have your primary care physician fill out form MV80-U based on an examination performed within the last 120 days.

Seizures

- Officially, you must be seizure free for a year. In practice, the DMV may accept 6 months. The MV80-U form must be filled out by a board certified/eligible neurologist or neurosurgeon based on an examination performed within the last 120 days.

Tips:

- **Renew early** if you anticipate Medical Review. You can renew as much as 6 months before your license expires. Do not wait for DMV to send you renewal forms. The Medical Review process takes time, up to 6 weeks they estimate. If you have to supply further information, it's another 6 weeks. Begin early and you won't be grounded while they review it.
- **Renew late** if you need time to recover. You have up to 2 years following your license expiration to renew using ordinary procedures. While, during that year, you can not drive, you will not necessarily have to take a written or road test and be treated like a new driver.

Comment

Some people think it is shocking that doctors are not required to report people with conditions which might affect driving to DMV. This "mandatory reporting" exists in a handful of states and is inconsistently applied, like the 55 mph speed limit. It forces your doctor to wear two hats: as your doctor and as an agent of the state. Some drivers would not seek treatment if they thought it might jeopardize their license. Given the right information, in an understandable form, the vast majority of drivers will, perhaps reluctantly, make the right decision.

APPENDIX II. *DRIVING ADVISEMENT: MEMO OF UNDERSTANDING*

between ____________________ (examinee) and ____________________ (examiner)

The computerized driving advisement procedures (Functional Visual Fields and Elemental Driving Simulator) have been developed to help people find out if they have necessary cognitive skills for driving safely. Driving is a very serious matter, because, as many of us are painfully aware, grave injury can be caused by crashes. Not only do drivers risk their own safety, but also that of other drivers, passengers, pedestrians and cyclists as well. It is hoped that these services will give useful information to help would-be drivers to make informed decisions.

1. **Conclusions based on comparison with how safe drivers do**. What kinds of conclusions can be drawn from these procedures? First, we have tested safe drivers of varying ages on these procedures and will be able to compare how you do to how they did. If you fall within their range of scores, however, you are not guaranteed to be safe on the road. Or, if you fall outside the normal range, it may not mean that you would be unsafe. Hopefully, this information would give you something to consider in your decision making.
2. **Cognitive only**. These procedures are designed to address the cognitive skills that a content analysis of driving showed to be important. Other areas must also be checked, including: vision, motor function, and neurological status.
3. **Does not replace road test**. Whatever conclusions either of us draws based on how you do on these tasks should ordinarily be verified by a specialized in-vehicle, on-the-road test by a driving evaluator who has been fully informed of your background.
4. **Legal requirements are your responsibility**. It is up to you to see that you satisfy the requirements of the law, including having a valid driver's license or learner's permit and insurance. New York State law requires that you answer DMV's questions about disabilities when you renew your license.
5. **Report**. This evaluation is, therefore, strictly advisory. You will receive a summary and explanation of your performance, together with my conclusions and recommendations. I will send the report to a third party only with your written authorization. If an insurance company is paying for these services, your signature below permits me to send a copy of my report to the company.

Our signatures below signify that we have both read and acknowledge the above statement.

____________________ (examinee signature) ____________________ (examiner signature)

____________________ (date) ____________________ (date)

Address to which report should be sent:

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