10 Driving and Visual Information Processing in Cognitively At-Risk and Older Individuals

Rosamond Gianutsos, PhD, FAAO, CDRS

Although few people question the importance of visual information processing for the safe operation of a motor vehicle, the relationship between vision and driving is surprisingly controversial (Nouri, Tinson, & Lincoln, 1992). While virtually all states in the United States and most countries have a minimum standard for acuity (usually 20/40 or 6/12), many researchers and driver rehabilitation specialists (Ramsey, 1990) question the importance of acuity per se, citing examples of persons who have driven safely with poor acuity. These experts believe that a much more critical, if not the most critical, factor is the integrity of the visual fields. Their evidence, however, is based largely on clinical experience rather than formal research: a study by Johnson and Keltner (1983) is one of the few available reports. The controversy sometimes emphasizes the relative importance of other functions, most notably attention (Owsley & Ball, 1993). This relationship between driving and vision comes into focus in individuals who are cognitively at risk, for example, from brain injury or advanced age.

Before examining the specifics of the relationship between vision and driving in cognitively at-risk individuals, it is important to consider some general issues about human abilities and safe driving. Nobody would dispute the fact that driving is an extremely complex form of human behavior for which many competencies are either required or helpful (Colsher & Wallace, 1993; van Zomeren, Brouwer, & Minderhoud, 1987). While there may not be a consensus regarding the "required" category, there is more agreement on what is "helpful." For instance, binocular vision is not required for operation of an ordinary motor vehicle; however, it is helpful in that it affords an appreciation of space, especially at night when texture gradient information (an important monocular cue for depth) is lost. Monocular drivers usually develop other techniques for evaluating spatial information.

Significantly, when multiple impairments are present, the combined effect may be considerably greater than the sum of the individual parts (Colsher & Wallace, 1993). In research, the components are called *main effects* and the combined effect is called the *interaction effect.* Impairments of two helpful competencies may produce an interaction that is deadly. For example, my experience with profoundly amnestic survivors of herpes simplex encephalitis—none of whom stopped driving—convinces me that it is possible to drive safely despite extremely poor recent memory; such amnesia combined with impulsivity, however, can lead to dangerous lane changes and last-minute turns to cope with a forgotten route.

On the other hand, cognitively intact individuals may indeed be able to deal with substantial but isolated and well-recognized impairments. A psychologist (Chapman, 1995) who had been struggling for 25 years with progressive loss of visual acuity due to Stargardt's disease described his own experience driving with field constriction associated with the use of special bioptic (telescope-like) lenses. He drove over 650,000 miles with the bioptic lenses and has only recently begun to limit his driving. In his experience, it was only when his acuity worsened to 20/240 correctable to 20/40 and fields narrowed to below 6.5 degrees that he began to question his ability to drive safely. Most jurisdictions that have standards for visual fields and driving specify well over 100 degrees in the horizontal meridian; it is astounding that this man could drive safely with such narrow fields.

However, it would be a mistake to conclude that peripheral vision is unimportant for driving. The logical error is failing to take into account the interaction effects: the effects of disabilities tend to combine multiplicatively, not additively. While a well-functioning person might be able to compensate for constriction of the visual fields, with cognitive impairment such compensation may require attentional and other mental resources that are unavailable or required for other tasks.

A positive view of interaction effects is to appreciate that there is much to gain from fixing a relatively small impairment that serves to multiply the impairment caused by another condition. If, for instance, reduced distance visual acuity (a minor impediment to safe driving) is corrected, the benefit may be a disproportionate gain of attentional resources previously needed to compensate for the poor acuity.

Wood (1993) and Szlyk, Brigell, and Seiple (1993) consider the combined effects of visual and cognitive impairment on driving. Many conditions that cause cognitive impairment also cause visual impairment, so this combination is, unfortunately, not rare. The good news is that many visual problems can be treated and some can be rectified without unusual expense, technology, or effort.

What conditions put a driver in the category "cognitively at risk"? Anything that affects the brain can compromise cognitive function. In this chapter the emphasis will be on the individuals with acquired brain injury—persons who developed normally until some event or condition affected brain function. Usually such people are seeking to resume or to continue driving. Persons with developmental disabilities, especially cerebral palsy and spina bifida, present a complex challenge for driver rehabilitation specialists, which will not be addressed here specifically. Another more common, but less widely recognized, etiology at risk for unsafe driving is attention deficit disorder, with or without hyperactivity. This condition usually does not combine with physical or visual disability.

The major etiologies to be considered include acquired brain injury (with cerebrovascular accident and traumatic brain injury the most common) and age-associated cognitive decline. Persons with progressive neurological conditions such as multiple sclerosis and Alzheimer's. Other forms of dementia present similar issues, together with some specialized considerations (e.g., the visual problems specific to multiple sclerosis) that are beyond the scope of this chapter. In cases where progression, variability in symptom expression, or recurrence is anticipated, there must be guidelines for reevaluating driving risk. If the initial evaluation is done early in the disease process, it can be used to establish a personal baseline and indicators for reviewing the situation. Planning can be started for mobility alternatives.

Age-associated cognitive impairment, though not universal and sometimes caused by correctable but undiagnosed problems, is a reality, especially as advances in medical treatment keep people living longer in better physical health. In some sense, the issues are similar to progressive conditions.

Stroke is the most common form of acquired brain injury, with older persons at increased risk. The most likely physical impairment following stroke is hemiplegia. Visually, the most common problem is hemi-field impairment, with or without hemi-inattention. Traumatic brain injury often strikes the younger, and sometimes inexperienced, risk-prone driver. Physical impairment, while similar to stroke, can be more severe, especially following prolonged loss of consciousness and immobility. Problems with motor coordination, balance, and vestibular function are not unusual after brain trauma. Not only may there be visual hemi-field impairment, but there is also a high incidence of accommodative and binocular dysfunction.

Driver Rehabilitation

Driver rehabilitation has advanced considerably in the last decade, especially under the auspices of the Association of Driver Educators for the Disabled, an interdisciplinary organization of occupational therapists, driver educators, and others. This organization has established a certification process leading to the title Certified Driver Rehabilitation Specialist (CDRS). While adaptation to accommodate physical disabilities is an important part of this specialty, addressing cognitive and sensory impairment is often the greater challenge. This latter enterprise, which includes evaluation, counseling, and intervention, may be called *driving advisement.*

The essential purpose of driving advisement is to enable the individual to make appropriate decisions about driving. Regardless of the legal context (i.e., some jurisdictions have mandatory reporting by professionals of drivers with certain diagnoses), the would-be driver is the ultimate licensor. On every trip, an implicit self-authorization is given; conversely, from time to time most drivers make conscious decisions to refrain from driving or to allow others to drive. These decisions are usually to accommodate some condition, such as fatigue, intoxication, or a broken bone. Older drivers frequently refrain from driving at night because they are sensitive to glare. Significantly, they recognize this problem and perceive it as interfering with their ability to drive safely. Little assessment of this problem (glare sensitivity) is needed: the problem is recognized by the driver, and steps are taken either to correct or to avoid it.

In the assessment part of driving advisement, the priority is on those conditions for which awareness may be compromised. The most striking example of such a condition is visual field impairment. Clinicians will frequently encounter persons who have dramatically constricted fields who insist that they are seeing everything. Hemianopic field losses are often unappreciated or underappreciated. The most convincing illustration for the neurologically intact individual is a demonstration in which an object is made to disappear in the area subtended by the physiological blind spot. (See Figure 8.1)

Sensory impairment needs to be evaluated because, unlike motor impairment, it can be inferred only indirectly from behavior and often the impairment does not lend itself to self-evaluation. It seems that the human organism is not built to monitor some sensory functions well. For instance, people with hearing problems may think others are mumbling. Another example is the loss of spatial vision following binocular dysfunction. It is not uncommon for persons with dramatic losses of acuity to present themselves for an eye exam with little or no complaint.

The driving advisement process usually includes an in-clinic and an on-the-road, behind-the-wheel component, typically (for obvious safety reasons) in that order. The on-road component can be deferred, based on severely deficient performance on the in-clinic component. Less often, a condition will be identified in the in-clinic component that disqualifies the person from licensure. A committee on which I served, charged with making recommendations regarding what should be included in driver rehabilitation assessment, concluded that no one should be recommended for driving without first demonstrating satisfactory performance on the road (Subcommittee on Driver Evaluation and Training for Individuals with Disabilities, 1993). Some functionally oriented driver rehabilitation specialists discount or minimize in-clinic findings, placing total reliance on the outcome of the road test.

The in-clinic assessment needs to address medical, sensory, motor, and cognitive functions. The medical consideration is the presence of conditions that could produce a rapid change in the person's abilities, including consciousness, vision, debilitating pain, or contact with reality. Included here is the effect of substances, prescribed and otherwise, that might affect the individual's performance. The sensory assessment emphasizes vision, although joint and position sense are important, especially for reliable and efficient pedal control. Motor function is particularly important in relation to the need for adaptive equipment, including mirrors.

It is in the areas of cognition and vision that the in-clinic assessment can have unique value because in these domains are hidden problems that may not be safely or intentionally tested in an ordinary road test. Recommendations for the vision screening will be discussed later. Table 10.1 summarizes features of procedures for evaluating cognition in relationship to driving.

Critical features include apparent (face) validity, psychometric properties (demonstrated standardization, reliability, and validity), and clinical practicality. Apparent, or face, validity (the test looks like it measures

Table 10.1 Features of procedures used for pre-driving advisement.

Comparative Summary of Major Driving Assessment Procedures

ISSUE	*Porta Clinic/Glare*	*Driver Performance Test*	*Doron Simulator*	*Driving Advisement System*	*Elemental Driving Simulator*	*Neuropsych. Testing*	*On-road Testing*	*Cog Behav Driver Inventory*	*Visual Attention Analyzer—Useful Field of View*	*Atari*
FACE VALIDITY	Mod. Low	Mod. High	High	Mod. High	Mod. High	Low	Highest	Mod. Low	Mod. Low	Mod. High
SCOPE	Focused	Focused	Focused	Broad	Broad	Test dependent	Broad	Broad	Focused	?
PROTOCOL	Standard	Standard	Select proc.	Standard	Standard	Select proc.	No standard	Standard?	Standard	No standard
NORMS	Marines	Yes	Non-empirical	Yes	Yes	Usually	?	Yes	Yes	No
RELIABILITY	not reported	not reported	not reported	Yes	Yes	Usually	?	Yes?	Yes	No
VALIDITY	not reported	not reported	not reported	Yes	Yes	Not for driv.	?	Yes	Yes	No
TIME (MIN)	15 min.	45 min.	60+ min.	60+ min.	20 min.	15–60 min.	60 min.	60 min.	30 min (?)	60 min.
SPACE/EQUIP.	Tabletop+20	VCR	Room	Computer	Computer	Tests	Vehicle+	Computer+Test	Console	Console
COST (EST.)	$1,200.	$200.	$30,000.	$1,800.+	$1.800.+	<$500.	Direct + ind.	$120.++	$20,000	$15,000.
SOURCE	DTE	ADSI	Doron	LSA	LSA	Test	self	PSS	VRI	Atari

ADSI = Advanced Driving Skills Institute, 4660 Brayton Terrace South, Palm Harbor, FL 34685 (813) 785-0034
Atari = Atari Games Corp., 675 Sycamore Dr., Milpitas, CA 95035
Doron = Doron Precision Systems, PO Box 400, Binghamton, NY 13902 (607) 772-1610—Jane Townsend
DTE = Driver Testing Equipment, Inc., 1020 S. Main Ave., Scranton, PA 18504, (717) 347-7772
LSA = Life Science Associates, 1 Fenimore Rd., Bayport, NY 11705, (516) 472-2111
PSS = Psychological Software Services, 6555 Carrollton Ave, Indianapolis, IN 46220, (317) 257-9672
++ CBDI also requires Brake Pedal RT, Keystone Driver Vis. Test, WAIS PC & DS, Trailmaking Test (time, cost addit'l)
VRI = Visual Resources Inc., Kristina K. Berg, 216 S. Jefferson, Suite 600, Chicago, IL 60661 (312) 454-0603

what it is supposed to measure) is important if the examinee is to be convinced of the relevance of the findings. It is central to the driving advisement process and must not be discounted as "mere cosmesis." The appeal of the on-road assessment is its face validity. Simulation attempts to maximize face validity, although procedures vary in what is simulated and range from hardware simulations (e.g., the Doron Simulator®) to task simulations (e.g., the Elemental Driving Simulator®).

Driving advisement procedures vary in their scope. For example, none, other than the on-road test, addresses binocular depth perception. In addition, they vary in whether they include a defined assessment protocol. Some (e.g., Doron Simulator®, neuropsychological assessment) consist of a large collection of potentially useful scenarios or tasks. With regard to psychometric development, it is amazing how often this crucial ingredient is lacking. Until recently the most widely used device, the Porto-Clinic Glare®, had norms derived from 18- and 19-year-old Marine recruits—a fact not generally known. No reliability and validity data were offered. Clinical practicality starts with cost of materials, but also includes space and therapist time.

Because most existing procedures did not possess all these features, in the late 1980s I developed the Driving Advisement System (Gianutsos, 1988; Gianutsos, Campbell, Beattie, & Mandriota, 1992) and subsequently the *Elemental Driving Simulator* (EDS) (Gianutsos, 1994; Gianutsos & Beattie, 1992). Research on the validity of the EDS is ongoing and includes significant correlations with an independent on-road assessment (A. Campbell, personal communication, 1995), at-fault crashes (Brown, Greaney, Mitchel, & Lee, 1993), and limitation of driving by older drivers (DeLibero, 1995). In the DeLibero study a group of older drivers (free of neurological diagnoses) were compared with a young adult group of drivers. EDS performance correlated strongly (r = .68) with reported driving pattern: specifically, the older drivers struggled with the EDS, but also reported that they limited their driving (e.g., avoided driving in bad weather, at night, long distances, and in congested or unfamiliar places). Interestingly enough, these drivers felt they were still above average in their basic abilities! Generally, their self-appraisals bore no relationship to their performance; however, they were making appropriate decisions about driving.

The EDS is experienced as difficult by most persons who are cognitively at risk. Licensed drivers who were tested for the purpose of collecting normative information, however, performed consistently and efficiently. Still, most feedback suggests that the EDS is more difficult than ordinary driving. That is as it should be. Most of the time driving calls for relaxed vigilance. However, in a heartbeat the task can require complex decisions implemented with precise and rapid timing. Driving advisement requires an aggressive and challenging exploration of all the potential areas of difficulty. It is far better to err in the direction of making the assessment too stringent than too lax.

The EDS is a physically elemental simulator protocol designed to address simple and complex reaction time, impulse control, response consistency, lateral responsivity, and steering steadiness. Individuals are asked to predict how well they will do compared to other licensed drivers and are later given norm-referenced performance ratings. Because the predictions and performance are anchored to the same numeric scale, the report affords a direct comparison of the two. If there is a high disparity, indicating that the person has unrealistic expectations, the clinician has a good foundation to address issues of judgment and driving beyond one's capabilities.

Performance on the road test is often regarded as the ultimate indicator of driving ability—much as it is in the licensure process. Yet the road tests used in most rehabilitation contexts fail to meet psychometric standards, including reliability and validity. Driving environments vary, courses vary, and so does the behavior of other drivers. Standardization of procedure, much less of scoring, is not possible in on-road tests. Most on-road assessment protocols (in the author's informal survey) emphasize the operational level of driving—the basic skills needed for keeping the vehicle on the road. Little attention is paid to the more proactive tactical (van Zomeren, Brouwer, & Minderhoud, 1987) level of driving, including, for example, route selection, anticipation of erratic behavior based on such clues as out-of-state plates, and even the decision of whether and when to make a trip. This tactical level of driving calls for precisely the kind of "frontal" abilities that are often compromised by traumatic brain injury. Typically, the road test evaluator assumes full responsibility for the route, which may or may not be a familiar driving environment for the examinee. Also, it can be impractical to evaluate comparative performance when tests are given at different times of day and in different weather conditions.

The bottom line is that the evaluation process is an evolving clinical art and far from perfect. Important as the on-road test is, especially to the would-be driver, it should not be the only or ultimate test. If a person does poorly on the in-clinic procedures, but does well on the on-road test, it does not mean that the in-clinic procedures should be discounted or overridden. The road test is not the ultimate measure of success; rather, the ultimate successful outcome is the accumulation of safe miles.

Visual Processing and Impact on Driving

Based on years of clinical experience, in a masterful application of an understanding of basic processes to an important activity of daily living, occupational therapist Carmella Strano (1989) analyzed the specific visual problems associated with brain injury and their impact on specific aspects of the driving task. Complementing Strano's analysis is the review by Shinar and Schieber (1991) of empirical research on this topic.

In clinical practice, static acuity is addressed first. Static distance acuity is almost universally included in licensure standards, where it tends to be overemphasized. However, it can be important in unfamiliar situations, where information must be derived from signs. Good distance acuity can permit early recognition of potential hazards, such as misdirection of gaze by another driver.

Contrast sensitivity, often reduced in older persons, can affect safety in night driving and in conditions where visibility is compromised by bad weather (Schiff, Arnone, & Cross, 1994). Some investigators (Shinar & Schieber, 1991) emphasize the importance of *dynamic acuity*—the ability to discriminate information in moving stimuli in driving. Dynamic acuity is most likely mediated by different neurological systems for vision and by receptors for motion as opposed to light intensity, what Suter (1995) calls the magnocellular or "where" pathway, together with a midbrain ambient system. Clinically, the distinction between conventional static and dynamic acuity has helped explain the mobility of some persons with apparently poor vision. Unfortunately, clinically practical methods for evaluating dynamic acuity are not yet available.

Format (iconic vs. verbal), size of letters, width, color, and composition of roadway markings are all parameters that can be used by highway planners and engineers to overcome problems with acuity. Individuals can make changes in the routes they drive, but they are usually unable to change the roadways. A personally unforgettable exception is the writer's own father, who sought her assistance in finding a good source of reflectors. Later she discovered that he had installed them at a difficult, otherwise unmarked turn he frequently had to navigate.

Near-point acuity is unlikely to be important for most aspects of driving, other than reading maps and certain gauges on the dashboard.

The dynamic functions of the visual system—those that depend on coordinated use of the musculature in the eyes—support binocularity, accommodation, and eye movements. Each of these can be helpful to the driver. For example, *stereopsis* (a product of binocular function) affords a three-dimensional appreciation of space. Loss of binocular function, and hence stereopsis, is common after traumatic brain injury. Also, if a person uses an eye patch to manage diplopia, or has lost an eye, stereopsis is lost. Less well appreciated, but possibly more frequent, is the loss of stereopsis in early stages of conditions that affect the elderly (cataracts, macular degeneration) where one eye is impaired first. Drivers use stereopsis in parking and making judgments about following distance and gaps in the traffic flow for merges and turns. Stopping too soon or too late at intersections is a symptom of poor stereopsis.

There is a fairly high incidence of impaired stereopsis in the general population, and a patient may never have had stereopsis. History is the best way to evaluate this possibility: Persons in certain occupations (e.g., pilots, police officers, and truck drivers) are required to have binocular vision and probably always had stereopsis. On the other hand, persons who had an eye turn when young or were given patching or eye exercises in childhood may never have had stereopsis. Under these circumstances, there was nothing to lose and in all likelihood such persons still use the monocular spatial analysis cues they used before the injury. It is the *loss* of stereopsis, not simply the *lack* of stereopsis, that is significant for driver rehabilitation. Other than for commercial drivers (who require binocular vision for licensure), this loss usually can be addressed through patient education and supervised practice.

Eye movement disorders are often difficult to treat, especially those characterized by spontaneous eye movements. If there is a restricted range of motion, mirrors and explicit head turns may enable safe driving.

Accommodative function may be helpful in allowing the driver to adjust focus from road to console. To address the loss of accommodation, which is almost universal in older drivers, automotive engineers have designed "heads up" displays in which important dashboard information appears on the windshield. Bi-, multi-, or variable-focus lenses also serve to compensate for loss of accommodation. In most cases this problem is easily and routinely addressed.

At the opposite end of the spectrum, neither easily nor routinely addressed, are visual field impairments. These have been alluded to throughout, and the reader is referred to other works by the present author and others on the subject (Gianutsos & Suchoff, 1997; Parisi, Bell, & Yassein, 1991). Visual field loss is compounded by a total or partial lack of awareness of that loss. If *homonymous hemianopia* (loss of visual responsivity in corresponding halves of the field of view) were experienced as a black stage curtain covering the field, it is unlikely that the individual would consider driving. When hemianopics attempt to drive, or perform dynamic visual search tasks, they often display a "robbing Peter to pay Paul" effect. They are so busy compensating that they fail to notice something on the intact side. This effect is also seen in steering, in which they have difficulty maintaining a central position in their lane. At one time they may drift too far into their missing field; at other times they drift into the intact field.

Since visual field impairment disqualifies one for licensure in many jurisdictions, and is regarded by many as incompatible with safe driving, there is little opportunity to evaluate its effects. For that reason it is perhaps appropriate to share my own clinical experiences in this regard. The EDS affords an extremely sensitive measure of responsivity to peripheral stimuli on the left and right sides while performing a preview tracking (steering) task. In 95% of the normative sample the difference in median response time is less than 0.10 second. If a person is 0.5 second slower on one side, the result will be flagged as extremely abnormal. Nonetheless, in more than one such case, driving performance was acceptable to an experienced road test examiner instructed to address this potential problem rigorously. Another individual with a dense left homonymous hemianopia from a stroke 6 months earlier continued to drive against advice. He bumped into furniture in the examiner's office, got lost, and could not fill out a paper and pencil form. On the EDS he was 1.5 seconds slower on the left side, and he missed some targets altogether. Apart from questionable judgment on this particular issue, he did well on other assessments, was well aware of the visual loss, and explicitly attempted to compensate. He was urged to pursue optical compensation using a reversing spectacle mounted mirror, and eventually did so. In New York State his field loss would have come to the attention of the licensing authorities only if his best corrected visual acuity were marginal, and he would have been required to submit a visual evaluation report. Unfortunately, New York does not afford immunity from a lawsuit for violation of confidentiality to concerned professionals who would report such cases.

I am aware of at least two cases in which persons with right homonymous hemianopia drove for several years, one with a reversing mirror. Both eventually stopped driving. In each case the final mishap was a crash in which the field problem was likely contributory, although in neither case did this information come to the attention of the authorities. One of these individuals, shortly after turning left onto a busy two-way commercial street, hit a parked delivery van on his right side. Another survivor of a severe stroke that left him with profound expressive aphasia, right hemiplegia, and a reduced visual responsivity in the lower right quadrant amassed over 100,000 safe miles. He actively denied any visual field impairment, although there were consistent reductions in response on functional visual field tasks (Gianutsos, 1991). For a month or two during which he was given a medication that made him drowsy, he had three minor scrapes on his right side. After stopping the medication, however, he once again drove safely.

My opinion is that it is very difficult for a person with homonymous hemianopia to maintain a safe driving record. In some cases where the problem is isolated and awareness is good, it may be possible to drive safely with mirrors and optical aids such as oversize, wide-angle, center-mounted rearview mirrors, reversing mirrors, and yoked prisms (Cohen & Waiss, 1993). Further, the amount and kind of driving may make a difference. Optometrist Daniel Gottlieb has reported favorably on this approach (Gottlieb, 1993; Gottlieb, Freeman, & Williams, 1992). My own approach is to demonstrate the problem to the patient by offering speeded visual processing tasks with feedback based on stimulus position. If the person can compensate on one task, switch to another. Let the person determine if he or she can generalize compensation to the new task. Increase the information density (visual complexity) of the display or the task complexity. Does the problem reemerge when the task is difficult or when the individual is tired? Have the person analyze and tabulate his or her performance separately for each side of the display. If the person does well on these off-road tasks and qualifies for driving lessons, be sure the driving instructor observes carefully for problems symptomatic of lateralized differential response and brings them quickly and bluntly to the individual's attention. Even with an optical device, the hemianopic driver must maintain an extraordinary level of vigilance. Such drivers should be monitored over an extended period and encouraged to keep a driving log and to discuss their experiences, including near misses.

Visual attention and visual perception have a significant cognitive aspect; however, they are built on a foundation of visual sensory processing, which logically and practically should be addressed first. The practical reason is that visual sensory function can often be treated, if not fixed, more easily than attention and perception can. Logically, attention can mean different things, including

- arousal
- sustained focus of effort
- resistance to distraction
- selection of relevant and filtering out of irrelevant information
- simultaneous or divided information processing
- mental flexibility or switching from one level or aspect to another efficiently.

Instead of "attention," it would be preferable to use terms that differentiate these aspects of information processing. Because of these many different meanings, attention (together with "motivation") is often used as a scapegoat, or explanation for variability that is not understood (an example of the nominal fallacy: naming something is not explaining it). A person responds inconsistently to stimuli presented to the field of vision contralateral to their brain injury: it is explained as "hemi-inattention." A boy is erratic about completing his schoolwork: his motivation is questioned, or he may be suspected of having attention deficit disorder.

With that caveat in mind, there are very real attentional problems associated with cognitive impairment that profoundly affect driving (Brouwer, Waterink, van Wolffelagr, & Rothengatter, 1993). It is possible to identify specific aspects of driving that require each of the six types of attention cited above (Mitchell, 1994). The best clinical research on this subject addresses the constriction in the *useful field of view* (UFOV) among older drivers (Ball & Owsley, 1991; Owsley & Ball, 1993; Owsley, Ball, Sloane, Roenker, & Bruni, 1991). Owsley, Ball, and their collaborators have demonstrated that recent driving records correlate with UFOV performance, that UFOV can predict driving, and that training can be used to counter these effects. The UFOV is a field of visual attention. One way to understand it is to consider the constriction of awareness that people experience when they are working hard on a specific task, such as being engrossed in a book or a movie. UFOV research has been used to account for the fact that older drivers have a disproportionate number of crashes making left turns at intersections where they need to deal with multiple issues in real time, for example, judging the gap in oncoming traffic, monitoring pedestrians, being aware of other drivers who may also be turning, and controlling their vehicle.

The field of visual attention can be assessed in several ways. A straightforward approach is to evaluate the functional visual fields using increasingly complex displays. While all people need more time to process informationally dense displays, some are more affected by the increase in information density than others. Using this approach, detailed in chapter 8 (Gianutsos, 1997) and in Gianutsos and Suchoff (1997), one can differentiate the contribution of sensory and attentional field impairment. Older drivers have more difficulty, relative to younger drivers, on the informationally complex tasks (Hall, 1995).

Finally, visual perception includes the interpretation of visual information. Recognition of objects (visual gnosis) may be delayed or impaired. Knowing that something constitutes a hazard is critical to dealing with it appropriately. The old saw that a driver must "expect the unexpected," is an implicit acknowledgment of the importance of efficient visual perception in driving. Clearly, visual perception is important in finding one's way (route finding).

Vision Screening for Driving

What then is recommended as a visual screening procedure in conjunction with driving advisement? A comprehensive examination by an eye care practitioner has clear advantages. Occupational therapists should address their efforts toward making this happen and assisting in appropriate understanding of and follow-through on recommendations. Usually, the eye care practitioner appreciates the therapist's help in working with patients who have known or suspected cognitive problems.

That said, a stereoscopic vision test can efficiently assess most of the aspects of vision cited earlier, especially in individuals sufficiently able to be candidates for driving advisement.

The one area that should be investigated further is the peripheral visual field. For this purpose, I use a collection of computerized tasks (REACT, SDSST, SOSH, and SEARCH) in which the attentional demands are progressively increased. These tasks (Gianutsos & Suchoff, 1997), which are together called PERFIELD, are very practical in that they may be conducted with most IBM-compatible computers. Normative data for younger and older adults accompany the programs. A summary sheet (Table 10.2) is useful to guide this part of the evaluation.

REACT is always used first. The task, which takes about 2.5 minutes, is repeated several times with varying conditions. Initially, it is conducted binocularly with eyes free to move and normal contrast. The examiner encourages response speed, especially on the central trials, which come first. Attention is drawn to the fact that the numbers that appear measure reaction time and that the goal is to get as low a score as possible. To

Table 10.2 Form for organizing data from functional visual field tasks.

Peripheral Visual Field: Functional Assessment

Patient: ______________________________ ID# ________

Examiner: ______________________ Date: __________________

Procedures:

--------- ***REACT (Reaction Time Measure of Visual Field)*** ---------

	Eye Tested	Fixate /Move	Dynamic /Stable	Contrast	Distraction	Mean Left	Mean Cntr	Mean Right	Median Left	Median Cntr	Median Right	Comment
1	Both	M	D	full	N	___	___	___	___	___	___	________
2	Both	M	D	full	Y	___	___	___	___		___	________
3	R	F	D	full	N	___	___	___	___	___	___	________
4	L	F	D	full	N	___	___	___	___	___	___	________
5	R	F	D	1%	N	___	___		___			
6	L	F	D	1%	N	___	___	___	___	___	___	________
7	___	___	S	___	___	___	___	___	___	___	___	________
8	___	___	___	___	___	___	___	___	___	___	___	________
9	___	___	___	___	___	___	___	___	___	___	___	________
10	___	___	___	___	___	___	___	___				

Variables addressed:

___ Eyes free to move vs. Eyes fixated

___ Binocular / Monocular

___ Normal vs. reduced contrast

___ Without vs. with distraction

___ Dynamic / Stable

Interpretation:

Field problems?:

Compensation?:

Prismatic assist: Effect:

Table 10.2 *Continued*

---------- ***SDSST (Single & Double Simultaneous Simulation)*** ----------

Administration		1:_____		2:_____		
Overall correct / N of trials:		___ / ___		___ / ___		
Errors						
		Left	Right	Left	Right	Pattern of impairment:
Single	Confusions	___				
	Omissions	___	___		___	Left or right side
	Intrusions	___		___		Confusion vs. omission
Double	Confusions	___	___	___	___	'Extinction' (Double << Single)
	Omissions	___		___		Prismatic assist: Effect:

---------- ***Visual Search—SOSH (Search for the Odd Shape) & SEARCH (Search for Shapes)*** ----------

Search Times		Left	Right	Both
SOSH				
	Median	_____	_____	_____
	Mean	_____	_____	
SEARCH				
	Median	_____	_____	_____
	Mean	_____		
	Error %		_____	_____

Interpretation:

explore the effect of distraction, the examiner can tell the patient, "We need to do this again, but you can answer some questions for me." Similarly, one can investigate the effects of fixation versus eyes free to move, and high and low contrast. The latter is most conveniently accomplished by testing the individual with special dark glasses that filter all but 1% of the light; that is, 1% transmission, gray-green wraparound lenses (very dark sunglasses) for implementing REACT low-contrast conditions, available from NoIR Medical Technologies, PO Box 159, South Lyon, MI 48178 (313-769-5565 or 800-521-9746). These can be placed over existing glasses. The patient often interprets the procedure as addressing night driving, although no claims are made in that regard. REACT conducted monocularly with fixation is most comparable to perimetric visual field testing. With eyes free to move, the individual is given the opportunity to demonstrate compensation for field loss. When hemianopic impairment is observed only with dark glasses, it is likely that there is a relative, but not absolute, loss.

SDSST is a computerized version of the Single and Double Simultaneous Stimulation Test, where stimuli are flashed on one or both sides in discrete trials. The computer tabulates omissions and confusions for each side of the display for single and double presentations. The classic "extinction" pattern, which is rather rare, is for errors on the affected side that occur only on double trials.

The SOSH (Search for the Odd Shape) task involves scanning an array of shapes ("Martian faces") for one that is different (the Martian that "fell asleep"), and poking him to "wake him up," the faster the better. This task is easy to understand and perform; however, some brain injury survivors encounter difficulty on this task. This pattern suggests reduced attentional capacity. This effect may be even more pronounced on SEARCH (Searching for Shapes). On both tasks the search times are displayed in the target location and summarized by quadrant and side.

One helpful feature of the PERFIELD procedures is that the results are displayed immediately in a format that the patient can understand. This feedback is of special value because it helps the individual become aware of visual field impairment.

In summary, these procedures clearly go well beyond the minimal standards for licensure. After all, driving advisement is for the purpose of giving the individual all the relevant information. While it is appropriate to address the issue of whether the person meets the minimal standard for licensure, it is not sufficient. The decisionmaking is the responsibility of the licensing authorities and, in a deeper sense, the prospective driver and concerned others. In driver rehabilitation the therapist is charged with identifying problems in functions that ordinarily are helpful for safe driving. In weighing the information and formulating recommendations, one must keep in mind the potential for interaction effects—compounding of impairments.

Acknowledgment

This chapter was made possible through the kind support and tranquility of Timbercreek.

REFERENCES

Ball, K., & Owsley, C. (1991). Identifying correlates of accident involvement for the older driver. *Human Factors, 33*(5), 583–595.

Brouwer, W. H., Waterink, W., van Wolffelaar, P. C., & Rothengatter, T. (1991). Divided attention in experienced young and older drivers: Lane tracking and visual analysis in a dynamic driving simulator. *Human Factors, 33*(5), 573–582.

Brown, J., Greaney, K., Mitchel, J., & Lee, W. S. (1993). *Predicting accidents and insurance claims among older drivers.* Southington, CT: ITT Hartford Insurance Group.

Chapman, B. G. (1995). Driving with the bioptic. *Journal of Vision Rehabilitation, 9*(4), 19–22.

Cohen, J., & Waiss, B. (1993). An overview of enhancement techniques for peripheral field loss. *Journal of American Optometric Association, 64,* 60–70.

Colsher, P. L., & Wallace, R. B. (1993). Geriatric assessment and driver functioning. *Clinics in Geriatric Medicine, 9*(2), 365–376.

DeLibero, V. (1995). *Self-appraisal and driving simulator performance in younger and older drivers.* Dix Hills, NY: Touro College School of Health Sciences, Department of Occupational Therapy.

Gianutsos, R. (1988). Computer programs for cognitive rehabilitation (Vol. 6): Driving Advisement System [Computer software]. Bayport, NY: Life Science Associates.

Gianutsos, R. (1991). Visual field deficits after brain injury: Computerized screening. *Journal of Behavioral Optometry, 2,* 143–150.

Gianutsos, R. (1994). Driving advisement with the Elemental Driving Simulator (EDS): When less suffices. *Behavior Research Methods, Instruments, & Computers, 26*(2), 183–186.

Gianutsos, R. (1997). Vision rehabilitation after brain injury. In M. Gentile & S. Schiff (Eds.), *A therapist's guide to the evaluation and treatment of vision dysfunction and low vision.* Bethesda, MD: American Occupational Therapy Association.

Gianutsos, R., & Beattie, A. (1992). Elemental driving simulator. *Proceedings of the Johns Hopkins National Search for Computing Applications to Assist Persons with Disabilities* (pp. 117–120). Los Alamitos, CA: IEEE Computer Society Press.

Gianutsos, R., Campbell, A., Beattie, A., & Mandriota, F. J. (1992). A computer-augmented quasi-simulation of the cognitive prerequisites for resumption of driving after brain injury. *Assistive Technology, 4,* 70–86.

Gianutsos, R., & Suchoff, I. B. (1997). Visual fields after brain injury: Management issues for the occupational therapist. In M. Scheiman (Ed.), *Vision: Screening and intervention techniques for occupational therapists.* Thorofare, NJ: Slack.

Gottlieb, D. D. (1993). *Enhancing awareness, increasing safety, and returning to driving for patients with visual field loss and neglect.* Paper presented at the meeting of the Neuro-Optometric Rehabilitation Association, International, Washington, D.C.

Gottlieb, D. D., Freeman, P., & Williams, M. (1992). Clinical research and statistical analysis of a visual field awareness system. *Journal of American Optometric Association, 63*(8), 581–588.

Hall, C. (1995). *Functional visual fields: Norms for younger and older viewers.* Dix Hills, NY: Touro College, School of Health Sciences, Department of Occupational Therapy.

Johnson, C. A., & Keltner, J. L. (1983). Incidence of visual field loss in 20,000 eyes and its relationship to driving performance. *Archives of Ophthalmology, 101,* 371–375.

Mitchell, S. (1994, October 20). *Brain injury and memory deficits in driver rehabilitation.* Paper presented at the meeting of ADED Northeast, Albany, NY.

Nouri, F. M., Tinson, D. J., & Lincoln, N. B. (1992). Cognitive ability and driving after stroke. *International Disability Studies, 9*(3), 111–115.

Owsley, C., & Ball, K. (1993). Assessing visual function in the older driver. *Clinics in Geriatric Medicine, 9*(2), 389–401.

Owsley, C., Ball, K., Sloane, M. E., Roenker, D. L., & Bruni, J. R. (1991). Visual/cognitive correlates of vehicle accidents in older drivers. *Psychology and Aging, 6,* 403–415.

Parasuraman, R., & Nestor, P. (1993). Attention and driving: Assessment in elderly individuals with dementia. *Clinics in Geriatric Medicine, 9*(2), 377–388.

Parisi, J. L., Bell, R. A., & Yassein, H. (1991). Homonymous hemianopic field defects and driving in Canada. *Canadian Journal of Ophthalmology, 26*(5), 252–256.

Ramsey, W. E. (1990). *Low vision and driving.* Presented at AAA Driving Instruction Course: Focus on the Handicapped, College Park, MD.

Schiff, W., Arnone, W., & Cross, S. (1994). Driving assessment with computer-video scenarios: More is sometimes better. *Behavior Research Methods, Instruments, & Computers, 26*(2), 192–194.

Shinar, D., & Schieber, F. (1991). Visual requirements for safety and mobility of older drivers. *Human Factors, 33,* 507–519.

Strano, C. M. (1989). Effects of visual deficits on ability to drive in traumatically brain-injured population. *Journal of Head Trauma Rehabilitation, 4*(2), 35–43.

Subcommittee on Driver Evaluation and Training for Individuals with Disabilities. (1993). *Final report.* Albany, NY: New York State Vocational and Educational Services for Individuals with Disabilities (VESID).

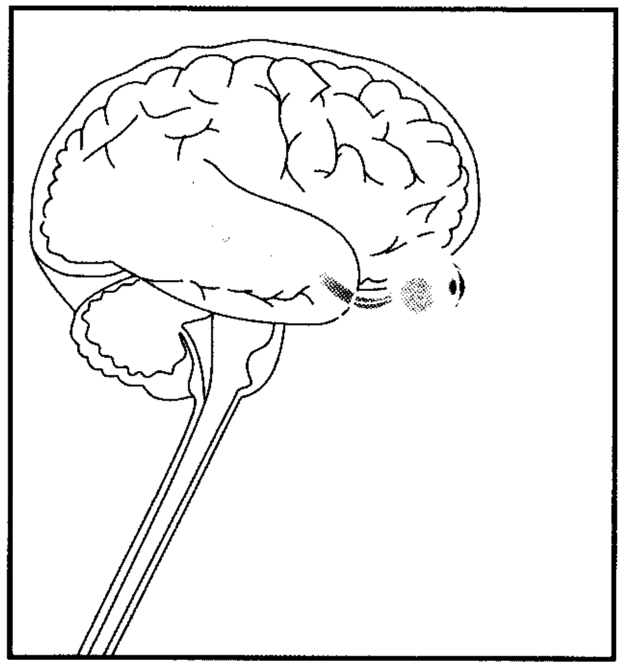
Suter, P. S. (1995). Rehabilitation and management of visual dysfunction following traumatic brain injury. In M. J. Ashley & D. K. Krych (Eds.), *Traumatic brain injury rehabilitation* (pp. 198–220). Boca Raton, FL: CRC Press.

Szlyk, J. P., Brigell, M., & Seiple, W. (1993). Effects of age and hemianopic visual field loss on driving. *Optometry and Vision Science, 70*(12), 1031–1037.

van Zomeren, A. H., Brouwer, W. H., & Minderhoud, J. M. (1987). Acquired brain damage and driving: A review. *Archives of Physical Medicine and Rehabilitation, 68,* 697–705.

Wood, J. M. (1993). Can driving performance be predicted by vision testing? [Abstract]. *Optometry and Vision Science,* 134.

FUNCTIONAL VISUAL BEHAVIOR







A Therapist's Guide to Evaluation and Treatment Options

Michele Gentile, MA, OTR/L
Editor

1997

The American Occupational Therapy Association, Inc.