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Visual Perceptual Aspects of Driving

■ Carol J. Wheatley, MS, OTR/L

Visual perception is critical to the safe operation of a motor vehicle. It has been estimated that 90% of the input required for driving is visual (Wylie, 1978). The brain's processing, interpretation, and reaction to the visual stimuli govern a person's capacity to drive.

This article examines the various aspects of visual perceptual processing deficits and their impact on the action of driving. Each visual perceptual skill will be analyzed separately. However, it is important to remember that the brain processes this information simultaneously and continuously (Ball & Owsley, 1991; Jennings, 1995). Assessment methods and an analysis of the results as related to a person's driving potential are also discussed.

This article focuses on the experienced driver with an acquired impairment in visual perception from a stroke, traumatic brain injury (TBI), or a degenerative disorder such as dementia or multiple sclerosis. The older driver may also show a decline in the speed and efficiency of visual processing in normal aging. They may have completed a rehabilitation program and are now interested in resuming active driving, or may be experiencing the effects of the aging process, and has been referred for occupational therapy by their physician, family, or the Motor Vehicle Administration (MVA).

Visual Acuity and Visual Fields

The state MVA sets minimum requirements for visual acuity and visual field range. Visual acuity is critical to the clear recognition of the environment as one moves through it at speed. Persons who have low visual acuity may not recognize a traffic sign or a traffic event until they are very close; therefore, their reaction time to the stimuli is reduced (Strano, 1993). Reduced contrast sensitivity may hinder a person's ability to see critical details in low light situations (poor night vision), or in situations where there is little contrast between an object and its surrounding environment (Stressel, 2000).

A visual field loss may result in the person missing critical information in one aspect of space while they are directing their gaze to another area. An example is the person who was looking at directional signs positioned to the right of the road in a parking lot, and did not see the pedestrian who stepped off the curb on the left. Although the person was very aware and compensated well for his visual field loss by frequent scanning to that side, events critical to driving are continuous and ongoing, and he began moving his vehicle before he had scanned sufficiently.

Ocular-Motor Skills

A person must be able to direct their gaze to all aspects of the visual field (visual tracking), and to rapidly focus on various visual targets, which is termed saccadic function (Strano, 1993). The slightly off-set views provided by the position of the eyes results in stereoscopic vision, allowing the appreciation of depth. Depth perception is important in judging the relative position of the vehicle to fixed objects, such as the curb or a fence, and to judge distance when moving, such as approaching a stopped vehicle ahead at a red light. Many contextual cues are available in the driving process to allow someone to compensate for depth perception limitations, which enables a person with vision in only one eye to drive safely. It is the combination of depth perception limitations with other perceptual and cognitive deficits that may hinder a person with a stroke or TBI from compensating for this loss.

Diplopia, or double vision, can occur as a result of a misalignment of the eyes. It is important to note the distance at which the diplopia occurs. For example, double vision at 15 inches would complicate a person's ability to read text, but the same person may have singular vision at a distance, so they would be able to see the road ahead and not be hindered by driving. Someone who experiences diplopia at a distance may benefit from an eye patch or prism lenses, and should be referred to a vision specialist.

Attention

Attention is a fluid process by which a person focuses on a given target, while maintaining an awareness of background events. When driving, a person must maintain an ongoing awareness and capacity to divide their attention between the vehicle's operation, position, speed, the condition of the roadway, and the actions of other drivers. A person cannot afford to become fixed on a given stimuli, such as pedestrian walking alongside the road, to the detriment of their ability to maintain an awareness of the larger driving environment. Internal distractions, such as emotions or preoccupations with a line of thought can also be detrimental. Conversely, a person cannot be distracted by the continuous input from the environment and not be able to appreciate the importance of the upcoming stop sign.

A reduction in the awareness of one half of the visual environment is a unilateral inattention or neglect. The deficit is distinguished from a visual field loss in that the person is able to see the stimuli on the affected side when their attention is directed to it, but they have a tendency to ignore that side of space. When driving, the person may tend to drift across the center line, or may drive too close to stationary objects, such as parked vehicles, on the affected side.

Spatial Relationships

A driver must be able to judge the position of their vehicle in relation to the fixed and moving objects in the environment. This skill is critical when pulling into a parking space and when determining a safe gap in traffic to make a left turn.

Visual Cognition

Good judgment is critical to safe driving, and is involved in many of the defensive driving techniques. A person needs to anticipate and react to potentially hazardous situations. They also need to appreciate the impact of their driving actions on other drivers to avoid inconveniencing others, or creating dangerous situations.

Planning skills are needed to select a route to a given destination, the time of day for travel, and the amount of time allowed to make the trip. Many older drivers tend to develop strategies to minimize

their risk by avoiding rush-hour travel, using familiar routes, and limiting their traveling distance.

People with topographical, or route-finding problems may develop various compensatory strategies, including designated routes, maps, written instructions, landmark utilization, and carrying a cellular telephone. Global positioning systems may provide additional assistance as the technology becomes more affordable.

Visual Processing Speed

Because events that occur when driving can happen at high rates of speed, the driver needs to process visual information quickly. If the traffic light turns yellow as a person approaches, they need to scan the intersection, look in the rear-view mirror, and quickly decide if they can safely go through the intersection before the light turns red, or if they can stop without impact from the vehicle behind them. A slow driver may cause traffic hazards by driving at an unsynchronized pace compared with other drivers.

Characteristics of Older Adults

As adults age, they tend to have more difficulty dividing their attention between multiple stimuli or multiple tasks (Brouwer, Waterink, Van Wolfflaar, & Rothengetter, 1991), and experience a narrowing of their useful field of view (UFOV) (Myers, Ball, Kalina, Roth, & Goode, 2000). Processing is slowed (Cox, 1989), and a person's awareness of their limitations decreases (Fox, 1989; Kaszniak, 1991). These changes are particularly problematic for people with dementia (Kaszniak, 1991; Parasuraman & Nestor, 1993). Older adults tend to compensate by reducing their driving speed, but may have difficulty with lane control as they attempt to navigate, or may make sudden turns as they recognize the desired intersection. They may appear to be inconsiderate of other drivers, and may create confusion in their efforts to handle the demands of the driving task.

Assessments

Clinical Assessment

The assessment process begins with an interview of the person, and if possible, their family. The person's pertinent medical and rehabilitation history is reviewed. It is recommended that the person complete their rehabilitation program before resuming active driving (Pierce, 1998). Some people view driving as an exercise, such as the person who failed the brake reaction test but believed that his right leg would get stronger if he resumed driving. A discussion of the person's residual problems can provide insight into their awareness of their limitations, as well as indicate the deficits which may impact their driving.

An assessment device for brake reaction speed is available from the American Automobile Association (AAA). The MVA establishes the minimum criteria for brake reaction speed. Left foot accelerators are available for those with limitations on the right. If the person cannot pass the brake reaction speed test with either foot, or if hand controls, mechanical or electronic, are not an alternative, then the driving evaluation is concluded. Recommendations can be made for additional therapy and a subsequent re-evaluation.

Stereo-optical vision testing equipment is available for accurate assessment of binocular and monocular function. This assessment provides an indication of the person's visual acuity, contrast sensitivity, color discrimination, depth perception, night vision, glare recovery, and phorias. The equipment may provide alternative testing of visual acuity using numbers, letters, or traffic signs, which can be useful for persons with reading or language limitations. Ocular-motor screening of scanning, saccadic function, and fixation should include stimuli at distances far and near to better simulate the conditions required for driving.

Visual perceptual and cognitive testing should include an assessment of attention, spatial relationships, visual memory, and spatial reasoning. Frequently used tests include the Motor Free Visual Perception Test, Hooper Visual Organization Test, Benton Visual Retention Test, and Trail Making Test (Brooke, Questad, Patterson, & Valois, 1992; Myers et al., 2000). Computerized tools include the UFOV (Myers et al., 2000), as well as comprehensive assessment instruments such as the Cognitive Behavioral Driver's Inventory, and the Dynavision Performance Assessment Battery (Klavora, Heslegrave, & Young, 2000).

The Driver Performance Test is a series of brief, videotaped driving scenarios, each followed by a multiple choice question. These videos, unlike the paper-and-pencil visual perceptual tests, involve movement of the images that change over time. The test more closely simulates potentially dangerous driving situations, but in the safe environment of the testing room. This tool can be very useful in providing an assessment of the person's ability to make quick observations and decisions to avoid driving hazards (Pierce, 1998).

The clinical assessment is best used to give the driver rehabilitation specialist an indication of the person's strengths and weaknesses in the processing of visual information. Research has been inconclusive as to the *predictive* capacity of visual perceptual testing instruments for driving as mixed correlations have been noted (Brooke et al., 1992; Galski, Ehle, & Bruno, 1990; Jennings, 1995; Klavora et al., 2000; Korner-Bitensky et al., 2000; Myers et al., 2000). The separation of the driving process into discrete elements, and testing each element individually belies the complexity and simultaneous nature of the driving task (Ball & Owsley, 1991). Someone with a long driving history before their injury will be using the skills they learned over many years, and may perform far better on the road than the clinical assessment may suggest. The final determination of a person's driving ability should be based on a behind-the-wheel evaluation.

On-Road Assessment

Guidelines have been written for the development of a driving test route (Fox, Bowden, & Smith, 1998). The route typically is arranged in phases (Stressel, 2000) that gradually increase the complexity of the driving environment, providing a range of driving speeds and road conditions. The person must demonstrate safe driving in each phase before progressing to the next phase. During the most complex phase the examiner should plan for the possibility that the driver will opt to abort the route and remain in a lower-demand driving situation.

The on-road assessment allows for observations of the person's ability to handle the vehicle under a variety of road and traffic conditions. The driver must be able to attend to various traffic signs and follow the posted speed limit. They must constantly be aware of the presence and actions of the other vehicles and modify their driving in response to those around them. Unanticipated situations, such as a delivery vehicle blocking the lane ahead, frequently arise and the person's ability to respond safely and avoid creating hazards can be evaluated.

Examination Results

After the driving evaluation a review of the test results and on-road assessment is provided, including the strengths and weaknesses noted. The person is often asked to provide a self-assessment of their performance, and to discuss their longstanding driving style or habits.

A successful outcome of the assessment often includes a recommendation for driver's training to improve the person's driving habits, compensate for deficits, or develop further skills with any recommended adaptive equipment (Hunt, 1993). An education program

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such as those offered by AAA or AARP may be beneficial to review driving skills.

In Maryland, drivers with designated medical conditions are required to undergo a review by the MVA Medical Advisory Board, and may be required to be re-examined for vision, brake reaction speed, and driving skill. Driver's training typically includes a period of driving practice on a variety of roadways, and includes the maneuvers of turnabout and parallel parking which will be needed for the MVA skills test. Older learners may need additional time and practice sessions for learning new skills, as they may be unlearning old driving habits or techniques (Hunt, 1993).

If the driving assessment reveals more serious deficits to safe driving, consideration should be given to remediating the problem. Further therapy may be recommended, or a period of driver's retraining may be considered, followed by a re-evaluation of the person's progress.

Significant driving problems may result in the recommendation to cease driving, with exploration of alternative transportation options available in the community. The federal government has recognized the growing need for older drivers to have a wider range of transportation options (U.S. Department of Transportation, 1997). These options are intended to ease the limitations imposed on a person's lifestyle when independent driving is no longer a safe activity.

Summary

In this article we analyzed the impact of visual perceptual deficits on the skill of safe driving, considering acquired impairment as well as the normal aging process. The need for driver rehabilitation for the older adult is expected to grow as the population ages, and the valuable contribution of occupational therapists to this field is acknowledged (U.S. Department of Transportation, 1997). The profession has a strong background in working with visual perception and cognition issues, and promoting independent functioning. Occupational therapists are encouraged to consider this area as a specialty in practice. ■

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Resources

Brake Reaction Test
Concerned About an Older Driver? A Guide for Families and Friends
AAA Foundation for Traffic Safety
1440 New York Avenue, NW
Suite 201
Washington, DC 20005
www.aaa.org

Creating Mobility Choices: Older Driver Skill Assessment and Resource Guide
55 Alive/ Mature Driving Program
AARP
601 E Street
Washington, DC 20049
www.aarp.org

Supporting the Mature Driver: A Handbook for Friends, Family Members & Advisors
AgeQuest
P.O. Box 1481
Royal Oak, Michigan 48068

The Association for Driver Rehabilitation Specialists (ADED)
P.O. Box 49
Edgerton, Wisconsin 53534
606-884-8833
www.driver-ed.org

National Highway Traffic Safety Administration (NHTSA)
U.S. Department of Transportation
400 Seventh Street
Washington, DC 20509
www.nhtsa.dot.gov

Carol J. Wheatley, *MS, OTR/L, is an Adaptive Driving Specialist, Maryland Rehabilitation Center, Division of Rehabilitation Services, Maryland State Department of Education, Baltimore, Maryland; cjw@toadmail.com*

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