BRAIN INJURY VISUAL ASSESSMENT BATTERY FOR ADULTS (biVABA)

TEST MANUAL

MARY WARREN OT, PhD, FAOTA, SCLV

Published by:
visAbilities Rehab Services Inc.

DISCLAIMER

The information in this manual is meant to provide a rationale for the assessments, and instructions and guidance on how to use assessment results to select interventions that enable the client to participate in daily occupations. In addition to instructions and descriptions of the assessments, the manual provides information on common types of vision impairment from adult acquired brain injury, their effect on occupational performance, and evidence-based interventions to improve compensation for the vision impairment. The information is not meant to substitute for the services of an ophthalmologist, optometrist, neurologist, neuropsychologist, or other health care or vision rehab professional.

We have made every effort to ensure that this revised manual is current, complete, and accurate. However, there may be unintentional typographical and content mistakes. The manual is not intended to provide a comprehensive compilation of all information available on visual assessment of adults with acquired brain injury. We urge you to make use of additional sources of material on this subject.

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The author would like to thank the many persons who contributed to the biVABA.

Dr. Josephine (Jo) C. Moore, Professor Emeritus, University of South Dakota School of Medicine, for the use of her amazing, detailed illustrations. Dr. Moore's skill at making this most complex of subjects understandable to a generation of clinicians has benefitted countless clients. Her dedication has ensured that neuroscience continues to be an integral part of occupational therapy education.

Dr. Lea Hyvarinen, University of Helsinki, for granting permission to include the LeaNumbers Intermediate Acuity Test Chart and the LeaNumbers Low Contrast Flip Chart with 10M Optotypes in the battery.

Dr. Bertil Damato, Consultant, Ophthalmic Surgeon, St. Paul's Eye Unit Royal Liverpool University Hospital for permission to include the Damato 30 Point Multifixation Campimeter in the battery.

Yolanda Cate, MS, OTR/L, SCLV, CDE for her assistance in creating the Spanish version of the Warren Text Card

The wonderful occupational therapy practitioners who contributed to the development of the original battery in 1998 and the subsequent revisions.

PREFACE

In my early clinical career, I worked mostly with adults recovering from stroke or traumatic brain injury. I had been well-trained in how to address motor limitations using Bobath, Brunnstrom, and NDT interventions. But I didn't know anything about assessing or treating the client's visual processing deficits. Although I had graduated with an OT degree from a fine university, I had received little formal education on vision impairment. I knew that double vision was possible, but I don't recall that hemianopia was ever mentioned, and neglect was barely mentioned. I was aware of Jean Ayres' newly emerging sensory integration theory but was taught that it only applied to children. I knew that many of my clients didn't see well but as I had no idea how to evaluate or improve their vision, I focused instead on their physical and cognitive limitations, as did my OT colleagues. As my clients consistently failed to fully achieve their goals, I slowly began to suspect that maybe their vision was to blame. Frustrated by my lack of knowledge, I launched a self-study on how to assess and treat visual impairment from brain injury. I studied the work of Getman, Frostig, Cratty, Ayres and others. I researched the types of vision impairment associated with brain injury. Mentored by Dr. Moore, I eventually developed the visual perceptual hierarchy to serve as a framework for assessment and intervention.[257, 258]

With a framework in place, I began to focus on assessments that would help me identify how vision impairment limited the client's ability to participate in occupations. I realized that the traditional diagnostic assessment that relies on tightly controlled test procedures and cut-off scores to identify types of vision impairment would not provide what I needed. Comparing my client's performance to other adults may help label the deficit but it would not enable me to fully understand how my client's vision facilitated or inhibited their occupational performance. I needed a *clinical tool* that would show me my client's strengths and weaknesses in using their vision for occupations. This desire became the rationale for selecting the biVABA assessments.

Using what I had learned, I identified four principles to guide the design of the biVABA.

1. A client's visual performance is not significant in terms of how it deviates from an established norm but how it interferes with functional ability.
2. OT evaluation should focus on identifying the client's strengths and weaknesses in using vision to participate in occupations.
3. Intervention is needed only when the client's ability to use vision prevents or interferes with performing a necessary or desired occupation.
4. Intervention should focus on maximizing strengths and minimizing weakness in the client's ability use vision to participate in occupations.

The subsequent assessments that I selected for the biVABA screen for impairment in the four visual areas that are most often impaired in brain injury. These visual areas include high and low contrast visual acuity, visual field, oculomotor function, and visual scanning and attention. Several assessments were designed by experts from ophthalmology and optometry; others I designed based on the research literature and clinical experience. The assessments do not use cut scores or other diagnostic criteria to classify the client as having a specific type or level of vision impairment. Instead, they combine information from short, standardized assessments with key clinical observations to identify the effect of the client's vision on occupational performance. Cuing and do-overs are built into the assessments to provide insight into the client's ability to compensate and learn from their mistakes to improve their visual performance.

I consider my primary contribution to the biVABA to be information on how to interpret and use the assessment results to develop effective interventions that reestablish occupational performance. Besides detailed instructions for administering the assessments, the manual describes expected occupational limitations and how to interpret assessment results and use them to set goals and provide intervention. The appendices at the end of the manual provide additional information on evaluation and intervention and a complete list of references.

This updated manual represents the culmination of over 40 years of study, research, and clinical experience working with adults experiencing visual impairment from brain injury. OT's familiar with my work should already understand the framework that underlies my approach to assessment and intervention. But, if you are unfamiliar with this approach, I strongly encourage you to read sections 1 and 2 before moving onto the sections that describe test procedures, interpretation, and intervention.

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1 Why Evaluate Vision?

1.1 The Importance of Vision to Everyday Living

See Appendix J: Illustration 1: Vision: An Extraordinary Gift, Dr. Josephine C. Moore for additional information

Vision plays a significant role in daily living because of two important attributes that add speed to our information processing.

- *Attribute 1*: Vision takes us father and faster into the environment than any of our other sensory systems. Our visual system is always out in front letting us know what we might encounter next. This advanced warning system enables us to **anticipate** and **predict** what will happen next and plan for it. We rely on vision to make countless daily decisions from the dramatic (whether to take cover from a tornado) to the mundane (where to sit in a crowded room). Vision also alerts us to upcoming challenges to our balance such as a curb or a banana peel on the floor and it functions so reliably that we rarely collide with objects or fall during the course of a busy day. In short, vision provides the gift of anticipation enabling us to successfully plan for situations.

- *Attribute 2*: As our only truly integrative sense, vision instantly informs us about every attribute of an object-color, size, weight, texture, shape, and temperature. For example, picture a large unopened plastic bottle of water in the refrigerator. W*ithout touching it* you know it will feel curved, smooth, cold to the touch, and heavy as you pick it up. You could identify these properties of the bottle without vision but not with the speed that vision can provide. Just as importantly vision supplies this information from a distance- you don't have to touch the bottle to identify its properties.

These visual attributes of speed and anticipation enable us to adapt to static and dynamic environments easily and successfully. As the only moving object in a static environment, we use vision to adapt to important spatial features like the placement of chairs within a room. We don't need to worry about our temporal adaptation (e.g., timing) because we decide how quickly to move and when to start and stop movement. Contrast this with a dynamic environment that contains stationary and moving objects. In this environment we must use vision to time our movement to either engage or avoid objects. Only vision provides the speed we need to successfully anticipate and adjust to this added temporal requirement. The speed at which we can process visual information allows us to rapidly extract detailed information about the environment and make rapid decisions. This enables us to successfully adapt to complex and dynamic environments with multiple objects moving around us such as when driving in rush hour traffic, shopping in a crowded grocery store, or playing a game of basketball or soccer.

Vision's efficiency as a conduit for sensory input into the brain has made it the primary way that we acquire information as we go about our day.[150] We rely on vision to guide our social interactions. We scrutinize gestures and facial expressions to judge our companion's mood and adjust our expressions and words accordingly. Vision also dictates and guides our motor actions: the sight of our favorite piece of pie triggers the search for a fork; an approaching tennis ball elicits movement of the racket to intercept it. Many of our favorite hobbies rely on vision as does driving-the ultimate dynamic I-ADL. We even transformed a device once used only for verbal communication into a *smartphone* that feeds us a constant stream of visual content throughout the day. In a nutshell-*vision rules* our day.

1.2 The Role of Visual Processing in Directing Participation in Occupations

Newer models of neocortical processing suggest that the brain uses past experiences to create a context for evaluating incoming visual information and predicting what is going to happen next.[14, 100, 101] We use this previously learned information to continuously run unconscious simulations that will keep us prepared to successfully respond to every situation that arises.[14] For example, the waiter pours you a steaming cup of coffee; based this sensory context you predict that the cup could burn your fingers when you pick it up and the coffee could burn your throat. So instead of grabbing the cup and taking a big gulp you decide to lightly touch the cup to see if it safe to pick up and sip the coffee to avoid burning your tongue.

It is important to remember that these predictive simulations are unlocked and activated by *context* and *environment*. Occupational therapists are well schooled in these two terms. The OT Practice Framework[7] defines context as "the environmental and personal factors specific to each client…that influence engagement and participation in occupations" (s9). Environment includes "animate and inanimate elements of the natural or physical environment." (s36). As the primary way we acquire information, vision dominates identification of the environment *and* context. As we go through life, we use vision to collect, combine, and store experiences in different environments to create specific contexts for our actions. Linking environment and context together enables us to construct plausible hypotheses for what we will *see* next when we move our eyes or *feel* next when we move our bodies.[14] Picture yourself standing in the produce aisle of the grocery store (environment) shopping for the ingredients for a pie (context) and you see a bin of round red objects. Based on the environment and context you predict that those objects are the apples that you need for the pie. If your apple prediction is correct, visual processing doesn't need to go any further-you simply select the number of apples that you need and move on to the next item on your list.[14]

The ability to make a correct prediction depends on *accurately seeing* the critical environmental features that trigger memory and unlock prediction. Vision impairment may cause a person to miss or mis-interpret the critical environment and task features that define the context and trigger prediction.[14] The client who lacks sufficient vision to accurately identify their surroundings may feel like they are in a bad dream where nothing makes sense. In response, this client may become fearful, agitated, or angry, and express their stress by shutting down, avoiding, and withdrawing. Sound familiar?

1.3 The Effect of Visual Impairment on Occupational Performance

Acquired brain injury can alter the quality and amount of visual input into the brain and the brain's ability to acquire visual input. Deficits in acuity, oculomotor control and visual field reduce the quality and amount of visual input while deficits in visual attention alter the ability to acquire visual input. A deficit in either ability can reduce the person's capacity to use vision to complete daily occupations.

The most obvious consequence of vision impairment is difficulty completing *vision dependent* activities which are activities that require vision to successfully complete. A simple way to identify vision dependent activities is to consider whether they can be successfully completed in a room with no sources of light. If you find yourself in such a room with a tray of food, would you be able to feed yourself? The answer is yes-it might be a messy process, but you wouldn't starve, nor would you be unable to dress yourself, use the toilet, or bathe. You might have difficulty applying make-up or shaving but I bet you could wash your face and brush your teeth. This is because basic-ADLS are not vision dependent. In contrast, most Instrumental-ADLS depend on vision. You would not be able to fill out a form, pay your bills or manage your medications in this dark room. Because vision impairment primarily affects the ability to complete I-ADLS,[19] it's easy to overlook its presence during inpatient recovery due to the emphasis on completing basic ADLs.

Another significant consequence of vision impairment is a loss of decisiveness, speed, and precision in completing occupations. The integrative nature of vision enables us to rapidly assess situations and formulate an accurate and successful response. Vision impairment forces the person to rely on their other senses and cognitive abilities to complete the activity. The person must put more time and mental effort into completing activities, which can cause fatigue and a dropping out of occupations. The person also makes mistakes because they didn't see a critical feature or object. Repeated errors may reduce the person's sense of autonomy and self-efficacy, which may lead to passiveness and reliance on others to complete occupations.[59, 74, 102, 256]

Unfortunately, vision loss is a hidden disability.[74] It is immediately obvious when a client can't use a limb, but we observe only the effect of vision impairment on the performance skills that it supports. The client's brain injury diagnosis may also mislead us. A client who responds slowly, makes errors and passively depends on others to direct their actions, can suggest cognitive impairment rather vision impairment; likewise, agitation and shutting down can suggest emotional dysregulation rather than a stress reaction due to an inability to interpret the visual world.

1.4 The Visual Perceptual Hierarchy Framework for Evaluation and Intervention

The ability to use vision to complete daily occupations requires integration of visual input within the brain to transform the retina's raw data into cognitive concepts (rules) that we use to interpret and understand the visual world. Visual perceptual processing can be conceptualized as an organized hierarchy of visual processes and functions that interact with and sub-serve each other to ensure this integration.[256, 257] The hierarchy shown in Figure 1.1, consists of three visual functions: ***visual acuity, visual fields,*** and ***oculomotor contro*l** that form the foundation for four visual processes***: visual attention, visual scanning, pattern recognition,*** and ***visual memory***. Within the hierarchy, each process is supported by the one that precedes it and cannot properly function without the integration of the lower-level process.

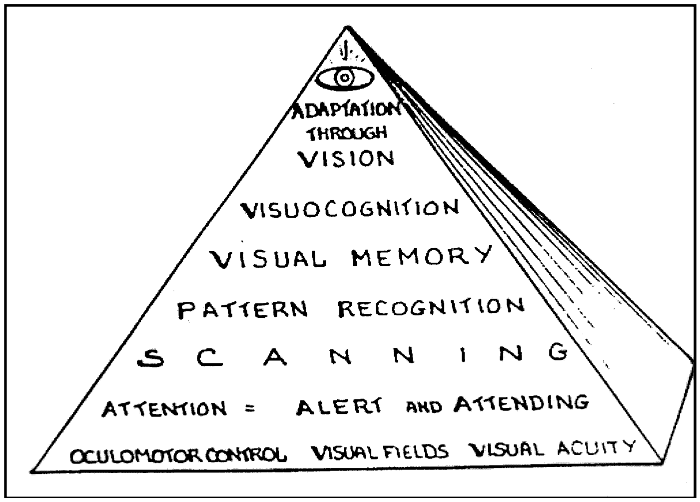


Figure 1.1: The Visual Perceptual Hierarchy. *Illustration courtesy of Josephine C. Moore OT, PhD.* Working together, these processes enable ***visual cognition***, the highest-order process in the hierarchy.

Visual cognition is the ability to interpret and integrate vision with other sensory information to identify, understand, and use objects to achieve goals. We begin to develop visual cognition in childhood as we combine vision with sensory input from the body to develop cognitive concepts (e.g., rules) for how space and objects operate.[150] We use these rules to interpret the images we see. Consider *size constancy*-the concept that an object occupies the same amount of physical space whether it is near or far from us.[5] We know from interacting with adults in childhood that the height of an average adult in the U.S. is between 5 and 6 feet. If, when looking in the distance, we see an adult who is 25 inches tall, we apply the rule of size constancy and predict that the person is several yards away and will become a full-sized adult as we move closer. Visual cognition enables us to complete complex visual analysis and as such, serves as a foundation for all academic endeavors and occupations.

Visual cognition controls the day-to-day application of vision to complete our daily occupations, but it must be supported by ***visual memory***, the second process level in the hierarchy.[5] We begin storing visual memories in infancy.[150] If we have normal visual processing, we will eventually establish a “library” in the posterior areas of the brain containing thousands of accurate, robust images that we can quickly access to unlock the context and predict what will happen next. Emotion is an important component of visual memory. We are more likely to attend to emotionally relevant objects, which increases the likelihood that their images will be stored in memory.[5, 64, 90, 150, 181] For example, it is easy to recall an image of your favorite food or your childhood pet but much more difficult to remember the face of the clerk who rang up your groceries.

To store and access images in memory, the person must recognize the pattern making up the image. ***Pattern recognition***, which sub-serves visual memory in the hierarchy, involves using the salient features of an object to identify and distinguish it from its surroundings.[90] For example, the salient feature that differentiates an "E" from an "F" is the lower horizontal line on the "E." Our ability to recognize patterns improves with repeatedly seeing it within a meaningful context.[69, 86] Thus children (and adults) spend hours viewing and deciphering patterns in order to develop a large library of images to assist with object recognition.[90]

Pattern recognition is dependent on the next process in the hierarchy: organized and thorough scanning of the visual array. ***Visual scanning*** (or search) is accomplished using *saccadic* eye movements. A saccade moves the fovea (the retinal area with the greatest ability to see detail) precisely onto a targeted object to clearly see and identify it.[137] When scanning a visual scene, the eyes selectively focus on the features and details required to accurately identify the context.[70, 133, 137, 141] The person ignores unessential details in the scene and scans the most important details several times to ensure accuracy.[70, 133, 137] Visual scanning occurs on two levels: an automatic, *reflexive level* largely controlled by the brainstem and a *voluntary level* driven by the prefrontal cortex.[89, 90, 137] On a reflexive level, visual search is automatically engaged by any novel object that moves or suddenly appears in the peripheral visual field.[89, 137] The eyes quickly move to locate and identify the object to protect us from an unexpected intrusion. In contrast, voluntary visual search is purposefully and consciously driven by a desire to locate a *specific* object, such as a misplaced set of keys, or to obtain specific information, such as where the exit is located.[57, 89, 133] We execute voluntary search based on where we anticipate an object will be found (e.g., the exit sign should be above a doorway). Voluntary search is also driven by highly visible features that "pop out" in the visual array.[5, 70, 141] For example, a bright red stoplight "pops out" to remind the driver to stop at a controlled intersection. Voluntary visual search is also efficiently completed using an organized, symmetrical, and predictable pattern based on the qualities of the visual array and the goal.[70, 137] For example, we always use a left to right/top to bottom scanning pattern when reading English.

Visual scanning is the outward expression of ***visual attention***, the process that precedes it in the hierarchy. The eye movements observed as the person scans reflect a shifting of visual attention from object to object.[89, 90, 94, 137, 141, 181] Visual attention is a critical prerequisite for visual cognitive processing. Clients with deficient attention may not search for visual information and miss the salient features needed to complete pattern recognition and lay down a visual memory. Clients who attend to visual information in a random and incomplete fashion also miss important details.[181] Neither client will be able to effectively use vision to make decisions.

The level and type of visual attention the brain uses depends on the type of visual analysis needed. For example, the type of attention needed to be aware that a chair is in the room is different from that needed to identify the style of the chair. The first instance requires a *global* awareness of the environment and the location of objects within it; the second requires *selective* visual attention to identify the features of the chair.[181] We must also be able to employ more than one type of visual attention at the same time. When crossing a crowded room to talk to a friend, we must monitor other people and obstacles to avoid collisions, while continuing to focus on our friend so we can successfully engage her. A large neural network that spans the brain is devoted to directing visual attention. The extensiveness of the network means that attention can be easily disrupted by brain injury, but it also increases the potential for recovery with intervention.[63, 90, 181]

The foundation visual functions: visual acuity, visual field, and oculomotor control, form the base of the hierarchy. Together these functions ensure that accurate visual information is delivered to the brain for perceptual processing. ***Visual acuity*** ensures the clarity of visual input; the brain must receive high quality, accurate visual input to identify objects. Impaired visual acuity prevents the brain from accurately perceiving visual detail. Intact ***visual fields*** ensure that the brain receives a complete picture of the environment. A visual field deficit can prevent the brain from registering all of the critical features and objects needed to identify the context of an environment. ***Oculomotor control*** ensures that accurate visual information is rapidly acquired when the body is moving or at rest, ensuring perceptual stability. Oculomotor impairment reduces the speed, accuracy, and efficiency of visual processing. Because they ensure the accuracy of visual input, any impairment of the foundation visual functions can have a profound effect on the higher-level visual processing in the hierarchy.

Acquired brain injury can disrupt visual processing at any one of the levels in the hierarchy. Due to its unity, a brain injury that disturbs a lower level will compromise the levels above it. It may appear that the client has a deficit in a higher-level process instead of the lower-level process that supports it. For example, a client may fail to locate the embedded figures on a figure-ground perception test not because this visual cognitive ability is impaired but because the client failed to search the left side of the embedded figures due to neglect or a left hemianopia. Intervention focused on improving figure-ground imperception will not be successful until the underlying deficits in visual attention and visual field are addressed. Focusing on improving foundational skills first should sound familiar as we are taught this approach to treating motor deficits. For example, when you observe that the client cannot use their hand to pick up an object, you surmise that their lack of success is due to a deficit in a foundational skill such as altered muscle tone, poor sensation, or muscle weakness. We understand that the client will not be able to use their hand until the underlying deficits are addressed in intervention. Unfortunately, we are usually taught a top-down framework to assess visual processing. This approach uses a standardized visual perceptual assessment to identify deficits in the products of visual processing (e.g., figure ground, visual closure etc.). These assessments often identify deficits in higher-level performance skills because they depend on lower-level processes. But because we didn’t assess those lower-level processes (acuity, oculomotor control, visual field, attention), we can only label the deficit; we have no understanding of how to provide an effective intervention.

1.5 The Occupational Therapy Approach to Evaluation

The Occupational Therapy Practice Framework[7] states that the overarching goal of occupational therapy is to assist the client to "*achieve health, well-being and participation in life through engagement in occupation*" (p. S5). Note that this statement does not include the word independence. Independence is defined by outcome (e.g., the client can independently don their shoes) whereas participation is defined by value and effort. With our help, a client may learn to put on his shoes independently but if he doesn't value this activity and it takes him 15 minutes complete it, there is a high probability that he will ask his wife to put on his shoes once he is discharged. After all, life is just too short to be spent putting a lot of effort into completing a meaningless activity. As OTs it is important that we abide by these three statements from our practice framework:

- "*Active engagement in occupation promotes, facilitates, supports, and maintains health and participation*." (p. s5)
- "*Participation occurs naturally when clients are actively involved in carrying out occupations or daily life activities, they find purposeful and meaningful*." (p.s5)
- "*Participation in occupations is considered both the means and the end in the occupational therapy process*." (p. s7)

Although it is important for clients to become independent in their daily occupations, participation is the ultimate goal of OT intervention. Following discharge, clients will reflect on their OT sessions and judge our success not by whether they can complete an activity, but whether they participate in the activity on a regular basis.

1.6 The Disconnect Between the OT Approach and the Traditional Approach to Evaluating Vision

Many of us were taught that purpose of evaluation is to identify and label the condition that limits the client's ability to complete a daily occupation in order to justify that the client needs skilled OT services. We were also taught that we should only use standardized diagnostic assessments with cut-off scores to identify and label the client's visual deficit. And we were taught that our documentation is more convincing if we use medical terms and OT centric language to describe the client's limitations and our intervention. While this approach produces impressive sounding documentation, it doesn't provide sufficient information on the client's abilities and limitations to enable us to select an effective intervention. Instead of providing a blueprint to guide our intervention, this approach leaves us struggling to establish measurable, achievable, client-centered goals and wondering which interventions would be most effective.

I believe that the disconnect between evaluation and intervention occurs because this traditional evaluation approach does not align with the OT Practice Framework. The practice framework states that *"The evaluation process is focused on finding out what the client wants and needs to do; determining what the client can do and has done; and identifying supports and barriers to health, well-being, and participation."*(s21) If, the primary goal of the OT intervention is to enable the client to re-engage in valued occupations, then it doesn't matter how much a client's vision deviates from a performance norm but instead how it interferes with occupational performance. Skilled OT intervention is justified when the client's vision interferes with performing a necessary or desired daily occupation. And if this is the OT role, then the purpose of evaluation is to:

1. Identify the client's limitations in occupational performance.
2. Identify whether and how the client's vision contributes to their limitations in occupational performance.
3. Identify the best intervention to enable the client to use their vision to participate in occupations.
4. Determine what to focus on first in intervention to achieve an optimal client outcome.
5. Identify the other vision professionals who should be on the rehab team to achieve an optimal client outcome.

Instead of attempting to label the condition, OT evaluation should focus on clearly linking vision impairment to occupational limitations. To accomplish this the OT must complete assessments that provide insight into how the client's vision hinders or facilitates occupational performance. We use evaluation to select an intervention that enables the client to use their strengths to mitigate their weaknesses. We also combine visual findings with findings about the client's motor, cognitive, emotional capabilities to determine the client's rehabilitation potential and set intervention goals. We may use some of the same visual assessments eye doctors use in order to identify the client's visual strengths and weaknesses, but we leave diagnosing and labeling to the eye doctors.

1.7 The Rationale for the biVABA Assessments and Test Procedures

Many changes in visual processing following brain injury are due to impairment in the foundation visual functions (acuity, oculomotor control, visual field) and the processes immediately above them (visual attention and visual search and scanning). Impairment at these lower levels reduces the brain's ability to complete complex visual processing and use vision for occupational performance. Therefore, evaluation should focus on screening for impairment at these levels. This shifts the focus from identifying deficits in discrete visual skills (like figure-ground imperception) that emphasize the distinctness of various components, to evaluating the visual skills needed to unify the system. This shift will enable you to do more than label perceptual deficits, it will help you *understand* how to improve the client's ability to use their vision to successfully complete occupations.

The biVABA was specifically designed as a tool to assist the OT to set achievable goals and select effective interventions. The assessments in the battery focus on the visual functions that enable a client to recognize pattern, lay down and access visual memories, and use vision to complete daily occupations. They include standardized and structured assessments to screen acuity, visual field, oculomotor control and visual scanning. The assessments assist the OT to identify the client's visual strengths and limitations by providing a structured way to observe how the client approaches and completes an assessment. You are encouraged to provide cuing, feedback and do-overs to determine if the client can improve performance, and the client is allowed to use strategies to improve their performance like repositioning test sheets, adding or removing lighting, and using their fingers as a guide. Observing the client's success or failure using such strategies helps determine the interventions that will enable the client to use their vision to complete tasks.

2 Types of Vision Impairment Following Acquired Brain Injury and How They Affect Occupational Performance

2.1 Visual Acuity

2.1.1 What is Visual Acuity?

Visual acuity is the ability to see visual details and color and provides the ability to clearly see high and low contrast details at near and far distances. It is an important foundation visual function that adds clarity to vision. By delivering high quality details, acuity contributes to the brain's ability to quickly identify objects and facilitates information processing and decision-making.

Acuity results from a multi-step process that begins with the focusing of light onto the retina. Light rays enter the eye through the pupil and are focused onto the retina via anterior eye structures including the cornea and the lens[152] (see Figure. 2.1). Photoreceptor cells in the retina record the basic components of an image that are relayed via the optic nerve and other pathways to the cortex for perceptual processing.[152] Although the concept is simple, the process is complex, involving multiple structures that communicate via complex pathways to create precisely coordinated action sequences. These pathways link the photoreceptor cells with the thalamus, brainstem, cortex, and cerebellum. The key action sequences of focusing include 1) precisely focusing the image onto the retinal photoreceptors through coordination of the anterior eye structures and eye movements 2) ensuring the photoreceptor cells are sufficiently suffused with light via the pupil 3) maintaining the sharpness of focus over a range of distances through eye movement and accommodation. This visual input is then transmitted via the optic nerve and other pathways through posterior cortical areas that attach language to the image and store it in memory.[137, 152] Any compromise of these structures or pathways may cause blurred vision.

2.1.2 Deficits in Visual Acuity

There are many causes of reduced acuity including congenital or acquired conditions; inherited or acquired imperfections in the eye structures; eye diseases that occur early or late in life; conditions that occur due to other diseases, neurological diseases, and eye and brain injuries.[32, 116] Ghannam et al.[85] identified reduced acuity in up to 70% of patients in the early stages of recovery from stroke. Their impaired acuity occurred from various causes including lost, dirty, or broken glasses. Ciuffreda et al.[48] identified 13 ocular conditions that had an elevated risk of occurring with TBI. Visual acuity deficits caused by brain injury generally involve disruption of one of the three action sequences described in the previous section: ability to focus light onto the retina, ability of the photoreceptor cells to accurately capture image and ability of the optic nerve and other pathways to the transmit the information to the rest of the brain for processing.[218] The next three sections describe types of vision impairment that can occur when brain injury disrupts these action sequences.

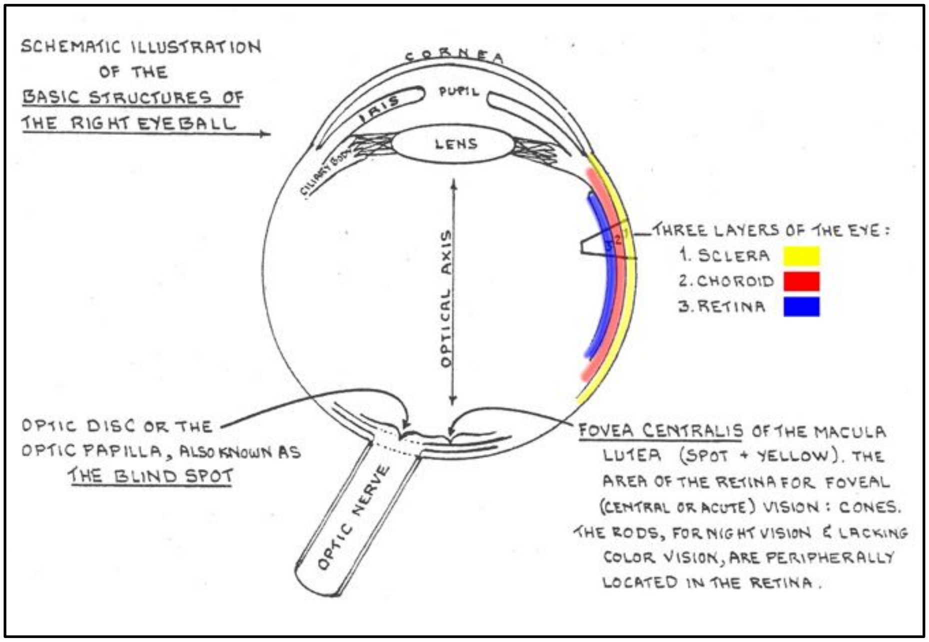


Figure 2.1: Structures of the eyeball. Images pass through the transparent cornea, lens and vitreous to focus on the photoreceptor cells of the retina and then onto the optic nerve. Illustration courtesy of Josephine C. Moore OT, PhD.

2.1.2.1 Disruption of the Ability to Focus an Image onto the Retina

The anterior eye structures must work in tandem with the oculomotor system to focus an image onto the retina long enough for the photoreceptor cells to extract visual details. Sharp focusing of the image onto the retina depends on the integrity of the anterior structures of the eye. The cornea must be smooth and transparent, the iris must be able to quickly contract and relax to change the size of the pupil, and the lens must be transparent and flexible. Light entering the eye passes through four transparent refractive media that help focus the image on the retina: the cornea, aqueous humor, lens, and vitreous humor (see Figure 2.1). Any opacity or irregularity in these structures will prevent light from properly reaching the retinal photoreceptor cells.

Focusing deficiencies from damage to the anterior eye structures and/or the oculomotor system are common following acquired brain injury.[137] Corneal scarring, trauma induced cataract and vitreous hemorrhage are three brain injury related conditions that reduce transparency.[48, 96, 139] Corneal scarring may occur from trauma to the eye incurred during an assault to the head. The damaged cornea forms a scar, creating an irregular surface that refracts the light unevenly and reduces transparency. A forceful blow to the eye can damage the lens and induce the eventual development of a cataract that clouds the lens. Eye trauma can also cause bleeding into the vitreous humor. Blood is opaque and the person experiences floaters, shadows, and darkness as the blood floats in front of the retina. The client’s primary complaint from each of these conditions is blurred vision that affects reading and seeing visual details. Of the three conditions, only vitreous hemorrhage creates a temporary condition that resolves without medical treatment.

The oculomotor system also contributes significantly to acuity by controlling *accommodation*-the ability to zoom in to focus on objects that are close to the face (see section 2.3.1 and illustration 2 in Appendix J).[232] The natural alignment of the anterior eye structures enables effortless focusing when viewing at a distance, but the structures must change and *accommodate* to focus on the short distance required for reading or other activities.[137] Accommodation occurs through a three step process: 1) the eyes *converge* (turn inward) to ensure that the corresponding photoreceptors in the retina are stimulated to capture the image, 2) the lens *thickens* to refract the light rays more strongly and shorten the focal distance, so that the image is focused onto the foveal area of the retina and 3) the pupil *constricts* to reduce scattering of the light rays and sharpen the image. Multiple areas of the brain are involved in coordinating accommodation including the retinal cone photoreceptor cells, the optic nerves, the lateral geniculate nucleus, the occipital lobes, the posterior parietal lobe, the frontal eye fields, the cerebellum, both nuclei of cranial nerve 3 and the oculomotor nerve.[232] Injury to the pathways connecting these areas can cause difficulty achieving and/or sustaining focus during near vision tasks. Accommodative disorders are estimated to occur in nearly half of adult and pediatric clients following traumatic brain injury.[49, 239] Focusing issues are also common in adults experiencing oculomotor impairment from stroke and neurodegenerative diseases like Parkinson's disease and multiple sclerosis.[40, 71] The client's most frequent complaint is difficulty maintaining focus when reading causing the print to blur and sometimes swirl on the page.[96, 121]

2.1.2.2 Disruption of the Ability of the Retina to Process the Image

The retina must be adequately perfused with light to capture high-quality images. Too little or too much light will degrade the image. The pupil regulates the amount of light entering the eye in response to changes in illumination by increasing or decreasing its aperture to ensure optimal perfusion of the photoreceptor cells in the retina.[86] The pupil is controlled through complex pathways involving the eye, brainstem, cortex, and cerebellum.[95, 231] Any condition that affects the responsiveness of the pupil diminishes the client's ability to rapidly adjust to changes in lighting. Difficulty regulating the speed and efficiency of the pupillary response may contribute to the elevated incidence of light sensitivity (photophobia) in clients with traumatic brain injury. Impairment of this reflex also interferes with accommodation as discussed in the previous section.[95, 137]

Retinal photoreceptor cells (see illustration 3 in Appendix J) can also be damaged by injury or disease. Age-related eye diseases (ARED) target the retina and are very common among adults over the age of 80 (see illustration 4 in Appendix J).[116, 251] The three most common ARED are age-related macular degeneration (AMD), diabetic retinopathy (DR) and open angle glaucoma (OAG)-(see section 2.1.2.3 for a discussion of glaucoma). AMD, the most prevalent cause of vision loss in older Americans, does not progress beyond the central visual field. The person never becomes blind, but damage in the central visual field can significantly reduce in visual acuity. Diabetes can cause several types of vision impairment, the most serious being diabetic retinopathy.[127] Diabetic retinopathy damages the central and peripheral areas of the retina and can cause blindness. Because the incidence of stroke also increases with age, it is not uncommon for an older client with stroke to also experience reduced visual acuity due to ARED. Unless the client discloses that they have an ARED, the vision loss from the eye disease may be overlooked or misdiagnosed as an attentional or cognitive impairment from the stroke. Other causes of retinal damage include stroke of the eye due to an occlusion of the central retinal artery. A central retinal artery occlusion (CRAO) may cause complete or partial blindness in the affected eye that is usually permanent.[145] Partial retinal detachment can occur following trauma to the eye.[139] The person may notice bright flashes of light or light progressing to shadow after the eye injury. Retinal detachment if not immediately treated, will result in permanent visual impairment.

2.1.2.3 Disruption of the Ability of the Optic Nerve to Relay the Retinal Image

Trauma is a common cause of optic nerve damage in clients with TBI. The injury may occur from a direct penetrating injury to the nerve or indirect trauma from forces transmitted during the impact to the brain.[214, 241] In severe closed head injuries stretching or tearing of the optic nerves can occur during the sudden deceleration of the head, usually resulting in bilateral damage to the optic nerves.[128, 241] Bilateral nerve injury can also occur from compression of the nerves due to increased intracranial pressure. Immediate, sudden, and complete loss of vision due to optic nerve trauma is often unresponsive to medical treatment and results in severe visual impairment or blindness.[128]

Glaucoma and multiple sclerosis are common neurodegenerative diseases that can cause optic nerve damage. Glaucoma is a collection of progressive optic nerve diseases that lead to significant vision impairment.[71] Open angle glaucoma (OAG) is one of the three age-related diseases that cause most of the low vision in older adults.[251] Glaucoma typically starts with vision loss in the mid-peripheral visual field and progresses simultaneously outward towards the periphery and inward towards the central field, eventually resulting in blindness if the disease process is not arrested.[137] The central field deficit significantly decreases visual acuity and the ability to see detail and color. Persons are typically unaware of the disease until it has progressed into the central visual field. Persons with Parkinson’s Disease appear to have higher rates of open angle glaucoma although the association between these two diseases is not fully understood.[71] Glaucoma can also develop following blunt trauma to the eye, and this is the form most likely to occur following TBI.[154] Persons with multiple sclerosis may experience optic neuritis-an inflammation of the optic nerve that can occur in one or both eyes. The central visual field is usually affected reducing the ability to see details, color and low contrast and the person often experiences light sensitivity.[40, 54] Early episodes of optic neuritis may only cause temporary vision loss, but the condition can eventually lead to permanent vision loss.[54]

2.1.2.4 Uncorrected Refractive Error

One last cause of reduced acuity must be mentioned. *Uncorrected refractive error* (URE) is a commonly occurring condition in American adults that causes a subtle but significant effect on occupational performance. Although some people enjoy perfect visual acuity throughout their lifetimes, many of us are born with or acquire refractive errors that reduce our visual acuity. Refractive errors (see illustration 5 in Appendix J) alter how light rays are focused onto the retina. They result from imperfections in the shape of the cornea or eyeball or from aging of the lens. Common refractive errors include hyperopia (far-sightedness), myopia (nearsightedness), astigmatism (uneven corneal surface), and presbyopia (age-related loss of lens flexibility).[184] Eye doctors are skilled at identifying and treating refractive errors using lenses or surgery. However, despite the availability of eye care, uncorrected vision impairment is a significant public health issue. It has been estimated that over eight million Americans experience unnecessary vision impairment URE.[247] Older adults make up the largest number of Americans with correctable vision impairment. Medicare covers the cost of an annual eye exam, but many older adults never receive this exam due to health reasons or limited access to eye doctors.[72, 167] Other older adults cannot afford to update their eyeglasses prescription as Medicare does not cover the cost of eyeglasses. These barriers are more likely to affect older adults residing in nursing homes and assisted living facilities where it is estimated that nearly a third of vision impairment can be corrected with glasses or surgery.[72, 167] Owsley et al.[167] found that residents in nursing homes with URE reported increased psychological distress, (e.g., worry, frustration, anxiousness) and depression. A subsequent RTC completed on the study participants showed that residents who received updated eyeglasses reported a decrease in psychological distress, an increase in social participation and fewer depressive symptoms.[168]

2.1.3 Occupational Limitations Caused by Reduced Visual Acuity

Blurred vision is the most common acuity complaint of persons with ABI and difficulty reading is their most common functional complaint.[32, 95, 196] Reading is a key component of many important I-ADLs. People need to read to shop in a store, eat in a restaurant, pay bills, drive a car, participate in a religious service, dial a cell phone, read a text, read a clock face, cash a check, wash a new garment, and measure weight, blood pressure and glucose level. Poor acuity causes more difficulty completing I-ADLS because they are more dependent on good acuity.[19] With some effort, a blindfolded person can complete all basic ADLs including dressing, bathing, toileting, feeding, and oral hygiene, but that same person would not be able to read a bank statement, accurately measure ingredients to bake a cake, or write a letter to a friend. Difficulty seeing small visual details and color also impairs fine motor coordination which can affect occupations such as meal preparation, medication management, financial management, grooming and shopping. Poor acuity may also impair the ability to locate landmarks and obstacles quickly enough to adapt to a dynamic environment limiting participation in community activities such as driving, shopping, and attending social events.

2.2 Contrast Sensitivity

2.2.1 What is Contrast Sensitivity?

Contrast sensitivity-also called low contrast acuity-is the ability to reliably distinguish the borders of objects as they degrade in contrast from their backgrounds.[166] Because much of the visual environment is made up of objects with low contrast borders and features, it could be argued that reduced contrast sensitivity contributes more to our ability to perceive and visually adapt to the environment than visual acuity. Common examples of low contrast features include unpainted curbs, curb cuts and steps; glass doors, water spilled on the floor or rising in a sink or bathtub, and facial features. Sub-optimal lighting conditions also reduce the contrast of objects in the environment.[116] Normal aging causes a progressive decline in contrast sensitivity largely due to optical changes in the eye.[116] A large longitudinal study on older adults without eye disease found that a 70-year-old adult required twice as much contrast as a 20-year-old to identify a faint object/feature and a 90-year-old needed 6 times as much contrast to identify the same object.[31] ARED generally causes a significant reduction in contrast sensitivity adding to the client's difficulty completing ADLs and increasing the risk for falls.[114,166]

2.2.2 Deficits in Contrast Sensitivity

Reduced contrast acuity can occur with stroke and TBI.[35, 85] Ciuffreda et al.[48] reported that approximately 20% of persons with mild TBI experience reduced contrast sensitivity. Bulens et al.[35] reported that nearly two thirds of participants with stroke affecting the posterior visual pathways demonstrated reduced contrast sensitivity. Reduced contrast acuity from cerebral lesions is thought to be due to destruction of neurons in the cortical areas that process visual information along with a decreased sensitivity in the surviving neurons due to disruption of neuronal interaction.[28] Decreased contrast sensitivity also occurs with neurodegenerative diseases including Alzheimer's Dementia, Parkinson's Disease, and multiple sclerosis.[54, 116, 132, 166, 221]

2.2.3 Occupational Limitations Caused by Reduced Contrast Sensitivity

Reduced contrast sensitivity is more likely to occur following stroke and TBI than reduced high contrast visual acuity. It can also occur without a change in high contrast acuity, and often occurs in conjunction with visual field deficits (hemianopia and macular scotoma).[35, 66, 125] When present, it interferes with the ability to complete a diverse number of daily occupations including reading, recognizing faces, locating objects, driving, navigating safely through environments, and using tools.[66, 166, 271] Persons with reduced contrast acuity also have difficulty completing activities in suboptimal lighting conditions and significantly benefit from enhanced illumination.[116, 125]

2.3 Oculomotor Control

2.3.1 What is Oculomotor Control?

Oculomotor control entails the ability to move the eyes together to provide a clear single image to the brain. The sole job of eye movement is to place an object of interest onto the fovea and maintain fixation as long as needed to accomplish the desired goal.[48, 137] This process is known as foveation and the need to foveate objects drives the oculomotor system.[137] This is a daunting task because human beings are mobile creatures who interact with dynamic environments. An image focused on the fovea is always in danger of slipping off when the head or target moves. Eye movements keep the target stabilized on the fovea during fixation, gaze shift, and head movement. Several oculomotor systems interact to provide this control including the vestibular-ocular-cervical responses, the optokinetic system, the saccadic system, the smooth pursuit system, and the vergence system (see illustration 7 in Appendix J).[137]

- The *vestibular-ocular-cervical responses* hold images of the seen world steady on the fovea during *transient* movement of the head and body. Even when completely stationary, we experience significant involuntary head movement from varied sources. Examples include smaller vibrations transmitted from the heartbeat, the support surface, and minute postural sway, and larger forceful head movements during activities like walking, running, or riding in a car. To counter this threat, the brain combines input from the vestibular, cervical, and ocular systems to produce compensatory eye movements. These eye movements occur automatically in response to head movement to keep the image on the fovea. The vestibular ocular reflex (VOR) is the primary reflex used to stabilize gaze during transient head movement supplemented by the cervical ocular reflex (COR).[137]
- The *optokinetic system* augments the vestibular-cervical-ocular responses to maintain foveal stabilization during *prolonged* head movement. Head movement lasting longer than 30 seconds results in adaptation of the VOR preventing it from eliciting compensatory eye movements. The optokinetic reflex relies on a continuous (e.g., tonic) signal from the retina rather than a short term (e.g., phasic) signal from the inner ear labyrinth to detect head movement and initiate compensatory eye movements. This ability enables the optokinetic reflex to take over the function of the VOR during sustained head movement.[137]
- The *smooth pursuit system* ensures that the target stays on the fovea during fixation and when the target is moving.[137] When the eyes and the target both are stationary, the smooth pursuit system supplies continuous small eye movements that move back and forth over the boundaries of the target to ensure that the image stays fresh on the retina and does not fade. If the viewer remains stationary as the target moves away, the target will eventually slip off the fovea and the image will blur. To prevent this, the smooth pursuit system initiates eye movement in the direction of the moving target. The eye movement increases in velocity until it matches the speed of the target, ensuring that the image stays focused on the fovea.

- The *saccadic system* directs the fovea towards an object of interest. Saccadic eye movements rapidly redirect attention to new objects and keep the brain informed of all possible threats and resources within the field of view.[137] Saccades are initiated under *involuntary control* via the brainstem when a possible threat appears in the environment and *voluntary control* via the prefrontal cortex to purposely search for a desired object. The eyes and head usually move together when searching the environment. We use a saccadic eye movement to initiate search but quickly supplement with smooth pursuit and head movement if the target lies in our periphery.[80, 137] The field of vision we can perceive when using head and eye movement together is wider than that achieved by eye movement alone. Therefore, our ability to completely scan our surroundings, depends more on our gaze stability and full neck range of motion than the ability to move each eye through its full range of motion.

- The vergence system helps to maintain foveation as objects move close to and away from the body. *Convergence* (moving the eyes inward towards the nose) occurs in conjunction with pupil constriction and thickening of the lens to produce accommodation (see section 2.1.2.1 and illustration 6 in Appendix J). During accommodation, convergence keeps the image aligned on corresponding photoreceptors in the two eyes to ensure that the person continues to clearly see only one image (known as sensory fusion) as the object moves closer. When the object moves away from the body, divergence (moving the eyes back to primary gaze) occurs to ensure that only one image continues to be seen.[137]

The parietal, temporal, occipital and prefrontal lobes, plus the thalamus, cerebellum, and brainstem form a complex network to ensure that eye movements are able to attain and maintain foveation.[137, 232] These divergent brain areas exert their control over eye movement using the same motor pathway comprised of three pairs of cranial nerves (CN): CN 3-oculomotor nerve; CN 4-trochlear nerve and CN 6-abducens nerve. Altogether these cranial nerves innervate seven pairs of striated extraocular muscles that move the eye and the internal eye muscles (iris and ciliary muscles) that control pupil size and the shape of the lens.[137] The muscles of the two eyes must work in tandem to produce the precise coordinated movements needed for binocular vision (see illustration 7 and 8 in Appendix J). The extensiveness and complexity of the pathways controlling eye movements makes them vulnerable to damage from many types of brain injury.[137, 233]

2.3.2 Deficits in Oculomotor Control

The prevalence of eye movement disorders from acquired brain injury ranges from 50% to 90% in studies.[21] Stroke and TBI cause the highest percentage of oculomotor impairment: up to 90% of persons with TBI and 87% of adults with stroke.[49] Most impairment occurs from damage to pathways and structures within the cortex, brainstem, and cerebellum. Accommodative disorders and convergence insufficiency are the most reported oculomotor conditions in persons with TBI.[48] Cranial nerve lesions and convergence insufficiency are the most reported oculomotor conditions in persons with stroke. Oculomotor impairment is also common in persons with Parkinson's Disease, multiple sclerosis, and Alzheimer's dementia.[137]

2.3.2.1 Oculomotor Impairment from Paralytic Strabismus

Cranial nerve lesions account for approximately 20% of oculomotor impairment from TBI or stroke.[197, 241] Damage to one of cranial nerves 3,4,6 can weaken or paralyze the extraocular muscle(s) that it innervates, and cause *acquired paralytic strabismus*.[137, 201, 202] *Strabismus* is a visual condition where the eyes do not align with one another because of muscle imbalance. *Paralytic* means that the muscle imbalance is due to paralysis of one or more of the extraocular muscles. *Acquired* means that the person was not born with this condition but acquired it from injury or disease. Restricted movement of one or more extraocular muscles causes a misalignment of the eyes as the person focuses on an object. The client has difficulty fusing the two images from the eyes into a single image and may complain of a double image that splits vertically or laterally, a ghosting image (like poor TV reception), a blurred image, or even a crooked or distorted image. The diplopia increases in the gaze direction controlled by the paralytic muscle and decreases in gaze directions away from the action of the paralytic muscle (called incomitant strabismus).[137] To minimize the diplopia, the adult client often assumes a head position that avoids the action of the paralyzed muscle. If a single image can't be attained, the client may use a head position that either allows the nose to occlude the second image or increases the disparity between the images to make it easier to identify the false image.

The client's performance limitations depend on whether the diplopia is constant or intermittent and whether it occurs at near or far distances. Milder CN injury may weaken but not paralyze the extraocular muscles. The affected muscle can still help move the eye so that the person can maintain sensory fusion when concentrating on a task. However, the weakened muscle often fatigues quickly causing the client to complain of intermittent diplopia, eye strain, headache, and poor concentration. More severe CN lesions cause significant or complete paralysis of the eye muscles resulting in constant diplopia and often a noticeable eye turn of the involved eye (see Illustration 8 in Appendix J). Eye doctors use specific medical terms to describe the extent of the strabismus. *Phoria* describes milder paralysis where the brain's need to maintain sensory fusion keeps the affected eye aligned with the other eye when focusing on an object.[202] *Tropia* describes moderate to severe paralysis where there is a noticeable deviation of the involved eye when focusing.[202] These terms are combined with four prefixes that describe the direction of the deviation: *eso*-the eye turns inward towards the nose; *exo*-the eye turns outward towards the temple; *hypo*-the eye turns downward; and *hyper*-the eye turns upward. For example, *esotropia* indicates a constant inward deviation of the eye during focus (e.g., a crossed eye) whereas *esophoria* indicates inward turning of the eye only when the eye muscle becomes fatigued.[202]

2.3.2.2 Oculomotor Impairment from Traumatic Brain Injury

Most oculomotor impairment results from damage to neural centers that coordinate eye movements.[9] TBI is a common cause of such injuries.[9, 49, 137] The damage occurs from shock waves transmitted through the brainstem and cerebrum during the TBI. The shock waves cause diffuse axonal damage to the pathways connecting the brain areas controlling eye movements and disrupt communication between these areas [9] Even mild head trauma (concussion) can cause pathway damage.[9, 49] Co-impairments may accompany TBI. They result from pathway damage sustained during the TBI and commonly include light sensitivity, post-traumatic headache, fatigue, and sleep disturbance.[6] Accommodative disorders-specifically convergence insufficiency-have been found to intermix with the other co-impairments from the TBI.[6, 153] Some co-impairments like light sensitivity tend to persist and may still be present up to two years following injury[146] (see section 2.3.3.3). Moderate to severe head injury often causes a combination of pathway and structural damage from focal lesions.[241] Damage to CN 3,4,6 for example can occur from focal lesions, tearing, contusion and compression from the head injury.[137, 241]

Oculomotor impairment can also occur from eye trauma sustained during the TBI. A penetrating eye injury can lacerate one of the extraocular muscles. A blow to the eye can also cause an orbital blow-out fracture. This injury occurs when the thin skeletal structure of the eye socket is fractured; it can entrap the inferior rectus and oblique muscles, restricting ocular motility. The client may experience enophthalmos, vertical diplopia and ptosis along with secondary complications from choroidal rupture, retinal hemorrhage, and glaucoma.[137, 154, 241]

TBI is also a frequent cause of visuo-vestibular dysfunction that causes inability to stabilize gaze during movement of the body and/or environment. Impairment can occur from damage to peripheral vestibular structures or central vestibular pathways.[137] Peripheral injuries (labyrinth of the inner ear; CN 8) can occur from displacement of inner ear structures due to rapid acceleration/deceleration of the head during the TBI, or from a skull fracture involving the temporal or petrous bones.[106, 137] Central vestibular injuries can occur from trauma to the brainstem or cerebellum. Oscillopsia, the perception of constant swirling and movement of the peripheral environment, is a common complaint among persons with visuo-vestibular dysfunction.[137, 236] The illusion of movement occurs from excessive slipping of visual images on the retina due to inadequate vestibular, cervical, and ocular responses during head movement.[137] Because visual stability is necessary for postural control, clients with oscillopsia and visuo-vestibular dysfunction often have impaired balance and postural control.[49, 54]

2.3.2.3 Oculomotor Impairment from Stroke

Stroke also causes oculomotor impairment.[49, 137, 197] Ciuffreda et al.[49] reported that 86.7% of participants with stroke demonstrated some type of oculomotor impairment-most commonly: strabismus, cranial nerve (CN) injury and convergence insufficiency. Rowe et al.[197] found that 54% of participants in large study of stroke survivors had oculomotor impairment. Within this group-18% had cranial nerve lesions involving CN 3,4,6. Vascular diseases including diabetes, hypertension, and atherosclerosis can also cause discrete lesions of individual cranial nerves.[137]

2.3.2.4 Oculomotor Impairment from Neurodegenerative Diseases

Persons with Parkinson's Disease often experience convergence insufficiency early in the course of the disease and develop diplopia and difficulty moving the eyes as the disease progresses.[137, 207, 269] Eye movement disorders are also common in persons with multiple sclerosis (MS) due to the inflammatory demyelinating nature of the disease.[54] Persons with MS may experience blurred vision, diplopia, nystagmus and oscillopsia.[54, 137] They can also develop a perplexing condition-*internuclear ophthalmoplegia (INO)*-from a lesion along the medial longitudinal fasciculus in the brainstem.[137] INO causes an inability to voluntarily adduct the eye on the affected side during horizontal gaze that is accompanied by nystagmus with abduction of the other eye. However, the person can adduct the eye when converging during accommodation. Persons with Alzheimer's dementia can also experience difficulty executing and controlling saccades due to changes in attention.[269]

2.3.3 Occupational Limitations Caused by Impaired Oculomotor Function

2.3.3.1 Convergence Insufficiency

Studies show that nearly half of all adults referred for visual assessment post brain injury complain of difficulties related to accommodation and focusing.[9, 96, 234] The most common focusing disorder is convergence insufficiency.[49, 96, 234] Persons with this condition have difficulty achieving or sustaining adequate focus during near vision tasks. The client often complains of fatigue, eye pain, or headache after a period of sustained viewing of near tasks especially reading.[32, 137, 191] Eye muscle fatigue from the exertion of sustaining convergence during reading breaks down sensory fusion and the client may experience odd visual phenomena such as the print swirling and moving on the page or the page going blank.[121] Because most persons with convergence insufficiency have normal cranial nerve function, their reading complaints may be mis-interpreted as perceptual impairment, inattention, or lack of effort, instead of oculomotor impairment.

2.3.3.2 Diplopia

Diplopia creates perceptual distortion that may significantly affect eye-hand coordination, postural control, and binocular use of the eyes. The client's functional limitations depend on whether the diplopia occurs at near or far focal distances. Diplopia that occurs at near distances (from 3rd or 4th CN lesion) can disrupt reading and activities that require eye hand coordination such as pouring liquids, writing, and grooming. Diplopia that occurs when viewing at a distance (from 6th or 4th CN lesion) can affect walking, driving, television viewing, and sports like golf and tennis. Persons with severe paralytic strabismus often assume an altered head position to maintain sensory fusion.[202] For example, a client with a left lateral rectus palsy (CN 6 lesion) may turn the head towards the left to avoid the need to abduct the eye; a client with paralysis of the right superior oblique muscle (CN 4 lesion) may tilt the head to the right to avoid the downward action of that muscle.[202] Without careful assessment of oculomotor function, there is a risk that altered head position is mistakenly attributed to instability of the neck or trunk rather than a functional adaptation used to achieve single vision.

2.3.3.3 Influence on Participation

Oculomotor impairment influences the client's willingness to participate in occupations. Its presence typically doesn't prevent the client from independently completing an occupation, but even mild oculomotor impairment makes it harder to use vision to complete occupations. The client must put more effort into focusing and moving the eyes which can increase visual stress, slow visual processing, and cause fatigue. The added stress and effort combined with co-impairments like light sensitivity can trigger post traumatic headache and make it difficult to participate long enough to complete activities. To reduce the stress, the client may begin to avoid environments and activities that place significant demand on the visual system. Reading is particularly stressful because it requires sustained focusing and attention and which is why difficulty reading is the most common complaint reported by persons with oculomotor impairment.[232] Activities in dynamic environments with lots of pattern and movement-such as driving or navigating community environments are also stressful.[96]

2.4 Visual Fields

2.4.1 What is the Visual Field?

The visual field is the area of the visual world that you can see when looking straight ahead. It reflects the functioning of the retinal photoreceptor cells and is analogous to the dimensions of a picture imprinted on the film in a camera (with the retina representing the film). The normal visual field extends approximately 60 degrees superiorly, 75 degrees inferiorly, 60 degrees to the nasal side and 100 degrees to the temporal side.[220] At the very center of the retinal visual field is the fovea-an area approximately 8 degrees in diameter and completely packed with cone photoreceptors.[220] We use the fovea to capture the visual details needed to identify objects. The fovea is embedded in the macula, and together they comprise the central visual field which is approximately 30 degrees in diameter.[220] The macula contains a mixture of mostly cone and some rod photoreceptor cells; it also contributes to object identification.[152] The peripheral field makes up the rest of the visual field and contains only rod photoreceptor cells that detect general shapes and movement in the environment. The peripheral visual field provides the background vision needed to orient within the environment. The blind spot lies on the border between the central and peripheral visual field on the temporal side of the field. The optic disc is located here and there are no photoreceptor cells in this area. Figure 2.2 illustrates the divisions and dimensions of the visual fields. Most of the visual field is binocular and is seen by both eyes. A small portion of the peripheral temporal field in each eye-known as the lateral or monocular crescent-can be seen only by one eye because vision in the other eye is blocked by the bridge of the nose.[152] When viewing Figure 2.2-note that field diagrams are drawn "as the client sees it" so that the field diagram on the right represents the client's right eye and vice versa.

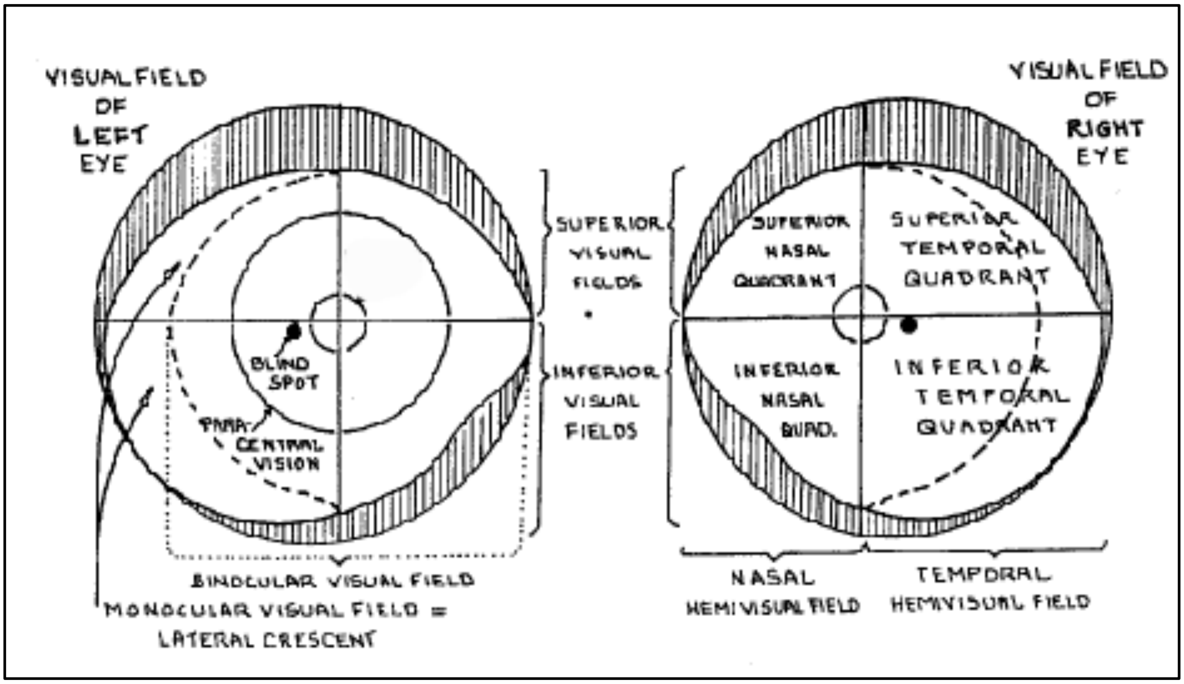


Figure 2.2: Visual field diagram illustrating the divisions of the visual fields as the person see them. Illustration courtesy of Josephine C. Moore OT, PhD.

The visual field is often depicted as a "hill of vision" (see Figure 2.3-next page) to describe its relationship to visual acuity.[180] The fovea lies at the peak of the hill. The fovea is the visual field area with the greatest acuity. The cone receptor cells within this area of the field can perceive even small and dimly lit targets. Visual acuity incrementally decreases as the field expands away from the fovea towards the peripheral visual field. The peripheral visual field is capable only of perceiving larger and brighter targets. The downward sloping of the hill represents this progressive decrease in visual acuity.

To successfully complete daily occupations, you must be able to keep track of the key objects in the environment that can provide either assistance or harm. For example, to successfully drive a car to a destination without an accident, you must see the vehicles directly ahead of you as well as those moving on the side. You must also see informational signs overhead and on the sides of the road along with pedestrians, bicyclists, animals, and other objects that may enter the path of your car. The visual field provides this panoramic picture. We use our visual field not only to see the "big picture" but also to see the details of objects. In reading, for example, the foveal field enables us to clearly see approximately 9 characters with each fixation.[182] This field information is enough to enable us to identify most English words quickly and accurately during a single fixation and to fluently read with good speed and comprehension.[182]

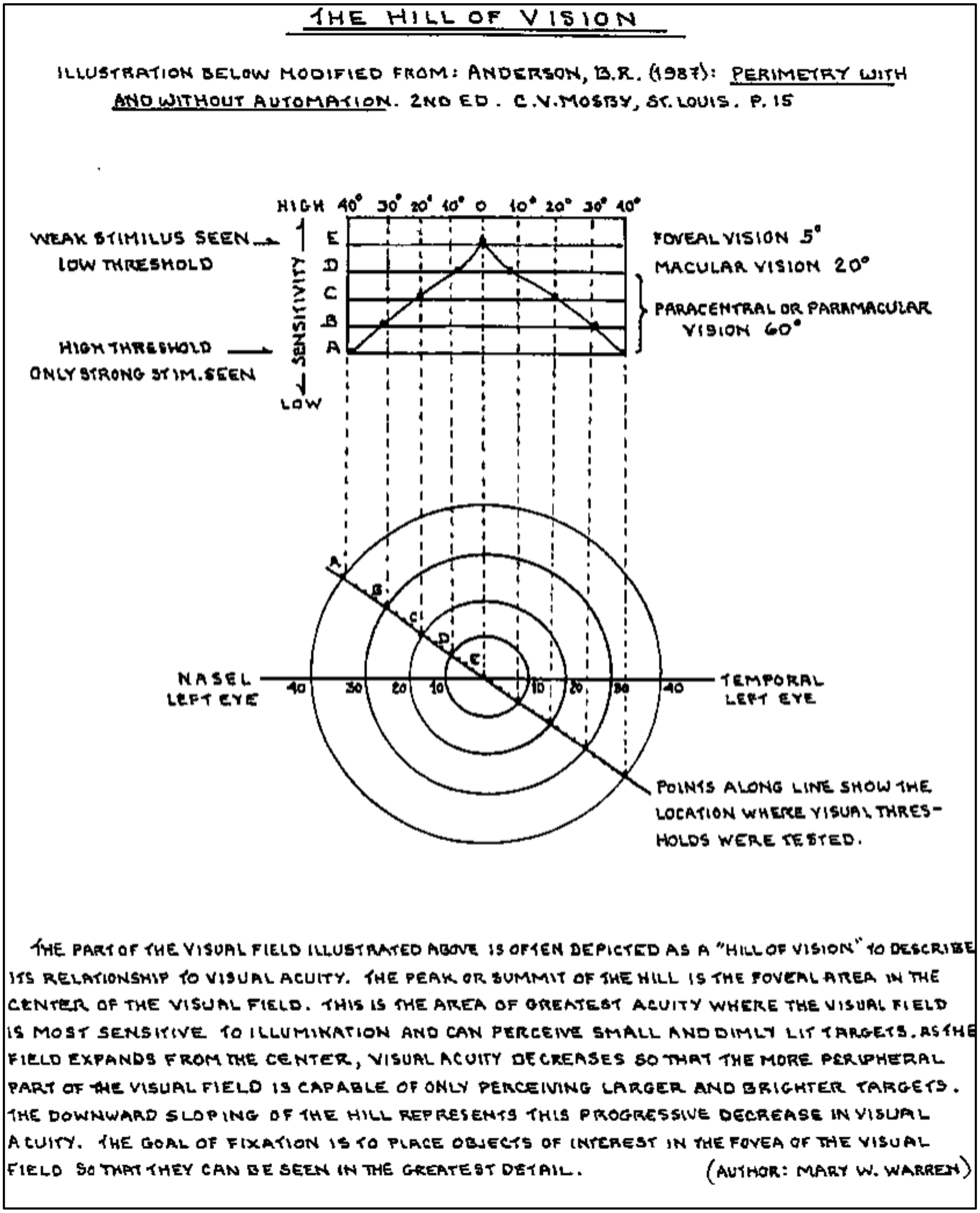


Figure 2.3: The "hill of vision" depicting the relationship between visual acuity and visual field. Illustration courtesy of Josephine C. Moore OT, PhD.

2.4.2 Deficits in the Visual Field from Acquired Brain Injury

Visual field deficits (VFD) occur from injury to the retinal photoreceptor cells or to the optic pathway that relays retinal information to the cortex.[86] Figure 2.4 illustrates this visual pathway as it transitions from the optic nerve to the optic tract to the geniculocalcarine tract (GCT). This pathway transects the entire brain from the eyes to the back of the head and its length makes it vulnerable to brain injury from stroke, TBI, tumor and neurodegenerative diseases including MS and Alzheimer dementia.[54, 86, 147] The location and type of the visual field deficit depends on where damage occurs along the pathway. Although any type of visual field deficit is possible following brain injury, homonymous hemianopia (HH) is the most identified deficit, occurring in approximately two thirds of persons with visual field deficit from stroke[195] and a quarter of persons with TBI.[34] Hemianopia (hemi = half; anopsia = blindness) means that there has been a loss of vision in one half of the visual field in the eye. Damage to the visual pathway posterior to (e.g., behind) the optic chiasm always causes a visual field deficit in both eyes. The term homonymous is used to indicate that the deficit is the same in both eyes.

Because of the crossing of optic nerve fibers at the optic chiasm, the geniculocalcarine tract (GCT) in each hemisphere carries information from one half of the visual field in each eye. The GCT in the right hemisphere carries a representation of the left half of the visual field in each eye and the GCT in the left hemisphere carries a representation of the right half of the visual field from each eye. A lesion occurring posterior to the chiasm within the right hemisphere causes a left homonymous hemianopia; the same lesion in the left hemisphere causes a right homonymous hemianopia.[86]

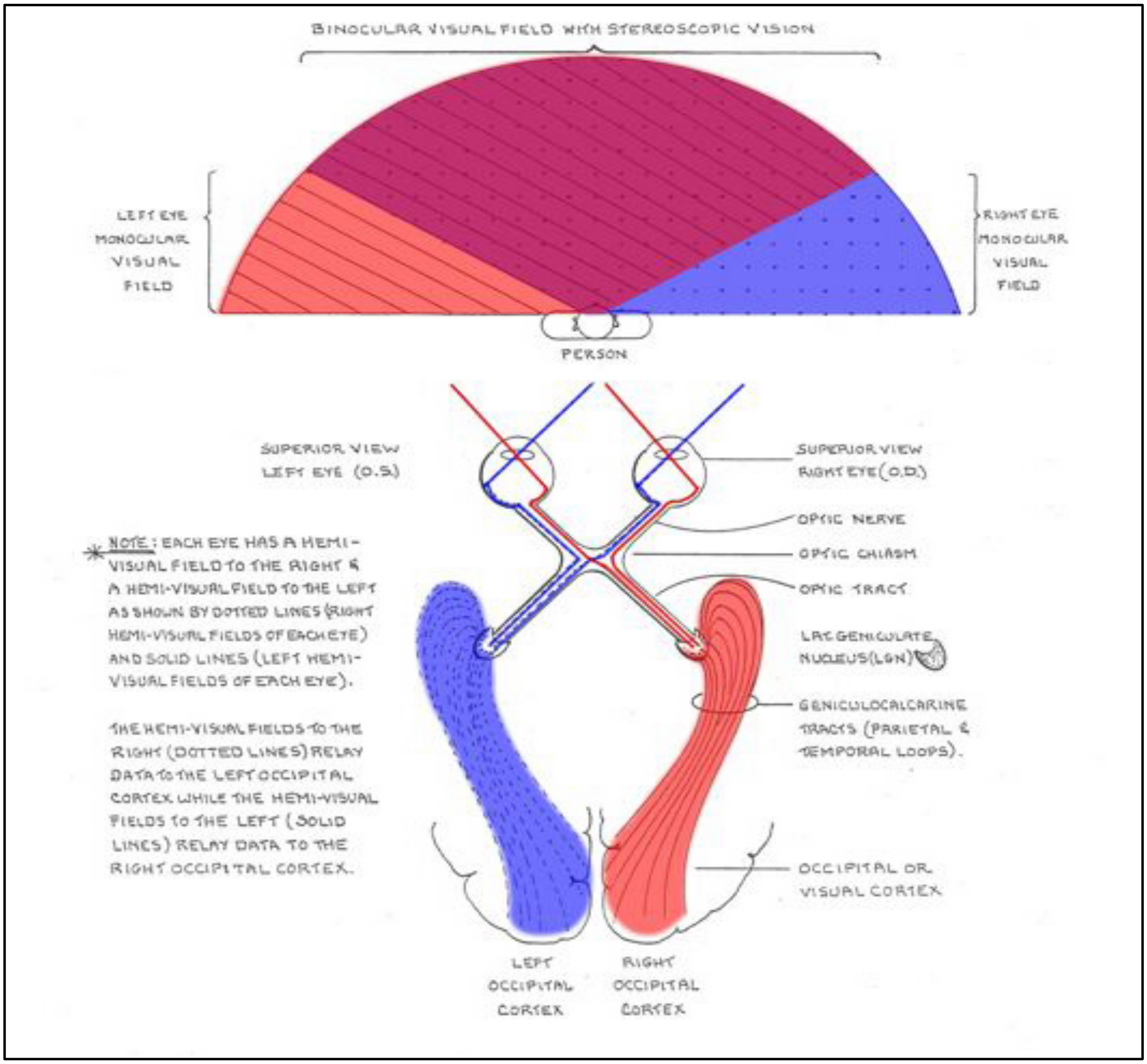


Figure 2.4: The visual field pathway. Illustration Courtesy of Josephine C. Moore OT, PhD. B**lue** shaded areas show pathways conveying visual field information captured in the retina of the **left eye**. R**ed** shaded areas show pathways conveying visual field information captured in the retina of the **right eye**. Note: nasal fibers of the optic nerve of each eye **cross over** at the **optic chiasm** to join the temporal fibers of the optic nerve of the other eye to create the **optic tract**. The optic tract now carries information from the left or right side of the visual field in each eye. The optic tract continues onto the **lateral geniculate nucleus** (LGN) in the thalamus. From the LGN the pathway continues onto the occipital cortex via geniculocalcarine tracts in the right and left hemispheres. The top of the diagram shows how the visual fields of each eye overlap to provide a binocular visual field in the center of a person's vision. The far ends of the field retain their individual color to show how the far peripheral field can only be seen by one eye as the nose occludes the other eye's view.

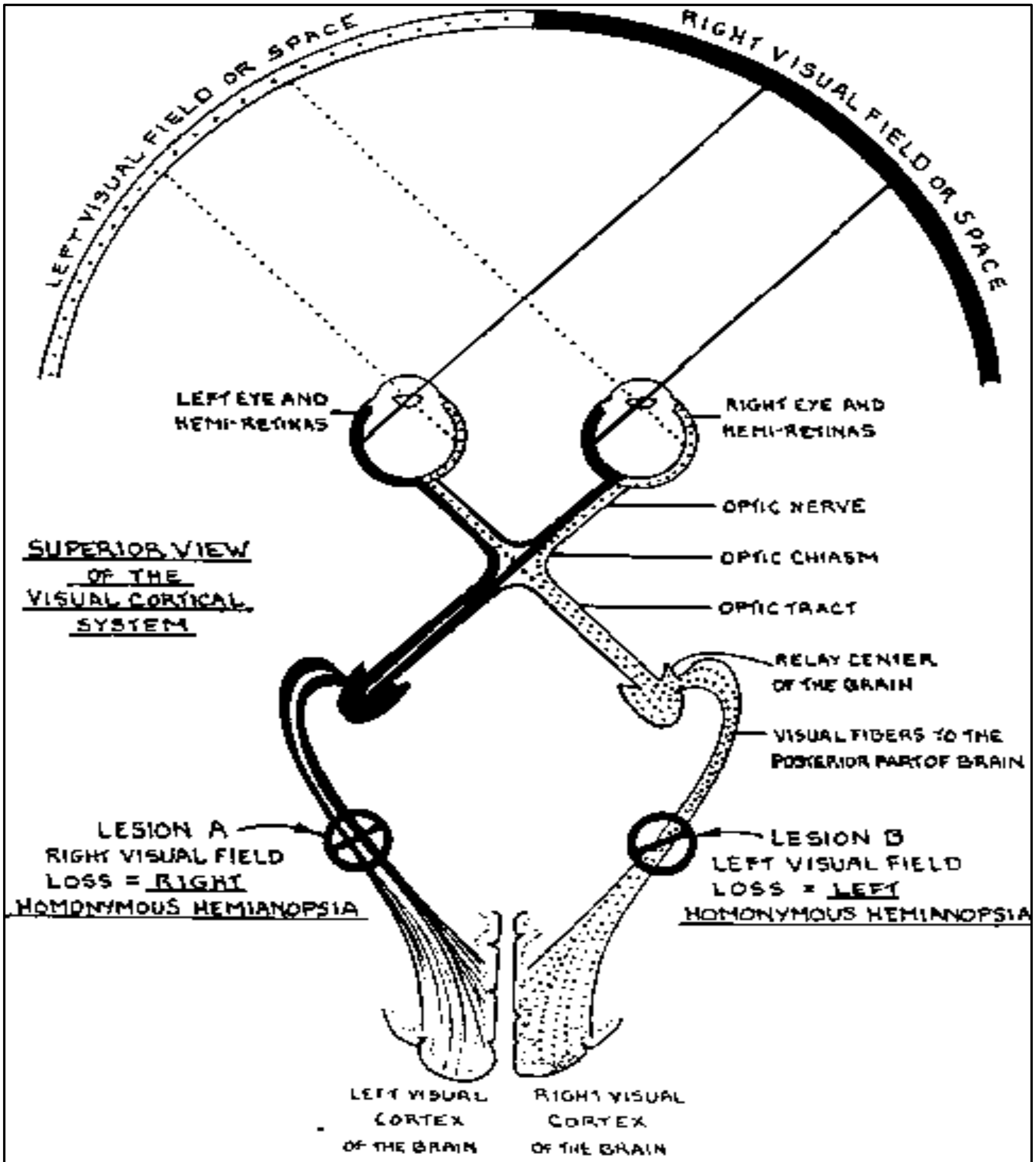


FIGURE 3 : SUPERIOR VIEW OF THE VISUAL CORTICAL SYSTEM SHOWING THE ANTERIOR PARTS (EYES, OPTIC NERVE, CHIASM & TRACT) AND POSTERIOR PARTS IN THE BRAIN (RELAY CENTER, VISUAL FIBERS AND THE VISUAL CORTEX) AT THE BACK OF THE BRAIN.

Figure 2.5: The visual field pathway showing the lesions causing a right hemianopia (lesion A) and left hemianopia (lesion B). Illustration courtesy of Josephine C. Moore OT, PhD.

The geniculocalcarine tracts are divided into two loops: the temporal loop and the parietal loop (Figure 2.6). The loops are named for the cortical areas traversed by the pathways. Input from the superior visual fields is carried through the temporal loop fibers. A lesion along this part of the tract causes a quadrantanopia in the superior visual field. Information about the inferior visual field is carried through the parietal loop fibers; damage along this pathway results in a quadrantanopia in the inferior visual field. If the lesion is large enough to damage the pathways of both loops, a hemianopia would occur with involvement of both the inferior and superior visual fields in one half of each eye.[70] Hemianopia with macular sparing can occur when the lesion occurs in the occipital lobe.[108] Clients with this type of field deficit retain 5-25 degrees of central vision but lose the peripheral visual field. Stroke-because it generally causes damage in only one hemisphere, most often causes the classic left or right hemianopia or quadrantanopia with or without macular sparing.[108] Bilateral damage to the occipital lobe-which can occur with trauma, hypoxia or inflammation-may cause deficits throughout both visual fields, significantly reducing the client's field and visual acuity and often leaving them with little usable vision. Spontaneous partial recovery of the visual field has been shown to occur in approximately half of persons with hemianopia, but a complete recovery of the visual field is uncommon.[274, 277] Pouget et al.[177] in a large study estimated that only approximately 10 percent of persons with

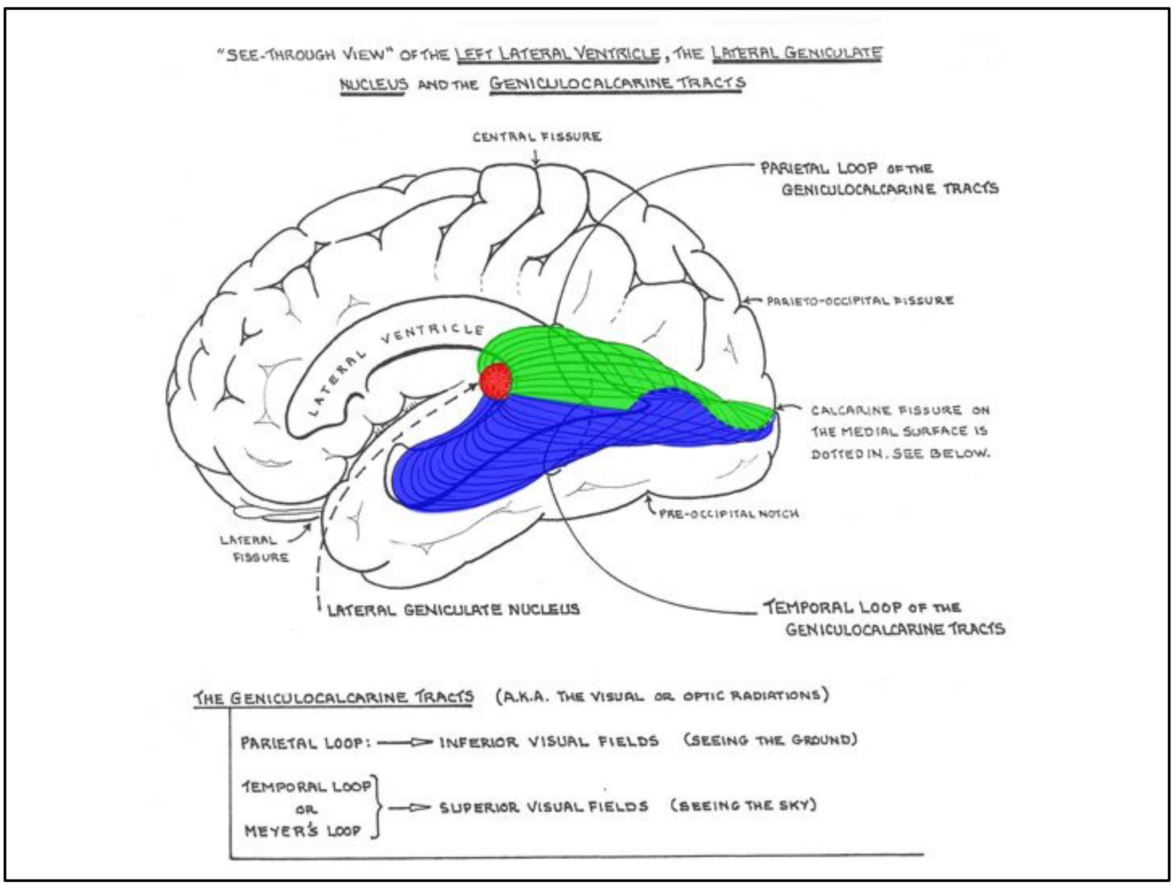


Figure 2.6: The temporal and parietal loops of the geniculocalcarine tract in the left hemisphere. Illustration courtesy of Josephine C. Moore OT, PhD.

homonymous hemianopia recover a full visual field. Most recovery occurs within the first 4 weeks after onset and the likelihood of improvement decreases significantly beyond 8 weeks.[277] Due to the low rate of complete recovery, hemianopia is generally considered a permanent visual impairment.[274]

2.4.3 Occupational Limitations Caused by Visual Field Deficit

Visual field deficit can limit participation in a significant number of daily living activities. The type of limitation depends on the extent of the field deficit and whether it affects the central or peripheral visual field. The brain relies on two forms of visual recognition to complete daily occupations. Recognition of "*where*" an object is in the environment alerts the brain to the presence of objects and is a precursor to the recognition of "*what*" the person is seeing.[69, 152] To be aware that there are objects in the environment does not require as precise visual information as that needed to identify the object. The brain only must be able to detect form, motion, and gradations in shading to detect the general location of an object. The rod photoreceptor cells comprising the peripheral retinal field are adept at capturing this information and the brain primarily relies on the peripheral visual field to complete "where" processing. A visual field deficit in the periphery diminishes the ability to detect motion and form causing the client to have trouble orienting to surroundings. In contrast, the ability to recognize "what" is being viewed requires extremely precise visual information. The cone photoreceptors in the central field that detect color, small details and contrast supply this information. A central visual field deficit can cause the client to have difficulty visually identifying objects.

We need both areas of the visual field to participate fully in activities and environments. Persons with central field deficits will have difficulty seeing small visual details and color which can impair reading, writing, and fine motor coordination. Occupations dependent on these skills include meal preparation, medication management, financial management, grooming and shopping. They may also have difficulty quickly identifying the details of landmarks and obstacles and experience difficulty participating in community activities such as driving, shopping, and social events. Persons with involvement of the peripheral visual field will have difficulty quickly detecting objects that are moving or blend into the background and objects in environments with low lighting. The person may not develop the big "picture" needed to accurately map the environment. This can affect the ability to recognize surroundings (orientation) and detect obstacles or landmarks fast enough to safely navigate environments (mobility). Without an intact peripheral field, the person is forced to use central vision as an anchor to guide ambulation, which leads to behaviors like shoe gazing (e.g., looking at the floor/feet when walking) or fixating a distant central target and walking towards it without looking to either side. Either behavior increases the risk of collisions or becoming lost while moving.

2.4.3.1 The Influence of Perceptual Completion on Visual Search

Although often considered mild when compared to the dramatic loss of the use of the limbs, homonymous hemianopia can significantly impact the client's ability to complete daily living activities and safely navigate environments. Hemianopia can alter the person's visual search pattern creating a slow disorganized search pattern characterized by multiple fixations that results in difficulty locating objects on the blind side.[274] These visual search changes can be at least partially explained by the influence of a visual perceptual process known as *perceptual completion*. The prefrontal lobes are tasked with directing visual search of the environment to quickly locate and catalog the items/features needed to complete occupations. The prefrontal lobes direct visual search by constructing an impression (picture) of the client's surroundings, and then directing search towards specific targets based on anticipation of where they would be found in the environment. One way the prefrontal lobes could construct this picture of the environment, would be to painstakingly locate and foveate each item in the person's surroundings, but this would require way too much time to enable successful adaptation to dynamic environments. So instead, the prefrontal lobes direct the eyes to sample locations in the environment and fill in (e.g., perceptually complete) the rest of the visual scene based on memory and expectation.[67, 86, 87, 100, 150, 181] The prefrontal lobes are amazingly skilled at using this method to build an accurate picture of the location of the items/features in familiar environments. For example, let's say I am lecturing to you in a hospital auditorium. You haven't been in this auditorium, but you have spent plenty of time sitting in lecture halls attending CEU events. Now I ask you if there is a fire extinguisher in the room. You probably didn't search for a fire extinguisher when you entered the auditorium, but your experience with hospitals prompts your prefrontal circuitry to direct your search towards the walls. Why? because your experience suggests that is where fire extinguishers are typically located in a room like this, and chances are you would be correct.

The speed that perceptual completion provides enables us to safely drive and participate in dynamic environments, but it can create challenges for the client trying to adapt to vision loss in the early stages of recovery. Research has shown that the prefrontal circuitry can perceptually complete the visual field even when the client has lost 50% of their vision due to hemianopia.[51, 210, 215] It is common for a person with hemianopia to be initially unaware of vision loss in an area of their field because they see a perceptually completed visual field without gaps or missing information.[45, 51, 102, 210] Perceptual completion creates two big challenges for the client. First, the prefrontal circuitry cannot include an unanticipated object in the perceptually completed scene unless the object was seen during the sampling process. As a result, the client may collide with a recently moved chair or trip over a toy in left on the floor. Secondly, perceptual completion makes it difficult for the person to determine the actual border between the seeing and non-seeing areas of the visual field or where a target might be located within the blind field. Without this information, the person is unable to confidently execute a single accurate saccade to locate the target in the blind field. Instead, the person often adopts a strategy of making repeated short "stair step" saccades towards the target until it is located.[144, 224, 274] To help you understand what a client might experience when searching the blind field, picture yourself in a tunnel completely devoid of light. You are instructed to run as fast as you can towards a wall at the end of the tunnel. You are told not to worry, as you will locate the wall when you run into it. In this situation would you run quickly towards the unseen wall or run slowly stopping frequently to put your hands out to feel for it?

2.4.3.2 The Effect of Visual Field Deficit on Performance Skills

During the initial stages of recovery, before conscious awareness of the field deficit, the client will experience the odd perception of seeing a complete visual scene where objects on the blind side are always appearing, disappearing, and reappearing, without warning.[52, 84, 138, 210, 274] This often causes the client to move slowly and tentatively when navigating environments and to rely on others to lead them through an unfamiliar environment. Even when the person becomes aware of a hemianopia, visual search into the blind field remains slow and delayed [51, 169, 224, 274] Slowness searching towards the blind side adds to client's challenges in navigating the environment and locating objects for daily activities.[51, 74, 102, 122, 151, 170, 256] Newer research suggests that persons with hemianopia may also search their intact (seeing) field more slowly although compared to their blind side, the person's slowness searching is milder and interferes less in daily activities.[44] These search changes are more pronounced in persons with left hemianopia and compound the person's difficulty in locating information from the environment. Additional research is needed to verify this initial finding, but it reinforces the importance of carefully assessing the client's ability to quickly search *both sides* of the visual field during high-risk activities such as driving.

The changes in visual search that accompany a complete homonymous hemianopia limit three important performance skills: mobility and orientation, reading, and eye hand coordination.[141] These are critical components of many daily occupations and improving them is a primary intervention focus.

- *Mobility and Orientation*: Persons with hemianopia experience frequent actual or near collisions with objects and a tendency to get lost especially in unfamiliar and crowded environments.[59, 102, 274] They often demonstrate behaviors during navigation that indicate they are experiencing stress and uncertainty.[274] Key behaviors to observe for include: using a stiff, short, and uncertain gait; staring fixedly at a distant target and moving towards it without looking at their surroundings or staring at the support surface immediately in front of them (shoe gazing). Shoe gazing is especially prominent during transitions such as walking through a doorway or down steps or a ramp. To remain oriented the client may extend their hand and use their fingers to trail along a wall using tactile input to maintain their position in space. Following is another often subtle behavior used to maintain orientation. The client lags slightly behind another person during ambulation to follow and use them as a guide. Difficulty monitoring the environment may cause the client to experience anxiety in crowded and dynamic environments. Sometimes the stress can be severe enough to provoke a panic reaction with sweating, heart palpitations, nausea, and hyperventilation. One client with hemianopia aptly described this sensation as "crowditis", reporting that he became physically ill if he had to go into a crowded environment like a grocery store or sports venue. The anxiety can become debilitating, leading to withdrawal from community activities and social isolation.[102, 256]

- *Reading*: When the border of the hemianopia comes into fovea, all or part of a targeted object may fall into the blind field. This can create significant challenges in reading.[25, 51, 102, 104, 151, 170, 177, 196, 212, 256, 274] Normally sighted readers view words through a "window" or perceptual span that allows them to see approximately 18 characters (letters/numbers) with each fixation of the eye.[196] The reader moves the eye from the center of one word to the center of the next using a series of alternating fixations and saccades. Each fixation lasts approximately 250 miliseconds (ms) and generally only one fixation is required to decipher the word.[182] The brain uses 50 ms to decode the word and 200 ms to plan the saccade to the next word in the sentence.[182] The saccade of a person reading English will move fixation 8-9 characters to the right which is the typical length of English words. The remaining partially decoded letters on the right side of the perceptual span are used to plan the next saccade.[182] The left side of the span is used to accurately identify words and locate the next line of text to navigate through text.

  Hemianopia shortens the perceptual span on the side of the deficit causing the client to see only part of a longer word during fixation and or even skip a small word.[135, 212, 274] For example, a client with a left hemianopia may read the sentence, "She should not shake the juice" as "He should not make the juice," transforming "she" into "he" and "shake" into "make." A right hemianopia can especially hinder reading. The shortened width of the span on the right side causes the person to miss letters on the right. For example, "She should not shake the juice" might be read as "She should not share the juice." More importantly a right hemianopia disrupts the person's ability to plan and execute an accurate saccade to the next word. The eye may land off-center so that only a few letters are seen or entirely miss the next word as in "She should share juice."[135, 212] Each time a word is seen incorrectly, the client must stop and re-read the word to identify it. Re-reading is called a regression and regressions significantly slow reading speed and reduce reading accuracy.[25, 274] The client also experiences difficulty accurately reading numbers and this can be particularly problematic. A nonsensical sentence will alert the client to errors made in reading words, but numbers often lack a precise context causing mistakes to go unnoticed. For example, a credit card bill for $288.00 may be misread as $266.00 and the error missed until a notice of insufficient payment is received. Clients who make numerical errors quickly lose confidence in their ability to pay bills and manage their checkbook, accurately read a recipe, or set of instructions, or complete medication management and often turn over these important daily occupations to someone else.[102, 151, 256]

- *Eye/Hand Coordination*: When the hemianopia has occurred on the same side as the dominant hand, the client may have trouble visually guiding the hand in fine motor activities. Writing legibility is often reduced.[151, 256] The client often cannot visually locate and maintain fixation on the tip of the writing instrument as the hand moves into the blind visual field. This may cause the client's handwriting to drift up down on the line or the client may improperly position handwriting on a form. The client also has difficulty completing activities like mending, sewing, pouring liquids, measuring, dialing numbers on a smartphone, texting and other fine motor activities that require visual monitoring of the hand.[256] Research shows that persons with HH have trouble completing daily living activities that are dependent on these performance skills.[102, 151, 256, 274] Reported ADL limitations include medication management, financial management, communication using computers, smart phones and tablets; meal preparation, home management, viewing TV and videos, and yardwork.[30, 51, 53, 102, 151, 170, 256] Generally, the more dynamic the ADL environment and the wider the field of view required to complete the task, the greater the limitation. Therefore, only minor limitations are experienced in a few selfcare activities (mostly grooming) compared to significant limitations in shopping, driving, and participating in community events. The client's ability to resume driving is always questioned although research has shown that some persons with hemianopia can safely resume driving with specific training.[30]

2.5 Visual Attention

2.5.1 What is Visual Attention?

Visual attention is the ability to closely observe objects to discern information about their features and their relationship to self and other objects in the environment. It requires focusing the brain, ignoring irrelevant sensory input and random thoughts, and sustaining this focus over a period of several seconds to minutes.[181] The ability to attend closely is significantly influenced by the environment and context and the person's motivation to acquire information and achieve a goal.[130] Visual attention is broadly divided into *selective* visual attention and *global* visual attention. Selective attention focuses on visual details such as differences between letters, numbers, and faces. It is used to recognize and identify objects.[69, 90] Global attention focuses on getting the big picture-the location of objects in the environment and their proximity to the person. Its job is to ensure that a person is oriented and moves safely through space; without it, collisions and disorientation when moving would be the norm.[69, 81] To be able to fully engage and learn from the environment, a person must simultaneously employ these two modes of visual attention at all times. The contribution of each is equally important to visual processing.

Coordinating visual attention requires an extensive, well-connected neuro network distributed through all areas of the cortex, brainstem, and cerebellum. Important hubs within this network include the visual cortical relay centers (circuitry in the occipital lobe and posterior areas of the temporal and parietal lobes), the frontal eye fields and prefrontal cortex, the hippocampus, amygdala, cingulate gyrus, and the brainstem reticular activating system. These hubs form network connections that feed forward information (this is what I am seeing) and feedback information (this is what I should see next) to direct our attention (see Figure 2.6).[101] The visual cortical relay centers beginning with the lateral geniculate nucleus and primary visual cortex refine the raw input from the retina to enhance critical features needed to complete the desired task. The refined information is then simultaneously sent to the posterior temporal and posterior parietal areas for further processing. Visual input processed through the posterior temporal circuitry links language to visual images to label and classify objects. This area utilizes the precise information supplied by cone cells and obtained via selective attention to identify visual details like color, shape, size, and juxtaposition to identify objects so they can be recognized, and their purpose identified. The posterior parietal circuitry links spatial visual information with movement to prepare the body to orient and move through space. Global attention to, and awareness of, the space surrounding the body and the body's relationship to that space is the function of this circuitry. To accomplish this, the posterior parietal area creates internal spatial and temporal maps of the body and maps of surrounding environments, space, and time.[81, 96] The maps are dynamic and continuously updated as the person moves through space in order to direct attention to the critical features needed to navigate space and manipulate objects.

Together, these posterior areas of the cortex provide a "library" of visual images integrated with movement and language to the prefrontal lobes to use in directing actions and achieving goals.[90] The prefrontal areas operate as the CEO of the brain. They establish the plan, identify the information needed to implement the plan, gather this information from the environment, posterior library, and body, and coordinate neural structures to execute the plan. Like any good CEO, the prefrontal cortex determines the best course of action based on input received from all of the sensory systems combined with memory and past experience. The frontal eye fields within the prefrontal cortex direct the search for specific objects in the environment to accomplish the goal. This visual search is guided by the anticipation of where the desired object typically would be found in the environment and based on visual memory.[70] Recall in the example in section 2.4.3 of searching for a fire extinguisher in a lecture hall. The visual memories from your previous experience with fire extinguishers directs your attention and search towards the walls of the room instead of the ceiling or floors. The prefrontal cortex also regulates visual attention on tasks through working visual memory.[90, 223, 275] Working memory is the ability to hold more than one piece of information "on deck" in memory and ready for immediate recall to assist in completing a task.[190] *Working visual memory* is the specific ability to hold on deck a picture of an object and its location while completing a task.[190] An example of working visual memory would be holding in mind a picture of a specific brand of canned tomatoes along with its location in the aisle while shopping for the ingredients to make chili. Its "working" memory in the sense that once you accomplish the task, you discard the memory of the tomatoes and replace it with the next item on your list. We use working memory to sequence and stay on task while completing activities.

Older areas of the cortex-the amygdala and hippocampus-also assist in directing visual attention. The amygdala reacts to all incoming visual input and assigns to it a level of emotional relevance ranging from no relevance to significant relevance (e.g., pay *ATTENTION to THIS*!). Connecting a strong emotion to a visual image strengthens the motivation to attend to it.[181] For example, a piece of chocolate sitting on a plate next to someone who LOVES chocolate tends to rivet their attention to the plate. In contrast, an object (kale?) without emotional relevance will go unnoticed. One of the jobs of the hippocampus is to create a context for incoming visual images by linking them to past experience. The hippocampus keeps potentially important visual input based on the context buffering in temporary memory to be reinstated later if needed. For example, you walk into a room and notice that a normally closed window is open (context) and thirty minutes later you realize that you haven't seen the cat-your helpful hippocampus jumps in and directs your attention back to the window to investigate.

The brainstem also contributes to cortical attentional processing through activation of the body's 4-step arousal sequence that goes back and forth between asleep, awake, alert and attending. The arousal sequence energizes the cortex and helps to maintain vigilance when attending.[117] It responds to tonic and phasic influence. *Tonic arousal* is strongly influenced by the sleep-wake cycle and circadian rhythms; some persons are early birds who are most alert in the morning and others are night owls who have difficulty waking up and attending until after the sun goes down. *Phasic arousal* is triggered by a specific event. The attention level of early birds or night owls would immediately increase upon hearing a fire alarm go off in their building.

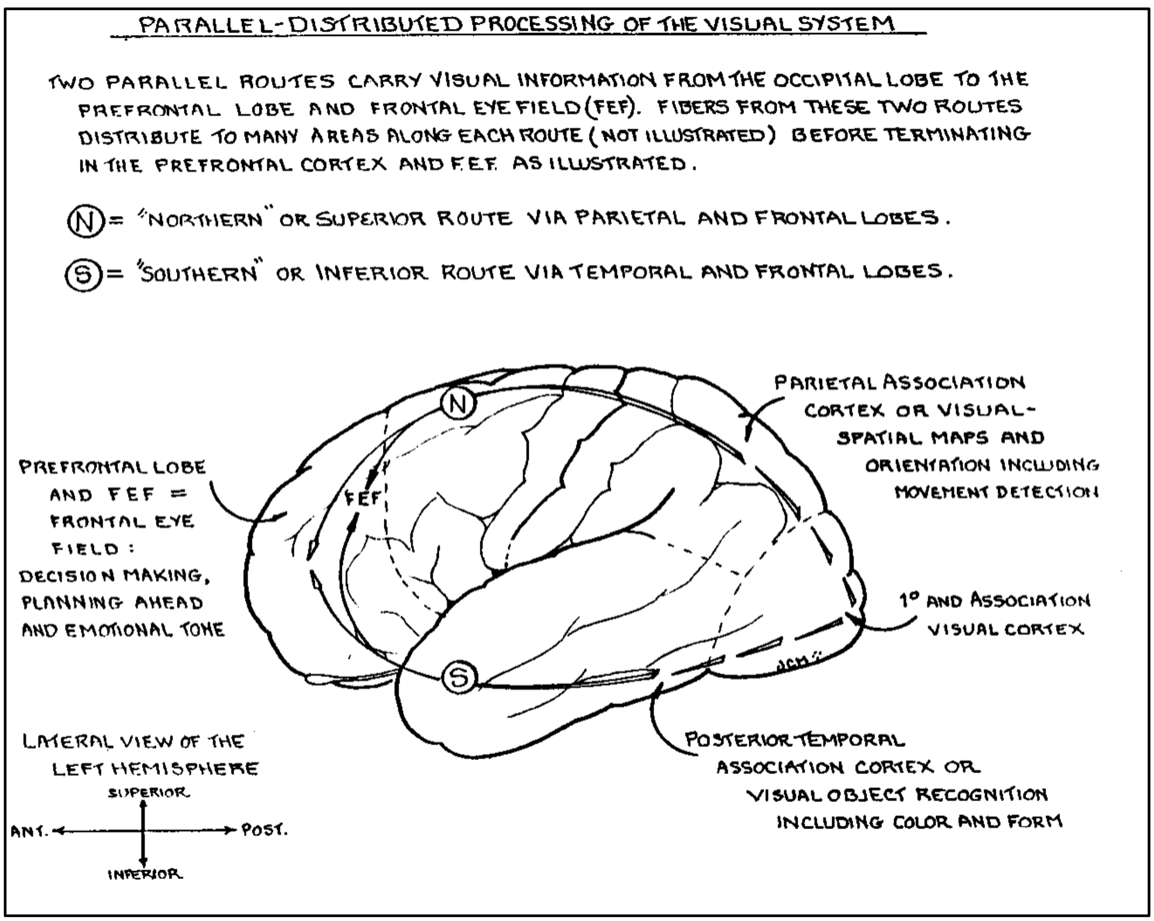


Figure 2.6: Major cortical centers Involved in modulating visual attention. Illustration courtesy of Josephine C. Moore OT, PhD.

2.5.2 Deficits in Visual Attention from Acquired Brain Injury

2.5.2.1 Neuro Networks that Control Attention

Long white matter pathways connect the key hubs to create an extensive neural network that controls attention.[5, 65] The extensiveness of this network means that any form of brain injury is likely to alter visual attention to some degree due to pathway or structural damage. Pathway damage (as occurs from diffuse axonal injuries sustained in TBI) can be particularly disruptive because it disconnects hubs from each other, including those that received no structural damage from the brain injury.[65, 92] Injury to the brainstem may reduce visual attention by diminishing the client's general level of alertness. The client can't be aroused sufficiently to attend and/or has difficulty sustaining sufficient attention to complete an activity. Injury along the visual cortical relay pathway that delivers visual input to the cortex, may degrade the quality and quantity of visual input available for processing. The client may not attend to certain objects or features in the environment because they weren't seen clearly enough to engage attention and unlock prediction and sequencing.

Structural damage, as occurs in stroke and moderate-severe TBI-can disrupt the function of key hubs that contribute to attention. Damage to the posterior temporal cortex may disrupt object identification. The client may have difficulty pulling details together to form meaningful patterns or link language to visual images to classify patterns, resulting in an agnosia or alexia.[93] Damage to the posterior parietal cortex may disrupt the ability to map the body and surrounding space. The client may not attend to important environmental features and landmarks and experience disorientation-unable to discern where they have been or where they are going. Injury to prefrontal areas may alter the client's ability to procure or use visual input to accomplish a task and achieve a goal. Visual search may become random because the client is unable to anticipate where to find an object and efficiently direct attention to that location. The client may have difficulty examining visual input to decide what is important to complete the task at hand. The client may indiscriminately attend to any object within their field of view exhibiting impulsive field-dependent behavior. Working memory may be diminished impairing the ability to stay focused on a task. Without the plan generated by working memory, the client maybe easily distracted by external and internal input. Damage to the older cortical structures-the amygdala and hippocampus-will affect memory. The person may lack the motivation to attend to and subsequently lay down new memories of objects. The object/event must have significant emotional relevance to register in memory or trigger memories to guide actions.

Visual attention is expressed though search and scanning. Therefore, a change in visual attention will be observed as a change in how the client searches for visual information. Normal search strategies are intentional, purposeful, and driven by the need to obtain specific information.[133, 157] The type of search pattern the person uses depends on the demands of the task. For example, a person reading English would use a left-to-right and top-to-bottom linear strategy. Whichever pattern the person uses, it will be efficient, symmetrical, and comprehensive, aimed at acquiring the greatest amount of information in the least amount of time. Although eye movements are used to carry out visual search it's important to remember that visual search is driven by attention.

2.5.2.2 Visual Spatial Neglect

Visual inattention commonly occurs following brain injury and may range from mild to severe.[90, 188] *Visual spatial neglect* is the most studied attention deficit in persons with acquired brain injury from stroke or head trauma. Visual neglect is predominantly caused by injury to the occipital, parietal, temporal and prefrontal areas of the right hemisphere.[188, 244] Left hemisphere cortical lesions can cause right neglect.[227] Right neglect causes less severe and obvious changes in behavior and is most apparent when the client is required to multi-task.[227]

Kerkhoff and Schenk [124] defined neglect as the "impaired or lost ability to react to or process sensory stimuli [visual, auditory, tactile, olfactory] presented in the hemispace contralateral to a lesion of the human right or left cerebral hemispheres." (p. 1072). There are several key words in this definition that delineate the features of neglect. First, the ability to attend can be "impaired" or "lost" implying that there are degrees of severity of the condition ranging from mild to severe. Second, persons can have difficulty "reacting" to stimuli (e.g., noticing and responding to it) and difficulty "processing" stimuli, (e.g., using the sensory information to complete a task). Third, persons can experience inattention to different forms of sensory input- not just visual. Finally, persons experience inattention to sensory input on the side of the body "contralateral" (e.g., opposite) to the location of the brain injury. This means that persons with right hemisphere lesions experience difficulty attending to visual input from the left side of the body/space and vice versa.

There is consensus among researchers that neglect represents a heterogeneous disorder characterized by a complex and diverse set of behaviors.[188, 125, 244] These behaviors can be generally grouped into three broad categories: 1) a lateralized spatial bias in attending to and searching space, 2) a lateralized inability to map and build internal mental representations of space on the left side of the body, and 3) a non-lateralized attention deficit that impairs arousal and the ability to focus, shift, and sustain attention.[2, 16, 188, 244, 245]

- Spatial bias restricts the person's ability to explore the space contralateral to the side of the brain injury. It is the most prominent and consistent behavior associated with neglect from right hemisphere lesions and shows up as difficulty or inability to explore space on the left side of the body.[163, 188, 244, 245] The person may make no attempt to search the left side or make fewer visual fixations and slower eye movements towards the left contributing to slow and incomplete search of left space.[129, 163, 254] The person demonstrates a bias towards the right side that creates an asymmetrical search pattern where the person initiates and confines search to the right side of a visual array.[163] This rightward bias can deprive the client of needed information on the left and impair their ability to complete ADLS that require attention to both sides of the body such as dressing, bathing, eating, grooming, meal preparation, home management, shopping.[10, 129, 130] The strong association of spatial bias with right hemisphere lesions is thought to occur because of a difference in the way the hemispheres direct visual attention.[65, 244,] [245, 276] As illustrated in Figure 2.7 the left hemisphere directs attention toward the right half of the visual space surrounding the body, while the right hemisphere directs visual attention towards both the right and left halves of space. If a lesion occurs in the left hemisphere, visual attention and search toward the right side are diminished, but the right hemisphere still provides some attentional capability. A similar lesion in the right hemisphere may completely eliminate attention toward the left because the left hemisphere does not direct attention toward the left side.

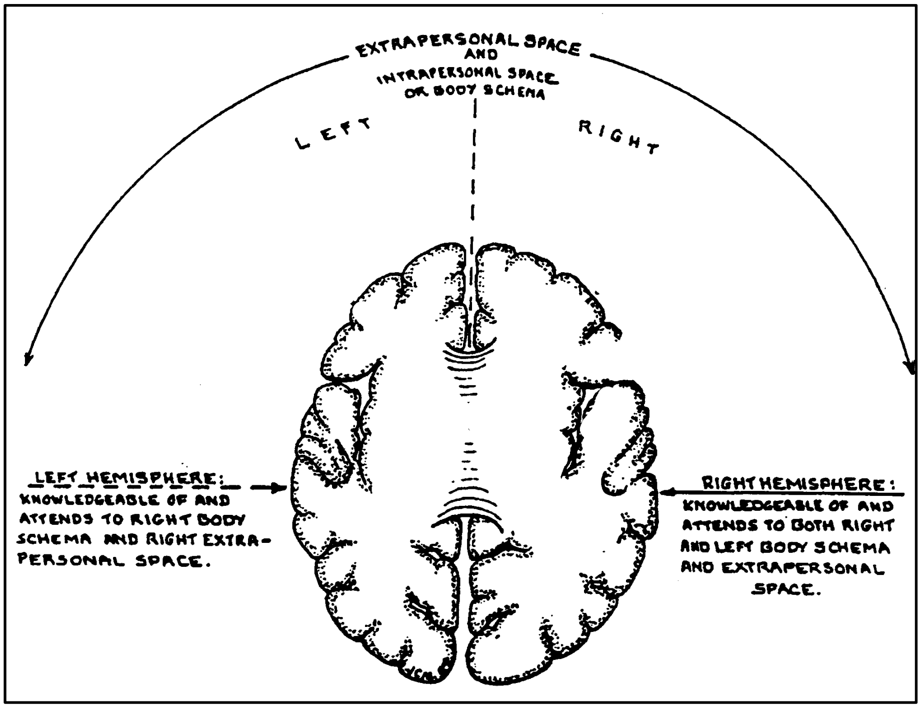


Figure 2.7: Differences in the direction of visual attention between the two hemispheres. Illustration courtesy of Josephine C. Moore OT, PhD.

Left neglect can be confused with a left hemianopia because clients with either condition show spatial bias and limited search of the left space. Although they can occur together, hemianopia and neglect are distinct conditions that disrupt search performance differently.[276] Hemianopia is a *primary sensory loss* that limits the amount of visual input into the cortex. It interferes with the client's ability to locate objects in the blind field but does not alter the brain's ability to direct attention. In fact, client with a left hemianopia *depends* on visual attention to compensate for vision loss by directing eye movements towards the left to gather visual information from the blind side. Unfortunately, perceptual completion (see section 2.4.3) can disrupt the client's ability to move the eyes far enough into the blind visual field to successfully locate objects making it appear that the client neglects the left side.[276] In contrast, a client with neglect loses the *attentional mechanisms* that drive the search for visual information on the left. The client (even if they have an intact visual field) makes little attempt to search the left side of the visual space.[163] Visual search is most significantly impaired when the two conditions occur together.[244] In this case the client does not receive visual input from the left side because of the hemianopia and does not compensate for the loss of visual input by directing attention toward the left side. Clients with both conditions show greater inattention toward the left visual space when completing ADLS[10] and experience more difficulty moving the eyes or the head towards the left side.[1, 124, 188, 244]

- Impaired mental representation of space: Internally generated cognitive maps create a mental representation of the space surrounding the body that person uses to orient to space.[18, 81, 89, 109] The maps are continuously updated as the body moves. Persons with neglect can experience a disruption in the mapping of space on the left side so severe that objects on the left simply disappear from their concept of space. According to Becchio and Bertone,[18] it is as though the mental map of space on the left side did not exist in the past, doesn't exist in the present, and will never exist in the future. As a result, the client doesn't attend to landmarks on the left side and does not build a map of environments on the left side. This diminishes the ability to orient to and maintain orientation in space and clients are often observed to literally be "lost in space" as they try to navigate environments.[26] Difficulty conceptualizing left space may explain the consistency of the client's inattention towards the left despite repeated cuing from the OT.[18] It may also explain revisiting-another commonly observed neglect behavior-where the person repeatedly reexamines objects located on the right side of a visual array while ignoring objects on the left.[188, 225] For example, when asked to locate the cup of pudding sitting on the left side of the dinner tray, the client repeatedly searches the right side of the tray even when cued to search towards the left.

- *Non-lateralized attention deficit*: Clients-especially those with persistent (also called chronic) neglect-often have difficulty generating adequate levels of alertness and sustained attention.[185, 223, 235, 237, 244, 245] Their inattention is **non**-lateralized in that it does not differ between the body sides and instead affects the brain's overall ability to receive and process visual information. This generalized diminishment of attention impairs the ability to begin and complete tasks.[2, 185] Clients with low arousal may have difficulty generating sufficient attention to engage in a task unless the energy requirements are amped up.[180] For example, the client must be seated on the edge of the mat instead of the wheelchair, so that the threat of falling over increases their alertness. Clients with non-lateralized inattention may have difficulty disengaging focus on one object to shift attention to another object, slowing their search performance even when attending to a task.[245] This slowness increases the length and effort required to complete a task, causing fatigue and poor performance.[244] Inability to sustain attention is particularly detrimental to successful completion of daily occupations as even basic ADLs require sequencing steps over time. When the client loses focus and drifts off during an activity, their lapse of attention disrupts working visual memory requiring the OT to provide continuous redirection to the task.

The incidence of visual spatial neglect averages between 50-70% in the early stages of recovery from a right hemisphere brain injury.[83, 120, 244] Fortunately, most neglect resolves during the first year of recovery and is significantly diminished by three months post injury in most persons.[83, 120, 161, 244] Disruption of the pathways that connect the frontal, temporal, parietal and occipital lobes together may account for the initially high incidence of neglect immediately after injury and the good potential for recovery.[65] Persons whose neglect persists beyond three months may have significant and persistent deficits that reflect structural rather than pathway damage within the brain.[120]

2.5.3 Occupational Limitations Caused by Visual Inattention

Because visual attention is modulated through an extensive neural network, some capacity for visual attention generally is retained even in cases of severe brain trauma.[150] On the other hand, changes in visual attention almost always occur with any brain injury, even a mild injury. Inattention creates asymmetry and gaps in the visual information gathered through scanning.[27, 179, 191, 242, 244, 193] The brain requires complete visual information delivered in an organized fashion to make appropriate decisions and direct actions. Without it, the person's ability to efficiently and successfully complete occupations decreases. Whether a client's inattention impairs performance depends on the task. Different tasks require different types and levels of attention. For example, reading a highly technical textbook can require enormous amounts of selective visual attention, but you can enjoy the comics page while listening to the TV and eating breakfast. Driving requires continuous global attention and vigilance to monitor the speed and position of other vehicles and objects and only sporadic selective attention to landmarks, street signs and traffic lights.

It's important to remember that how and whether inattention manifests following brain injury depends on the demands of the task and environment. This is an important consideration in evaluation and intervention. All ADLS require attention to both sides of the body and environment and the ability to sequence multiple steps over time. Tuning out and drifting off disrupts ADL performance as does attending to only one side of the body/space. Performance limitations observed during ADLs include difficulty locating items, sustaining attention to task completion, multi-tasking, and rapidly and accurately assessing situations to complete activities in dynamic environments. The more dynamic the environment and the more ambiguous the task and outcome, the greater the client's attentional limitations will impair task performance. Performance limitations will be most noticeable in daily activities that require significant working visual memory and sustained attention. Examples include participating in driving, shopping, sports, work, and other I-ADLS. These limitations may persist even in a client who appears to have completely recovered from neglect. For example, a client with good recovery, may show no inattention to the left and drive safely along familiar country roads going to and from the small town he grew up in, but show marked inattention to the left and dangerous driving maneuvers when attempting to drive to an appointment in a larger, less familiar city.

It's important that the client recovering from neglect reclaim as many occupations as possible. The most informative evaluation includes 1-2 more challenging I-ADLS to provide a complete picture of the client's attentional capabilities and limitations. This will help the OT set the most appropriate goals and timeframes for the client. When providing intervention, the OT must carefully examine the requirements of the targeted ADL and determine if the client will be able to successfully complete it in all situations or in some situations. In the case of the driver, he does not need to completely give up driving if he is willing to limit driving to environments that match his attentional capabilities.

3 General Information About Using the biVABA

This section provides general information that applies to all assessments and types of clients.

3.1 What Types of Brain Injury are Appropriate to Evaluate with the biVABA?

The biVABA assessments evaluate basic visual functions and visual attention. The battery was designed specifically to assess changes in visual ability in persons with brain injury from CVA and TBI (including concussion), brain tumor, anoxia, and degenerative neurological diseases like Parkinson's Disease, Alzheimer's Dementia, and multiple sclerosis. The assessments that screen visual acuity, reading acuity, contrast sensitivity and visual field can also be used to evaluate clients with low vision from age-related eye disease (macular degeneration, glaucoma, or diabetic retinopathy-see section 2.1.2.2).

3.2 Is the biVABA Appropriate to Use to Evaluate Children?

Basic visual functions (acuity, contrast sensitivity, eye movements, and visual field) are established in early childhood. The assessments that screen these functions can be given without modification to children ages 12 and older. Some of the assessments can be used with modification to evaluate younger school age children depending on the child's reading level.

These are important considerations if you use the assessments with children under 12.

- The client instructions are written for adults; you may need to simplify instructions.
- The assessments require that the client can reliably recognize single letters, numbers, and frequently used words. The *word search* visual search subtest (see section 4.4.2.1) for screening visual attention uses 2 kindergarten-first grade words: *the* and *at* and the sentences on the Warren Text Card (see section 4.1.2.6) require a 5th grade reading level.
- The Damato campimeter was designed for an adult-size head. Some children may subjectively meet this requirement. The 2-person Kinetic Confrontation Test only requires that the child can follow simple directions and attend well enough not to cheat.
- The interpretation of the test performance sections provided in the manual are based on research completed on adults with brain injury. This will specifically affect the interpretation of test results for visual attention and oculomotor control.

3.3 When Should You Administer the biVABA Assessments?

There are two reasons why It's important to begin evaluating vision as soon as possible

1. Vision is the primary sensory system we use to engage and interact with the world. Because of this, vision impairment significantly impacts the ability to participate in daily occupations and navigate through environments.
2. Visual processing provides a foundation for cognition and motor performance (see section 1.3). As a result, vision impairment may appear as cognitive and motor impairment and may influence client performance on cognitive and motor assessments.

The biVABA includes structured observational assessments. Client observation is the cornerstone of a functional evaluation and our most valuable evaluation tool. It provides insight into client's ability to use vision to complete occupations and will help you select the standardized assessment that will best increase your understanding of the client's limitations and strengths. The observation checklists are especially helpful when evaluating lower functioning clients and clients in the early stage of recovery. You can complete the observation checklists by directly observing the client, by interviewing the client/family, and/or by comparing notes with other members of the rehab team.

The behaviors on the checklists are those most often observed in clients with visual impairment. Each assessment lists the behavior most often associated with that specific vision impairment. There is a little overlap between assessments because some behaviors are associated with more than one type of vision impairment. Observing a *pattern* of behaviors combined with *errors on other assessments* provides much stronger verification of a visual processing deficit than observing a single behavior. These observations also help to establish the link between visual impairment and limitations in daily occupations needed to justify OT services.

3.4 General Test Procedures

3.4.1 Use of Eyeglasses for Testing

Many clients will have pre-existing eye conditions (often from childhood) that have been corrected for with eyeglasses. These include refractive errors (myopia-nearsightedness, hyperopia-farsightedness, and astigmatism-see illustration 2 in Appendix J); phoria, and other muscle imbalances. The biVABA assessments assume the client used their best corrected vision to complete the assessment. If the client's eyeglasses are missing or broken, note this in your documentation, and increase the size, luminance, and contrast of key test components to ensure they are visible. If you test the client without their eyeglasses, remember any abnormal eye position or movement you observed may be because the client's eyeglasses corrected for that deficiency. Also remember that a client with a history of childhood oculomotor impairment may display deviant eye movement without experiencing a functional limitation.

3.4.2 Testing Order

The biVABA is a collection of independent assessments that measure different aspects of visual perceptual processing. You are not required to administer every assessment. Instead choose the assessments that will provide the most information about the client's vision based on your initial observations. That said, the hierarchical and integrated nature of visual perceptual processing (depicted by the visual perceptual hierarchy in section 1.4) dictates that assessment be completed from the bottom up following the order that each level contributes to perceptual processing. Evaluation should start with the foundation skills (acuity, visual field, and oculomotor control) and continue on to assessment of visual attention and scanning and visual cognition. The foundation skills also have a hierarchy. Visual acuity and contrast sensitivity are considered core visual assessments that should be completed on every client (see section 4.1.1.1). They must be administered first to 1) establish a general baseline for how well the client sees and 2) determine whether the client can see the test items used for the other assessments. Likewise, the status of the client's visual field must be known in order to accurately identify deficits in oculomotor control and visual attention. Following this order provides the most accurate picture of the client's capabilities and limitations in visual processing.

3.4.3 Modifying Test Procedures

The biVABA does not focus on diagnosing or labeling a specific vision impairment. The purpose of the biVABA is to assist you to identify the client's visual strengths and weaknesses and link them to functional limitations to develop an effective intervention plan. It is easier to figure out the best intervention by observing the client's visual approach to a task and their ability to modify an unsuccessful strategy to complete a task. Flexible test procedures are required for this assessment approach. It's important that a client be able to position test materials as desired and that you are free to experiment with cuing and modifications to assist the client to complete the task. Modify biVABA test procedures as you desire as long as you don't alter the fundamental purpose of the assessment. Examples of suggested modifications are included with the test instructions in Section 4. Be sure to document the success or failure of the modification on the assessment form.

3.4.4 Explaining the Test to the Client

Gaining insight into how vision has changed empowers the client to adjust to vision loss and learn to use their current vision to participate in daily occupations. Use the evaluation process to educate the client. Provide as much explanation about the assessment as possible without overwhelming or confusing the client. Describe the aspect of vision you are evaluating, how it contributes to the client's ability to use vision for activities, how it might have changed following brain injury, and how the assessment will measure it. Keep your explanations short and simple; use everyday terms (e.g., use *field cut* instead of *hemianopia*); avoid medical terms (e.g., use *eye turn* instead of *strabismus*), abbreviations (e.g., arm instead UE) and OT centric terms, (use *looking* instead of *scanning*). Do not worry that these explanations give the client an unfair advantage in completing the assessment. If a significant disability exists, the client will still make errors despite this added information. Examples of how to explain each assessment to the client are included in the test instructions in Section 4.

3.4.5 Interpreting Test Results to the Client and Family

Just as important as understanding the purpose of the test is the client/family understanding of their test performance. Test results should be described in terms of how they affect the client's ability to complete daily activities. For example, if the client misses test targets on the left side of a visual search subtest due to an asymmetrical search pattern, you might explain that he uses this same pattern when trying and failing to locate his toothbrush. Test interpretation provides a great opportunity to educate the client/family and increase their understanding of the client's visual impairment.

Persons with normal visual processing can easily complete the biVABA assessments and most clients don't perceive the assessments to be particularly challenging. Always allow a client to retake an assessment to improve their performance. If the client's performance does improve, it is a positive indication of their ability use feedback or practice to improve. If the client's performance does not improve, it indicates limited insight or learning capacity. Either result provides useful feedback to the client and helps you establish appropriate goals and time frames for intervention.

4 Test Instructions

Please refer to the assessment forms located in Appendix C when reading this section. The psychometric properties of the assessments are located Appendix B.

4.1 Visual Acuity

The biVABA includes 3 standardized charts to measure acuity. The LeaNumbers Intermediate Acuity Test Chart and the Warren Text Card measure high contrast distance and reading acuity respectively. The LeaNumbers Low Contrast Flip Chart measures contrast sensitivity.

4.1.1 Assessment Considerations

4.1.1.1 Why You Should Measure Visual Acuity First

The three assessments that comprise the visual acuity screening are core tests that should be completed as early as possible on EVERY client. A client who is struggling to see may miss critical features/items or perform very slowly on tasks. If visual acuity is not assessed first, these behaviors may be mistakenly attributed to changes in cognition instead of a vision deficit. Bertone et al.[22] demonstrated this in a study where they artificially blurred the vision of normally sighted college students and tested their ability to complete nonverbal neuropsychological tests used to assess cognitive status in adults. They found that even a slight reduction in acuity from 20/20 to 20/40 resulted in poorer performance on certain nonverbal tests. Similar studies have also shown that uncorrected visual impairment can mistakenly appear as cognitive impairment in adults[75, 111, 217] and children.[192] Most neuropsychological assessments assume that the client has normal acuity and do not require assessment of visual acuity prior to administering the test. But not knowing the client’s acuity status risks that impaired acuity is misidentified as cognitive impairment and the acuity deficit is never addressed. The high incidence of poor acuity among hospitalized adult patients is another reason an acuity screening should be the first assessment completed.[172, 268] Leat et al.[134] found that 89% of inpatients on a general medicine floor had vision impairment but only 30% reported vision problems. Within this group 62% had low vision on testing including 36% with severe low vision. Ten of the study participants experienced a fall during hospitalization and 100% of the fallers had vision impairment. In another study, Rowe et al.[195] found that 56% of a cohort of 1,033 persons admitted for stroke had reduced acuity from central visual field impairment. In addition, patients are often admitted without their prescribed eyewear. Lotery et al.[140] found that over a quarter of inpatients on a stroke rehab floor, did not have their eyeglasses with them in the hospital. Among those who had glasses, nearly 25% were dirty, scratched or needed repair. Roche et al.[187] reported similar findings in a study of persons admitted onto an orthopedic floor: 25% of the patients did not have their glasses with them and of those who did, 85% of the spectacles were dirty or in poor repair.

4.1.1.2 Room Lighting

Acuity shares a linear relationship with illumination. As illumination decreases, so does acuity (no one can read a letter chart in the dark). The eye chart must be fully and evenly illuminated to obtain an accurate acuity measurement. The room should also be illuminated with a non-glaring light source to reduce visual stress.

4.1.1.3 Viewing Distance

Because acuity is depicted as a fraction of distance over letter size, the measurement is not accurate unless the viewing distance is accurate. The two high contrast acuity test charts are fitted with a cord to measure the viewing distance.

4.1.1.4 Client Response

Clients with brain injury often experience deficits in cognition, language and attention that may interfere with their ability to provide an accurate and timely response when identifying optotypes on a chart. An optotype is the target that the client views on the acuity chart. It is usually either a number, letter, or symbol.

- The client may need extra time to locate the optotypes on the chart, process the image, and respond.
- Slowness in responding does not necessarily indicate that the client lacks the acuity to identify the optotypes. Instead observe whether the client's speed in identifying the optotypes slows down as they become smaller or fainter.
- Quickly identifying optotypes on preceding rows and then suddenly slowing down and struggling strongly indicates that the client has reached their maximum acuity.
- If the client struggles to identify optotypes on every row-but is accurate-continue the test until the client can no longer identify the majority of the optotypes in the row.

4.1.1.5 The Client's Primary Language and Reading Grade Level

The most accurate ***near*** vision charts use sentences rather than single optotypes. Persons with reduced visual acuity often experience *crowding* when reading where the space between letters and words are diminished. Crowding makes it harder to clearly distinguish letters and words.[136] As a result, a client's reading acuity level is often lower than their single optotype acuity. Reading is the most often completed near acuity activity and reading acuity provides a better indicator of the client's ability to complete this task. However, the ability to read words accurately and fluently is also strongly influenced by the client's primary language and literacy level. Clients asked to complete a reading acuity chart in their second language or to read beyond their grade level may stumble on words and read slowly (e.g., low reading fluency) or misread words (e.g., low accuracy). To obtain an accurate measurement, the reading acuity chart must use the client's primary language and the sentences should be at or below the client's reading grade level. The biVABA includes an English and Spanish version of the Warren

Text Card with sentences written at the 6th grade reading level. Appendix G provides information on how to determine the reading grade level for text.

4.1.1.6 Eye Dominance

The dominant eye establishes and directs fixation on an object; the non-dominant eye follows the lead of the dominant eye and assists in the process. A preference has been shown for right eye dominance, but it does not match the predominance of right handedness.[13] Many persons cross dominance where they are right-handed and left eye dominant or vice versa. Some persons are *equi-dominant* and have no specific eye dominance.[13] A person with strongly established dominance is likely to use the dominant eye at least 3 times to view a target.[13] Persons with a different acuity level or type of refractive error in each eye may use one eye for distance and the other eye for near. Eye dominance may be resistant to change once established. For example, a person may automatically attempt to use the dominant eye to direct fixation in reading even if that eye has been injured or has poorer acuity or resist occluding the dominant eye to eliminate diplopia. Because it influences how the client uses the eyes for reading and viewing objects, eye dominance should be measured prior to measuring acuity.

4.1.1.7 Distance vs. Near Acuity

Focusing deficiencies, uncorrected refractive errors, and paralytic strabismus affect near and distance acuity differently. For example, a client who has difficulty focusing may experience blurred vision when attempting to read, but clearly see the road when driving. In contrast, a client with paralytic strabismus from a 6th CN lesion will see clearly to read, but experience doubling/blurred vision when driving. Because brain injuries frequently cause focusing issues, it is important to measure the client's near and distance acuity and **compare** the difference in acuity levels. **An acuity level that is 2-3 lines lower for near vision than distance vision suggests that the client may have a focusing deficiency.**

4.1.1.8 Use of Prescription Eyewear

Eyeglasses and contacts correct for refractive errors that the client was born with or acquired in life. Refractive errors may remain stable during childhood and early adulthood and a client's prescription may not need to be changed. However, the refractive capability of the eye begins to change during one's 40's due to aging. *Presbyopia* is common and reduces the person's ability to focus up close to see print clearly. Reading glasses or bifocals are needed to make up the difference. Older adults experience more age-related diseases that reduce acuity including cataract, macular degeneration, glaucoma, and diabetic retinopathy. It is important to question the client about their need for non-prescription and prescription eyewear and ask how often they see the eye doctor and the approximate date of their last eye exam. Older adults without eye disease should have their eyes examined yearly. Older adults also frequently need to have their eyeglasses updated. Many countries with universal health care pay for new eyeglasses and eye exams. In the U.S., Medicare pays for an annual eye exam but does not pay for the eyeglasses. This prevents adults without the financial resources to purchase new eyeglasses from achieving optimal visual acuity.

4.1.1.9 Visual Complaints

Persons with significant vision impairment may periodically experience a visual disturbance where they see unusual visual images. *Phantom vision* (also known as Charles Bonnet Syndrome) is the best known of these visual conditions.[162] It is often reported by persons with macular degeneration and other age-related eye diseases; persons with hemianopia may also experience it.[246] The person has periodic episodes where they see images that aren't really there. The person may see a formed image such as a Cheshire cat sitting on the television or see a pattern of flashing or swirling lights. No sounds or smells accompany the images, and the person knows that they are not real. The images typically appear randomly and last just a few minutes. The exact cause of phantom vision is still unknown, but it is considered a benign condition. A client experiencing phantom vision may be reluctant to mention these episodes because they fear appearing "crazy." Asking whether the client "sometimes see things that aren't really there" provides an opportunity to educate the client about the condition and provide reassurance that it is common, and the images will eventually stop appearing. Clients with TBI or stroke may also report episodic shimmering vision in the peripheral or central visual field. Less is known about this condition. Its appearance in the central field-usually during reading-may signal that the person is unable to maintain binocular vision during focus (see section 2.3.3.1). Its appearance in the peripheral visual field may be related to a visual-vestibular impairment (see section 2.3.3.2).[194]

4.1.2 Test Instructions

General Instructions to the Client:

> *I am going to give you some tests to see how clearly you can see at a distance and up close. You will need to wear your eyeglasses for some of these tests if you use them to see far away objects or for reading. I am going to ask you a few questions before we get started with the tests.*

4.1.2.1 Key Visual Complaints/Observations

Test Item:

Visual Acuity Assessment form

Procedure:

1. Use the checklists embedded throughout the assessment to identify potential limitations and strengths using vision. Begin making these observations during your first encounters with the client and as you work with them on ADLs. Use the checklist with family members and other team members to verify your observations and obtain a different perspective on the client's abilities.

2. Be sure to observe for light sensitivity as this is a very common co-impairment that causes significant visual stress.
3. Look for consistencies in behaviors and use this information to determine the key assessments you should complete.

4.1.2.2 Questions about Eyewear, Eye Care and Visual Complaints

Test Item:

Visual Acuity Assessment form

Procedure:

1. Begin the assessment by asking the client (or family) about the use of eyewear. This includes use of contact lenses.
2. Use the *Eyewear Use* checklist. Be sure to tick all of the boxes-each answer helps to determine whether the client should see an eye doctor.
3. Ask the client to describe their vision. Use the *Key Visual Complaints/Observations* checklist to prompt the client about commonly occurring complaints.

4.1.2.3 Pupil Size and Symmetry

Test Items:

Visual Acuity Assessment form
Distant target (large enough to be seen easily at 6 feet without eyeglasses)

Environment: well-lighted room with a non-glaring light source. Ensure that the light source does not shine directly into the client's eyes

Procedure:

1. Seat the client comfortably without eyeglasses; bring the target closer if the client has difficulty seeing it at 6 feet (do not bring the target closer than 3 feet). The client can also wear their eyeglasses to see the target.
2. Observe the pupils of both eyes as the client fixates on the target.
3. Record whether the pupils match each other in size on the assessment form.

Instructions to the Client:

"I am going to look your pupils to see if they are the same size. Please look straight ahead and keep your eyes fixed on the [target] as I check your eyes.

4.1.2.4 Eye Dominance

Test Items:

Visual Acuity Assessment form
Plastic card with 8mm hole
Flower design card (from the design copy test)

Environment: well-lighted room with a non-glaring light source directed from behind the client onto the design card; ensure that the light source does not shine directly into the client's eyes.

Procedure:

1. Seat the client comfortably, wearing eyeglasses if needed.
2. Place the card with the 8mm hole on the table in front of the client.
3. Hold the flower design card directly in front of the client so the client can easily see it. Instruct the client to pick up the card and look through the hole with one eye to view the flower. ***DO NOT*** explain eye dominance or why you are giving this test until **afterward-it is important that the client respond automatically, without thinking about which eye to use.**
4. Repeat the test three times.
5. Record the eye the client used to view the flower on the 3 trials.

Instructions to the Client:

I am going to check to see how well you can see the flower (show flower design copy card) when you look through the hole in this card (show card with 8mm hole). Please pick up the card with the hole in it and hold it up to your eye to view the flower."

2nd Trial: "Great job, let's do it one more time"

3rd Trial: "Great job, let's do it one final time"

4.1.2.4.1 Alternate Methods for Determining Eye Dominance

1. Hand the client a cardboard tube or a rolled-up piece of paper. Instruct the client to use the tube to view a specific distant target. Repeat the test 3 times using different targets. The eye that the client uses to view the object is the dominant eye.
2. If the client is unable to communicate or follow directions, question family members/friends as to whether they remember the eye the client uses to view through a camera, a gun scope, a magnifier, a telescope, or a microscope.

4.1.2.5 Distance Acuity

Test Items:

LeaNumbers Intermediate Acuity Test Chart
Visual Acuity Assessment form
Clip-on occluder or eye patch (optional)
Easel to hold chart if needed

Environment: well-lighted room with a non-glaring light source directed from behind the client onto the chart; ensure that the chart is FULLY illuminated, and that light source does not shine directly into the client's eyes.

Procedure:

1. Seat the client comfortably. If the client wears prescription eyeglasses with distance correction, they **must be worn for this assessment.**
2. Instruct the client to hold the black spoon occluder attached to the chart against the eye that is not being tested. The client should hold the occluder with the handle horizontal to the ground to keep the cord from crossing their line of sight. If the client is unable to hold the occluder, use a clip-on occluder for the eyeglasses or an eye patch to cover one eye.
3. Stretch the cord attached to the occluder until it is taut to position the chart at 1 meter. Measure this distance starting from the face of the chart to the client's cornea (don't touch the cornea) or to the surface of the client's eyeglasses lens.
4. Center the chart at the client's midline (hold the chart or place it on an easel).
5. Make sure that the chart is **fully and evenly illuminated** (the room does not need to be well illuminated as long as the chart is fully illuminated).
6. Instruct the client to begin reading the numbers starting at the TOP of the chart (20/1000 acuity line). Most clients will have much better visual acuity than 20/1000 but starting at the top enables the client to practice identifying the numbers and moving across the line and from row to row. It also provides an opportunity to observe for the effect of a hemianopia on reading (see section 4.1.3.1.3).
7. The client uses the reading pattern to progress through the chart-moving across each row from left-to-right, and through the rows from top-to-bottom. You may use a pointer to highlight the number and help the client proceed through the chart.
8. If the client accurately identifies the numbers on the front of the chart, turn the chart over and proceed through the rows on the back of the chart.
9. Allow the client with perceptual and cognitive deficits as much time as needed to identify the letters and encourage the client to give their best performance (see section 4.2.1.5)
10. If the client wears a bifocal, observe to make sure they use the upper portion of the lens to view the chart. Pay careful attention to whether the client tilts the head back to use their reading ad to view the chart as this suggests difficulty clearly seeing the numbers on the chart. If you observe this, stop the test, and remind the client to view through the top portion of their eyeglasses.
11. Record the Snellen and metric fractions and the metric (M) print size for the last row on which the client can accurately identify 3/5 of the numbers.
12. Test the dominant eye first, then the non-dominant eye, then using both eyes together. Remove the occluder and reestablish the 1-meter test distance when testing the eyes together.
13. For a quick screen, omit testing the eyes individually and just test both eyes together.

Instructions to the Client:

"I am going to check how well you can see by having you read out the numbers on this chart. Please start at the top of the chart and read the numbers down as far as you can. Because each of your eyes may see differently, we will complete the test 3 times. First using your ___eye, then your___ eye and then using both eyes together. Please hold this

occluder in front of your ____eye to make sure that you can't see anything with that eye. During the test you can turn your head from side to side if that helps you to see the numbers more clearly, but you cannot lean forward or away from the chart."

4.1.2.5.1 Modified Procedures for Clients with Limited Language, Cognition, Attention

Clients with limited language, cognition or attention may have difficulty following standard test procedures. Several procedures can be modified without compromising the acuity measurement as long as the test distance and chart illumination are not altered. Acceptable modifications include:

1. If the client has difficulty locating the target number in a row and pointer doesn't help, cover up the other numbers on the row (or all of the other numbers on the chart) so that only the target number is visible. Record the client's acuity as the last line the client can easily identify the single presented target.
2. If the client is unable to verbally identify the number, create a card with the 4 numbers printed on it and instruct the client to point to the number on the card that matches the number seen on the chart.
3. If the client has good yes/no reliability using a head nod or raising the hand, use a forced choice method and ask the client is this an ___ or an ____?
4. If the client has difficulty focusing and sustaining attention, divide the test into short segments and test 1 row at a time over several days. Allow the client as much time as needed to identify the target and provide rest breaks as needed.

4.1.2.6 Reading Acuity

Test Items:

Visual Acuity Assessment form
Warren Text Card (English Version)
Warren Text Card (Spanish Version)

Environment: well-lighted room with a non-glaring light source directed from behind the client onto the card; ensure that the chart is FULLY illuminated and that the light source does not shine directly into the client's eyes.

Procedure:

1. Determine the client's eye dominant eye and distance acuity before giving this test. In addition, query the client about their ability to read (primary language and reading grade level) to ensure that this test card is appropriate (see section 4.1.1.5). Being asked about the ability to read could be embarrassing for a client who may have received less education or has a reading disability or believes they should be able to read English well even though it is their second language. Thoughtfully approach the topic to determine if the client can read English at a 6th grade reading level.

2. Seat the client comfortably. If the client wears prescription eyeglasses with near correction (single lens or bifocal), they **must be worn for this assessment** to obtain an accurate measurement of the client's reading acuity.
3. Test the client's vision using *both eyes together*; each eye is **not** tested separately.
4. Center the card at the client's midline; the client can hold the card, or it can be placed on an easel; make sure that the card is fully and evenly illuminated.
5. Stretch the cord until it is taut to position the card at 16 inches (40cm). Measure this distance starting from the card's surface to the client's cornea (do not touch the cornea) or to the surface of the client's eyeglass lens.
6. Instruct the client to read the sentences out loud starting on the top row and continue reading down the card as far as possible, turning the card over for the smaller print.
7. Allow clients with language and/or cognitive deficits as much time as needed to identify the words.
8. Record the Snellen fraction, the metric print size and the diopters of magnification needed for the last row the client was able to accurately read most of the words in the sentence without effort. These are located on the right side of the card.
9. Do not count it as an error if a client with hemianopia misreads a word due to the field cut but note such errors as they suggest that the hemianopia may be interfering with reading.

Instructions to the Client:

"This test is to find out the smallest size of print that you can read. Please hold the card and read the sentences out loud to me beginning with the sentence at the top of the card (indicate location of the first sentence). Some of these sentences are silly so don't worry whether you are reading them correctly. You can turn your head from side to side if that helps you to see a word more clearly but do not to move the card closer or farther away than this (demonstrate the card distance).

4.1.2.7 Contrast Sensitivity

Test Items:

LeaNumbers Low Contrast Flip Chart
Soft tipped pointer
Visual Acuity Assessment form
16-inch (40cm) length of cord/ribbon (see procedure step 4)

* NOTE: The surface of the test cards is extremely sensitive to environmental pollutants. Take the following precautions to avoid damaging the card surface.

- Always close the flip chart after use.
- Do not leave the test cards exposed to light or dust.
- Do not touch the surface of the cards with your fingers (use the pointer).
- Always keep your fingers on the edges of the chart.
- For cleaning instructions see Appendix K.

Environment: well-lighted room with a non-glaring light source directed from behind the client onto the chart; ensure that the chart is FULLY illuminated, and that light source does not shine directly into the client's eyes.

Procedure:

1. Measure distance visual acuity prior to giving this test.
2. Seat the client comfortably wearing eyeglasses if needed.
3. Hold the chart by the side edges-do NOT touch the face of the cards.
4. Center the chart at the client's midline 16 inches (40cm) from the client's cornea (do not touch the cornea) or from the surface of the client's eyeglasses lens. Note-this chart does not come with an attached 16-inch (40cm) cord. Make your own using string, ribbon, or cord.
5. Test the client using both eyes together-each eye is **not** tested separately.
6. Explain to the client that the test uses the numbers 5, 6, 8, 9.
7. Flip the cover of the chart back to reveal the first card.
8. Use the soft tipped pointer to point out the first number on the card (*remember do not touch pointer to the card).*
9. Instruct the client to identify the number.
10. If the client accurately identifies the number without effort, move on to the next card.
11. If the client hesitates to read the number or misreads a number on a card, return to the previous card, and instruct the client to read the entire line of numbers, then have the client try again to identify the numbers on the next card. It takes effort to see the faint numbers and some clients need to practice focusing before they can see them.
12. If the client reports seeing nothing on the card, encourage them to continue to view the card to see if the number slowly appears on the line. Images appear and disappear when the client is close to their contrast threshold, and it may take longer to recognize the number.
13. Record the percent of contrast on the last card that the client was able to accurately identify a number.
14. Refer to the table in Section 4.1.3.1.5 to identify the functional limitations the client may experience.

Instructions to the Client:

"The purpose of this test to find out how well you can see objects that are very faint-for example water spilled on the floor. Sometimes a brain injury will cause you to lose this kind of acuity. The test measures this by asking you to identify numbers on these cards. The numbers are 5, 6, 8, 9. I will ask you to tell me the first number in each line. The numbers will become fainter as we flip through the chart, and it may be hard to see them. Take your time and do your best. You can turn your head from side to side if that helps you to see the number more clearly but do not move the card closer or farther away than this (demonstrate the card distance)."

4.1.3 Interpreting the Client's Performance on the Acuity Assessments

4.1.3.1 Key Client Complaints/Observations

4.1.3.1.1 Pupil Size and Symmetry

Normal pupils are round, normal size, and symmetrical. Pupil size is partially determined by the amount of ambient light available. In a well illuminated room, the normal size of an adult's pupil is approximately 3mm and a child's pupil may be up to 5mm. Older adults may have smaller pupil sizes. Some medications such as those prescribed for glaucoma may also reduce pupil size.[137] Approximately 20% of the adult population have asymmetrically sized pupils (a condition known as physiologic anisocoria) but the difference in pupil size is less than 1mm and the pupils respond consensually (equally) to light.[137] Impaired pupil responses can have many causes. A dilated pupil in one eye may indicate blindness in the eye, optic nerve atrophy, or a 3rd cranial nerve lesion among other conditions. A physician evaluates the pupil to determine whether there are unilateral afferent abnormalities caused by conditions such as optic neuritis, optic nerve injury or retinal detachment. Changes in the pupil's ability to respond to light can affect the client's ability to read, see in dimly lit rooms and adjust to changing light levels within environments. The client may experience visual stress in these circumstances, reducing their motivation to engage in reading activities and a desire to avoid challenging environments.

The client's pupil(s) is small **and constricted.** This indicates that diminished light is coming into the eye that may reduce retinal function (in the way low light affects exposure of camera film); the client may require a brighter non-glaring light to clearly see objects and details.

One pupil is dilated**.** If the client has vision and the pupil remains dilated during accommodation, the client may experience blurred vision when focusing at a near distance. This could cause difficulty reading and completing other near vision tasks. If the pupil doesn't constrict in bright light, the client may have trouble transitioning from brightly lit to dark environments or increased sensitivity to light.

4.1.3.1.2 Eye Dominance

Near distance activities typically require better acuity and more refined oculomotor control because the eye is moving short distances between targets (think of moving the fovea from word to word when reading). Reduced acuity or oculomotor control in the dominant eye typically has a greater detrimental effect on reading performance or activities that require precise eye/hand coordination than impairment in the non-dominant eye. A client with strong eye dominance will have difficulty and may be unable to successfully switch to using the other eye to direct reading saccades and precise hand movements. Eye dominance doesn't significantly contribute to completing daily activities if both eyes have normal vision. Strongly dominant clients with significant vision impairment in their dominant eye, usually experience fatigue when forced to use their nondominant eye to complete reading and other fine motor activities. The client may experience frustration and subsequent avoidance of the difficult activities. Eye dominance is also an important factor in applying occlusion to eliminate diplopia due to oculomotor impairment. See section 5.7.1.3 and Appendix H for additional information.

The client consistently uses either the right eye or the left eye to view the flower through the hole in the card during all three trials. This indicates that the eye is the dominant eye for viewing near distances.

The client uses either the right or left eye to view the flower through the hole in the card. This indicates that the client may not have a dominant eye for near distances and switches dominance depending on the task demands.[13]

4.1.3.1.3 LeaNumbers Intermediate Acuity Chart

The client's visual acuity using the eyes together is 20/60 or less. Eye doctors measure visual acuity to determine whether magnification is needed to see visual detail-and if it is needed-how much magnification should be used. The client with visual acuity in the normal to near normal range (20/20-20/60) may just need a stronger refraction in their eyeglasses and should be referred to an optometrist or ophthalmologist. A client with acuity less than 20/60 when wearing their eyeglasses may have a condition that causes low vision. Any client with acuity below the normal range, should be referred for an eye exam to determine the reason for acuity loss and to determine if, and how, vision can be enhanced. Unless someone on the rehab team has experience or credentialing in low vision rehabilitation, a client with diagnosed low vision should be referred to a low vision optometrist or a low vision rehabilitation program.

The client leans into the chart to view the numbers. Leaning towards the chart indicates that the client is reaching their limit of resolution and can no longer clearly see the numbers.

***The client turns the head from side to side to view the target number*.** Clients with an established macular scotoma from macular degeneration may use a head turn to move the scotoma out of the way to clearly see the target number. The same behavior may be observed in a client who is aware of their hemianopia or tunnel vision. This is a useful compensatory strategy, and it indicates that the client has insight into how their field loss affects their vision. It also doesn't alter the distance from the chart, so the acuity measurement is still accurate.

***The client omits numbers on one side*.** Clients with left homonymous hemianopia or hemi-inattention may make errors such as starting to read in the middle of the line of numbers rather than on the left side (see section 2.4.3.2). Clients with right homonymous hemianopia may not finish reading a line of numbers. When this is observed, point out the omitted numbers and ask the client to identify them; remind the client to turn their head if needed to see the numbers in the row. A client with hemianopia should be able to comply with this request; a client with hemi-inattention may not have the attentional capability to comply.

The client misreads numbers with similar configurations. Generally, errors where the client misreads similar numbers-such as a *5, 6, or 9*, instead of an *8* suggests reduced acuity rather than a deficit in cognition, perception, or language. The exception is the client who has aphasia or dyslexia.

The client has greater difficulty identifying larger numbers than smaller numbers. This may indicate that the client has a significant visual field deficit and may have only a small island of visual field remaining. This type of visual field deficit can occur following central retinal artery occlusion, an optic nerve injury or an occipital lobe injury. In a client with macular degeneration, this behavior can indicate the presence of a ring scotoma where the client has a small island of intact retina surrounded by a donut shaped scotoma.[210] Regardless of the cause, specialized low vision reading instruction is needed to enable the client to read and referral should be made to a low vision specialist.

4.1.3.1.4 Warren Text Card

Reading is an integral component of many important I-ADLS. Consulting and collaborating with eye doctors, providing appropriate assistive technology and instruction, modifying tasks to reduce reading demands are all important OT interventions.

The client is unable to accurately read the sentence at the 20/20 or 20/25 line ("you cannot leave without the children" or "I could have driven some more this morning"). Eye doctors strive to provide eyeglasses that enable the person to see print as small as (.4M-.5M) to provide reading reserve (e.g., less stress and fatigue) when reading the more commonly used print size of 1M (20/50 acuity). A client who easily reads the 20/50 line ("Kim does not like to wear cold shoes") should have sufficient acuity to read most print materials but may have difficulty with small print. Difficulty reading below 20/50 may indicate that the client's eyeglasses need to be updated. The *metric diopters needed* (third column on the chart) indicates the strength of the eyeglasses needed to enable the client to see the corresponding sentence on the card. For example, a client who can't read the 20/50 line would need at least 2.5 diopters of strength in a pair of store-bought reading glasses to read the sentence "Kim does not like to wear cold shoes." You might provide a pair of 2.5-3 diopter reading glasses to see if they help the client read more easily (see section 5.5.3.5). BUT NOTE: this is a very simplistic explanation of **one** of the factors that influence acuity; **many other factors** go into determining the best refraction for the client. A client with **less than** 20/25 vision should be referred to an eye doctor in order to have optimal vision.

The client leans into the chart to read the sentences. Leaning towards the chart indicates that the client is reaching their limit of resolution and can no longer clearly see the words.

The client leans aways from the chart to read the sentences. Leaning away from the chart may indicate that the client is having trouble with accommodation and is trying to increase the distance from the chart to reduce visual blur. This behavior is often observed in clients with convergence insufficiency.

The client shuts one eye or squints to read the sentences. This indicates that the eyes are not working together. The client with diplopia from a 3rd or 4th CN lesion may be trying remove one image to reduce visual blur and see the words more clearly. If the client has macular degeneration, it may indicate non-congruous macular scotoma in the eyes (e.g., the size and shape of the scotoma in one eye is very different from the size and shape of the scotoma in the other eye). The client shuts one eye (often the non-dominant eye) to remove one of the images in order to see more clearly.

***The client complains that the text is shimmering, floating, changing colors, disappearing*.** These odd visual changes generally indicate the eyes are no longer able to maintain fusion and focus to see print clearly. Clients with convergence insufficiency and other focusing issues may complain of odd visual changes in text as their eyes become fatigued from the effort of trying to work together to maintain a clear image.[121]

***The client omits letters or words on one side*.** Clients with left or right homonymous hemianopia and those with macular scotomas may make errors where they omit the beginnings or ending letters of words or transform words (into a similar word) because they do not see the entire word during fixation. They may also omit words at the beginning or end of a line of text. Generally, these types of errors occur more frequently on larger text and less frequently as the text decreases in size. If perimetry testing shows the presence of a field deficit in the fovea, the client may require specialized low vision intervention to learn to compensate for field loss when reading (see section 5.8.7). Clients with neglect may make similar errors on the left side of words or sentences and may start reading a sentence in the middle.

***The client has difficulty reading words in larger print sizes and less difficulty as the words decrease in size*.** This may indicate the presence of a visual field deficit that narrows the central visual field to a small "island" of vision. This type of field loss can occur following central retinal artery occlusion, optic nerve injury or occipital lobe injury. For clients with macular degeneration, it can indicate the presence of a ring scotoma where fixation is surrounded on three to four sides by dense scotoma. Specialized low vision reading techniques are needed to enable the client to read.

4.1.3.1.5 LeaNumbers Low Contrast Flip Chart

Dr. Lea Hyvarinen is a low vision ophthalmologist and internationally recognized expert in vision charts. Her Lea Charts are widely used with children and adults. Dr. Hyvarinen developed the flip chart to provide quick screening of contrast sensitivity by testing only the range of contrast levels required to complete most everyday activities. Dr. Hyvarinen believes that there is little value in classifying contrast sensitivity as mild, moderate, severe, profound and her charts do not assign such values.[113] She recommends instead that therapists think about how a decrease in high or low contrast information will impair the client's performance in various activities. To assist biVABA users to document the results of the client's performance on the Flipchart, Dr. Hyvarinen developed a set of clinical observations paired with the contrast level that the client can identify on the chart. This provides a functional interpretation of the client's performance to use for documentation, client/family education and recommendations to the team.

Interpretation of Client Accuracy on the LeaNumbers Low Contrast Flip Chart Test	
Client correctly identifies numbers on all 5 lines (1.25% contrast level)	The client has good contrast sensitivity for communication, orientation, and mobility; special modification of the environment is not needed.
Client only correctly identifies numbers on the first 4 lines (2.5% contrast level)	The client will likely have difficulty seeing facial expressions and recognizing friends across the street. He or she may have difficulty detecting curbs and other low contrast drop offs. Increased lighting may assist the client to recognize low contrast features. Modification of the environment to increase the contrast of important environmental features is recommended.
Client only correctly identifies numbers on the first 3 lines (5% contrast level)	The client likely will have difficulty detecting subtle changes in the support surface, reading materials printed in low contrast formats, seeing black and white photographs, facial features, water, and other low contrast items. Magnification and increased lighting may assist the client to recognize low contrast features. Driving performance should be carefully evaluated especially with regards to night driving and driving in cloudy conditions.
Client only correctly identifies numbers on first 2 lines (10% - 25% contrast level)	Enhancement of contrast is needed for the client to function safely and independently. The client may require assistance to walk safely in environments. Driving performance should be carefully evaluated especially with regards to night driving and driving in cloudy conditions.
Client does not see any numbers (Contrast level is above 25%)	Contrast sensitivity function is extremely limited, and enhancement of contrast is needed for the client to function (see section 5.5.2). The client may require assistance to ambulate safely in environments. Ability to resume driving is highly questionable and should be carefully evaluated.

4.2 Oculomotor Control

The *Oculomotor Control Assessment* is a quick screening tool that uses a “listen and look” approach. The OT *listens* to the client’s complaints of difficulties using their eyes together to focus and locate objects and *looks* for deviations in oculomotor control that may account for these complaints.

4.2.1 Assessment Considerations

4.2.1.1 The OT Role

In our role working with the client to complete occupations, OT is often the first rehab team member to observe the client having difficulty using their eyes together to complete activities. The oculomotor assessment will help the OT link observations of the client’s ability to make eye movements to limitations completing daily occupations. Diagnosing the cause of the impairment (e.g., a cranial nerve lesion, convergence insufficiency or other focusing impairment) is the role of the ophthalmologist or optometrist-the professions best qualified to make a differential diagnosis of this complex visual impairment. If our screening suggests oculomotor impairment due to the brain injury, the next step is to seek a referral to these eye doctors for further evaluation.

4.2.1.2 Visual History

It is important to begin the assessment by asking about the client’s visual history to identify whether oculomotor impairment occurred from the current brain injury. Adult clients with a childhood history of oculomotor impairment or reduced acuity in one eye (amblyopia) often demonstrate eye movements that deviate from the norm. However, most have adapted to these oculomotor changes and do not experience functional limitations. Therefore, oculomotor deficiencies from early childhood conditions are usually not significant unless they cause a functional limitation. Other clients may have a history of eye injuries (black eye, orbital blow out fracture) or a previous brain injury (concussion). These injuries can also alter eye movements.

4.2.1.3 Room Lighting

Light sensitivity is a common co-impairment in clients with oculomotor impairment. A client with sensitivity may keep the eyes partially or completely closed in rooms with bright, glaring, or fluorescent lighting. The room should be illuminated with a **non-glaring light source** to reduce visual stress. The lighting should be just bright enough to enable you to clearly see the client’s eye movements. Avoid shining light directly onto the client’s face. Avoid using a penlight as a target and never shine a penlight directly into the client’s eye. Doing so will cause visual stress and may agitate the client and reduce their cooperation.

4.2.1.4 Medications

Clients routinely take multiple medications during their recovery from brain injury. Some of these medications may affect the client's visual system and exacerbate visual symptoms. There is little research on the relationship between medications and visual complaints in clients with TBI and stroke. Han et al.[99] compared two groups with vision symptoms from TBI or stroke; one group consumed medications and the other group consumed no medications. The study found that persons taking medications reported a 2-fold increase in light sensitivity, increased complaints of poor depth perception, and dry eye compared to the non-medication group. The most consumed medications in study participants were anti-anxiety/antidepressants, anticonvulsants, opiate/combination analgesics and cardiac/antihypertensives. All of these medications include light sensitivity as a side effect suggesting that the medication may have contributed to the complaints of light sensitivity in this group. Opiate/combination analgesics may have contributed specifically to dry eye. More studies are needed to establish a relationship between medications and visual symptoms in clients with ABI, but the Han study reinforces the importance of reviewing the client's medications and including questions about light sensitivity, depth perception and dry eye in the initial assessment.

4.2.1.5 Arousal/Attention Level

The client's ability to maintain arousal (see section 2.5.1) and attend to a target can directly affect their ability to focus and move their eyes. Evaluate the symmetry of the eyes and eye movements when the client is the most alert, rested, and attentive. If needed, break the assessment into short segments and evaluate the client over several days. Although this is not a long assessment, it can be fatiguing and stressful for a client with oculomotor impairment. Using brightly colored kinetic targets (like a kid's pencil topper that bounces and moves) will engage the client's attention more than a static target as will a target with a face on it. Be creative and **avoid using** your low contrast finger or the very boring tip of your pen as a target.

4.2.1.6 Visual Acuity

Always measure acuity before assessing oculomotor control as a certain level of visual acuity is necessary for visual fixation. Reduced visual acuity may cause visual blur when viewing small details-a common complaint in clients who have age-related eye disease. If the client is unable to see the target, the eyes may wander, creating the impression of oculomotor impairment. Optic atrophy, vitreous hemorrhage and macular scotoma are examples of conditions that may prevent fixation and cause eye movements that mimic paralytic strabismus. If the client has reduced acuity, increase the size and brightness of the target.

4.2.1.7 Client Complaints/Observations

Clients often report and demonstrate specific changes and limitations using their vision for certain activities. These complaints and observations offer insights into the type of oculomotor impairment they are experiencing. Table 4.2.1 lists common complaints and observations of clients with difficulty focusing or aligning the eyes.

Table 4.2.1: Common Complaints/Observations: Clients with Difficulty Focusing or Aligning Eyes

Focusing	Eye Alignment
Impairment affects activities that require focusing on close objects and/or sustaining focus at close distances-reading, needlework, device use etc.	*Misalignment affects activities that require viewing and/or focusing on an object at a specific distance or in a specific direction*
Visual blur	Visual blur
Eye fatigue from sustained focusing	Doubling images
Forehead pain or pain surrounding the eye	Crooked/distorted images
Squinting eyes to view near target/object	Ghosting images (like bad TV reception)
Red rimmed eyes, tearing, blinking, rubbing eyes after attempting to focus	Turning head sideways or tilting head up or down to view target
Dry itchy eyes after sustained focusing	Shutting one eye to view a target/object
Leaning back away from object/target to focus	Image disappears when one eye is shut
Complains words break apart, float, change colors, shimmer, disappear when reading	Feeling/being off balance during movement
	Past pointing when reaching for an object

4.2.1.8 The Cardinal Directions of Gaze

The eye muscles work synergistically to move the eye through 9 gaze directions depicted in the diagram below.

	straight up	up and to the left
towards the right	primary gaze (eyes straight ahead)	towards the left
down and to the right	straight down	down and to the left

4.2.1.9 Characteristics of Cranial Nerve Lesions

Cranial nerves 3,4 and 6 control the extraocular muscles that move the eye (see sections 2.3.2.1, 2.3.3.2). Damage to each CN creates a specific set of limitations described in Table 4.2.2

Table 4.2.2: Eye Movement Changes from CN Lesions 3,4,6

CN 3: Oculomotor Nerve	CN 4: Trochlear Nerve	CN 6: Abducens Nerve
Difficulty making vertical eye movements and moving eye inward towards the nose	Difficulty moving the eye down and out (as when looking at neighbor's test to cheat on exam)	Difficulty making horizontal eye movement-moving eye outward towards the ear
Client may tilt head upward to view a target placed above the head or tilt it downward to view target placed below the chest	Client may tilt head toward lesion side (unilateral CN4 lesion) or tilt head downward (bilateral CN4) to view central target	Client may turn head to view a target placed towards the periphery on the involved side
Eye maybe turned outward (exotropia) when viewing a central target in primary gaze	Eye maybe turned upward (hypertropia) when viewing a central target in primary gaze	Eye may be turned inward (esotropia) when viewing a central target in primary gaze
Eye may be drooped or closed (ptosis); pupil may be dilated		
Client C/O blurred or double vision when reading or completing close work	Client C/O blurred or double vision reading; on curb/step or walking on uneven ground	Client C/O blurred or double vision driving, walking, playing golf, tennis etc.

4.2.1.10 Corneal Reflections

The corneal reflection is the spot of light reflected off the cornea of the eyes from an ambient source or a penlight. Observing the corneal reflections in primary gaze is a quick and accurate method to assess ocular alignment. Facial injuries can distort the appearance of the eyes and may make it appear that they are not aligned with one another. Corneal reflections provide a **true** indication of eye alignment.[137] If the eyes are aligned, the corneal reflections will appear in the center of the eye as the client views a centrally placed target held directly in front of the face (eyes in primary gaze) and the locations of the reflection in each eye will match. If one eye is deviated (positioned outward, inward, up, or down), its corneal reflection will be off-center and appear on the either the inner, outer, upper, or lower rim of the iris instead of the center of the pupil. Persons with significant astigmatism in one eye may have a cornea that is more oblong than round or dimpled rather than smooth. The corneal reflection in the astigmatic eye may be slightly off center and not precisely matched with the other eye, but the client will not show any other signs that the eyes are misaligned.

4.2.1.11 Visual Vestibular Impairment

Clients with visual-vestibular impairment may have trouble stabilizing gaze and experience visual blur during head and body movements. They may also experience shimmering and movement in the peripheral visual field that may be constant or occur with body movement. Because visual stability is a necessary component of postural control, the client may also complain of or demonstrate impaired balance. Referral to a PT or OT trained in vestibular rehabilitation should be made to address the client's limitations.

4.2.1.12 The Best Test Targets

Persons in the early stages of recovery may have difficulty attending to targets. The best targets for clients with low attention are those with interesting designs or motion. Targets with faces (animal or human) are particularly effective because we are inherently drawn to focus on the face. Kinetic targets are also effective as the eye is drawn to movement. The least effective target is your low contrast finger or the tip of your very boring pen. Penlights are useful because they enable us to view the corneal reflections. BUT the intense, bright light may irritate a client with light sensitivity and cause the client to become agitated or shut down. Ambient room lighting is often sufficient to see the client's corneal reflections and eliminate the need for a penlight. If the penlight is required, never shine it directly into the client's eye.

4.2.1.13 Testing Eyes Separately or Together

Just as it is more difficult to move the upper extremities together than to move one arm at a time, binocular movement of the eyes is more difficult to produce than monocular eye movement. Deviations in eye movements are more readily observed on a binocular test that requires the eyes to move together to track a target through the 9 cardinal points of gaze (see diagram in section 4.2.1.8). The assessment focuses on the client's ability to produce controlled eye movement through the **mid-range of motion** directly in front of the face. Tracking a target in this area should be easy and effortless as we repeatedly make eye movements within this range during a typical day. If a wider eye movement is needed to locate a target, eye movement is combined with head movement as it is more efficient to use the head and eyes together.

4.4.1.14 Eye Turns, Head Turns, Head Tilts

Persons with eye misalignment may only be able to eliminate the double image by assuming a head position that avoids the action of the paretic muscle.[202] For example, a client with a left lateral rectus palsy (CN 6 lesion) may turn the head toward the left to avoid the need to abduct the eye; a client with paralysis of the right superior oblique muscle (CN 4 lesion) may tilt the head to the right to avoid the downward action of that muscle.[201, 202] In some clients, the altered head position is a functional adaptation the client uses to obtain single vision and not a result of neck or trunk instability. For this client altering their head position to minimize or eliminate diplopia may impair their postural control and mobility.

Clients with significant paralysis of an eye muscle may show an eye turn when viewing the target in primary gaze (see Table 4.2.2 and section 2.3.2.1). *Tropia* is the suffix applied when there is a noticeable deviation in the position of one eye as the client focuses on a target. *Phoria* is the suffix used when the eye muscle is weak, but deviation of the eye prevented by the brain's need for sensory fusion and is not noticeable when the client is focusing on an object. These terms are combined with a prefix that indicates the direction of the deviation. There are four prefixes used: *eso*-meaning the eye turns inward towards the nose; *exo*-the eye turns outward towards the temple/ear; *hypo*-the eye turns downward *hyper*-the eye turns upward. *Esotropia,* for example, indicates an observable, inward, deviation of the eye commonly described as “crossed eyes” whereas, *esophoria* indicates the eye drifts inward when the client is not focusing on an object but aligns with the other eye when the client focuses on an object.

Clients with phorias usually complain of intermittent diplopia that appears when the client is tired or not feeling well. Although the client can maintain single vision by forcing the eyes to work harder to stay aligned, the client pays the price in visual stress that can manifest as headaches, eye strain, or decreased concentration. If a phoria is suspected, ask the client about visual stress during activities that require sustained focus such as reading, needlework, watching television or working on their computer.

4.2.1.15 Near Point of Convergence

The near point of convergence (NPC) is the nearest point in space that a person can focus on an object and maintain a single image.[165, 208] It is an important measure of the person’s ability to accommodate and eye doctors pay close attention to it when assessing the client’s focusing ability. The near point of convergence in a typical adult is approximately 2-4 inches (6-10 cm) from the bridge of the nose. However, several factors influence this distance including age, refractive errors, the pupil’s ability to contract, visual acuity and so on. Eye doctors consider all of these factors when interpreting the NPC in their diagnosis of an accommodative disorder. Without this depth of knowledge, the OT is unable to determine whether a client’s NPC is significant; therefore, taking time to measure it provides little value. The OT acquires more valuable information about the client’s focusing ability by observing how easily the client converges the eyes over several repetitions. Convergence is a very practiced skill-we converge our eyes every time we read or look at our phone or computer. A person with normal focusing abilities should be able to track a target in and out multiple times without any sign of visual stress (e.g., blinking, eyes watering, eyes reddening, shutting an eye). *Any sign* of stress during convergence strongly indicates a focusing deficiency and the client should be referred to an eye doctor for a more thorough evaluation.

4.2.1.16 Diplopia Testing

Diplopia testing is completed only when the client complains of or demonstrates diplopia. It is used to determine the severity of the diplopia and whether it is due to a tropia or a phoria. Diplopia testing is based on the principle that the eye uses the fovea to view objects in order to see them clearly-a process known as foveation (see section 2.3.1). If an eye that is not fixating on a target is suddenly required to foveate, it will achieve foveation by moving the eye towards the target. Therefore, if both eyes fixated the target, neither eye will move when one eye is covered but if the eyes are **not** aligned, the deviating eye will move to take up fixation when the other eye is covered. Clients with phoria can align the eyes for short periods of time to fixate on a target but can’t maintain that alignment without experiencing significant stress (headache, eye pain, fatigue). To uncover a phoria, the occluder must cover the eye for **at least 2 seconds** to break fusion and allow the eye to drift, then quickly be moved to the other eye.

If movement of the eye is observed on either of the tests, seek a referral to an eye doctor for further evaluation and diagnosis. To quantify the severity of the diplopia, the eye doctor places prisms of increasing power (measured in diopters) over the deviating eye and repeats the cover test until no eye movement is observed. The doctor records the dioptric strength of the neutralizing prism to quantify the extent of the deviation and determines whether to prescribe prism to assist the client to achieve and maintain single vision. The application of temporary Fresnel prisms to improve sensory fusion can reduce visual stress during recovery and improve the client's ability to participate in fully in their rehabilitation program.

4.2.2 Test Instructions

General Instructions to the Client:

> *"I am going to give you some tests to see how well you can move your eyes together to clearly see objects. Using the eyes together is important for good balance, reading and eye hand coordination. Sometimes a brain injury damages the centers that control eye movements."*

4.2.2.1 Visual History and Key Client Complaints/Observations

Test Item:

Oculomotor Control Assessment form

Procedure:

1. Use the key client complaints/observation checklists embedded throughout the assessment to identify potential limitations and strengths using eye movements to complete activities. Begin making these observations during your first encounters with the client and as you work with them on ADLs. Use the checklist with family members and other team members to verify your observations and obtain a different perspective on the client's abilities.
2. Be sure to observe for light sensitivity as this is a very common co-impairment with oculomotor impairment and causes significant visual stress.
3. Obtain a basic visual history using the first section of the form as a guide. Ask a family member to supply the information if it is not possible to obtain it from the client.
4. Look for patterns in the client's responses that suggest limitations in a specific aspect of oculomotor control. Note whether the client's complaints of fatigue and concentration appear to be related to activities that require sustained focusing. Pay attention to whether the client's visual difficulty seems to change with focal length or direction of eye movement.

4.2.2.2 General Appearance

Test items:

Oculomotor Control Assessment form

Interesting distant target-large enough to be seen easily at 6 plus feet

Environment*:* well-lighted room with a non-glaring light source directed from behind the client; ensure that the light source is not shining directly into the client's eyes.

Procedure*:*

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they need to wear them for this assessment.
2. Observe the client's eyes as they focus on a distant target placed directly in front of the face at eye level.
3. Complete the checklist on the form. Record asymmetries in eyelid function, eye position and head position.

Instructions to the Client:

"I am going to look at your eyes to see if they look the same. Please look straight ahead and keep your eyes fixed on the [target]as I check your eyes."

4.2.2.3 Corneal Reflections

Test Items:

Oculomotor Control Assessment form
Penlight (if needed)
Interesting distant target large enough to be seen easily at 6 plus feet
Interesting near target

Environment: well-lighted room with a non-glaring light source directed from behind the client; lower the room illumination if you have difficulty seeing the client's corneal reflections.

Procedure:

1. Seat the client comfortably wearing prescription eyeglasses if typically worn. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If the client's eye position is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape for the short duration of the test.
3. Hold or place an interesting target directly in front of the client at eye level.
4. Begin with a distant target.
5. Instruct the client to focus on the target.
6. Check to see if you can view the client's corneal reflections using just the ambient room lighting-if not use the penlight to view the reflection.
7. If using the penlight-center it in front of the client's face approximately 12 inches from the tip of the nose. If the client exhibits any sign of light sensitivity, tip the penlight vertically to slightly direct the light upward so it does not directly shine into the eyes.
8. Observe the corneal reflection in each eye as the client fixates the target and record the position of the reflection on the form.
9. Repeat using a near distance target.

Instructions to the Client:

"I am going to look at your eyes to see if they line up together. [If using a penlight-include *I am going to use this penlight so I can look at the light reflect off your eyes to see if it is in the same place on both eyes*]. *Please look straight ahead and keep your eyes fixed on the [target] as I check your eyes."*

4.2.2.4 Eye Movements

4.2.2.4.1 Tracking Eye Movements

Test Items:

Oculomotor Control Assessment form
Interesting target (see section 4.2.1.12)

Environment: well-lighted room with a non-glaring light source directed from behind the client; ensure that the light source does not shine directly into the client's eyes.

Procedure:

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If eye movement is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape for the short duration of this test.
3. Instruct the client to focus on the target.
4. Try to keep the target approximately 20 inches from the face and move it at a steady pace-not too fast and not too slow-through the 9 cardinal directions of gaze (see section 4.2.1.8)
    - *Primary Gaze*: Hold the target directly in front of the bridge of the nose.
    - *Horizontal-Right/Left*: Start with the target in front of the nose, move the target towards the right shoulder, then back towards left shoulder. The total excursion of the target should not exceed 15 inches.
    - *Vertical-Up/Down*: Start with the target in front of the nose; move the target vertically towards the top of the head, then down towards the Adam's apple. The total excursion of the target should not exceed 15 inches.
    - *Diagonal-Left/Right*: Start with the target by the left shoulder; move the target diagonally towards the top of the right side of the head. Stop when the target is slightly above the right shoulder. Reverse directions. The total excursion of the target should not exceed 15 inches.
    - *Diagonal-Right/Left*: Start with the target by the right shoulder; move the target diagonally towards the top of the left side of the head. Stop when the target is slightly above the left shoulder. Reverse directions. The total excursion of the target should not exceed 15 inches.
5. **Again-do not move the target more than 15 inches in any direction**. This enables you to test the client's control of eye movements within the mid-range where they typically occur.

6. Observe whether both eyes stay on the target as it moves. Key observations:
    - Both eyes move an equal distance in each direction.
    - The corneal reflections match in both eyes as they move in each direction.
    - The proportion of iris to sclera [white of eye] is equal in both eyes as they move in each direction.
7. Observe the client's ability to execute controlled eye movements. Key observation:
    - The eyes stay on target with minimum jerking movement as the client tracks the target through the mid-range.
8. Observe for signs of visual stress. Key observations:
    - Blinking, squinting, tearing, eyes reddening, shutting eyes while tracking the target.

Instructions to the Client:

"I am going to look at how well you can move your eyes together by having you follow this [target] as I move it in different directions. It's important to keep your eyes on the [target] as I move it."

4.2.2.4.2 Convergence

Test Items:

Oculomotor Control Assessment form
Interesting target

Environment: well-lighted room with a non-glaring light source directed from behind the client; ensure that the light source does not shine directly into the client's eyes.

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If eye movement is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape for the short duration of the test.
3. Instruct the client to focus on the target.
4. Begin approximately 20 inches from the face, move the penlight at steady pace-not too fast-not too slow-towards the bridge of the client's nose.
5. Both eyes should stay fixed on the target and move inward to follow it.
6. At some point as the target nears the bridge of the nose, the client will reach the near point of convergence (see section 4.2.1.15) and be unable to continue to converge the eyes. At this point, the client may report double or blurred vision, or you may observe one or both eyes move off the target.
7. Move the target back to starting position and repeat the test several more times.
8. Carefully observe the client's performance using the checklist on the form.

Instructions to the Client:

"I am going to see how long you can stay focused on this [target] as I move it towards your nose. As the [target] gets close to your nose, you may feel eye strain, and the target

may double or get blurry. Please let me know as soon as this happens. I will stop and move the target back to where it started. Keep your eyes on the target as I move it back towards the starting position. I am going to repeat this test several times to see if you can easily stay on the target."

4.2.2.5 Diplopia Testing

4.2.2.5.1 Cover/Uncover Test

Complete this test when you observe an eye turn, or head turn/tilt and suspect the client may have a tropia (see sections 4.2.1.14 and 4.2.1.16).

Test Items:
Oculomotor Control Assessment form
Interesting distant and near targets
Handheld plastic occluder

Environment: well-lighted room with a non-glaring light source directed from behind the client onto the target; ensure that the light source is not shining directly into the client's eyes.

Procedure:
1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If eye movement is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape during short duration of the test.
3. Instruct the client to focus on the target. The target should be positioned at eye level and at midline and behind the examiner so that it is more than 30 inches away from the client's face. The client's eyes should be in primary gaze as they focus on the target.
4. While the client fixates the target, use the occluder to **quickly cover the eye that appears to have intact oculomotor control.**
5. As you cover the eye, observe the **uncovered** eye to see if it moves to fixate on the target.
6. If eye movement is observed, record the direction that the eye moved using the checklist or diagram on the assessment form.
7. Repeat the test **several times** to confirm your observation of whether the uncovered eye moved and the direction it moved.
8. Repeat the test this time observing the movement of the other eye.
9. If neither eye moves on the test, repeat the test on both eyes using a near distance-target placed 16 inches (40cm) from the eye.
10. If neither eye moves when tested at the far or near distance, complete the alternate cover/uncover test to check for a phoria.

Instructions to the Client:

"I am going to see if your eyes can stay focused on the [target] as I cover and uncover each eye. It is important that you keep your eyes focused on the [target] during the test."

4.2 2.5.2 Alternate Cover Test

Complete this test when the client's complaints suggest eye misalignment and you didn't observe movement on the cover/uncover test-suggesting the client may have a phoria (see sections 4.2.1.14 and 4.2.1.16).

Test Items:

Oculomotor Control Assessment form
Interesting distant and near targets
Plastic handheld occluder

Environment: well-lighted room with a non-glaring light source directed from behind the client; ensure that the light source is not shining directly into the client's eyes.

Procedure:

1. Seat the client comfortably wearing prescription eyeglasses if needed. If the client has worn eyeglasses since childhood, they must wear them for this assessment.
2. If eye movement is difficult to observe because of eyelid ptosis, tape the eyelid up with surgical tape during short duration of the test.
3. Instruct the client to focus on the target. The target should be positioned at eye level and at midline and behind the examiner so that it is more than 30 inches away from the client's face. The client's eyes should be in primary gaze as they focus on the target.
4. Quickly switch the occluder back and forth between the eyes while the client fixates on the target. **HOLD** the occluder over the eye for **a full *2 seconds*** before switching**.**
5. Observe whether the eye ***under cover*** moves to take up fixation when the occluder is removed and record the direction that the eye moved on the assessment form using the checklist or diagram.
6. Repeat the test several times to confirm your observation of whether the eye moved and the direction it moved.
7. Repeat the test observing the movement of the other eye.
8. If neither eye moves on the test, repeat the test on both eyes using a near distance target placed 16 (40cm) from the eye.
9. If neither eye moves at the far or near distance, but you still suspect a phoria, repeat the test several more times to fatigue the eye-repetition can sometimes unmask a phoria.

Instructions to the Client:

"I am going to see if your eyes can stay focused on the [target] as I cover and uncover each eye. It is important that you keep your eyes focused on the [target] during the test."

4.2.3 Interpreting the Client's Performance on the Assessments

Eye doctors are the most qualified professionals to diagnose, prescribe and provide an intervention plan for the client with oculomotor impairment. The client's performance on the OT screening should be used to request and justify a referral to the eye doctor for further evaluation, diagnosis, and treatment.

4.2.3.1 Visual History

The client's responses can reveal much about the type and severity of their oculomotor impairment. Use this information to determine the assessments to include in your evaluation.

***The client reports history of childhood strabismus, lazy eye, or amblyopia*.** Wearing a patch, having had eye surgery, and completing eye exercises as a child all suggest the presence of a congenital (not acquired) strabismus. A client with this history may have long-standing deficiencies in oculomotor control. Most persons adapt to oculomotor deficiencies that occur early in life and they do not interfere significantly reading and other tasks. The client with longstanding childhood acuity or oculomotor impairment in one eye, may be more likely to perceptually suppress visual information from the "lazy"eye. This client may not complain of blurred or doubling vision even when there is an obvious eye turn or mismatch between the corneal reflections. This client's oculomotor issues are more subtle and complex and require an eye doctor's evaluation.

***The client reports trauma to the eye or orbit*.** Damage to the eye or orbit from the current-or even a past injury-may cause several visual deficits. Extraocular muscles can be entrapped in the orbital fracture that restricts eye movement and causes pain during eye movement. A blow to the eye can cause a retinal detachment or damage the optic nerve that sometimes causes a severe reduction in acuity. Poor acuity can cause dis-coordinate eye movement. Clients with orbital/eye trauma should have had an ophthalmology exam following the injury. A client who has not had a thorough eye exam should be referred to an eye doctor to rule out a vision threatening condition.

4.2.3.2 Key Client Complaints/Observations

4.2.3.2.1 Focusing Difficulty

Clients with focusing impairment must put much more effort into seeing clearly at near distances. Many of their complaints reflect fatigue and eye strain from this extra effort. Difficulty reading is the number one voiced complaint of persons with focusing impairment.

***The client complains of visual blur and inability to keep objects in focus*.** Visual blur is the most reported complaint of persons with focusing issues. But it is also important to remember that persons with reduced acuity or central scotoma (common in macular degeneration) also report visual blur and difficulty keeping objects in focus. Be especially sure you have measured acuity and obtained an accurate visual history from an older client that includes asking about age-related eye disease.

The client complains of difficulty reading. Difficulty reading is the number 1 complaint of persons with focusing issues. But it is also a common complaint of persons with reduced acuity hemianopia and other visual field deficits that affect the central visual field, and also persons with light sensitivity. Be sure to assess these areas of visual performance when the client complains of difficultly reading.

The client complains of eye fatigue, eye strain, and headache when completing tasks that require sustained focusing. These complaints suggest that the client must put more effort into completing the task. The complaints are most likely to be made when questioned about reading -the most common daily activity dependent on sustained focusing. Persons with reduced acuity also must put more effort into near distance tasks like reading because of their difficulty seeing small and low contrast details. Clients are also more likely to experience eye fatigue, strain, and headache when fitted with total occlusion (e.g., a pirate patch) to eliminate double vision because they are forced to use one eye at a time for reading and near tasks. Consider using partial occlusion instead of total occlusion (see section 5.7.1.2).

The client complains of dry, itchy eyes after a period of sustained focusing. These complaints are associated with dry eye-a common condition where the tears don't sufficiently lubricate the surface of the cornea. There are many causes of dry eye including aging, allergies, medications, diseases (Parkinson's Disease and rheumatoid arthritis are common causes). Be sure to follow up with questions about whether the client has been diagnosed with dry eye and if it is a new or longstanding condition. We also blink less when concentrating on a task, which can cause the eyes to feel dry and itchy after a period of sustained focusing. When a younger client without risk factors or an identified cause of dry eye, complains of dry itchy eyes, it suggests that client is putting extra effort into focusing and is blinking less as a result.

The client complains of difficulty sustaining concentration during reading and other near vision tasks. Clients with acquired brain injury often have limited attentional reserves. The increased effort required to maintain focusing may drain these reserves and limit their ability to sustain concentration during a task.

The client blinks excessively, eyes water, or become red-rimmed during or after focusing on targets. These are clear signs that the client is experiencing visual stress completing the activity. They are often observed in the client with convergence insufficiency or another accommodative disorder after a period of sustained focusing.

The client complains that images break apart, float, change color, shimmer, disappear after a period of sustained focusing). This complaint is frequently due to muscle fatigue during reading and suggests convergence insufficiency (see section 2.3.3.1). As the eye muscles fatigue from the exertion of sustaining convergence during reading, the person's ability to fuse images breaks down and the client may experience these odd visual phenomena.

The client leans back to focus on a near task. Moving away from a task is usually done to relieve accommodative stress by increasing the focal distance. It suggests convergence insufficiency or another accommodative disorder. It is also a common reading adaptation used by persons with presbyopia who have not yet invested in a pair of reading glasses.

The client squints to focus on a near target. A person usually squints to see more clearly or to reduce light sensitivity. It may suggest difficulty focusing, reduced acuity in one eye compared to the other, or visual stress. But remember that a squint can also be a facial tic.

The pattern of the client's complaints suggest difficulty completing activities that require a sustained focus in near vision. This suggests difficulty with one of the components of accommodation, the presence of convergence insufficiency, or eye misalignment from 3^{rd} or 4^{th} cranial nerve involvement.

The pattern of the client complaints suggests a difference in ability to perform activities at different focal lengths. This suggests difficulty with accommodation if the client is experiencing problems with near distance or a muscle imbalance due to paralytic strabismus from damage to CN 3 or 4. If the client has no complaints about reading but complains of difficulty seeing clearly at a distance, it may suggest a muscle imbalance due to paralytic strabismus from CN 6 damage or reduced distance acuity.

4.2.3.2.2 Visual Vestibular Impairment

The client experiences blurring vision with head movement. This suggests that the client is unable to keep images stable on the fovea when the head/body is moving. It suggests visuo-vestibular dysfunction.

The client complains of shimmering/visual motion in the peripheral visual field. This may suggest increased sensitivity to visual motion which is a common complaint in persons who have had a TBI (see section 2.3.2.2). Optometrists trained in vision therapy may use bi-nasal occlusion or prism to reduce the perception of motion in the visual field.[48, 194]

4.2.3.2.3 Diplopia

The client reports images that are doubled, blurred, ghosting (like bad TV reception), crooked. These all suggest that the brain is unable to completely fuse the image to achieve single vision and suggest eye misalignment due to CN 3,4,6 lesions.

The client experiences past pointing or reaching. This may suggest that the strabismic eye is the dominant eye.

The client feels off balance when walking or displays impaired balance. This may suggest a 4^{th} or 6^{th} cranial nerve lesion. If the client's balance issues only occur when descending steps, it may indicate a 4th CN lesion; other balance issues may be related to a 6th CN lesion or visual vestibular impairment (see section 2.3.2.2).

The diplopia disappears when one eye is closed. This suggests that the diplopia is due to a muscle imbalance from acquired paralytic strabismus or another condition.

The diplopia does NOT disappear when one eye is closed. This suggests that the diplopia is due to damage to the structures of the eye or the retina. The client should be referred to an ophthalmologist or optometrist for an eye exam.

The diplopia is characterized by objects splitting side to side (horizontally). This suggests either 3rd or 6th cranial nerve involvement.

The diplopia is characterized by objects splitting one on top of the other (vertically). This suggests 4th cranial nerve involvement.

The diplopia is present only in near vision. This suggests either 3rd or 4th cranial nerve involvement.

The diplopia is present only in distant vision. This suggests 6th cranial nerve involvement.

The diplopia is constantly present. This suggests the presence of a tropia.

The diplopia comes and goes throughout the day. This suggests the presence of a phoria.

The diplopia is present only with gaze in one direction. This suggests that the diplopia is due to muscle paresis from a CN 3,4,6 lesion or muscle impingement if the client has experienced an orbital blow out fracture.

The diplopia is present in all directions of gaze. If this occurs with one eye covered, this may suggest that the diplopia is due to damage to the structures of the eye or the retina. The client should be referred to an ophthalmologist or optometrist for an eye exam.

The client with symptoms that suggest the presence of diplopia can fuse and perceive one image at a specific distance from the face. This suggests that some binocular capability is present. If the client's injury is recent (less than 6 months) it suggests that the muscle paresis may be resolving.

4.2.3.3 General Appearance

The client has a dilated pupil or lowered eye lid (ptosis). These are characteristics of a complete 3rd cranial nerve lesion. Fixed dilation of the pupil reduces accommodation and may increase visual blur when focusing on tasks in near space. Ptosis reduces the available superior visual field and can interfere with navigation and driving. Ptosis may also prevent diplopia by occluding vision in one eye.

Noticeable deviation in the position of one eye with complaint of diplopia. This suggests a tropia most likely due to eye misalignment from paralytic strabismus.

Noticeable deviation of the eye without complaint of diplopia. This may suggest reduced acuity in the eye severe enough to prevent the client's ability to fixate on a target (without fixation, the eye may deviate). Complete an acuity test to determine if the client has sufficient acuity to see and fixate a target. It may also suggest the presence of a long-standing strabismus that the client has adapted to by perceptually suppressing vision in one eye. Suppression is common in long-standing or congenital strabismus, but most adults with *newly acquired* paralytic strabismus are unable to suppress visual information and must use an altered head position to eliminate the diplopia.

The client assumes a deviated head position to view the target. This suggests paralytic strabismus and diplopia due to tropia. A "chin down" position suggests bilateral 4^{th} cranial nerve involvement; the head turned toward the left or right suggests a 6^{th} cranial nerve lesion; head tilt towards a shoulder suggests a unilateral 4^{th} cranial nerve lesion. Use of a deviated head position will eliminate diplopia but may interfere with the client's postural adaptation and mobility-be sure to observe balance and ask about falls.

Nystagmus is observed (quivering of the eyes). This may suggest cerebellar and/or brainstem involvement but there are many causes of nystagmus. If the nystagmus occurred following the brain injury and is present in primary gaze, the client may experience blurred vision.

4.2.3.4 Corneal Reflections

The position of the corneal reflections indicates whether the eyes are aligned when focusing on an object. The reflections should match in location; asymmetry in the position of the reflections between the two eyes may suggest a tropia and paralytic strabismus. Remember persons with an irregularly shaped cornea in one eye may have unequal corneal reflections despite normal ocular alignment (see section 4.2.1.10). Therefore, mis-matched corneal reflections are not significant without other signs of misalignment such as diplopia or deviations in eye position and movement. When the corneal reflections indicate that eyes are misaligned, but the client denies diplopia, possible causes include a congenital or long-standing strabismus with sensory suppression of the deviating eye or very poor acuity in one eye that prevents fixation.

The corneal reflection is positioned on the outer (lateral) rim of the iris in one eye. This suggests that the eye is turned inward (esotropic) and a possible 6^{th} cranial nerve lesion.

The corneal reflection is positioned on the inner (medial) rim of the iris in one eye. This suggests that the eye is turned outward (exotropic) and a possible 3^{rd} cranial nerve lesion.

The corneal light reflection is positioned on the upper rim of the iris in one eye. This suggests hypotropia.

The corneal reflection is positioned on the lower rim of the iris in one eye. This suggests hypertropia and a possible 4th cranial nerve lesion.

4.2.3.5 Tracking Eye Movements

The primary clinical observation is visual stress combined with difficulty/inability keeping both eyes fixated on the target as it moves through the 9 cardinal directions of gaze.

The client's eyes redden, begin watering, blink repeatedly, squint; the client shows other signs of visual stress when attempting to follow the target through the 9 cardinal directions of gaze. Following a target on its short excursion through the midrange of the 9 cardinal directions of gaze should be easy and effortless as these eye movements are repeatedly made throughout a typical day. Any signs of visual stress when tracking a target is significant. It suggests that the client has difficulty moving the eyes together possibly due to misalignment from a CN 3,4,6 lesion or difficulty coordinating eye movements due to pathway damage.

***One eye does not move as far as the other eye to stay on the target as the eyes move through the cardinal directions of gaze*.** This suggests restricted movement of one eye in a direction of gaze and suggests paresis/paralysis of the muscle initiating that movement from damage to CN 3,4,6. If the client has had an orbital blow out fracture (see section 4.2.3.1), muscle impingement may be restricting movement and movement usually causes pain.

***The proportion of sclera to iris does not match in the 2 eyes as the eye moves through the 9 cardinal directions of gaze*.** As the eyes track the target the proportion of sclera (white of the eye) to iris should be equal in both eyes. The client should show other signs of paralytic strabismus (e.g., diplopia and functional limitations).

Gaze-evoked nystagmus is observed. This appears as a quivering of the eye when it moves into an eccentric (off-centered) position. It suggests that the client is experiencing difficulty maintaining this position. The appearance of nystagmus can be due to muscle weakness, but it can also be due to age as older adults show more gaze-evoked nystagmus.[137] Its presence during abduction of the eye in conjunction with inability to adduct the other eye may indicate an intranuclear ophthalmoplegia (INO) due to a midbrain lesion (more common in multiple sclerosis).[137] Eye doctors use this symptom for diagnosis-observing it in a younger client may be a reason to refer the client to an eye doctor.

***The eyes jerk as the client tracks the target*.** An eye jerk means that the client was unable to keep the target on the fovea and initiated a saccade to catch up and re-establish fixation (the jerk is the saccadic eye movement). Some jerking of eye movements is normal, especially in children and older adults, and does not impair focusing on the image. Continuous jerking as the eye tracks an object within the mid-range of eye movement disrupts focusing. It may cause visual blur and visual stress.

4.2.3.6 Convergence

The primary clinical observation is difficulty and visual stress when attempting to converge the eyes as the target moves inward towards the nose. The primary client complaint is difficulty reading or completing another task that requires sustained near focusing.

The client follows the target in towards the nose and returns to the starting position 3-5 times without signs of visual stress or effort. This suggests the client has normal convergence (yay!).

***The client shows signs of stress when tracking the target inward: blinking, tearing, eyes reddening, sighing*.** This suggests that the client has difficulty converging the eyes. Convergence should be effortless and never produce stress. Request referral to an eye doctor to address convergence if the client demonstrates any sign of stress.

***The client is only able to follow target inward 1-2 times before fatiguing or showing signs of stress*.** This suggests that the client has difficulty converging the eyes. Convergence should be effortless and never produce stress. Request referral to an eye doctor to address convergence if the client demonstrates any sign of stress.

The client complains of headache or eye irritation after tracking the target inward. This suggests that the client has difficulty converging the eyes. Convergence should be effortless and never produce stress. Request referral to an eye doctor to address convergence if the client demonstrates any sign of stress.

***The client leans or tilts their head backwards to avoid moving the eyes inward* as the target moves towards the nose**. If this occurs as the target begins to move inward, it suggests that the client has difficulty converging the eyes. Request referral to an eye doctor to address the client's ability to converge. If it occurs when the target is close to the bridge of the nose-it suggests that the client reached their near point of convergence.

Only one eye follows the target inward. The client may be unable to move one eye inward due to a 3rd cranial nerve lesion. A central scotoma (from age-related eye disease) may also prevent one eye from seeing the target to follow it inward.

Neither eye follows the target inward. The client may be unable to converge the eyes and will experience significant difficulty completing any near vision task. But it could also suggest that the client misunderstood the directions or is unable to see the target well enough to track it.

4.2.3.7 Diplopia Testing-Cover/Uncover Test

***The uncovered eye moves towards the target when the other eye is covered*.** This suggests the presence of a tropia. Clients with a tropia generally complain of constant diplopia when viewing objects.

The uncovered eye moves inward to fixate on the target. This suggests an exotropia and possible 3rd cranial nerve involvement. The client generally complains of blurring or double vision when completing near vision tasks.

The uncovered eye moves outward to fixate on the target. This suggests an esotropia and possible 6th cranial nerve involvement. The client generally complains of blurring or double vision when completing distance tasks such as monitoring the support surface and driving.

The uncovered eye moves downward to fixate on the target. This suggests a hypertropia and possible 4th cranial nerve involvement. The client may experience blurring or double vision when reading or when monitoring the support surface when descending steps or curbs.

The uncovered eye moves upward to fixate on the target. This suggests a hypotropia. The client may experience blurring or double vision when viewing at a distance or when switching viewing distance from near to far as when copying notes from a blackboard.

4.2.3.8 Diplopia Testing-Alternate Cover Test

The eye that was covered moves inward to fixate on the target when the other eye is covered. This suggests exophoria and possible 3rd cranial nerve involvement. The client may experience blurring or double vision when reading, especially after a period of sustained viewing.

The eye that was covered moves outward to fixate on the target when the other eye is covered. This suggests esophoria and possible 6th cranial nerve involvement. The client may experience blurring or double vision when viewing at a distance, especially after a period of sustained viewing.

The eye that was covered moves downward to fixate on the target when the other eye is covered. This suggests hyperphoria and possible 4th cranial nerve involvement. The client may experience blurring or double vision when reading, especially after a period of sustained viewing or when looking downward to monitor the support surface.

The eye that was covered moves upward to fixate on the target when the other eye is covered. This suggests hypophoria. The client may experience blurring or double vision, especially when viewing at a distance or switching viewing distance from near to far as when copying notes from a blackboard.

4.3 Visual Fields

The Visual Fields Assessment focuses on screening assessments that can be completed bedside, in the clinic, or in the home. Two tests are included: a gross measurement of the peripheral field using the Two-Person Kinetic confrontation Test, and a more precise measurement of the central visual field using the Damato Campimeter.

4.3.1 Assessment Considerations

4.3.1.1 Visual Field Test Requirements

The process of measuring the visual field is known as perimetry. There are many types of perimeters. The tests vary from bedside assessments that provide a gross indication of field loss to the very precise imaging of a microperimeter that uses real time imaging to measure the central twenty degrees of the visual field. All perimetry testing-regardless of type-has three requirements:

1. The client must fixate on a central target during the test.
2. A second target(s) of a specific size and brightness is presented in a designated area of the visual field.
3. The client must acknowledge when the second target appears without breaking fixation on the central target.

The client's ability to stay fixated on the central target while targets appear in different areas of the visual field is critical to obtaining an accurate measurement. The client must also be able to sustain attention over an extended period of time. These attention requirements must be considered when selecting the best assessments to screen for a visual field deficit.

4.3.1.2 Clients with Low Visual Attention

Accurate perimetry testing depends on the client's ability to attain and sustain attention throughout the test. Any limitation in the client's attentional capability will reduce test accuracy. The test environment should be free from auditory and visual distractions. Test the client when they are well rested and alert. If the client is able to attend for only a few minutes, considering administering the assessment in short segments over a period of several days. Always use clinical observations to supplement the results from the screening assessments.

4.3.1.3 Importance of Clinical Observations

Always begin the evaluation with questions and observations about difficulties completing daily activities using the checklists in the first section of the assessment form. Clients with fluctuating and/or limited attention, and deficits in language and cognition, may provide unreliable perimetry results. Observing the client and listening to their perception of their difficulty completing activities can provide clues as to the location and extent of a possible field deficit. Client and family reports of difficulty completing activities that depend on an intact visual field (navigating through environments, reading, directing the hand in activities) provide insight into presence of a visual field deficit. Observations can also help distinguish whether the client has a left hemianopia or left neglect.

Another reason that clinical observations are important is that clients with visual field deficits often cannot describe how their vision has changed due to the influence of perceptual completion on visual processing (see section 2.4.3.1). Persons with visual field deficits see a perceptually completed visual field without gaps or missing information. There is no black curtain or black spot indicating the area of field loss. Furthermore, the person believes what they see and acts on this erroneous information.[102] However when questioned about their activities, clients often report experiences that suggest visual field loss. Some examples include collisions or close calls with objects on the blind side, disorientation when moving through an environment, difficulty reading and writing, and clumsiness with fine motor tasks. The client may also report an awareness that *"there is something wrong with my vision"* but attribute their difficulties to a change in acuity or depth perception. Generally, only the most astute client who experiments with their vision can describe the location and extent of a field deficit.

4.3.1.4 Cheating and Test Accuracy

Impaired ability to generate and sustain attention increases the chance that the client will cheat on the assessments by looking for the second target. Cheating by looking for the second target can cause a false positive where the client identifies a target that would not be seen if they had stayed fixated on the central target. False positives reduce the test's ability to detect the field deficit and the client may appear to have less field loss than is actually present. The instructions for the Two-Person Kinetic Confrontation test and the Damato Campimeter include procedures to reduce the incidence of cheating. The Two-Person Kinetic test includes a front examiner to observe for cheating on the test; the Damato Campimeter positions the examiner facing the client to observe for eye movement towards the target window to see the black dot. Instructions for both tests encourage the examiner to "prime" the client to attend to the central target before testing a field location. Following these directions will increase the reliability and accuracy of the test results.

Using an optimal target also decreases cheating and increases test accuracy. It is important that ONLY a lighted penlight be used as the target for the Two-Person Kinetic Confrontation Test. This is because the examiner brings the target from behind the client's head and moves it towards the nose. The rod photoreceptor cells in the peripheral retina will be the first to detect the target. These photoreceptors detect light, and motion and the bright moving light of the penlight provides the optimal target to activate them. Substituting your low contrast index finger or a pen as the target forces the client to rely only on movement to detect the target. The client may not detect the target as quickly resulting in two undesirable outcomes: 1) the client-anticipating the target's appearance but not seeing it-may be tempted to cheat and look for it reducing the reliability of the test or 2) the client may not identify the target until it moves further into the central field suggesting a deficit in the client's peripheral visual field that is not really there (e.g., a false positive). Replacing the front examiner's flower design card with a boring target like a pen, also encourages cheating simply because it is difficult to sustain attention on boring targets.

Moving the target at the correct speed also decreases cheating and increases accuracy. If the penlight is moved too slowly, the client will be tempted to look for it. If the penlight is moved too quickly, the client may not be able to respond fast enough to identify it until the target has moved forward. When this occurs, the client will appear to have more or less deficit in the peripheral field than is actually present.

4.3.1.5 Screening vs. Diagnostic Evaluation

Screening Assessments: The Two-Person Kinetic Test is an example of a confrontation test, where the examiner confronts the field by presenting a moving or static target as the client fixates a central target. Confrontation tests are “bedside” screening assessments that can be completed quickly using little equipment. Although they are widely used to screen for visual field, it is important **not** to assign them the same significance as a diagnostic test. Under close scrutiny, the confrontation test been shown to be unreliable in detecting visual field loss. Trobe, et al.[240] compared the results of confrontation testing by an ophthalmologist to results from a diagnostic Goldmann perimetry test and found that confrontation testing missed almost 50% of the visual field deficits detected by the perimeter test. They concluded that confrontation testing can indicate the presence of a gross defect in the visual field but lacks the sensitivity to stand alone as the only assessment of the visual field. If a significant deficit is present, the test likely will confirm its presence, however subtle or partial changes in the visual field, especially when macular sparing has occurred, can easily go undetected (see sections 2.4.2 and 4.3.1.8). The results of a screening assessment **must be** confirmed with a diagnostic evaluation.

Diagnostic Evaluation. Testing is completed using either a static or kinetic presentation of the target. In *static presentation*, the target appears in a specified area of the visual field without moving to that location. In a kinetic presentation, the target silently moves in from the periphery until it is identified. In addition to determining the size and location of a visual field deficit, a diagnostic test also measures the sensitivity (or acuity) within the field by testing visual thresholds at various points in the field. Every point within the visual field has a visual threshold-determined by the weakest stimuli that is just visible at that location under specified testing conditions. Visual threshold is the lowest at the fovea (indicating the greatest acuity) and highest in the periphery (indicating lower acuity). Eye doctors use a computerized bowl perimeter such to obtain a definitive diagnosis of a hemianopia or other field deficit. The *Humphrey Visual Field Analyzer* is the gold standard perimeter in the United States. To complete the test, the client places the chin on a chin rest and fixates on a central target inside the bowl-shaped device. As the client fixates the central target, a second lighted target is silently displayed inside the bowl at varying locations and intensities. The client responds to each seen target by pushing a small button. When diagnosing a field deficit, lighted targets are often presented in over a hundred locations within the field using a step threshold sequence where the intensity of the target is incrementally increased until the target is detected. The result is an accurate measurement of the areas of absolute loss (no response) and relative loss (decreased retinal sensitivity) within the field.

Two barriers are often encountered in completing the diagnostic evaluation using an instrument like the Humphrey. First, diagnostic testing requires sustained visual fixation over an extended period of time-sometimes up to 30 minutes per eye. Persons with brain injury commonly experience limited visual attention especially in the acute stages of recovery and may not be able to reliably complete a diagnostic perimetry test. Secondly, the client must be referred out to the eye doctor's office to complete the testing. These requirements often delay the definitive diagnosis weeks to months into the recovery period depending on the severity of the brain injury. Bruce et al.[34] estimated that a median of 5 months was required to complete an accurate diagnostic evaluation of the visual field in persons with traumatic brain injury. Knowing this, eye doctors often delay completing diagnostic testing early in recovery and suggest waiting 6 months. This recommendation isn't based on recovery as very little recovery of field occurs after 4 weeks, (see section 2.4.2) but instead on the ability to obtain an accurate (no cheating) diagnostic test. In most cases therefore, screening assessments must be used until the client has sufficient visual attention to complete a diagnostic perimetry test.

4.3.1.6 Relative Visual Field Losses

Visual field loss can range from complete loss (an absolute deficit) where the retinal field is unresponsive to light no matter how bright the target is, to a partial loss (relative deficit) where the retinal field may respond when shown a very bright target. It is not uncommon for both types of deficits to be present within the affected field following brain injury. Clients with relative field losses may respond inconsistently during field testing depending on the visibility of the target. Bright targets like the moving penlight on the 2-Person Kinetic Confrontation Test and the black dot on the Damato Campimeter are more likely to elicit a response than the examiner's low contrast wiggling finger. It is also important to administer the assessments in an environment with good non-glaring light. The results from the screening assessment should always be compared with clinical observations. It is difficult to identify relative visual deficits, so if the screening assessment shows no deficit but the clinical observations suggest that a deficit is present, the clinical observations should carry the greater weight in deciding whether the client has a visual field deficit.

4.3.1.7 Hemianopia vs. Other Types of Visual Field Deficit

All types of visual field deficit are possible following acquired brain injury, but hemianopia is the most commonly documented field deficit in both stroke and TBI (see section 2.4.2). Hemianopia is defined as blindness in one half of the visual field-either left or right field or superior or inferior field. A complete hemianopia affects the entire visual field-central and peripheral on one side. The client loses 50% of the visual field. The term homonymous means that the same amount of visual field deficit is present in both eyes.

4.3.1.8 Macular Sparing

Some clients with hemianopia experience macular sparing where they retain 5-25 degrees of the central visual field but lose the peripheral field (see section 2.4.2). The client with macular sparing will report fewer difficulties with reading, writing and other activities dependent on the central visual field and will likely do well on the Damato Campimeter. But the client may have challenges with safe navigation and driving. It is important to always assess the peripheral visual field using the Two Person Kinetic Confrontation test.

4.3.1.9 Phantom Vision and Other Co-Impairments

Persons with visual field deficit can experience co-impairments including light sensitivity, reduced contrast sensitivity, and phantom vision. Light sensitivity and reduced contrast sensitivity *occur from the brain injury*, whereas phantom vision (also called Charles Bonnet Syndrome-CBS) results *from the vision impairment*. Phantom vision is a unique visual disturbance that can occur when there has been significant vision loss.[162] It is common in persons with age-related eye diseases and can occur in persons with hemianopia.[91, 246] During a phantom vision episode, the person sees images that aren't there. The person may see a formed image such as a Cheshire cat sitting on the television or see a pattern of flashing or swirling lights (aka photopsia). No sounds or smells accompany the image, and the person knows that it is not real. The images typically appear only periodically for just a few minutes. The exact cause of phantom vision is still unknown. But eye doctors agree that it is a benign condition that often occurs in persons with significant vision impairment and does not signal that the person's vision is changing. The client experiencing phantom vision may be reluctant to mention these odd episodes to family or health care providers. Asking whether the client "sometimes see things that aren't really there" provides an opportunity to educate the client about phantom vision and provide reassurance that it is common, and the images will likely stop appearing after a while.

Reduced high contrast acuity and oculomotor impairment are not typical co-impairments. If the assessment identifies deficits in these areas, refer the client to the eye doctor to address them.

4.3.1.10 Visual Fields Assessments

The Two-Person Kinetic Confrontation test and the Damato Campimeter help to identify the possible location of the visual field deficit. This is important information but in order to set the most appropriate intervention goals, the OT must determine how the deficit affects the client's ability to complete daily occupations. Remember a visual field deficit is likely to be a permanent deficit and the client's ability to compensate for it in daily occupations is the key to successfully living with it. Section 4.5.1.2 describes additional assessments that provide insight into the client's ability complete occupations typically affected by a visual field deficit.

4.3.2 Test Instructions

General Instructions to the Client:

"I am going to give you some tests to find out if you can see objects in all areas of your visual field. The visual field is everything that you can see when you look straight ahead [use your hands to illustrate the width of the visual field]. A brain injury can cause blindness in a part of your vision-sometimes just in one eye and sometimes in both eyes. It is difficult for a person to figure out if their eyes have been affected. These tests will help me to find out if you have lost some vision in your eyes. It is important to find that out because visual field loss can cause problems with reading, walking, and driving. I will test one eye at a time."

4.3.2.1 Two-Person Kinetic Confrontation Test

The assessment provides a gross screening of the visual field using a moving target presented in 4 locations: right and left sides to screen for hemianopia and superior and inferior sides to screen for altitudinal deficits.

Test items:

Visual Fields Assessment form
Patch occluder
Penlight target (NO substitutions! See section 4.3.1.4)
biVABA flower card design or a similar interesting target that is large enough to be seen at 1 meter without eyeglasses

Test Environment: If needed-dim the room lighting to enhance penlight visibility. Room lighting must be sufficient for the front examiner to view the client's eye for cheating during fixation. This test requires the client's full concentration; ensure that the room is free from visual, auditory, and physical distractions.

Procedure:

1. The test requires a front and rear examiner:
    - **The front examiner** is an extra person whose sole job is to make sure that the client maintains fixation at all times on the central target during the test and does not "cheat" by looking for the penlight target. This person can be a family member, a student or other person capable of completing this task. The front examiner sits directly across and approximately 1 meter from the client. The examiner holds a visible target (e.g., the biVABA flower design card) directly in front of the client's face at eye level and encourages the client to stay focused on the card throughout the test. The examiner observes the client's eyes and alerts the rear examiner if the client breaks fixation on the target and looks for the penlight (see Figure 4.1).
    - **The rear examiner** is the OT who tests the client's visual field with the penlight. The rear examiner stands behind (or to the side of the client if needed) and

moves the lighted penlight forward toward the client's nose. The examiner holds the lighted penlight within **2 inches** of the client's head in order to provide a very bright target. The examiner moves the target at a not-too-fast, not-too-slow pace from behind the ear towards the nose moving the penlight in a tight arc to keep it close to the client's head at all times.

Figure 4.1: Examiner positions for 2-Person Kinetic Confrontation Test

2. Seat the client comfortably with eyeglasses **off**, if worn.
3. Test each eye separately.
4. Use the patch occluder to cover the untested eye.
5. The rear examiner shows the lighted penlight to the client and explains how the penlight will start behind the client's ear and move forward toward the client's nose.
6. The rear examiner holds the penlight and stands behind the client.
7. The rear examiner instructs the client to fixate on the front target and say "now" or raise a hand to indicate they see the light when it appears.
8. As the client fixates the front examiner's target, the rear examiner brings the lighted penlight forward moving in an arc-keeping the penlight **close to the client's head**. *(Note: if the target is moved too fast, the client will not be able to respond quickly enough to obtain an accurate field measurement).*
9. The front examiner observes the client's eye during the test to ensure that the client maintains fixation on the target and does not look for the penlight.
10. When the client indicates seeing the penlight target, the rear examiner notes the location and records it on the recording form (Figure 4.1).
11. The rear examiner moves the penlight forward using the positions of the clock as a guide: 3 o'clock, 9 o'clock, 12 o'clock and 6 o'clock. The 3 o'clock position is located on the client's right side and the 9 o'clock position is located on the client's left side.
12. To help the client attend throughout the test, "reset" the client's attention for each test location by reminding them to focus on the front target (see section 4.3.1.4).
13. When presenting the penlight from the 6 o'clock location, stand on the client's occluded side and position the **unlit** penlight at stomach level far enough away from the client's

body to ensure the light isn't directed up under the client's chin or up their nostril. Turn on the penlight when the light is in position.

14. If the client breaks fixation and looks for the penlight during the test, **do not** record the response and present the penlight in that location again at the end of the test.
15. **To test the right eye***:* occlude the client's left eye with the eye patch.
16. **To test the left eye***:* occlude the client's right eye with the eye patch.
17. **To test the right and left half of the visual field:** move the penlight from the 3 o'clock and 9 o'clock positions.
18. **To test the superior and inferior half of the visual field:** move the penlight from the 12 o'clock and 6'clock positions.

Instructions to the Client:

"We are going to use two people to give you this test. *[Name]will sit in front of you and hold this target for you to look at [indicate flower design card]. While you look at the target, I am going to stand behind you and move this penlight from behind your ear towards the front of your face. As soon as you see the light from the penlight, please raise your hand or say "now". It is VERY IMPORTANT that you keep your eye focused on the target that [Name] is holding at all times during the test and that you do not try to look for the light. If you move your eye to look for the light the test is not accurate. [Name] will be watching your eye to make sure that you do not move your eye to look."*

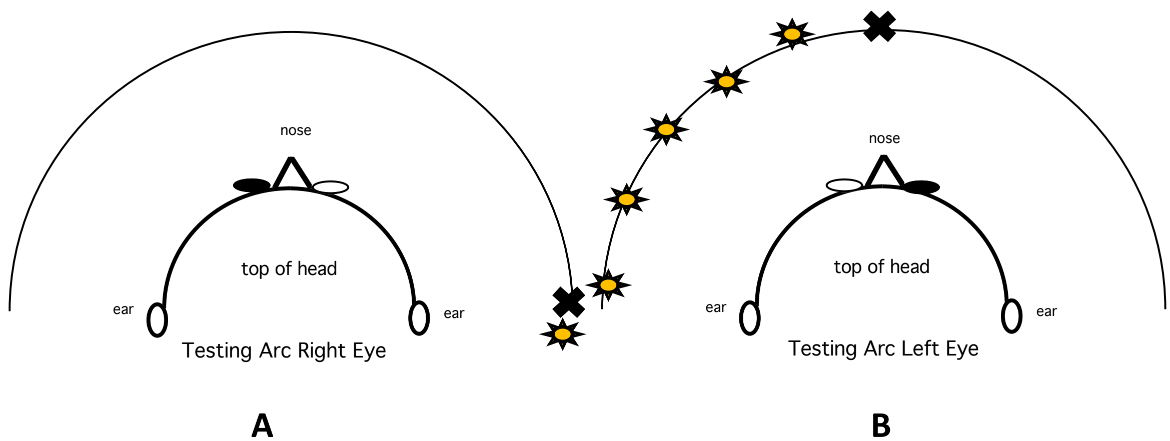
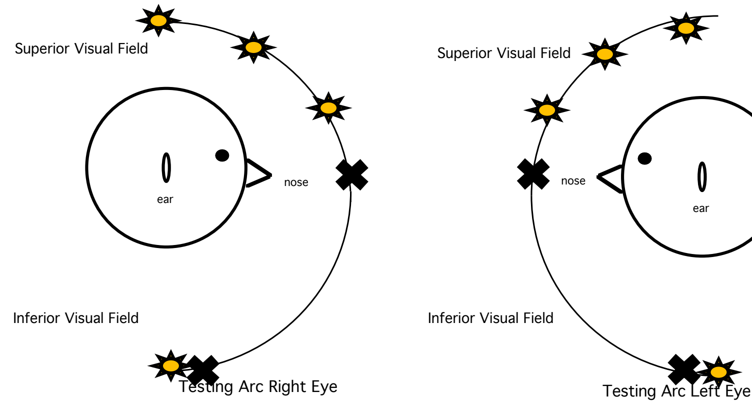


Figure 4.2: Illustration of a left hemianopia on the recording form. [penlight symbol] indicates the penlight as it moves toward the nose. **X** indicates the location where the client indicated first seeing the penlight. The client acknowledged the penlight as soon as it appeared on the right side when testing the right eye **(A)** and when it moved into the right field in front of the face **(B)** when testing the left eye. [occluder symbol] indicates the location of the occluder on the eye.



A **B**

Figure 4.3: Illustration of a superior field deficit on the recording form. indicates the penlight as it moves toward the nose. **X** indicates the location where the client indicated first seeing the penlight. The client acknowledged the penlight as soon as it moved into the inferior field in front of the face in both eyes **(A)** and when it appeared in the inferior field in both eyes **(B)**. The figure does not show the occluder on the untested eye.

4.3.2.2 Damato 30 Point Multifixation Campimeter

The Damato 30-Point Multifixation Campimeter provides a more precise alternative to confrontation testing of the central visual field. The test was designed by Bertil Damato, MD, PhD, FRCOpht. Dr. Damato's goal was to provide a simple, portable, and accurate perimetric measurement of the central visual field. The advantage of the test for assessing clients with brain injury is that the examiner does not have to place second target in different locations and the client does not need to sustain fixation for more than a few seconds. This increases the reliability of the test by minimizing both examiner and client error.

The test chart shown in Figure 4.4 consists of numbered targets that test 30 points in the **central** visual field. The second target is a 6-mm black dot that is shown in a centrally placed window on the chart. The test uses a unique strategy that relies on moving the eye rather than the target. The examiner instructs the client to fixate on one of the numbered targets on the chart, then moves the black dot into the central window. The client indicates when the dot appears. If the client does not see the black dot, that point within the visual field is recorded as a loss on the recording form. The client successively moves the eye to view each numbered target until the entire central field is mapped. The campimeter's ability to identify central field deficits was compared against the gold standard Humphrey Visual Field Analyzer and found to have a sensitivity of 81% and a specificity of 72% suggesting good accuracy.[200]

4.3.2.2.1 Campimeter Components

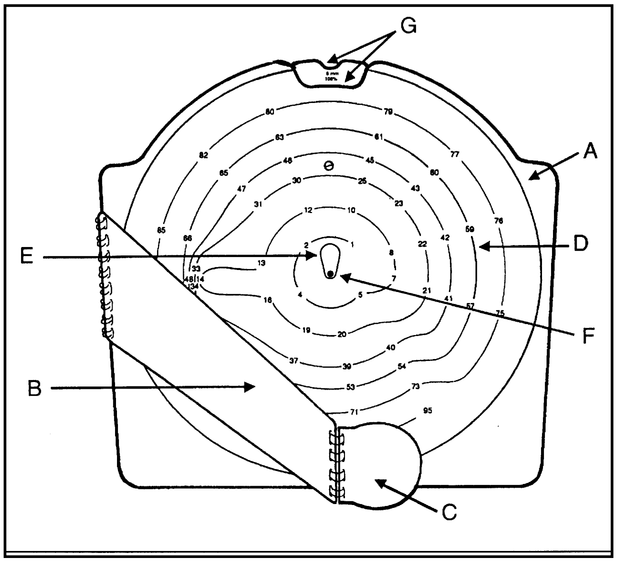


Figure 4.4: The Damato Multifixation Campimeter (*Illustration courtesy of Bertil Damato M.D.)*

A) *Test chart.* The chart is made of a hard, white plastic laminate printed with a circular test grid of black numbers. The chart is printed on both sides. One side of the chart is used to test the right eye and the other to test the left eye. The surface should be kept free of dirt and smudges. See Appendix K for cleaning instructions.

B) *Side arm*. The rigid side arm and eye cover helps the client maintain the correct viewing distance of 13 inches (33.3 cm) from the chart. It is important that this distance be maintained during the test to ensure the accuracy of the field measurement. The arm also ensures that the tested eye is viewing the correct test grid.

C) *Eye cover*. The eye cover is used to occlude vision in the untested eye. It is important that the field in each eye be tested monocularly to obtain an accurate measurement. If the client is unable to keep the eye cover in place, use an eye patch in combination with the cover to ensure that the untested eye remains occluded throughout the test.

D) *Test grid.* The test grid consists of 30 target numbers providing 30 test points within the 30-degree central visual field. The fixation targets are numbered to simplify communication with the client and recording of the results. The numbering is random to ensure that the client actually looks at the numbers without guessing. The lines linking the numbers direct the eye movements from one fixation target to the next. The test grid for the right eye is printed on one side of the chart and the test grid for the left eye is printed on the other side of the chart.

E) *Target window*. This window frames the second (black dot) target for the test. The window is shaped to minimize shadow on the circle and is 10 mm wide to ensure an error of less than 1 degree in placement of the second target during the test.

F) *Target*. A 6 mm black dot is used as the second target for the test. The dot has 100 % contrast and is large enough to be detected by clients with reduced acuity. The dot is printed on a movable disc so that it can appear and disappear within the window.

G) *Finger notches on the target disc*. The target disc is moved back and forth to display and remove the black dot from the window. Notches on the disc help the examiner accurately position and move their finger to present the target. This ensures that minimal cues are given to the client as to when the target appears.

4.3.2.2.2 **Test Instructions**

Test Items:

Damato 30 Point Multifixation Campimeter
Damato Campimeter plastic recording form template-use this to make a paper copy to record performance
Book stand (optional)
Eye patch or clip-on occluder (optional)

Environment: well-lighted room with the light source directed from behind the client onto the chart to evenly illuminate its surface; ensure that the light source does not shine directly into the client's eyes. This test requires the client's full concentration; ensure that the room is free from visual, auditory, and physical distractions.

Procedure:

1. Use the Damato recording form template to make a paper recording form.
2. Seat the client comfortably at a table wearing eyeglasses **IF** needed to identify the numbers on the chart. Eyeglasses will make it more difficult to observe whether the client cheats by moving the eyes toward the target window-use eyeglasses only if needed.
3. Instruct the client to hold the campimeter upright on the table top or use a book stand.
4. Stand behind the chart and face the client so you can observe the client's eyes to ensure the client fixates on the number and doesn't look to the window in anticipation of the dot appearing.
5. Instruct the client to position the eye cover. Fold the eye cover inward to occlude the untested eye. *(Note: use an eye patch or clip-on occluder in conjunction with the side arm if the client is unable to use the eye-cover to occlude the eye)*.
6. Continue to use side arm to maintain the correct distance from the chart (Figure 4.5).
7. Make sure that there are no shadows on the chart surface.
8. Adjust the card so that it faces the client squarely, with the target window directly in front of the eye being tested (Figure 4.5).
9. Tilt the card backward and forward until the client feels comfortable (Figure 4.5).
10. Make sure that neither the chart nor the client's head is tilted sideways (Figure 4.7)
11. **When positioned correctly, the tip of the client's nose should be pointing at the target window** (see Figure 4.6).

12. **Provide a practice session** before you start the test.
    - Make sure the target window is blank. Instruct the client to focus on the window and say "Now" when the black dot appears in the window, then move the black dot into the window. Repeat this step several times until the client responds every time the dot is shown. *(Note: if it is difficult to move the dot into the window-check your hand position on the chart-you may be inadvertently squeezing the front and back sides of the chart together making it difficult to move the target disc).*
    - Point to random numbers on the chart and ask the client to identify them. Repeat this step several times. If the client consistently identifies the numbers, continue onto the test. See section 4.3.2.2.3 if the client is unable to see or accurately identify the numbers.
13. Begin the test.
14. Show the client the number 1 on the grid.
15. Instruct the client to keep looking at the number 1 and to say "now" when the black dot appears.
16. Move the dot into the target window while watching the client's eye closely to ensure the client remains fixated on the number.
17. If client doesn't see the dot, **place a black mark** over that number on the assessment form **or write down the number** (Figure 4.8).
18. Remove the black the dot from the window.
19. Instruct client read aloud the next number.
20. **Prime and refocus** the client's attention by reminding them to keep focusing on the number (repeat this with every new test location-you can't repeat it enough).
21. When you are sure that the client is focused on the number, move the black dot into the target window.
22. If you are unsure whether the client was attending, immediately retest the number before moving onto the next number.
23. Repeat this process until the client has viewed all numbers.
24. To help identify cheating:
    - Vary the delay before presenting the black dot so that the client cannot guess when it will appear.
    - Present a blank window periodically to ensure the client's responses are genuine.

Testing the Blind Spot

1. The blind spot is used to ensure that the client's head is properly positioned, and the eye is aligned with the center of the chart.
2. The numbers 8, 29, 31 on the chart indicate areas where the natural blind spot will occur.
3. The client should **not see** the black dot at one of these locations if the head is properly aligned on the chart.
4. Test number 8 first; if the client sees the black dot at this location, test numbers 29, 31
5. If the client sees the black dot at all three locations, check the client's head to make sure it is properly positioned (the tip of the nose is directly opposite and pointing towards the target window).

6. If the client continues to **see** the black dot at all blind spot locations but you are sure that the head is aligned properly-continue with the test.

Testing the Field of the Right Eye

1. Place the eye-cover in the client's **left hand** and have the client hold the **right** edge of the chart with the **right hand**.
2. Instruct the client to cover the left eye by holding the cover (folded inward), against the client's closed eyelid or against the eyeglass lens.

Testing the Field of the Left Eye

1. Turn the chart over.
2. Place the eye-cover in the client's **right hand** and have the client hold the **left** edge of the chart with the **left hand**.
3. Instruct the client to cover the right eye by holding the cover (folded inward) against the closed eyelid or against the eyeglass lens.

Instructions to the Client:

> *"This test will carefully measure whether you have lost vision in the very center part of your field, the area you use to read and identify objects. I will test this by having you focus on a number on this chart [show a number] and then tell me when you see this black dot appear [show the black dot in the target window]. I will test each eye separately so you will need to cover one eye during the test. To cover your eye you will hold this [show side arm with eye cover] against your eye. It is very important that you follow these instructions, so we will practice several times before you take the test."*
>
> *"Hold the cover against your eye."*
> *"Look at the number "1" and keep looking at it."*
> *"Say 'now' when you see the black dot appears."*

Figure illustrations are courtesy of Bertil Damato, MD

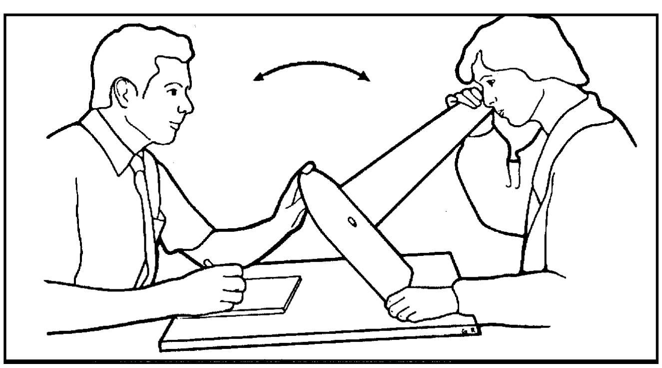


Figure 4.5: **Correct position**. Adjust the chart so it faces the client squarely and tilt the chart backward and forward until client feels comfortable.

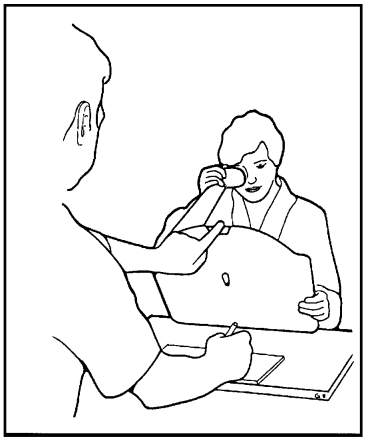


Figure 4.6: **Correct position**. Make sure that the tip of the client's nose is pointing at the target window.

Figure 4.7: Incorrect position. Monitor the client's head to make sure the **client does not** tilt or turn it during the test.

4.3.2.2.3 Modifications for Difficult-to-Test Clients

The instructions can be modified to test clients with limitations in cognition, language, attention without significantly altering the validity and reliability of the test.

1. *If the client has difficulty seeing the number target or maintaining focus*. Use a laser pointer or small sticker on your fingertip as the fixation target instead of the number.
2. *If the client has difficulty sustaining attention or limited endurance*. Reduce the number of test locations from 30 to 15. Have the client fixate on every other number to keep the targets evenly distributed throughout the field. Reducing the number of targets will reduce the sensitivity of the test to identify discrete deficits but it still provides a gross indication of a field deficit in the central visual field.
3. *If the client has difficulty sustaining attention or limited endurance*. Break the test into short segments and give it over several days.
4. *If the client has difficulty speaking*. Instruct the client to raise a finger to indicate when the black dot appears.

4.3.2.2.4 Recording the Client's Performance

Dr. Damato designed the recording form to accommodate the unique way the chart is constructed (where the eye moves to a location and target always appears in the central field). The recording form is turned one way to record the results and the other way to report the results (see Figure 4.8). The orientation of the form is clearly labeled. Position the form to read "this way up to record results" when you administer the test. After recording the client's results, rotate the form to read "This way up to interpret results."

The circles on the test form represent the field diagrams for each eye. On the field diagram, mark each target number with a black dot if the client **did not see** the black dot when it appeared as the client fixated the number (Figure 4.8). When the assessment is complete, the arrangement of black dots on the field diagram display the client's visual field deficit.

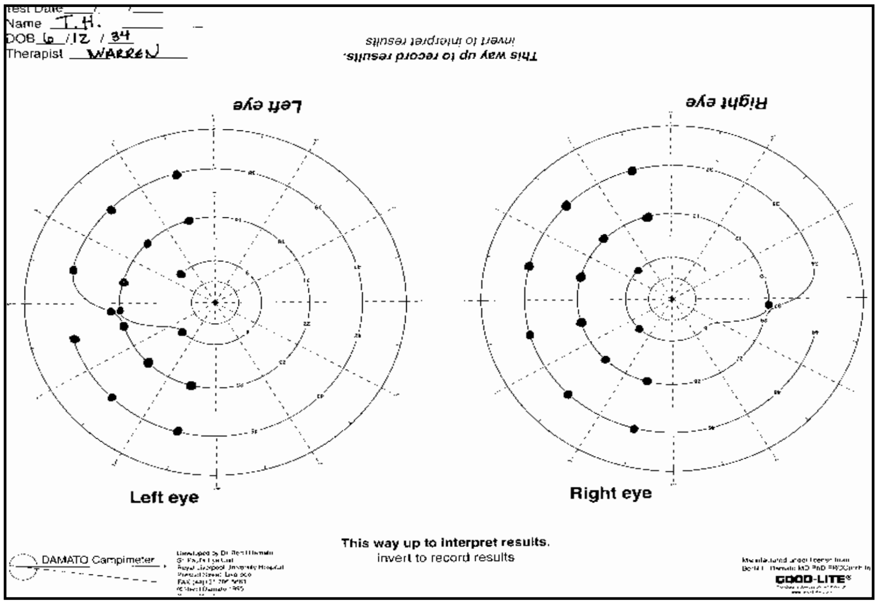


Figure 4.8: This example shows a left homonymous hemianopia in the central visual field. Note: field diagrams are interpreted as the viewer sees them-the left side of the diagram indicates the left side of visual field deficit and so on.

4.3.3 Interpreting the Client's Performance on the Assessments

4.3.3.1 Key Client Complaints/Observations

The client demonstrates or reports several behaviors that suggest navigation and orientation issues stemming from hemianopia or other visual field deficit (VFD). Carefully screen the client for a VFD in the peripheral field in one or both eyes. Consult with the rehab team especially PT and Nursing to determine if they have observed similar behaviors in the client.

The client demonstrates or reports several behaviors that suggest mobility issues stemming from hemianopia or other VFD. Carefully screen the client for a VFD in the peripheral field in one or both eyes. Consult with the rehab team especially PT and Nursing to determine if they have observed similar behaviors in the client.

The client demonstrates or reports several behaviors that suggest reading issues stemming from hemianopia or other VFD. Use the Damato campimeter to carefully screen the client for the presence of a VFD in the central field in one or both eyes. Recheck the client's high contrast visual acuity and reading acuity. Gather more information about the client's reading limitations using the Telephone Number Copy Test (see section 4.5.2), and the Pepper Visual Skills for Reading test (see section 4.5.5.3) if you have this assessment. You should also consult with the Speech Language Pathologist about your findings to discuss vision vs. language deficits.

The client demonstrates or reports behaviors that suggest eye/hand coordination issues stemming from hemianopia or other VFD. Deficits in eye/hand coordination are most likely to occur when the VFD is on the same side as the dominant hand (see sections 2.4.3.2 and 5.8.8).

4.3.3.2 Two Person Kinetic Confrontation Test

The client DOES NOT SEE the penlight in all locations on the LEFT SIDE (9 o'clock, 6 o'clock, 12 o'clock). This suggests the presence of a **left** hemianopia.

The client DOES NOT SEE the penlight in all locations on the RIGHT SIDE (3 o'clock, 6 o'clock, 12 o'clock). This suggests the presence of a **right** hemianopia.

The client DOES NOT SEE the penlight with either eye in the lower area of the visual field (6 o'clock position). This suggests a visual field deficit in the inferior field. When it affects both the left and right halves of the inferior field, it is characterized as an altitudinal defect. A complete loss of visual field in the lower visual field affects the client's ability to accurately monitor changes in the support surface and obstacles in the affected field, increasing falls risk and difficulty safely navigating environments.

The client DOES NOT SEE the penlight with either eye in the upper area of the visual field (12 o'clock position). This suggests a VFD in the superior field. When it affects both the left and right halves of the superior field, it is characterized as an altitudinal defect. A complete visual field deficit in the superior field affects the client's ability to orient to the environment and may cause difficulty navigating environments without getting lost.

The client DOES NOT SEE the penlight in the upper area of the visual field (12 o'clock position) but does see it in lower area of the visual field (6 o'clock position) on the RIGHT SIDE. This suggests a **right** quadrantanopia affecting the **superior** visual field. Quadrantanopia causes less field loss, and it is easier for the client to compensate for it. It may cause functional limitations only in specific conditions-as when a sign or object is located in the **RIGHT** upper field.

The client DOES NOT SEE the penlight in the upper area of the visual field (12 o'clock position) but DOES SEE IT in the lower area of the visual field (6 o'clock position) on the LEFT SIDE. This suggests a **left** quadrantanopia affecting the **superior** visual field. Quadrantanopia causes less field loss, and it is easier for the client to compensate for it. It may cause functional limitations only in specific conditions-as when a sign or object is located in the **LEFT** upper field.

The client DOES NOT SEE the penlight in the lower area of the visual field (6 o'clock position) but DOES SEE IT in the upper area of the visual field (12 o'clock position) on the RIGHT SIDE. This suggests a **right** quadrantanopia affecting the **inferior** visual field. Quadrantanopia causes less field loss, and it is easier for the client to compensate for it. It may cause functional limitations only in specific conditions-as when an object or barrier is located in the **RIGHT** lower field and may increase risk of collisions and falls.

The client DOES NOT SEE the penlight in the lower area of the visual field (6 o'clock position) but DOES SEE IT in the upper area of the visual field (12 o'clock position) on the LEFT SIDE. This suggests a **left** quadrantanopia affecting the **inferior** visual field. Quadrantanopia causes less field loss, and it is easier for the client to compensate for it. It may cause functional limitations only in specific conditions-as when an object or barrier is located in the **LEFT** lower field and may increase risk of collisions and falls.

The client DOES NOT SEE the penlight until it is almost directly in front of the shoulder on the left side. This suggests that the peripheral visual field is impaired on the **left side**, but the client may have **no deficit** in the central visual field (see section 4.2.1.8). Testing with the Damato Campimeter may help confirm that there is no central field deficit. Deficits confined to the peripheral visual field usually do not affect reading and other near vision tasks but can create significant problems in mobility and navigation.

The client DOES NOT SEE the penlight until it is almost directly in front of the shoulder on the right side**.** This suggests that the peripheral visual field is impaired on the **right side**, but the client may have **no deficit** in the central visual field (see section 4.2.1.8). Testing with the Damato Campimeter may help confirm that there is no central field deficit. Deficits confined to the peripheral visual field usually do not affect reading and other near vision tasks but can create significant problems in mobility and navigation.

The client DOES NOT SEE the penlight until it is directly in front of the face on BOTH SIDES. This suggests that the client may have tunnel vision. It is not a common visual field deficit, but it can occur with anoxic brain injuries, tumors, and other neurological and retinal conditions. Depending on the size of the intact central visual field, the client may have minimal problems reading and seeing visual details but significant problems with mobility and navigation.

The client repeatedly breaks fixation and must be continually redirected back to the test. This indicates that the client has poor attention, and the results of the test may not be accurate. The OT may need to rely on clinical observations to determine if a VFD may be present.

4.3.3.3 Damato 30 Point Multifixation Campimeter

Test interpretation is straight forward. The pattern of black dots on the field diagrams indicates the location and size of the visual field deficit (see figure 4.8). The client and family should be shown the field diagram. It is very important that the client and family understand the size and location of the deficit and whether it is in both eyes. To help the client/family visualize the deficit, shade in the field deficit, and draw a nose between the two diagrams on the recording form to provide a clearer picture of the size and boundaries of the deficit. This is also a good time to educate the client and family about visual field deficits. Be sure to cover these points: 1) the damage occurs in the brain on the opposite side of the field deficit, 2) the field loss is in both eyes, 3) it is not a problem with the eye but rather a problem with the brain receiving the image from the eye.

The recording form shows that the dots fill the entire RIGHT half of the visual field on both field diagrams. This suggests a **RIGHT** hemianopia affecting the central area of the visual field. Because the border of the field deficit is right next to fovea (the area used to see small details and color) it is likely the client will experience difficulty reading. If the hemianopia is on the same side as the dominant hand, the client may also have trouble monitoring the hand during writing and other fine motor activities.

The recording form shows that the dots fill the entire LEFT half of the visual field on both field diagrams. This suggests a **LEFT** hemianopia affecting the central area of the visual field. Because the border of the field deficit is right next to fovea (the area used to see small details and color) it is likely the client will experience difficulty reading. If the hemianopia is on the same side as the dominant hand, the client may also have trouble monitoring the hand during writing and other fine motor activities.

The field diagram shows the dots confined to a superior quadrant (quadrantanopia). This type of deficit usually causes fewer occupational limitations. If the deficit extends into the foveal area (inner ring of numbers on the field diagram) the client may experience reading difficulty. The client may also have difficulty locating objects/signage in that area of the upper field which may affect navigation and driving.

The field diagram shows the dots confined to an inferior quadrant (quadrantanopia). The client may be unable to accurately monitor changes in the support surface and obstacles in the affected field, increasing falls risk and difficulty safely navigating environments. The client may also experience difficulty reading if the deficit extends into the macular area.

The field diagram shows a half moon pattern of dots along the outer edge of the diagram on one side (target numbers in the 30s and 40s). If the Two Person Kinetic Confrontation Test suggests a peripheral deficit on this side, the client may have macular sparing, which occurs in about 30% of all hemianopias (see section 4.3.1.8). The client should experience few if any problems with reading and seeing visual details but may have difficulty with mobility and navigations.

The recording form shows black dots filing the superior quadrants on both field diagrams. An altitudinal defect affecting the superior quadrants of both eyes is a frequent corollary of traumatic brain injury.[243] Depending on how close the field deficit comes to the foveal area (inner ring of numbers), the client may experience difficulty seeing overhead signage and objects. This could create challenges with orientation and safe navigation. Driving performance should be very carefully evaluated. Depending on how close the field deficit comes to the foveal field (inner ring of numbers) it could also affect reading and page navigation.

The recording form shows black dots filling the inferior quadrants on both field diagrams. Depending on how close the field deficit comes to the foveal area (inner ring of numbers), the client may experience difficulty seeing objects on the floor and could contribute to falls. A complete loss of visual field in the lower visual field affects the client’s ability to monitor the support surface during ambulation and may cause significant limitations in mobility and significantly elevate the client's falls risk. Driving performance should be very carefully evaluated. Depending on how close the field deficit comes to the foveal field (inner ring of numbers) it could affect reading and page navigation.

The deficit is observed only in one eye. This indicates that the injury is anterior to (e.g., in front of) the optic chiasm and affecting the optic nerve or retina (see section 2.1.2.2 and 2.1.2.3). Common causes of this type of deficit include optic nerve trauma, retinal damage and central retinal artery occlusion (a stroke of the eye). If the entire central visual field has been affected and the Two Person Kinetic Confrontation Test shows vision loss on both sides in the same eye, the client has monocular vision. Persons with monocular vision often experience difficulty with mobility due to reduced peripheral vision and depth perception. If the involved eye is also the dominant eye, the client may experience fatigue and stress when completing reading and other near vision tasks.

The deficit appears in all four quadrants. Some brain injuries can involve the entire central field producing a "Swiss cheese" type field where the client retains "spotty islands" of vision scattered throughout the blind field. This client may have been diagnosed with cortical blindness. The client with this kind of deficit will have significant functional limitations in all daily activities from reading to mobility. Sophisticated testing using an automated perimeter like the Humphrey Visual Field Analyzer, or a microperimeter is needed to diagnose this visual field deficit.

The deficit is on the side of the client's dominant hand. The client may experience reduced eye hand coordination and have difficulty writing legibly, pouring, cutting and other tasks that require monitoring of the hand to complete.

4.4 Visual Attention

Evaluation of visual attention is based on the concept that how efficiently and completely a person attends to and assimilates visual information determines how effectively they can use the information to complete activities. The evaluation assesses two important components of visual attention: visual search and scanning, and internal conceptualization of space. Cancellation tests are used to measure visual search and scanning; design copy is used to measure conceptual representation of space.

4.4.1 Assessment Considerations

4.4.1.1 Assessment Accommodations

As a skill found at the intermediate level of the visual perceptual hierarchy, visual attention is affected by deficits in the foundation visual functions: visual acuity, oculomotor control, and visual fields. It's important to evaluate these functions prior to measuring visual attention and make accommodations to minimize their influence on performance. Aphasia and motor impairment can also affect performance on these tests. A client with aphasia may have difficulty completing the subtests containing letters and words and perform better on those that use shapes. Examples of possible modifications include:

- The biVABA includes two visual search subtests that use symbols as targets (*complex circles search-structured and random)*. The "no" symbol was specifically chosen as the target for these subtests because it is familiar symbol.
- A client experiencing diplopia should wear occlusion to eliminate double images.
- For clients who have difficulty with numbers or physical limitations, the test instructions for *the random plain circles-simple and crowded* can be modified by instructing the client to use a marker to fill in the circles (instead of numbering them) while you observe the client and record their search pattern on a separate form.
- You can also build up the marker to make it easier to grip or use a chisel point marker

4.4.1.2 Why use Cancellation Tasks?

The biVABA visual search subtests are cancellation tests.[244] These tests require the client to locate and "cancel" out a target hidden among distractors arranged in a structured (e.g., in rows) or unstructured array (e.g., randomly scattered on the page). The client is instructed to search the array and locate as many targets as possible. Completion time and accuracy are typically used as performance measures.

Cancellation tests enable you to observe how the client searches for information and determine whether the client's ability to initiate and execute an efficient search pattern is influenced by the structure and complexity of the visual task. Specifically, they help answer these clinical questions:

1. Does the client initiate and use a structured search strategy?
2. Does the client carry out the search pattern in an organized, efficient way?
3. Does the client completely search the visual array to locate all of the targets?
4. Does the client's performance decrease as the complexity or density of the visual array increases?

Adults without brain injury use specific search strategies to ensure an accurate performance on cancellation tests.[17, 259] These include strategies that are linear, organized, symmetrical, thorough, and consistent. Warren, Moore and Vogtle[259] studied the performance of typical adults on the biVABA visual search subtests and found that most participants:

- Used a left to right/top to bottom linear (reading) strategy (see Table 4.4.1 and Figure 4.4).
- Consistently employed the same search strategy to complete a *single* subtest.
- Consistently employed the same search strategy to complete *all* subtests.
- Checked the accuracy of their work especially on the first subtest and on subtests with complex arrays. Older adults checked the accuracy of their work more frequently than younger adults.

Research has also shown variability in search performance among adults without brain injury. Benjamins et al.[17] in a large study of 523 typical adults identified a small cluster of participants who omitted targets on a cancellation test (N=18); another cluster who revisited previously cancelled targets (N=18) and a larger cluster (N=125) who accurately cancelled targets using inefficient search strategies. The Warren et al. study[259] also found variability in the participant's search strategies on the biVABA visual search subtests. A small percentage of participants (1-4 %) used search patterns other than the left-to-right, top-to-bottom strategies and a small percentage (< 10%) switched search strategies during the subtests. There is no difference between men and women on performance, but age does influence performance, with older adults completing cancellation tests more slowly than younger adults.[17] Tables 4.4.1 and 4.4.2 describe the findings from the Warren et al. study (see section 4.4.4.2).

Research conducted as far back as the 1970's has established the efficacy of using cancellation tests to identify neglect. This research showed that persons with neglect use visual search patterns that reflect three characteristics of neglect: 1) inattention to the left side 2) difficulty focusing and sustaining attention and 3) difficulty searching complex arrays that place greater demand on visual attention.[2, 188, 225, 244, 264] Table 4.4.3 (see section 4.4.3.1.3) describes the key observations on cancellation tests associated with these characteristics.

4.4.1.3 Right vs. Left Neglect

Left neglect is more common than right neglect-present in nearly half of persons in the early stages of recovery from a right hemisphere injury (see section 2.5.2.2).[244] Its primary characteristic-spatial bias against the left and towards the right side-is observed as an omission of targets on the left side of the visual search subtests. Right neglect can and does occur but exerts a less obvious influence on visual search.[277] The client may show no signs of inattention to the right side on subtests with structured and less crowded visual arrays (*single letter search-simple, word search, random plain circles-simple, random plain circles-crowded)* but show inattention to the right on subtests that stress attentional capabilities (*random complex circle search*).

4.4.1.4 Distinguishing Between Left Neglect and Left Hemianopia

Left neglect is often confused with left hemianopia because both conditions may cause the client to be unaware of visual information on the left side. But they are distinctly different conditions and do not have the same long-term effect on performance. Therefore, it is important to distinguish between the two conditions by carefully observing the strategy the client uses to locate targets on the visual search subtests.

As a primary sensory loss, hemianopia may prevent the client from accurately seeing the affected field, but it does not impair the client's attentional capability. Perceptual completion (see section 2.4.3.1) may limit the client's search towards the blind field resulting in an abbreviated search pattern and omissions on the visual search subtests. But when cued to search for targets on the blind side, the client will use attention to direct eye/head movement towards that side. The client will also employ attention to initiate and carry out an organized search pattern and to rescan an area to check for accuracy.

In contrast, clients with neglect lose the attentional mechanisms that drive the search for visual information. The client may make no attempt to search for information on the left side and display little eye movement or head turning toward the left side. When searching for targets, the client will often use a disorganized, random, and asymmetrical pattern that is initiated on and confined to the right side.[36, 244] The client often searches quickly and does not check for accuracy. When left hemianopia is combined with left hemi-inattention, the client experiences the most severe form of neglect (see section 2.5.2.2). The client's hemianopia causes him to miss visual information on the left side and his hemi-inattention prevents him from using attention to compensate for the hemianopia and search the left side. The hemianopia exaggerates the client's inattentive behavior on the assessments and increases errors on the visual search subtests. When the conditions occur together it is important to determine the severity of the inattention as this will determine whether the client is able to learn the strategies needed to compensate for the hemianopia.

4.4.1.5 Nonlateralized Inattention

Persons with right hemisphere injuries may also experience non-lateralized inattention (see section 2.5.2.2). This disrupts the client's ability to initiate and sustain attention.[2, 185, 245] Table 4.4.4 describes the key observations of non-lateralized inattention on the visual search subtests.

4.4.1.6 Importance of Providing Cues and Do-Overs

The purpose of evaluation is to determine the client's strengths and weaknesses in using vision to participate in daily occupations. When assessing attention, the purpose is to determine whether and how well the client is able to use attention to search for visual information. *Cuing* provides an opportunity to observe the client's ability to use attention to improve search performance. If cuing improves the client's performance, add it to your intervention toolkit and share it with the rehab team. If cuing does not improve performance, remove it from your toolkit and focus on modifying environment and task to enable the client to use their limited attention to complete occupations. Visual, physical, and verbal cuing is allowed and encouraged when assessing the client. Use it sparingly and provide it only when it is apparent that the client cannot correct performance without assistance. *Do-overs* provide an opportunity to observe whether the client can use feedback to improve performance. A client who uses feedback to improve performance demonstrates the ability to use attention/cognition to compensate for vision impairment suggesting good rehabilitation potential. A client who is unable to use feedback to improve performance will require more task modification and structure to compensate for their attention deficit. This valuable information helps you set an appropriate rehabilitation goal.

4.4.1.7 Why are the Subtest Forms so Wide?

The wider format of legal-size paper improves the sensitivity of the test to detect deficiencies in visual search due to neglect and hemianopia. The inconvenience of purchasing legal size paper for the copier and filing the larger form is offset by a better opportunity to observe the client's strengths and weaknesses.

4.4.1.8 Why are There so Many Subtests?

The 7 subtests have specific characteristics that allow you to observe a different aspect of the client's ability to direct visual search and attention. As a group, they feature simple to complex visual arrays with structured and unstructured formats.

- Subtests with *Structured Visual Arrays* (single letter search simple and crowded, word search, structured complex circle search) require the client to search through targets arranged in an organized, linear format. The structure of the array cues the client to use a "reading pattern" to search for targets-moving row by row or column by column. The structure also assists the client to maintain their place as they search each row.
- *Subtests with Unstructured visual arrays* (random plain circles-simple and crowded, random complex circles search) require the client to search for targets arranged in a random format. The client must use attention to impose a structure on their search pattern as they complete the subtest.
- The *random plain circles-simple and crowded* subtests were designed to provide tangible documentation of the client's search pattern. By numbering the circles, it is possible to see the pattern the client uses to shift attention from target to target. These are also the only subtests where the client is told the exact the number of targets to

locate. The combination of knowing the number of targets and sequentially numbering them may help client accurately complete these subtests. Administering these subtests can help you determine if providing an explicit outcome will strengthen the inattentive client's ability to sustain attention.

4.4.1.9 Do I Need to Administer the Visual Search Subtests in a SPECIFIC Order?

The short answer is NO-there is no requirement to administer all of the subtests or to use any specific order. The advantage to giving every subtest is that it increases the sensitivity of the test and provides the best indication of the client's ability to modify visual attention to meet the demands of increasingly difficult tasks.[11] When given in the order on the assessment form the subtests place increasing demands on the ability to direct and sustain attention to help determine whether there is a ceiling/limit to the client's ability to employ visual attention. The disadvantage is that it can take 15-30 minutes for a client to complete all 7 subtests depending on their limitations.

Use your limited time wisely and select the subtest *that helps to answer your clinical question.* Select the order and number of subtests based on what you want to learn about the client's attentional capability. When time is limited, select 1-2 subtests that will help confirm or expand your initial impression of the client's attentional capabilities based on your clinical observations. The following examples describe different clinical scenarios for selecting subtests.

- *Example 1*: Your new client is 9 months into recovery. He wants to resume driving and asks to be referred for a driving evaluation. The medical notes indicate that he had left neglect in the early stages of his recovery. You want to know whether he is still inattentive to the left side. Selecting the *random complex circles search* subtest will place the most demand on the client's attentional capabilities. If he performs well on this search subtest (e.g., attending to both sides of the form and using a structured pattern to accurately search for targets) you can move onto other assessments that evaluate his ability to attend and quickly respond in dynamic environments to help decide if he is ready for a driving assessment. If he performs poorly on the subtest (e.g., uses a random pattern to search for targets only on the right side of the form) it suggests that he is not yet ready to resume driving. To get a clearer understanding of his current abilities and you may want to observe how he performs on less demanding subtests that use a structured format (*structured complex circles search*) or more obvious targets *(single letter search-simple or crowded*). Findings from these subtests will help select an intervention to strengthen those skills.

- *Example 2*: Your new client is in acute care-1-2 days into recovery: The newly hospitalized client is sleep deprived, adjusting to medications, and traumatized by the circumstances that caused the brain injury. All of these factors will strongly influence the client's ability to attend. Instead of a using search subtest at this early stage of her recovery, it is best to assess her attention by observing her complete selfcare activities using an evidence-based instrument like the *Catherine Bergego Scale* (see section 4.5.5.2 and Appendix D). If you want to use a visual search subtest to screen for inattention*, the random plain circles-simple* is a good option because the directions are simple, and the test is short. This subtest will also produce a visual depiction of the client's ability to search both sides of a visual array at this stage of her recovery and provide a useful baseline for progress.

- *Example 3*: Your client is in the early stages of recovery from a right hemisphere stroke and just starting intensive inpatient rehabilitation. Clients with a brain injury to the right hemisphere often experience neglect (see section 2.5.2.2) during the first weeks of recovery.[244] The initially observed neglect will resolve within the first year of recovery for most of these clients and only about a third with early signs of neglect will continue to experience long term (e.g., chronic) neglect.[120, 161] It's important to understand the client's strengths and weaknesses in visual search to select the most appropriate intervention and it's also important to establish a performance baseline to gauge recovery. In this scenario, administering all of the biVABA visual search subtests and the design copy test would provide the most comprehensive picture of the client's current strengths and limitations to provide a baseline for recovery. Evaluate the client in a quiet environment and consider reducing the effect of fatigue by giving one subtest a day.

- *Example 4*: Your client is beginning outpatient rehabilitation. Most neglect resolves within the first few months of recovery.[120] One way to track this recovery is to administer the visual search subtests to obtain a baseline performance and then periodically re-administer them to check improvement. You do not need to administer all 7 subtests: instead choose one with a structured array *(single letter search-simple and crowded or word search*) and one with an unstructured array (*random complex circles search*).

4.4.1.10 Why include a Design Copy Test?

Design copy also has a long research history-dating back to the 1940s. Observing the client copy a line drawing of a familiar object like a clock, house, or flower provides information about the ability to conceptualize space on the left side.[43, 244] Clients with left neglect from right hemisphere lesions may omit details on the left side of their drawings and elaborate, elongate and/or skew the drawing towards the right side, suggesting difficulty accessing a mental representation of the left side of the image.[38, 244, 115, 155, 189, 193]

4.4.2 Test Instructions

General Instructions to the Client:

> *"I am going to give you some tests to find out if you can look for information and objects in an organized way. Brain injury can cause your ability to search to become disorganized. This can make it difficult for you find the items and information you need to complete your daily activities. These tests look at how you use your vision to search and will help me figure out how to improve your ability to find the items you need."*

4.4.2.1 Visual Search Subtests

Test Items:

Visual Attention Assessment Form

Plastic templates of the subtests to make paper copies and score the subtests

- Single Letter Search-Simple
- Single Letter Search-Crowded
- Word Search
- Structured Complex Circles Search
- Random Plain Circles-Simple
- Random Plain Circles-Crowded
- Random Complex Circles Search
- No symbol target card (flip side of clock design card) for complex circles search subtests

Red fine tip marker

Timer

Environment: well-lighted room with the light source directed from behind the client onto the tabletop to evenly illuminate the subtest; ensure that the light source does not shine directly into the client's eyes. This test requires the client's full concentration; ensure that the room is free from visual, auditory, and physical distractions.

Procedure:

1. Seat the client comfortably at a well illuminated writing surface. The client should be wearing eyeglasses if needed for reading.
2. Use the subtest templates to make paper test forms for the client.
3. Place the paper subtest form at the client's midline.
4. Hand the client the red marker.
5. Instruct the client to cross out the designated target(s) and put the marker on the table when finished.
6. On the complex circle subtest-position the "no" symbol card directly above the paper where the client can clearly see it.
7. The client may reposition the subtest. Note these changes on the recording form.
8. Begin timing when the client initiates the search pattern.
9. Observe client's search strategy to locate targets and record it on the form.
10. Provide verbal, physical, or visual cues if the client is struggling to locate targets (see section 4.4.1.6)

    Examples of Verbal Cues:

    - "*Remember the sheet is very wide*"
    - *"There are more [circles/letters/words] on your [left/right] side"*
    - *"There are [insert number] [circles/letters/words] on the sheet"*
    - *"There are [insert number] circles left to find (on the left or right side)"*
    - *"There are [insert number] letters/words left to find [on the left or right side]"*

Examples of Physical Cues:

- Gently turn the client's head towards the left or right side of the subtest.
- Place the client's hand on the left or right border of the subtest to draw attention to it.
- Point to the left or right border of the subtest.

Other Cues:

- Draw a bright red anchoring line on the left or right side of the subtest, remind the client to look for the red line (this cue often works well for the client with hemianopia but not the client with neglect).
- Provide an auditory cue on the neglecting side such as a chiming ring sound on your phone.

11. Stop timing when the client places the marker on the table.
12. Record the number of correct responses on the assessment form. The flip side of the plastic templates show the location of the targets to enable you to count the number of correct responses quickly and accurately.
    - Canceling the wrong target (e.g. an E instead of an F) is counted as an error.
    - Cancelling the wrong target **but immediately** correcting the mistake without cuing is **not** recorded as an error.
    - On the open circle tests-returning to a circle and numbering it again (e.g., double numbering) is a key observation and should be noted (Table 4.4.4, section 4.4.3.1.3); mis-numbering circles by going out of sequence (e.g., 1,2,4,5,) should also be noted.
13. Use the table in Appendix F to quickly calculate the percentage of correct responses.

Instructions to the Client:

Single Letter Search-Simple and Crowded

"There are seven rows of letters on this page. Read through the letters and cross out the ***P*** *and the* ***F*** *every time you see them (point to the examples of the letters at the top of the form). Remember to cross out only the P and the F. When you are finished, place your marker on the table."*

Word Search

"There are seven rows of letters on this page. Included among the letters are the words ***the*** *and* ***at*** *[point to the 2 words at the top of the form]. Search for these two words and underline them when you see them. Remember: only underline* ***the*** *and* ***at****. When you have found all of the words, place your marker on the table."*

Random Plain Circles-Simple and Crowded

"There are ***20 (or 40)*** *circles scattered across this page. Number the circles in order as you see them. Place the number inside of the circle. When you have numbered all of the circles, place your marker on the table."*

Structured Complex Circles Search

"There are 6 rows of circle shapes on this page. Search through the circles and cross out the one that looks like this [point to "no" sign circle on the card and the

top of the form]. Remember-cross out only the circle that looks like this. When you are finished, place your marker on the table."

Random Complex Circles Search

"There are many circle shapes scattered across on this page. Search through them and cross out all of the circles that look like this [indicate the card with the "no" symbol]. Remember-cross out only the circles that look like this. When you are finished, place your marker on the table."

4.4.2.2 Design Copy

Test Items:

Visual Attention Assessment form
3 design cards (house, flower, clock)
3 sheets of 8.5" x 11" paper
1 pencil

Environment: well-lighted room with the light source directed from behind the client onto the table to evenly illuminate the card and paper; ensure that the light source does not shine directly into the client's eyes. This test requires the client's full concentration; ensure that the room is free from visual, auditory and physical distractions.

Procedure:

1. Select a design card (house, flower, clock)
2. Provide 1 sheet of paper per design.
3. Place the sheet of paper and the design card at the client's midline.
4. Position the paper directly in front of the client; position the design card directly above the paper.
5. Instruct the client to copy the design as accurately as possible.
6. The client may reposition the paper or design card during the test. Note these changes on the recording form.
7. Provide verbal or physical cues if the client leaves off detail in the drawing
   Examples of Verbal Cues:
   - "Look carefully at [the figure] to make sure you have seen everything."
   - "Does your drawing look complete?"

   Example of Physical Cue:
   - Place client's hand on left or right side of the page to draw attention to that side.
8. Review the accuracy of the client's performance and record on the assessment form.

Instructions to the Client:

"Copy this drawing of a [house, flower, clock] as accurately as you can. Draw only what you see-do not add extra details. How well you draw is NOT important. But it is important to include all of the details in the drawing. Take as long as you need. Put your pencil on the table when you are finished."

4.4.3 Interpreting the Client's Performance on the Assessments

4.4.3.1 Visual Search Subtests

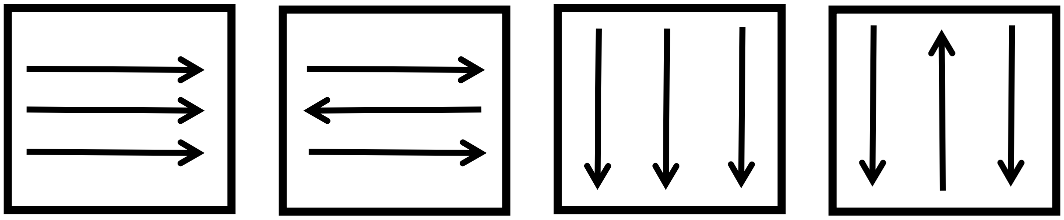
4.4.3.1.1 Interpreting Accuracy and Completion Time

Many factors affect the ability to focus and sustain visual attention. Poor visual acuity, difficulty focusing, blurred vision and hemianopia affect accuracy identifying targets as can aphasia, medications, a noisy environment, and a good night's rest. It is not possible to state unequivocally that reduced accuracy on a visual search task is due only to visual inattention unless all other cognitive, physical, environmental, and visual functions are accounted for and controlled during the assessment. This is the primary challenge when only scores for completion time and accuracy are used to determine that the client has visual inattention. The scores may provide a glimpse into the effect of ineffective search on performance, but they do not provide information on how or why the client performed so poorly.

Providing effective intervention depends on identifying the client's strengths and weaknesses in visual attention so that strengths can be used to compensate for weaknesses. The biVABA is not a diagnostic assessment (see sections 1.6, 1.7), it is a tool to assist the OT to select the best intervention to obtain an optimal client outcome. Research has shown that adults with normal visual attention use varied strategies to complete visual search tasks,[17] but all *effective search strategies* have certain characteristics that deliver an accurate performance.[259] Research also shows that adults with neglect use ineffective search strategies that cause errors in visual search (see section 4.4.1.4). The biVABA visual attention subtests focus on the relationship between the search strategy the client used to complete the subtest and the accuracy of the client's performance measured as the percentage of correct responses on the subtest. Generally, effective search strategies result in good accuracy and ineffective search strategies result in poor accuracy. When this correlation is not observed, other factors may be influencing the client's performance.

4.4.3.1.2 Effective Search Strategies

It is necessary to understand the characteristics of successful search strategies in order to identify ineffective strategies. Adults without brain injury when tasked to search for targets on a cancellation test employ organized, efficient search strategies that enable them to quickly locate and identify targets. The Warren et al.[259] research on the biVABA visual search subtests identified the search strategies that enabled typical adults to complete the subtests efficiently and accurately (see section 4.4.1.2.). Most study participants used one of the search strategies shown in Figure 4.4.1. Table 4.4.1 describes the frequency that each pattern was used, and Table 4.4.2 shows the typical performance times on each subtest.



Horizontal Left to Right **Horizontal Back/Forth** **Vertical Left to Right** **Vertical Back/Forth**

Figure 4.4.1: Typical search strategies on the biVABA visual search subtests.

Table 4.4.1: Frequency Study Participants Used a Specific Visual Search Strategy and Checked Their Work on the Visual Search Subtests.

Search Pattern	Single Letter Search Simple	Single Letter Search Crowded	Word Search	Structured Complex Circles Search	Random Open Circles Simple	Random Open Circles Crowded	Random Complex Circles Search
Horizontal L to R	65%	67%	86%	68%	62%	57%	43%
Horizontal Back/Forth	20%	22%	6%	21%	10%	11%	23%
Vertical L to R	5%	0%	0%	1%	11%	10%	1%
Vertical Back/Forth	1%	1%	3%	3%	9%	10%	11%
Vertical L to R	0%	0%	0%	1%	0%	0%	1%
Diagonal	0%	0%	0%	0%	1%	1%	0%
Circular	0%	0%	0%	1%	1%	3%	0%
Switched Strategy	7%	9%	3%	4%	4%	6%	18%
Other Strategy	0	1.2%	3%	1%	3%	3%	4%
Checks Work	40%	36%	26%	15%	1%	3%	32%

* The subtests were administered during a single session in the order shown in the columns. This may have contributed to the progressively lower percentage of participants checking their work until the last and most difficult subtest (Random Complex Circles Search).
** N = 81; Age Range: 26-86 years; 34 males, 47 females; 90% white; 30% over age 60 years

Table 4.4.2: Performance Times (in seconds) of Typical Adults on the Visual Search Subtests

Subtest	Median Time	Fastest Time	Slowest Time
Single letter search simple	63	32	141
Single letter search crowded	79	42	215
Word search	79	38	166
Structured complex circles	43	24	120
Random open circles simple	22	13	43
Random open circles complex	48	30	99
Random complex circles	60	24	196

4.4.3.1.3 Ineffective Search Strategies

Clients with neglect often employ ineffective search strategies that reduce accuracy on cancellation tests like the visual search subtests (See section 4.4.1.4). Clients who use an ineffective search strategy may not acquire sufficient visual information or acquire it in such a way that it can be used to accurately complete visual processing. Tables 4.4.3 and 4.4.4 describe ineffective search strategies observed in clients with neglect.[2, 36, 188, 225, 244, 264]

Table 4.4.3: Key Observations on Cancellation Tests that Suggest Neglect

Neglect Characteristic	Key Observation
Spatial bias-inattention to left side	Omits targets on the left side of the array
	Initiates search on the right side of the array
	Confines search to right side of the array
	Repeatedly searches the right side of the array (revisiting) instead of searching left side
	Does not respond to cues to search left side
Difficulty focusing/sustaining attention	Cancels similar but incorrect targets
	Stops before completing the test
	Searches quickly, misses details
	Searches slowly, skips over targets
Difficulty searching complex arrays	Initiates random search pattern
	Pattern becomes random as client searches
	Stops quickly-may show signs of fatigue
	Ability to locate targets decreases as pattern density increases within the array

Table 4.4.4: Key Observations on Cancellation Tests that Suggest Non-Lateralized Inattention

Neglect Characteristic	Key Observation
Difficulty generating attention	Slow to initiate search-requires nudging to start; may require therapist to physically place hand on the subtest
	Closes eyes during test, falls asleep
Difficulty focusing/ directing attention	Field dependent: indiscriminately engages with items in front of them or extraneous activities occurring around them
	Revisiting: repeatedly re-examines right side of array or target
	Perseveration: Repeatedly crosses out the same targets (usually on right side)-unable to progress through the array
	Uses a random search strategy
Difficulty shifting attention	Stays on a single target for several seconds after cancelling it
	Slow to shift attention to find a new target
Difficulty sustaining attention	Frequently, easily gets off task and requires redirection
	Quickly stops searching and puts marker down to end test before searching all rows to locate targets

4.4.3.1.4 Key Observations

The client demonstrates an abbreviated search pattern with omissions on one side.
Hemianopia and neglect both frequently cause an abbreviated search pattern. The *client with hemianopia* abbreviates the pattern because they do not see of border of the visual array on the "blind" side and is unaware that they have not scanned far enough to find all of the targets on that side. The client with neglect abbreviates the search pattern because they lack the attentional capability to search the neglected side. The key difference between the two conditions lies in the ability to use attention to direct performance. The client with hemianopia will use attention to initiate organized and predictable search strategies to locate targets. On structured arrays (the structured *letter, word, symbol search subtests*), the client will likely use a left to right pattern. On unstructured arrays (the *random open and complex circle search subtests*), the client may use a right-to-left pattern if the hemianopia is on the left side. Usually, when cued that there are unmarked targets on the blind side, the hemianopic client will turn the head and reexamine that side to locate the remaining targets. In contrast *the client with neglect* lacks the attentional capability to devise an efficient search strategy. The result is a random, unpredictable, and inefficient search pattern that fails to locate targets on the affected side. The attention deficit also prevents the client from using cues to improve performance. Using an abbreviated search pattern to one side causes the client to miss visual information needed for reading, safe navigation and mobility, and ADLs that require attention to both sides of the body such as dressing. Table 4.4.5 summarizes the key performance observations that distinguish left hemianopia from left neglect on the visual search subtests.

Table 4.4.5: Key Observations: Left Hemianopia vs. Left Neglect on the Visual Search Subtests

Left Hemianopia	Left Neglect
Search pattern is symmetrical; Initiates left to right pattern but may begin in middle of the array	Search pattern is asymmetrical; initiated and confined to the right side of the array
Attempts to search towards left side of the array	No attempt to search towards left side of array
Search pattern is organized, structured	Search pattern is random, inefficient
Client rescans to check accuracy	Client does not rescan to check accuracy
Client effort and search time corresponds to the search demands of the array	Client completes task quickly; effort does not correspond to the search demands of the array
Responds to cues and improves search performance	Does not respond to cues or improve search performance
Client may use fingers on non-dominant hand to help guide search across the row	No attempt to use a strategy to help guide search across the row

The client uses an asymmetrical search pattern. This behavior strongly suggests neglect especially when observed on tasks with structured visual arrays such as the *single letter and word search* subtests.[11, 126] Instead of initiating search on the left side of the array and moving towards the right, the client demonstrates asymmetry-initiating search from the right side and confining search to the right side; does not typically cross midline. Use of the pattern significantly reduces the amount of visual information the client acquires during search. It may disrupt reading and navigation and disrupt the client's ability to locate items needed to complete ADLs.

The client uses a random search pattern. Observation of a random, unpredictable search pattern strongly suggests the presence of neglect.[36, 225, 264] Clients who use random search patterns are generally unable to gather cohesive information during visual search. It would be as though one tried to comprehend a novel by reading one sentence on page 34, another on page 67, and another on page 23. When the random search pattern occurs in conjunction with an abbreviated search pattern and/or an asymmetrical search pattern it strongly indicates that the client has neglect.[244] The severe disruption in information processing usually causes difficulty locating and analyzing visual information, and significant ADL limitations.

The client quickly completes the subtests making multiple errors. This performance suggests that the client has reduced ability to focus and sustain attention which is associated with non-lateralized inattention due to neglect (See Table 4.4.4).[185, 245] The client may have difficulty staying on task to complete ADLs.

The client slowly completes the subtest making multiple errors. Clients with significant visual impairment (poor acuity, visual field deficit, oculomotor impairment) or language deficits may require several minutes to complete each subtest and also make numerous errors. However, because they can maintain their concentration on a difficult task over an extended time, their low accuracy may be due to limitations other than inattention. Improvement in these other functions should improve the client's performance on the visual search subtests.

The client accurately completes the structured search subtests but makes numerous mistakes on the unstructured search subtests. This suggests that the client has limited attentional capability that breaks down as the demands on visual search increase. It is important to observe and compare the client's performance in a cluttered environment (e.g., a grocery store) to a less cluttered environment (e.g., a bedroom); and on tasks with relatively simple, uncluttered arrays (grooming) versus tasks with more cluttered, complex visual arrays (meal preparation). Simplifying and structuring tasks may facilitate independent performance.

The client accurately cancels targets on subtests that contain fewer targets and distractors, but accuracy decreases on subtests with more targets and distractors. Clients with neglect locate fewer targets when searching dense arrays containing many targets (*e.g., single letter search crowded*) and on arrays with many distractors (e.g., targets that are similar to the designated target) such as complex circle search.[226]

The client crosses out letters/shapes similar to the target. This could suggest that the client is unable to retain the target's salient features in short term memory to accurately distinguish between targets. When combined with a quick performance, it may suggest the client is unable to sustain fixation long enough to identify all of the salient features of the target. Both of these behaviors suggest neglect. However, if the client has a deficit in acuity, oculomotor or visual field it may simply be that client does not see the targets accurately. In either case, the client may have difficulty with activities with dense visual detail such as reading a bill or locating an item on a shelf in a grocery store.

The client skips lines on the structured search tests. Clients with left hemianopia can have difficulty accurately locating the next line of print due to difficulty/inability to execute an accurate long leftward saccade towards the blind field. This may cause the client to inadvertently skip lines of print. A client may also skip lines due to inattention. A client with either condition may have difficulty reading accurately.

The client skips over and does not cross out targets. When the targets are omitted only on one side, it suggests the presence of a hemianopia or hemi-inattention or a combination of the two conditions (e.g., neglect). If the client randomly skips over targets throughout the subtest and has difficulty executing an organized search pattern, it suggests impaired non-lateralized inattention. Clients with a complete hemianopia that extends into the fovea may also randomly omit targets throughout a subtest but their search pattern is generally organized.

The client initiates a structured and organized search pattern at the start of the subtest but the pattern becomes disorganized and random as the test progresses. Clients with limited attention may show increasing difficulty engaging and maintaining attention. This may be due to reduced ability to sustain attention or fatigue from the effort of attending. The client may benefit from breaking tasks into shorter segments.

The client's overall performance declines as several subtests are administered. Clients with limited attention may show increasing difficulty engaging and maintaining attention as the length of the testing session increases. This may be due to reduced ability to sustain attention or fatigue from the effort of attending. The client may benefit from breaking tasks into shorter segments.

The client double numbers the circle targets on the simple and crowded plain circle subtests or perseverates on cancelling the same target(s) on the search subtests. These behaviors suggest that the client has difficulty using working visual memory to direct visual search and sequencing.[155] Perseveration is commonly observed in persons with neglect.[38]

The client's performance improves in response to cuing. This is an important observation because it shows that the client can modify attention to improve performance. Most persons with hemianopia possess this capability but persons with neglect lack it. Determine the type of cues that work best for the client and incorporate them into interventions.

The client does not respond to cues to improve performance. This is an important observation because it shows that the client is unable to use attention to improve performance. Most persons with hemianopia possess this capability but persons with neglect lack it.

The client combines visual search strategies or switches strategies when completing a subtest(s). Research shows that a small percentage of typical adults combine or switch strategies especially if they feel that their initial strategy is too slow or inaccurate.[17, 259] If the client shows no other changes in visual search or attention and completes the subtest with acceptable accuracy you can chalk this up to personal choice.

The client uses a vertical search strategy on the letter and word search tasks. While most persons will, out of learning and habit, initiate a left to right horizontal search pattern on visual arrays that use letters, numbers or words, some typical adults may use a vertical strategy.[259] As long as the client completes the subtest with acceptable accuracy, use of a vertical strategy is considered an effective strategy.

The client initially misses a target but locates it when checking their work. Rechecking work to locate missed targets on a cancellation test is observed in typical adults.[259] It occurs more often on subtests that demand greater attention-those with crowded or random arrays (*single letter search-crowded, word search, structured complex circles search, random complex circles search*). Older adults more frequently recheck their work than younger adults.[259]

The client is unable to cross out the target accurately and places the mark to one side of the target. This does not suggest reduced visual attention but may indicate reduced eye-hand coordination due to poor acuity, hemianopia, diplopia, or other oculomotor impairment.

The client slowly but accurately completes the subtest using a structured search strategy. This may indicate a general slowness in processing speed, a language deficit such as aphasia, a visual field deficit, or reduced acuity. The observation that the client used effective search strategies and was able to sustain attention to complete the subtest shows a strength in visual attention. ***The client uses the fingers of the non-dominant hand to maintain their place and guide their search across the line as they cancel targets***. Use of this strategy suggests that the client has a hemianopia that is affecting the fovea. Persons with hemianopia must alter their search strategy to compensate for the vision loss. Unless the client also has neglect, you should observe a left-to-right reading search strategy on subtests with structured visual arrays (*letter searches, words search, complex circle search*). Using this strategy improves accuracy BUT it also increases search time which can cause fatigue.

4.4.3.2 Key Observations on the Design Copy Test

Clients with right hemisphere brain injury may experience representational neglect-a condition where the left half of space (and often body) is not represented on the spatial maps that guide visual search disrupting the person's concept of space.[255] Design copy taps into the clients' ability to conceptualize space and plan actions. Research has identified two distinct drawing characteristics that are strongly associated with left neglect: 1) omitting details on the left side of the drawing and 2) expansion and/or elaboration of details on the left or right side of the drawing due to perseveration.[43, 190, 193] There is no consensus yet on the underlying cause of these behaviors, but omissions are attributed to difficulty exploring left space and perseveration is attributed to inability to plan and monitor performance.[193]

The client draws half of the house, flower or clock. (Figure 4.4.2. example F). This strongly suggests neglect [244] especially when the client shows the same left sided omission of targets on the visual search subtests, has difficulty attending to items on left side, and difficulty incorporating the left extremities into ADLS and maneuvering a wheelchair. The Catherine Bergego Scale (see section 4.5.5.2 and Appendix D) is a good follow up assessment to use.

When copying the clock, the client draws a circle but numbers only half of the clock. (Figure 4.4.2 examples B and G). The client may be able to draw a complete circle because the circle is a well-established perceptual construct but is unable to number the clock on the left side because of an inability to move into that space due to neglect.[43] It is unlikely that a client with only a left hemianopia will make this mistake because they can access an internal representation of this object. But the client with neglect may not be able to access a completed representation of the clock.

The client omits details on the left side of the drawing. Omission of details on the left side is a strong indicator of neglect. Omitting 1-2 petals on the flower or a single leaf (Figure 4.4.2, example A) suggests mild neglect. Leaving off the entire left half of the house (example F) or all of the numbers on the left side of the clock (example B) suggests neglect.

The client elongates details on the right side of the drawing or skews the drawing towards the right side. Elongation of details on the right side (the pedal in Figure 4.4.2, example C) suggests graphic perseveration-a behavior associated with neglect.[43, 188]

The client initially draws an incomplete or half drawing, then attempts to correct the drawing after viewing it. (Figure 4.4.2 example E). Recognizing that the drawing is incomplete suggests that client has at least some ability to conceptualize left space.[115] A client with mild neglect or a left hemianopia would have the attentional capability to attempt to correct the drawing. The addition of the second window on the left side of example E may suggest perseveration.

T*he client drawing is simplistic-symmetrically lacking details.* Simple drawings that omit details on both sides of a figure (Figure 4.4.2 example D) are associated with left hemisphere injuries and aphasia and may partially reflect a challenge in planning movement.[41]

***The client elaborates the drawing adding extra detail**s.* This may occur on either the left or right side of the drawing when, for example, the client adds a or sun or curtains to the drawing of a house. Research has suggested that it is a perseverative behavior associated with neglect and most often observed in right hemisphere injuries.[188, 189]

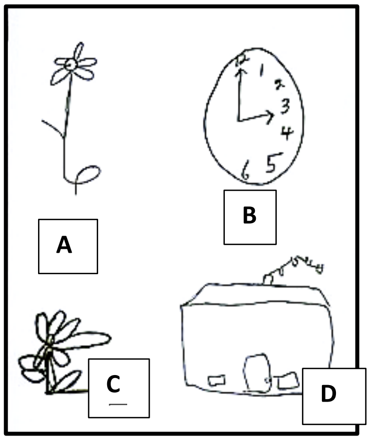
The client leaves out tiny details such as a loop on the smoke or the dot in the center of the hands on the clock. These are not considered errors if the primary details (e.g., the smoke, the house, and the hands on the clock) are present and accurately depicted.

The client unsuccessfully attempts to correct drawing. Figure 4.4.2 examples E and G. The client's attempt to correct the drawing suggests some ability to conceptualize space but their lack of success also suggests difficulty conceptualizing space.

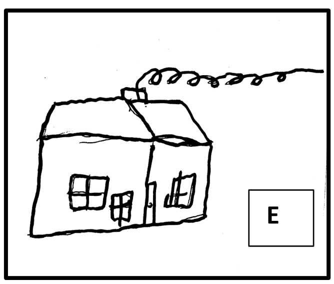
The client's performance improves in response to cuing. This is an important observation because it shows that the client can modify attention to improve performance. Persons with only primary sensory loss (hemianopia) possess this capability but persons with neglect lack it.

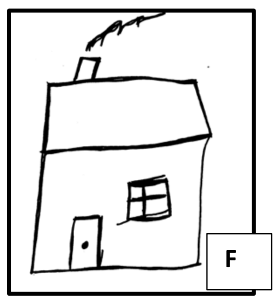
The client does not respond to cues to improve performance. This is an important observation because it shows that the client is unable to use attention to improve performance. Most persons with hemianopia possess this capability but persons with neglect lack it.

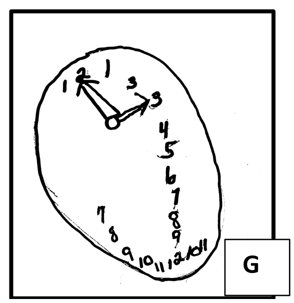
Figure 4.4.2 Examples of Client Design Copy Performance



A: Omits details on left side.
B. Half numbering-omits details on left side.
C. Elongation of details towards the right side.
D. Simplistic; symmetrically omits details in the drawing.
E. Client drew half of house (right side) then added the second half (left side) with elaboration.
F. Half drawing.
G. Client began numbering clock on the right side and was unable to move leftward; tried again to number the left side beginning with number 7 but moved rightward to avoid moving into left space.







4.5 Additional Attention/Vision Assessments

These 7 short assessments help you gain more insight into the client's ability to attend and use vision to complete activities. Three assessments were developed specifically for the biVABA: *Telephone Number Copy Test, ScanBoard, and ScanCourse*. The other four assessments can be readily accessed for free or purchased.

4.5.1 Assessment Considerations for biVABA Assessments

4.5.1.1 Which biVABA Assessments are Appropriate for Clients with Suspected Neglect?

All three assessments provide additional insight into a client's ability to attend. The ScanBoard, because of its simple design, will not detect subtle changes in attention. It is best used to assess a client in the very early stages of recovery in conjunction with the Catherine Bergego Scale (see section 4.5.5.2 and Appendix D). The ScanCourse requires that the client be able to walk or independently move their wheelchair through the course. It is the only biVABA assessment that looks at the client's ability to combine visual attention with movement and can provide good insight into the client's ability to use visual attention for navigation. The Telephone Number Copy Test (see section 4.5.2) provides information about the client's ability to selectively attend to detail and sustain attention. It is also the only assessment that evaluates the client's ability to accurately read numbers-an important component of I-ADLs like financial management, medication management and meal preparation. When combined with the Pepper Visual Skills for Reading Test (see section 4.5.5.3), it provides a comprehensive assessment of a client's ability to use vision for reading. The test is not appropriate for a client with alexia, agraphia or other forms of aphasia that affect reading, or a client with uncorrected visual acuity and/or oculomotor impairment.

4.5.1.2 Which biVABA Assessments are Appropriate for Clients with Suspected Hemianopia?

All three assessments can provide additional insight into how hemianopia may disrupt the client's search pattern. The Telephone Number Copy Test adds insight into the client's accuracy identifying numbers-a common challenge for clients with left or right hemianopia (2.4.3.2). The ScanCourse (see section 4.5.4). provides useful information on whether the client turns the head far enough into the blind field to locate needed information during ambulation-necessary for orientation and safe navigation through environments Observing certain patterns on the ScanBoard (4.5.4.2) can help confirm the presence of hemianopia in the early stages of recovery.

4.5.1.3 Why do the Telephone Number Copy Test and ScanCourse Provide Do-Overs?

These assessments provide the opportunity to observe the client's ability to complete tasks that place greater demands on attention. The Telephone Number Copy Test requires the ability to sustain attention to complete a detailed task that requires sequencing; the ScanCourse is a dual attention task that requires the ability to shift attention from side to side while walking. Providing a ***do-over*** on these more difficult tasks enables you to observe whether the client can use feedback to improve performance. A client who benefits from feedback demonstrates the ability to use attention/cognition to compensate for vision impairment and thus good rehabilitation potential. A client who is unable to use feedback to improve performance will require more task modification and structure to compensate for their attention deficit. This valuable information helps you set an appropriate rehabilitation goal.

4.5.2 Telephone Number Copy Test Instructions

Test Items:

- Visual Attention Assessment form
- Paper copy of the Telephone Number Copy Test
- Black medium point ink pen
- Timer

International Users*:* You may modify the test form to create numbers that correspond to the format used in your country. Be sure that you use 18-point size bolded font on the telephone numbers to match the test, and that the spacing on your form is the same. Use the Visual Attention Assessment form to record the client's performance.

Environment: well-lighted room with the light source directed from behind the client onto the tabletop to evenly illuminate the test; ensure that the light source does not shine directly into the client's eyes. This test requires the client's full concentration; ensure that the room is free from visual, auditory, and physical distractions.

Procedure:

14. Use the Visual Attention Assessment Form to record the client's performance
15. Seat the client comfortably at a well illuminated writing surface. If the client wears prescription eyewear or over-the-counter eyeglasses for reading, they **must be worn for this assessment.**
16. Place the test at the client's midline.
17. Hand the client the black medium point ink pen.
18. Instruct the client to copy each telephone number on the left side of the page onto the line next to it and to place the pen on the table when finished.
19. The client may reposition the form. Note these changes on the recording form.
20. Begin timing when the client begins reading the first telephone number.
21. Observe and record client's search strategy to identify the numbers and copy the telephone number on the corresponding line on the form.
22. Provide verbal, physical, or visual cues if the client is struggling.

    Examples of Verbal Cues:

    - *"Remember there are 7 numbers in a telephone number*."
    - "*Remember to look at the numbers closely, some numbers look alike*."

Examples of Physical Cues:

- Gently turn the client's head towards the left or right side of the test form.
- Place the client's hand on the left or right side of the test form to draw attention that side.
- Point to the left or right border of the test form.
- Point to the copying line.

Examples of Other Cues:

- Draw a bright red anchoring line on the left side of the test form, remind the client to look for the red line (this cue often works well for the client with hemianopia but not the client with neglect).
- Provide an auditory cue (side such as a chiming ring tone on your phone) on the neglecting side to draw attention to that side.

10. Stop timing when the client places the pen on the table.
11. Count and record the number of errors (misidentifications or omissions) the client made copying the individual numbers.
12. There are 80 possible errors on the test: 70 individual numbers and 10 dashes.
13. *Omission* is leaving a number/dash out of the sequence.
14. *Misidentification* is writing down an incorrect number.
15. If the client copied down a number incorrectly but immediately corrected the error without cuing, note this on the recording form but do not count it as an error.
16. Inform the client of the number of individual errors they made copying down the numbers and instruct the client to find and correct all of the errors.
17. Begin timing when the client begins to search the test to locate the first error.
18. Record the number of errors made both before and after self-correction on the recording form.
19. Record the percentage of correctly copied telephone numbers before and after self-correction. Each telephone number is considered a single item when calculating the percentage. For example: There are 10 telephone numbers on the test; a client who copies down 8 of the telephone numbers correctly would have a test accuracy of 80%.

Instructions to the Client:

Before the test begins:

"There are 10 telephone numbers on this page. Read each telephone number carefully and copy it down on the blank line next to it [indicate the line]. When you finish place your pen on the table. Try to be as accurate as you can, I am going to count the number of errors you make in copying the numbers."

After the client completes the test-if errors are made:

"You made __ errors in copying down the numbers. Please recheck your work and try to find and correct your errors. When you have finished, place your pen on the table."

4.5.2.1 Interpreting Client Performance on the Telephone Number Copy Test

The ability to accurately read numbers and copy down a sequence of numbers is a component of financial management, written communications, and medication management. Poor accuracy could cause the client to make mistakes that may go initially go undetected until the client receives feedback on their error (for example, the wrong amount paid on a bill). Slowness in reading numbers increases effort and lengthens the time required to complete occupations like financial management. These challenges may cause the client to question their ability to complete these important tasks and increase their reliance on others.

4.5.2.1.1 Key Observations on the Telephone Number Copy Test

The client uses the fingers on the non-dominant hand to maintain their place and guide their search across the line as they copy the telephone numbers. Use of this strategy suggests that the client may have a hemianopia that is affecting the fovea. Persons with hemianopia must alter their search strategy to compensate for the vision loss. Using this strategy improves accuracy BUT it also increases copying time which can cause frustration and fatigue.

The client copies a number incorrectly but immediately corrects the error. Persons with normal visual attention sometimes write down the wrong number or transpose numbers. Realizing and correcting the mistake suggests good capability to attend and accurately identify numbers.

***The client omits one digit in the number sequence*. ** This may suggest the presence of a hemianopia or other central visual field deficit or inattention. Clients with hemianopia sometimes leave out a digit when copying a sequence of numbers and do not detect the error until they recheck their work. A client with inattention may not locate the error on recheck.

The client writes down a similar but incorrect number. This may suggest the presence of a hemianopia or other central visual field deficit. Persons with hemianopia may write down a similar but incorrect number because they do not see the entire number. For example, a client with left hemianopia may see a *3* or *9* when viewing an *8* and a client with a right hemianopia may see a *6* when viewing an *8*. The numbers most often misidentified are 3,6,5,8,9, and 4. Persons with hemianopia most often make mistakes reading numbers located on the affected side and persons with neglect make mistakes on the neglecting side. The client with hemianopia should be able to locate and correct errors when rechecking their work, whereas the client with neglect may not be able to correct their errors.

The client omits the first number(s) in the sequence. This may suggest the presence of a left hemianopia or neglect. If the error is due to solely to hemianopia, the client will likely locate the error when rechecking their work and correct it. If neglect is present, the client may not locate the error on the recheck even with cuing.

T***he client omits the first number after the dash***. For example, instead of 884-2633, the client writes 884-633. This error is uncommon and has only been observed in clients with hemianopia.

The client drifts on the line when writing down the numbers. This may suggest a hemianopia that extends into the fovea. Clients with a complete hemianopia located on the same side as their dominant hand, often drift on the line. This occurs because the field deficit prevents them from seeing to monitor their pen tip. The same handwriting behavior is observed in clients with central scotoma from an age-related eye disease like macular degeneration.

The client's performance improves in response to cuing. This is an important observation because it shows that the client can modify attention to improve performance. Most persons with hemianopia possess this capability but persons with neglect lack it. Determine the type of cues that work best for the client and incorporate them into interventions.

The client does not respond to cues to improve performance. This is an important observation because it shows that the client is unable to use attention to improve performance. Most persons with hemianopia possess this capability but persons with neglect lack it.

The client doesn't locate errors when rechecking performance. This suggests neglect. Clients with neglect are often unable to focus their attention to locate errors when rechecking their accuracy while clients with hemianopia can use attention to correct errors.

4.5.3 ScanBoard Instructions

This assessment was developed for the biVABA to screen whether the client employs an organized and symmetrical strategy to search for visual information in extrapersonal space (defined as reaching space).[260, 267] The test consists of 10 numbers arranged in a "butterfly" pattern on a large plastic board (see Figure 4.5.1). Acceptable inter-rater and test-retest reliability, and test validity was shown on a sample of adults with and without stroke.[260]

Test Items:

- Visual Attention Assessment form
- ScanBoard
- easel (optional)

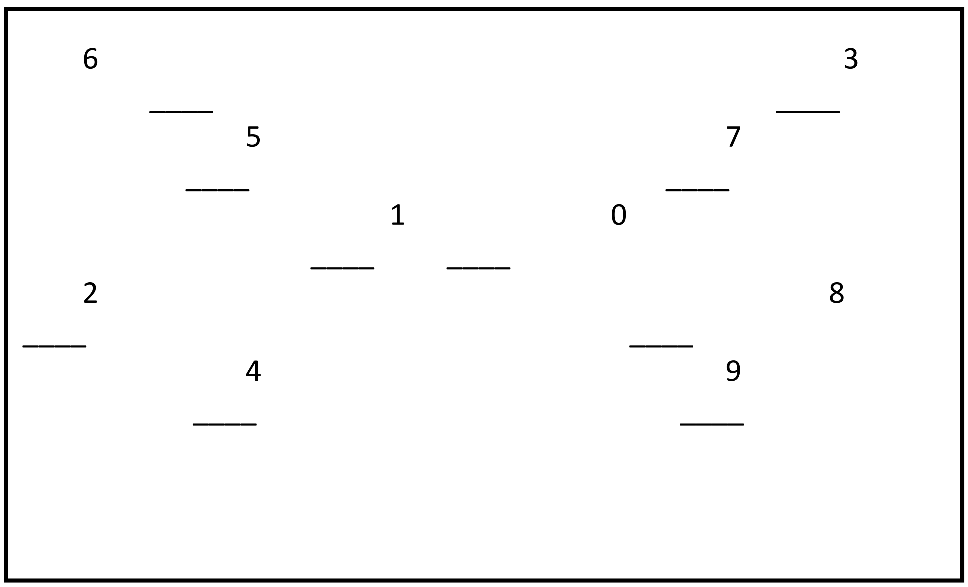
Environment: well-lighted room with the light source directed from behind the client to evenly illuminate the surface of the Board; ensure that the light source does not shine directly into the client's eyes. This test requires the client's full concentration; ensure that the room is free from visual, auditory, and physical distractions.

Procedure:

1. Seat the client comfortably in a posturally secure seated position with good midline orientation.
2. The client should be wearing eyeglasses if needed to see at a distance.

3. Position the ScanBoard on a table or easel. Make sure the board is positioned at eye level at the client's midline and within arm's reach so that the client can easily touch each number on the board.
4. Instruct the client to point out the numbers on the board as he/she sees them and tell you when finished.
5. The client may either point to or touch the numbers on the board to show their location.
6. The client does not have to verbally state the number as it is pointed out.
7. On the assessment form, use the line under each number, to order in which the client identified the numbers (see Figure 4.5.1).
8. Do **not** cue the client during the test and allow the client to indicate when finished.
9. Stop the test if the client begins to point out the numbers in numerical sequence (e.g., 1,2,3…). Instruct the client to begin again and point out the numbers as he/she sees them-not in sequence.

Figure 4.5.1: ScanBoard recording form.



Instructions to the Client:

"There are 10 numbers on this board. Point out the numbers to me as you see them. Do not try to point them out in order-just point to them as you see them. Point slowly because I will be writing down the numbers you see. Stop when you have seen every number.

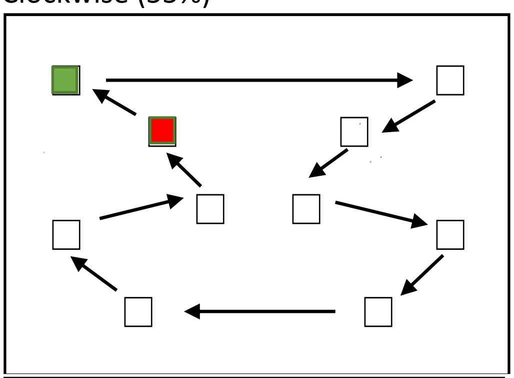
4.5.3.1 Interpreting the Client's Performance on the ScanBoard

4.5.3.1.1 Effective Search Strategies on the ScanBoard

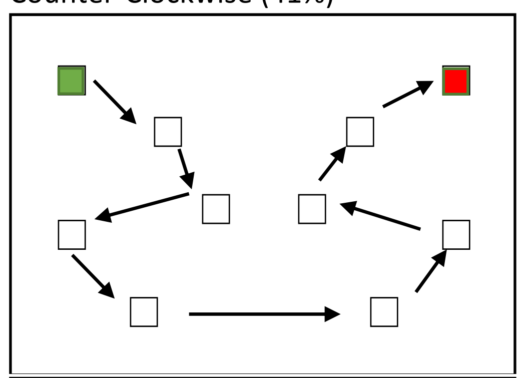
Warren[260] compared the Scanboard performances of a cohort of adults with stroke, and an age and sex-matched control group of adults without brain injury. The study found that participants in the control group used organized, sequential search patterns to quickly identify the 10 numbers. The control group participants predominantly used one of three patterns: clockwise (55%), counterclockwise (41%), and back and forth linear pattern (4%). Figure 4.5.2 shows the two most prevalent patterns. Sixty-five percent of the participants began search on the upper left side of the board and used a left-to-right and top-to-bottom strategy to locate the numbers.

Figure 4.5.2: Examples of the two most prevalent search patterns used by the control group. *Green square is the starting position; red square is the ending position.

Clockwise (55%)



Counter-Clockwise (41%)

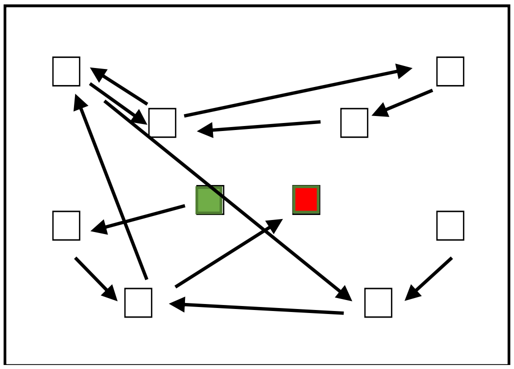


A client with normal visual attention may show a variation of these patterns. Their performance is considered to be normal if the pattern includes these elements: 1) the pattern is organized and predictable 2) the pattern is initiated from left to right 3) all numbers are identified and are identified only once.

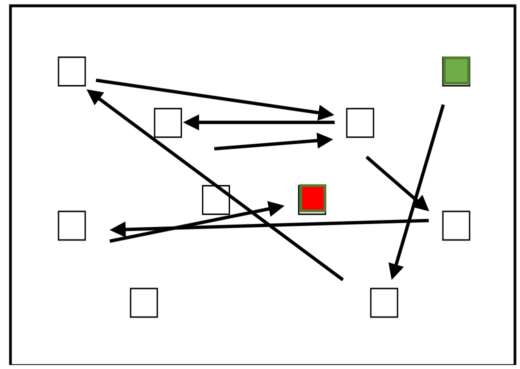
4.5.3.1.2 Ineffective Search Strategies on the ScanBoard

The Warren [260] study found that 48% of participants with stroke used search patterns that resulted in omitting numbers (often on one side of the board) or pointing out the same number more than once. Thirty-five percent initiated search on the right side of the board (compared to 8% in the control group) and 13% showed no discernible pattern when searching the board. The difference between the stroke and control groups was statistically significant ($p < .01$). Figure 4.5.3 illustrates 2 examples of the ineffective search strategies observed in the Warren study.

FIGURE 4.5.3: Examples of Ineffective search strategies used by participants with stroke
*Green square is the starting position; red square is the ending position.



Client initiates pattern in center left; uses random pattern; points to numbers 6,5,0,9,4 twice.



Client initiates pattern on upper right; uses random pattern and omits numbers 4 and 0.

4.5.3.1.3 Key Observations on the ScanBoard

The client uses an unpredictable and random search pattern. A random search pattern strongly suggests neglect especially when searching such a simple arrangement of numbers. This client likely will have significant difficulty locating items for ADLs and other activities.

The client initiates the search pattern from the right side of the board. The normal search strategy is a left to right strategy. Observing the client begin on the right side of the board suggests neglect especially if the client proceeds to use a disorganized and incomplete search pattern and omits targets on the left side. If the client begins on the right side but executes an organized, predictable, and complete pattern to locate targets it may suggest left hemianopia.

The client identifies numbers only on the right side of the board. This may suggest a left hemianopia if the client used an organized search pattern to locate targets on the right side and abbreviated search towards the left side. This observation suggests neglect if-in addition to missing numbers on the left side-the client uses a random, disorganized search pattern (see section 2.5.2.2).

The client identifies numbers only on the left side of the board. If the client's search pattern is organized and initiated from the left side, this abbreviated pattern suggests the presence of a right hemianopia. It suggests neglect if client combines the abbreviated pattern with a disorganized, random search pattern.

The client identifies the same number more than once. If combined with a random search pattern, the client may not realize that the number was previously identified. If the client repetitively selects the same number, it may indicate perseveration. Both observations suggest neglect (see section 2.5.2.2).

4.5.4 ScanCourse Instructions

> The ScanCourse is a structured task analysis that provides an opportunity to observe the client's ability to complete a dual attention task that combines visual search with ambulation. Lund et al.[142] studied the measurement properties of the ScanCourse on a sample of 48 participants with neurological impairment. The researchers standardized the ScanCourse directions and course layout to complete the study; a copy of their research manual is available in Appendix E. The study found that the ScanCourse showed high interrater reliability and test-retest reliability and good validity for assessing the ability to complete a dual task of sequentially following and identifying a path of targets.

Test Items*:*

Visual Attention Assessment form
*3" by 5" plain index cards (21)
*21 1-inch black vinyl stick-on letters/numbers or a black marker to create target cards
*Tape or mounting putty to attach the target cards to the wall

**These items are not included in the biVABA*

Environment: Well-lighted hallway with even illumination (no shadows on the walls). Avoid florescent lighting if possible. The hallway should be lightly traveled and long enough to place the 10 test targets in various locations about 2-3 feet apart on each side of the hallway. If needed use an adjoining hallway to extend the course. This test requires the client's full concentration; ensure that the hallway is free from visual, auditory, and physical distractions.

Procedure:

1. Set up the course (do not let the client view this step).
2. Assemble 21 target cards: place a single letter or number on each card (use card 21 as an example to show the client what the targets look like). Note: stick on "Post it" notes can be used as the target card when you need to temporarily attach the cards to the wall-this works well when testing in the client's home. You can use colors or symbols on the target card instead of numbers or letters for clients with reading difficulties or the client can simply point to the cards (see section 4.5 4.1).
    - Attach 10 cards along each side of a long hallway or corridor.
    - Randomly place the cards at: floor level, eye level, waist level, above eye level locations. Vary the spacing of the cards-some close together, others farther apart)
3. Bring the client to one end of the hallway.
4. Instruct the client to identify the targets while walking down the hallway. The client must identify the cards while moving; stopping to identify the target is counted as an error.

5. Follow the client down the hallway and keep a silent count of the number of targets missed on each side of the hallway. *The client does not have to accurately identify the target; the client only must accurately locate the card.*
6. If the client did not locate all of the cards, calculate the percentage of correct responses on each side of the hallway (e.g., 8/10 cards located on the right indicates 80% accuracy in locating the targets on the right side).
   Record the number and percentage of targets located by the client on the Visual Attention Assessment form under Trial 1.
7. If the client did not locate 100% of the targets, provide this feedback to the client [see example of instructions to the client below) and instruct the client to walk down the hallway again to see if the client can improve their performance.
8. Repeat the test (Trial 2) with the client reversing course and walking down the hallway in the opposite direction of the first trial.
9. Re-calculate the percentage of accurate results and record the percentage on the recording form under Trial 2.

Instructions to the Client:

"This is a test to see how well you can search for targets when you are walking. I have placed 20 cards with [number/letters] on them like this one [show example] in various locations on both sides of this hallway. You must read out the [number/letter] on the cards as you walk by them. Do not stop and look for the cards, you must continue walking and read the [number/letter] on the card as you walk by."

If the client makes errors on Trial 1

"You missed [X number of targets] on the right side and [X number of targets] on the left side. It may be because… [Provide specific feedback such as-you didn't turn your head far enough to the left side… you were looking at your feet…]. Let's try it again, this time be sure to … [repeat feedback]."

4.5 4.1 Interpreting Client Performance on the ScanCourse Test

A person must be able to combine vision and ambulation to safely navigate an environment. A client who walks without monitoring surrounding environmental features is at risk for collisions, falls and disorientation (getting lost is a common complaint of persons with hemianopia). This client will require supervision in community environments. Driving is **not** an option for a client who performs poorly on this test.

4.5.4.2 Key Observations on the ScanCourse Test

The client misses targets only on one side of the hallway during Trial 1. This observation suggests the presence of a hemianopia or neglect. If after receiving feedback on Trial 1, the client accurately completes Trial 2, the errors committed on the first trial suggest inadequate compensation for a possible hemianopia and **not** inattention. If the client, after receiving feedback on Trial 1, makes as many or more errors on Trial 2, it suggests the influence of neglect.

The client randomly misses targets on both sides of the hallway. This observation suggests difficulty attending due to non-lateralized inattention from neglect especially when observed in a client with right hemisphere injury (see section 4.4.1.5). A Less common cause is the presence of significantly restricted peripheral vision (e.g., tunnel vision) from an anoxic brain injury, a bilateral optic nerve injury, glaucoma, or severe retinal disease.

The client must stop to locate and identify the target. This suggests that the client is unable to integrate vision with ambulation and must complete one or the other. Having to stop to search is observed in clients in early recovery from hemianopia. The behavior usually ceases following intervention that teaches the client to compensate for the hemianopia during ambulation.

The client misses cards placed in unexpected locations. This suggests that the client does not monitor the entire visual environment while walking. It is observed in clients in early recovery from hemianopia who tend to look straight ahead or at the floor when traversing the course. The behavior usually ceases following intervention that teaches the client to compensate for the hemianopia during ambulation.

The client misidentifies the target on the card. The intent of the ScanCourse is to determine if the client can and will turn the head both directions to locate targets in sequence. Accuracy in identifying the target on the card is a secondary concern. Therefore, misidentifying the target is NOT considered an error on this test. You can use colors or symbols on the target card instead of numbers or letters if the client has alexia or the client can simply point to the cards. That said, you may have reasons for requiring that client accurately identify the target. For example, you may want to assess the client's attention to detail. Modify the test as needed to provide the observations that you feel will enhance your understanding of the client's strengths and weaknesses in this dual task.

4.5.5 Additional Assessments to Identify Functional Limitations

These assessments help you gain additional insight into how the client's vision affects their ability to complete daily occupations.

4.5.5.1 Self-Report Assessment of Functional Visual Performance

Persons with hemianopia typically only have difficulty completing ADLS that rely on vision to complete. The *Self-Report Assessment of Functional Visual Performance* (SRAFVP) is a standardized assessment developed specifically to measure a client's ability to complete vision-dependent activities of daily living. Originally developed to assess ADL performance in older adults with age-related eye disease,[248] Mennem et al.[151] validated the assessment on persons with hemianopia. The Mennem[151] study found that the assessment accurately measured vision dependent ADLs in three areas: reading, eye-hand coordination, and mobility.

The SRAFVP uses an interview format that allows the client to identify the ADLs that they most value. The assessment covers 38 basic and instrumental vision dependent ADLS. The SRAFVP toolkit is available as a free download from the Occupational Therapy Department, University of Alabama at Birmingham (www.uab.edu/shp/ot/post-professional/low-vision-gc/student-resources). **NOTE**: be sure to download the **original SRAFVP** (not the R-SRAFVP) to use the assessment with clients with hemianopia.

4.5.5.2 Catherine Bergego Scale

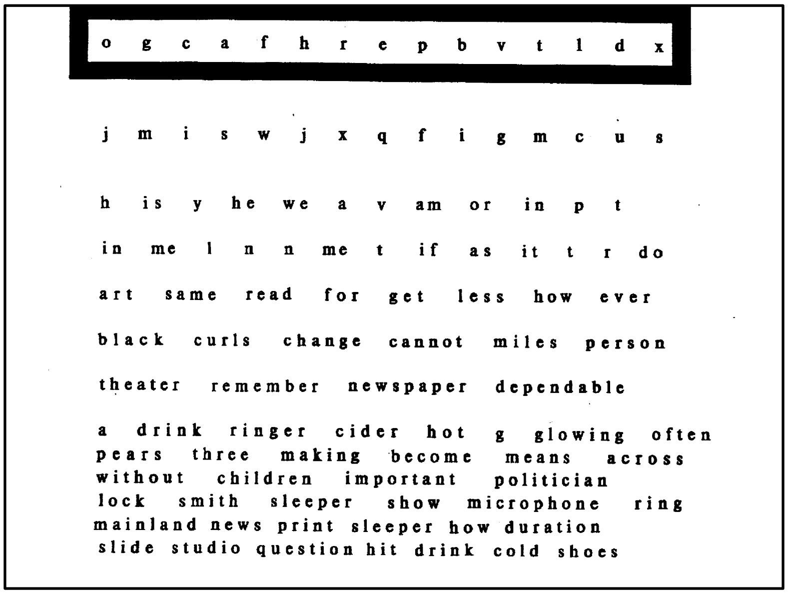
The Catherine Bergego Scale (see example in Appendix D) is a widely used assessment that measures the influence of neglect on the client's ability to complete basic ADLS and navigation. Azouvi et al.[10] developed the assessment and subsequent studies have established its reliability and validity as a neglect assessment.[143, 148] The OT observes the client complete ten ADL and mobility items and assigns each item a point value using a 4-point rating scale (0-no neglect, 1-mild neglect, 2-moderate neglect, 3-severe neglect). The points are summed to provide a cumulative score ranking the client's level of neglect: no neglect (0 points) mild neglect (1-10) moderate neglect (11-20), and severe neglect (21-30).

4.5.5.3 Pepper Visual Skills for Reading Test

The Visual Skills for Reading Test assesses the influence of central visual field loss on visual word recognition and reading. The test (better known as the Pepper Test) was developed to assess reading performance persons with macular scotoma from macular degeneration. The client reads single letters and words printed on a card (see Figure 4.5.4). The card contains words that can be transformed into another word if misread. Because the words don't appear within the context of a sentence, the person must rely solely on vision to identify the word. The test includes three versions in varying print sizes to accommodate clients with reduced acuity and to permit retest. The test measures reading accuracy and corrected reading rate and provides information on the prevalent types of reading errors.

Blaylock et al.[25] validated the Pepper test on persons with hemianopia and found that it provides an effective way to measure the interference of the visual field deficit on reading performance. Persons with hemianopia make errors on the Pepper test consistent with the side of their field deficit.[25, 256] For example, a client with a left hemianopia may read the word "radish" as "dish" and a client with a right hemianopia may read the word "mustard" as "must." The Blaylock study found that persons with hemianopia demonstrated a lower reading speed, averaging 50-75 words per minute which is about 50 words less than persons without hemianopia and 75% of the participants made reading errors. Their most common errors included omissions (didn't see the word) and misidentifications. Similar types of errors may be observed on the *Warren Text* card (see section 4.1 3.1.4); and the *Telephone Number Copy Test* (see section 4.5.2).

Figure 4.5.4: Example of a Visual Skills for Reading Test card.


o g c a f h r e p b v t l d x

j m i s w j x q f i g m c u s

h is y he we a v am or in p t

in me l n n me t if as it t r do

art same read for get less how ever

black curls change cannot miles person

theater remember newspaper dependable

a drink ringer cider hot g glowing often
pears three making become means across
without children important politician
lock smith sleeper show microphone ring
mainland news print sleeper how duration
slide studio question hit drink cold shoes

The VSRT is out of print, but the manufacturer still carries the instructions manual and scoring sheets for current users. Contact Fork in the Road Vision Rehabilitation Services

The S-K Read Chart manufactured by Precision Vision uses a similar format as the Pepper.

4.5.5.4 Light Boards

To safely navigate dynamic and complex community environments, the client must use a wide scanning strategy that quickly and efficiently covers the affected side. The client also must rapidly shift attention back and forth between the central and the peripheral visual fields to keep track of objects moving within the environment. A client who is compensating well for a hemianopia or inattention should be able to symmetrically search both the right and left halves of the visual field with equal speed when standing still or moving. Large interactive light boards, which are primarily used for intervention, provide an opportunity to compare the client's speed and efficiency in searching the right and left halves of the visual field and their ability to divide attention between the central and peripheral field. Clinics use many types of lightboards: some examples include the Dynavision D2[23] Bioness Integrated Therapy System[222] and the NVT.[103] The boards use a game format to engage the client while recording the number and speed at which targets on located on the board during the game. Most boards provide a variety of games at varying skill levels; select a game that tests the visual search capability you want to know more about.

If you don't have a light board, you can create a task analysis using a laser pointer to observe the client's search capability. Stand behind the client and randomly project the laser beam onto various locations on a blank white wall. Instruct the client to locate and touch the projected laser dot. Note the strategy and the time needed to locate the dot and compare performance between the blind and intact fields.

5 Intervention

We must address visual impairment because it forces our clients to give up occupations that are meaningful to them and important for independent living. Vison impairment also causes the client to question their self-efficacy and autonomy-the ability to control and successfully respond to the environment.[98, 102] Without intervention, the person will experience a decline in their quality of life and an increase in depression and anxiety.

Recovery from brain injury often spans months and years rather than days or weeks. Some vision impairment-notably some forms of oculomotor impairment and visual inattention can improve over time (see sections 5.7.1., 5.9.1).[161, 171] Other vision conditions like visual field deficit cause a permanent impairment.[34, 195] Currently, there is little research evidence to support the efficacy of interventions that aim to restore visual function to normal pre-injury levels.[82, 176, 197, 198, 234] In addition, many proposed restorative interventions require a significant amount of practice and can't feasibly be implemented during the brief time allotted to therapy.[124, 198, 233, 234] To provide the best client outcome, rather than focusing on restoration of visual processing, OT intervention should concentrate on enabling the client to use their current visual abilities to participate in valued activities and occupations. This approach aligns with the overarching goal of OT intervention, as stated in the practice framework, to promote the client's health and participation despite disability.[7] It is also consistent with research showing that neuroplasticity within the brain is stimulated when a person attempts to engage in meaningful tasks.[63]

Intervention should focus on adaptation and empowerment. Adaptation enables the client to use their current vision as effectively as possible to participate in daily occupations. Empowerment evolves from the client's understanding of how the visual condition limits their ability to complete occupations and how they can minimize its negative affect through modification and compensation. This knowledge gives the client control over their condition by promoting an active problem-solving approach that fosters adaptation and mastery instead of avoiding difficult tasks.[57] Thoroughly understanding their condition also empowers the client to advocate for what they need from eye doctors, physicians, and healthcare providers.

As occupational therapists, we view occupation as an outcome and an intervention.[7] Using occupations as intervention has several key advantages in improving performance skills like visual search or sustained attention:

1. With few exceptions, occupations require integration of the body sides and body space and thus naturally promote attention and search to both sides. Playing scales on the piano[27] and listening to music through headphones[42] have been shown to improve attention towards the left side in persons with chronic left neglect.
2. Completing a well-practiced and valued occupation enables the client to tap into their expertise. This reduces metabolic demand within the brain and in turn, reduces effort, and fatigue.[64, 102, 130, 181, 203]

3. Objects used in everyday activities are established as generic memories that can be accessed by a broad range of sensory input.[90] This increases the likelihood that even clients with severe brain injury may be able to recognize and appropriately use these objects within the context of an everyday activity.

5.1 Key Questions to Guide Setting Goals and Selecting Interventions

There are 2 key questions to answer that ensure your intervention aligns with the practice framework.

1. What does my client **want** and **need** to do?
   - Clients will go to great lengths to complete valued occupations.
2. Can I improve my client's ability to **compensate** for their limitations in visual processing?
   - If you answer **YES** to this question, focus on improving performance skills like compensatory visual scanning training that will enable the client to compensate for the vision impairment in activities.
   - If you answer **NO**, focus on modifying the environment and task to facilitate the client's ability to use their current vision to complete occupations. This includes training the client to use adaptive devices and technology to compensate or substitute for vision. For example, train the client to use voiceover and text to speech apps to eliminate the need to read text.

5.2 Setting Goals

Follow the AOTA Practice Framework[7] and make participation the goal instead of independence. Letting go of the belief that restoring vision and independence is the *only* path to recovery forces you to be client-centered and focused on the client's priorities. Aiming for participation forces you to be more creative and use modification, adaptive devices, and technology rather than exercises to achieve the goal. A client ultimately won't participate in an activity they don't care about but will go to great lengths to participate in an occupation that is important to them. Make co-occupation the goal Instead of independence. Co-occupations require each member to contribute to completing the task.[7] Examples include participating with a spouse to prepare the evening meal or put a child to bed. Co-occupation enables the client to take an active role in family life and make a useful contribution. Assisting the client and partner to identify co-occupations and figuring out the modifications needed to make it happen helps both adjust to living with brain injury.

5.2.1 Setting the Best Goal

The best goal is one that focuses on an explicit occupational outcome. Some examples include:

1. The client will consistently use strategies to compensate for vision impairment to locate and select items during the weekly grocery shopping trip with her husband.

2. The client will identify home and task modifications that support his ability to compensate for vision loss to complete meal preparation.
3. The client will employ strategies to minimize visual stress and prepare the evening meal.
4. The client will compensate for vision loss to accurately fill her weekly medication pillbox.

5.3 Team Approach is Best

Using a team approach is essential to obtaining an optimal outcome for the client with vision impairment.[8, 63, 76, 79, 160] This is especially true when the client has unusual, severe, or permanent vision impairment. There are many vision professionals who add valuable insight and intervention to assist the client to achieve their goals.

5.3.1 Collaborating with Eye Doctors

5.3.1.1 Ophthalmologist vs. Optometrist

The best client outcome is achieved when we collaborate with an ophthalmologist or optometrist. These eye doctors increase our understanding of how the client's vision has changed and the prognosis for recovery. They vary in their approach to the client with brain injury based on their educational preparation and professional role.

Ophthalmologists are primarily responsible for diagnosing and treating the medical conditions that cause the visual impairment. As physicians (MDs) ophthalmologists are trained to answer the question: "What caused the vision impairment, and will it get better?" Neuro-ophthalmology is a subspecialty of both neurology and ophthalmology. Board-certified neuro-ophthalmologists are the ultimate authority on visual impairment from brain injury, but they are a small subspeciality. In 2020, only eight states in the U.S. had enough neuro-ophthalmologists and 6 states did not have any.[266] Because of their limited numbers, neuro-ophthalmologists often only see the most complex cases and are rarely the first eye doctor to evaluate a person with vision impairment from brain injury. Ophthalmologists provide valuable information about how the client's vision has changed and whether it will improve. However, they rarely offer explicit direction to the rehab team on the best interventions to enable the client to use their vision more efficiently.

Optometrists are licensed health care professionals (like OT and PT) who hold a clinical doctorate in optometry (OD). They are not physicians, but they also diagnose and treat medical conditions causing vision loss and provide most of the primary eye care in the United States.[265] In addition to answering the question "What caused the vision impairment?" their training prepares them to answer the question "What can be done to improve vision?" They have extensive training in the use of lenses and prism and are often especially adept at treating oculomotor impairment and focusing deficiencies. They are comfortable in the role of providing direction and input to assist the rehab team to enable the client to use vision more efficiently.

Some optometrists specialize in neurorehabilitation and focus on persons with vision impairment from brain injury.[265]

5.3.1.2 Reasons to Consult Early with Eye Doctors

Early consultation with an eye doctor is important as there are many correctable vision impairments that can significantly improve the client's ability to participate in rehabilitation (see sections 5.3.1.1 and 5.7.1) Undiagnosed vision impairment can lead the rehab team in the wrong direction by creating a false picture of the client's limitations. This often occurs when the client adopts a visual compensatory strategy that limits their ability in another area. For example, a client with bilateral 4th CN palsy may hold their head forward and down to eliminate double vision when viewing objects. While successful in reducing double vision, this visual strategy can interfere with the client's ability to walk and complete tabletop activities. The rehab team, observing these behaviors, may mistakenly believe it is due to poor neck /trunk control instead of oculomotor impairment and attempt to address it through strengthening.

Prompt diagnosis of the vision impairment and early intervention improves the client's ability to fully participate in rehabilitation. Many eye doctors advocate for early consultation beginning with a brief "bedside" exam to rule out vision threatening conditions (orbital fracture, optic nerve or retinal injury) and progressing to a more comprehensive office exam as the client's cognitive and physical function improves.[79, 160, 213, 249] An ophthalmologist or neurologist will likely complete the initial bedside exam because as MD's they have hospital privileges. However, the optimal medical rehabilitation model is to have an optometrist on the rehabilitation team. The OD evaluates and diagnoses the client's vision impairment and provides the team with information on prognosis and medical/optical management.[79] Although their numbers are increasing, relatively few optometrists are integrated into rehab teams at this time. Instead, the client must be referred out to the eye doctor's private practice and obtaining an outside referral can be a difficult and time-consuming process. The OT will be expected to provide evidence to the medical director or case manager that a visual impairment may be limiting the client's occupational performance. To advocate for referral, the OT must screen for visual impairment and link it to limitations in occupational performance.

5.3.2 Collaborating with Vestibular Specialists

Brain injury, especially from TBI, can injure the pathways that integrate vision, neck proprioceptors and vestibular centers within the brain. The resulting visual vestibular impairment can reduce gaze stability during head and eye movement causing blurred vision, nystagmus, and oscillopsia (presence of constant motion with the visual field). Vision is generally worse when the client moves the body or the eyes to walk, read and complete daily activities and it can be accompanied by dizziness, vertigo, and nausea. PTs and OTs who have completed a certification course in vestibular rehabilitation provide the therapy. Neuro-optometrists may also provide vision therapy using prism and eye exercises.[48, 194]

5.3.3 Collaborating with Non-Medical Vision Rehabilitation Professionals

These professionals work outside of the healthcare system. They are not licensed health care providers, and their services are not covered by medical insurance in the U.S. This creates a barrier to referral and collaboration, but their understanding of how vision impairment influences daily living can be very helpful to the OT. It's worth it to seek out these professionals in your community and establish a relationship with them.

5.3.3.1 Certified Orientation Mobility Specialists (COMS)

The COMS instructs persons with vision impairment to use their remaining senses to safely navigate from one place to another. COMS provide services to children and adults in various settings, including school systems and private, state, and VA (Department of Veterans Affairs) programs.[263] Services are usually community-based. The goal of orientation and mobility (O&M) instruction is to develop independent travel skills. To achieve this goal, the COMS focuses on developing cognitive spatial concepts and efficient sensory skills along with optical devices, compensatory techniques, and travel aids to guide movement in space. COMS have either a baccalaureate or a master's degree from an accredited university. In 1990, professionals with baccalaureate or master's degrees in a related field became eligible for O&M certification after completing an approved university program.[263] This rule change allowed occupational therapists to obtain additional credentialing in O&M in the United States.

5.3.3.2 Certified Vision Rehabilitation Therapist (CVRT)

As a sister profession to occupational therapy, CVRTs train persons to use adaptive skills, devices, and technology to compensate for vision loss in completing daily occupations. Originally known as rehabilitation teachers*,* CVRTs work with children and adults in various settings, including the VA, state vocational rehabilitation programs, private agencies, and special education programs.[175] Their knowledge and skill set is especially important in achieving an optimal outcome for a client with acquired brain injury who is newly blinded and unable to use vision.

5.3.3.3 Certified Low Vision Therapist (CLVT)

This specialty certification was established in 1997 for professionals working specifically with persons with low vision.[261] The professionals who hold this certification represent a variety of backgrounds, including COMS, CVRTs, optometrists, educators, nurses, and occupational therapists. The CLVT works as part of an interdisciplinary team with a low vision physician. CLVTs provide intervention using optical devices and compensatory techniques that enable the person to use vision more efficiently to read, write, and complete daily activities. The CLVT must be a licensed health care provider to be reimbursed for services provided to Medicare beneficiaries, thus OTs with the CLVT credential can bill Medicare when providing OT services to clients with low vision.

5.3.3.4 Orthoptists

Orthoptists work on an ophthalmology-led eye care team to treat vision disorders, eye misalignments, disorders of binocular function.[78] These professionals are much more common outside of the United States, but the number of training programs is increasing in the U.S.

5.4 Evaluation is the First Step of Intervention

Addressing vision limitations from brain injury is complex because brain injury doesn't just cause vision loss. The client may also have motor and speech impairment, impaired cognition and difficulty regulating emotions. Each of these impairments influences how the client views and interprets the environment and context for daily occupations. The fact that vision loss is a hidden impairment and visual processing provides a foundation for movement, cognition, and social interaction (see sections 1.3 and 1.4) adds another level of complexity. There are few outward signs that indicate a client has a vision impairment and vision impairment often mimics deficits in movement, cognition, and social interaction. As a result, some vision impairment may not become apparent until other performance areas improve.

We tend to think that the purpose of evaluation is to label the deficit to justify the need for skilled occupational therapy intervention. But evaluation is actually the first step in intervention. The sole reason for evaluating the client is to select the best intervention to obtain an optimal client outcome. A good evaluation enables you to:

1. Identify the client's imitations in occupational performance.
2. Identify the factors that contribute to these limitations.
3. Determine if intervention is needed (because sometimes it isn't).
4. Identify the best intervention to achieve an optimal outcome.
5. Identify what to focus on first during intervention.
6. Determine who needs to be on the rehab team.

Knowing the key client behaviors that indicate vision impairment and the key assessments that describe vision impairment enables you to connect the client's visual limitations to their occupational limitations. Making this connection will help you:

1. Clearly communicate information to the rehab team about the clients' functional limitations so that they can also provide appropriate accommodation and intervention.
2. Justify the need for skilled OT intervention by identifying how the client's vision has changed and how it affects occupational performance.
3. Establish achievable goals by aligning intervention with the client's functional impairment.

5.5 Intervention for All Types of Vision Impairment

5.5.1 The Most Important Tool in the OT Intervention Toolkit

Environmental and task modification is the most important tool in the OT toolbox. Simply put, it is our superpower-the skill that we possess that other rehab professionals do not. There is no question that we are well-trained in using task analysis to achieve an optimal fit between the client and the task and environment. Our practice framework[7] identifies this as a key intervention for all clients, and it is particularly important for clients with vision impairment.

Our focus on the fit between environment and task is well supported by newer models of neocortical processing (see section 1.2) that suggest the brain uses past experience to create a context in which to evaluate incoming visual information and predict what is going to happen next.[14, 100, 101] For example, you see your mug of steaming coffee and based on your coffee drinking experience you predict that the cup will feel warm when you pick it up. The brain uses previously learned information to continuously run unconscious stimulations (like the coffee example) to predict what will happen next. These simulations keep you prepared to successfully respond to situations as they arise. The key take-away message is that the ability to make an accurate prediction depends on the ability to *accurately see* the critical environmental features that trigger memory and create the context to unlock prediction. As stated earlier, vision is the primary way we acquire information about our world and as such it dominates the interpretation of environment and context. Vision impairment may reduce the accuracy, quality, and completeness of visual input into the brain causing the person to miss the critical environment/task features needed to define the context and trigger prediction. As a result, the person may not be able to successfully participate in the activity or occupation.

5.5.2 Basic Principles of Environment/Task Modification

Persons with vision impairment regardless of the cause, are strongly influenced by the visual properties of the task and the environment. These properties include contrast, pattern, size, and brightness. A client's success in using their current vision to complete daily occupations depends on the OT's ability to create a visible and explicit environment that facilitates rather than inhibits visual processing. Because increasing visibility is the most important OT intervention for **all types** of vision impairment, the key components of this intervention are described below and mentioned again in the sections on specific visual deficits.

Use Contrast to Identify Key Components of the Task and Environment. Key components are those features of a task or environment that guide completion of the desired occupation. Add contrast by changing background color so it differs from the object/feature to help the client see it. Adding contrast can be as simple as using a black cup for milk and a white cup for coffee. When background color cannot be changed add color to highlight critical features. For example, on carpeted stairs apply a line of bright orange duct tape to the carpet on the edge of each step to distinguish between them. Contrast also enables the client to locate a desired item more quickly as illustrated in Figure 5.1.[52, 68]

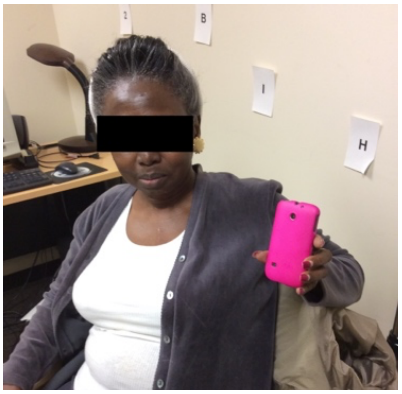


Figure 5.1: Example of using contrast to increase visibility.

After we discussed adding contrast to make it easier to locate objects, my client with hemianopia replaced her gray smartphone cover with a bright pink one. She excitedly showed me the modification during her next session and told me that she hadn't lost the phone since.

Reduce/Eliminate Background Pattern in Environments and Objects. Persons with visual processing deficits perform best in simple environments that contain only the objects needed for daily occupations.[68] Patterned backgrounds have the effect of camouflaging visual details. Using solid colors on background surfaces (bedspreads, place mats, dishes, countertops, rugs, towels, furniture coverings) increases the visibility of objects placed on them. Clutter also creates background pattern in an environment, making it more difficult to locate needed items. Cluttered environments with haphazardly placed objects are challenging even for persons with normal visual processing. If possible, reduce the number of objects in a setting and arrange needed objects in an orderly fashion. Place items that are used daily on accessible shelves in single rows. Store rarely used items on upper and lower shelves or remove them. Use commercially available organizing systems to store items together to create workstations. For example, place all items used for grooming in a basket on a tray (see Figure 5.2). Reducing clutter and adding structure creates an **explicit and predictable** environment that places less demand on visual attention. Once the environment is organized and simplified, educate the client and family on the importance of maintaining the structure. Developing the habit of putting items back where they belong reduces frustration and facilitates independence.

Enlarge Critical Features of Objects and Environments. Increasing the size of a feature or object makes it more visible. Enlarge the print on instructions, medications, calendars, and other items. The last line of print that the client can easily read on the reading acuity test card wearing their eyeglasses provides a starting place for enlarging print-generally persons prefer to read 3-5 points greater than their minimum acuity (see Appendix G).[136] Increase contrast along with size-as it does little good to enlarge text if the print is faint. Black on white or white on black print is more visible than any other color combination. Modify the accessibility settings of digital devices to adjust the brightness and background color of the screen; enhance the size, color, and boldness of text, icons, and cursors. Many commonly used items are available in larger print, including calculators, clocks, watches, telephones; health devices like glucose monitors, blood pressure cuffs and scales; leisure items like playing cards, games, and puzzles. These items can be purchased through specialty catalogs that carry low-vision products and are also increasingly available from large box retailers like Target and Walmart.

Eliminate Vision-Dependent Steps in Tasks. If it is not possible increase the visibility of a task component, consider eliminating the vision-dependent step from the occupation. For example, apply toothpaste directly onto the tongue rather than the toothbrush and purchase pre-chopped vegetables. Train the client to use internet-connected virtual assistants like Siri and Alexa to perform tasks such as dialing numbers, turning on lights, setting a timer, telling the time, temperature, and weather forecast and ordering items.

Add Adequate, Good Quality Lighting. Increasing the intensity, amount and quality of available light enables the client to see objects and environmental features more readily. For example, it is easier to identify facial features when a person's face is fully illuminated. Strategically place task lighting to provide full, even illumination of the task without areas of surface shadow. The light should be positioned as close to the task surface as possible to obtain optimal brightness and illumination of the task.[51]

Figure 5.2: Visible workstation for medication management.
The tray keeps the medication management items in one place. The black/white surface (made from craft foam sheets) provides a high contrast pattern free surface that enables the client to accurately identify the shape and size of pills. The medication bottles are labeled in large print. The gooseneck lamp has a bright non glaring LED bulb. The light is positioned close to the tray surface to provide bright illumination without shadow.

Many persons with acquired brain injury experience photophobia (see section 2.1.2.2) defined as an abnormal sensitivity to light that is uncomfortable and often painful.[32, 62, 272] Light sensitivity is common in persons with stroke, TBI, neurodegenerative diseases (PD and MS), and age-related eye disease.[62, 272] For these persons, light is often friend and foe. They need more illumination to see the details in environment while at the same time lighting often causes visual stress and its uncomfortable side effects including excessive blinking, tearing, eye pain, and headache. The visual stress may cause a client to avoid or limit participation in settings where lighting cannot be controlled including virtually all community environments. The light sensitive person may also take extreme measures to reduce light by wearing dark sunglasses and wide brimmed hats indoors or using thick drapes on windows and turning off all of the lights within a room.

The challenge is to find lighting sources that provide adequate illumination without discomfort. Fluorescent lighting, commonly used because of its energy efficiency, is actually the least tolerated light source. Fluorescent lighting emits a short wavelength 50-60 HZ flicker that can be quite noxious to persons with light sensitivity.[6, 62, 272] Halogen and LED lighting provide a well-tolerated bright illumination that works well for most light sensitive clients. However, consider all types of lighting including fluorescent as clients vary widely in their lighting preferences.

Other techniques/strategies for light sensitive clients include:

- Change the background on computer screens and smartphones from white to a darker color to alleviate eyestrain.
- Use blinds to deflect incoming light upward and filter light from windows.
- Cover glossy surfaces such as countertops and floors with rugs, or mats to reduce reflected light.[52]
- Use tinted eyeglass lenses or fit over shields (combined with a wide brimmed hat outdoors) to reduce glare and ease discomfort in when lighting cannot be controlled (such as in community environments).[15, 62, 72, 79]

The OT must also help the client establish performance patterns that support occupational performance. Establishing routines such as shopping at off hours to avoid a crowded grocery store reduces both cognitive and visual stress. Establishing a habit of leaving the house keys in a bowl by the door reduces the need for visual search; cleaning eyeglasses daily ensures a brighter image.

5.6 Intervention for Reduced Acuity

5.6.1 Reduced Acuity = Reduced Participation

Persons who don't see well miss or misinterpret details in tasks and environments. They may not accurately recognize the context of a setting which will diminish their ability to predict and therefore direct actions. They will make mistakes (that we may interpret as cognitive impairment) and those mistakes will cause them to feel stress, anxiety, and fear about participating in occupations and environments. They may slow down, shut down and avoid participation leaving a void in their occupational performance.

Reduced acuity limits the ability to see small or distant visual details and will make it difficult for the client to complete some daily living tasks. The more the daily task relies on vision, the greater the visual stress and limitations the client will experience. Eating (other than food identification) usually is not affected, nor is dressing once clothing is identified. But any activity that requires reading will be affected. The list includes meal preparation, medication management, financial management, telling time, setting thermostats and appliance dials, using a smart phone, reading overhead signs and traffic lights.

5.6.2 Address Correctable Vision Loss

5.6.2.1 Determine Whether Vision can be Improved

Reduced acuity can often be corrected with eyewear or surgery. Seek referral to an eye doctor if the client has less than 20/25 acuity wearing their eyeglasses on the LeaNumbers Intermediate Acuity Chart or the Warren Text Card, or if it has been more than 2 years since an older client's eyeglasses were updated.

5.6.2.2 Evaluate the Client's Eyewear

Make sure client is wearing glasses and the glasses are clean and in good repair. Research shows that persons are frequently admitted to rehabilitation floors without their prescription eyewear. Lotery et al.[140] studied patients admitted to a stroke rehab floor and reported that over a quarter who wore prescription glasses did not have their glasses with them and among those who did, nearly a quarter of the eyeglasses were dirty, scratched or needed repair. Roche et al.[187] also found that a quarter of patients admitted onto an orthopedic floor did not have their glasses with them and for those with glasses, 85% of the spectacles were dirty or in poor repair. Lotery et al.[140] also found that approximately half of their participants needed stronger glasses.

5.6.3 Inform the Rehab Team

Make sure the team knows about the client's vision loss and how to assist the client to compensate. We *are* the experts in using vision for functional activities and must claim the role of vision expert. As the vision expert we must ALWAYS screen the client's vision and share our findings with our colleagues. We must also provide suggestions to our colleagues on the most effective accommodations to enable the client to participate in their interventions.

5.6.4 Advocate for the Client

Visual acuity is the most important of the three foundation visual functions within the visual perceptual hierarchy (see section 1.4) because it strongly influences the ability to safely navigate, read, and complete ADLS. Reduced visual acuity must be addressed as early as possible in recovery to obtain an optimal client outcome. It is easy to document the client's limitations and pass the buck to others to obtain services. But if your team doesn't have access to an eye doctor, it is your role to advocate for the client. Work with social services to locate funding for new eyeglasses when needed; work with the case manager and the physician to get the client referred to an eye doctor.

5.6.5 Ensure the Client Receives Accessible Handouts

It is the OT's role to ensure that the team (including nursing) knows how to create a visible environment and task for the client who doesn't see well (see section 5.5.2). This includes creating visually accessible handouts to ensure that the client can accurately read printed materials like handouts, labels, and home programs. The two critical components of accessible reading materials are visibility and readability.[25] Visibility is print size and contrast; readability is formatting, word use, and sentence construction. Appendix G provides information on to how create visible documents for the client using information gained from their performance on the Warren Test Card. The Appendix also includes information on how to make the text easier to read (readability). A client with reduced acuity must allocate more attentional resources to decoding words. This extra effort may cause the client to experience stress and fatigue which can reduce comprehension. Modifying how information on handouts is written and formatted can reduce this stress and increase the readability of the materials. Share the Appendix information with the rehab team to ensure that their handouts are also visible and readable.

The third column on the right side of the Warren text Card-*metric diopters needed*-provides the *approximate* minimum number of diopters of magnification required in eyeglasses or a magnifier to read standard 1M print. Non-prescribed reading glasses are sold in pharmacies and on Amazon in strengths that range from 1-6 diopters. Clients whose acuity falls in the normal to near normal reading acuity range (20/20-20/60) may be able to read print using a pair of these stronger “store bought” glasses. It is OK to have non-prescribed reading glasses available in various diopter strengths to try out with your client. **But this is not a long-term solution**. Common refractive errors like myopia (near-sightedness), hyperopia (far-sightedness) and astigmatism significantly influence acuity and can only be corrected with prescription lenses (see Appendix J illustration 2 and section 2.1.3). Referral to the eye doctor for refraction and prescription of eyeglasses is critical to achieve the clearest vision. Clients with acuities less than 20/60, must use hand-held, stand magnifiers, or video magnifiers to read. Unless a member of the rehab team has experience in low vision and an understanding of optics, this client should be referred to a low vision optometrist or a low vision rehabilitation program to determine their magnifier needs.

5.6.6 If Your Client has Reduced Low Contrast

Clients with reduced contrast sensitivity experience an increased falls risk, difficulty reading, and difficulty completing ADLs with low contrast features. You must modify the client’s environment and tasks to increase the visibility of key features. Use the interventions described in section 5.5.2 to increase contrast, reduce pattern, enlarge features, provide good quality and even illumination.

5.6.7 If Your Client has Low Vision

Low vision permanently impairs a person’s ability to clearly see objects, details and color and is caused by eye conditions that cannot be corrected by medical procedures or eyeglasses. Unlike blindness, persons with low vision usually retain some useable vision. The person can see but does not see well and especially has difficulty seeing small details and low contrast forms. Low vision can occur from acquired, congenital, or hereditary conditions and diseases but age-related eye disease (ARED) is the leading cause of low vision in developed countries like the

United States (see section 2.1.2.2).[251] Three age-related eye diseases cause most of the low vision in older Americans: age-related macular degeneration (AMD), open-angle glaucoma (OAG) and diabetic retinopathy (DR). These are chronic and progressing diseases that have no cure; vision loss cannot be reversed and typically increases the longer one has the disease. The severity and permanence of the vision loss requires intervention from specialists in optometry, occupational therapy, and orientation and mobility to enable the client to continue a live a productive life. OTs without low vision training and certification can provide modifications to increase the visibility of tasks and environments, but referral to a low vision program provides the best outcome for the client.

5.6.8 Connect the Client with Free Resources

Most countries provide free resources to assist persons who have poor acuity from low vision or brain injury. Easily accessed resources in the U.S. include:

- The National Library Service for the Blind and Physically Handicapped offers free recorded books, magazines, and music through its Talking Books lending library program. (http://www.loc.gov/nls/) Each state has at least one talking book library.
- Many states offer free radio-reading services in conjunction with a university-sponsored public radio station. Radio-reader services provide a variety of special programming for persons with disabilities, which often includes reading local newspapers.
- Pharmacies will provide large-print medication labels; many restaurants will provide large-print menus, and most businesses will provide statements and bills in large print.

5.7 Intervention for Oculomotor Impairment

Oculomotor impairment generally does not prevent the client from independently completing an occupation, but it does affect participation in daily activities and quality of life.[32, 37, 232] The client may have trouble coordinating eye movements for reading[183] and other activities. Images may double and blur; the client may be unable to sustain focus on near objects or quickly switch between near and far focal distances. These difficulties, especially when combined with light sensitivity, can cause the client to experience significant visual stress, that may trigger the onset of headache, eye strain, neck strain, and fatigue.[6, 37, 79, 106] The client may begin to avoid participating in activities that trigger visual stress. The most stressful activities often require reading or take place in community environments that require the person to adjust to bright and changing lighting such as driving. Computer work and viewing television may also cause significant stress due to sustained focus, light sensitivity, and screen glare.[79]

5.7.1 Ophthalmology/Optometry Role

Ophthalmologists and optometrists offer interventions to reestablish fusion and binocularity.[98] The intervention selected for a client depends on the prognosis for recovery, the client's ability to participate in therapy, financial resources, and the eye doctor providing the consultation. Both eye doctors use occlusion, prism, and lenses to improve vision, but they differ in their use of eye exercises.[48, 63, 137, 174, 198, 202, 203, 233, 234] Most oculomotor dysfunction resolves without intervention within six months following the brain injury.[171] During this recovery period, ophthalmologists generally only prescribe prism, lenses, or occlusion whereas optometrists may also prescribe vision therapy exercises to improve accommodation and binocular use of the eyes.[48]

5.7.1.1 Lenses

The eye doctors may prescribe lenses to reduce blurred vision in clients with accommodative (focusing) impairment. The lenses help the client achieve and maintain focus, reducing the amount of effort the client must put into reading and other near distance tasks. This often increases concentration, improves reading, and reduces headache and eye pain due to eye strain.

5.7.1.2 Prism

Both eye doctors use prism to reestablish single vision in the primary directions of gaze in persons with paralytic strabismic (see illustration 9 in Appendix J).[48, 98, 137,173] The eye doctor places the prism on the lens of the strabismic eye to shift the image until it overlaps the image from the other eye and creates single vision.[202, 203] The client wears the prism only as long as needed to maintain fusion. If recovery is expected, the eye doctor usually applies temporary plastic Fresnel press-on prisms and gradually reduces the diopter strength of the prism as the muscle weakness resolves. If recovery isn't expected or does not occur, the eye doctor may have the prism permanently ground into the client's eyeglass lens to provide the clearest vision.

5.7.1.3 Occlusion

Diplopia causes images to double and blur; the resulting distortion creates confusion for the client and limits participation in daily activities. Occlusion is often used during the recovery period to eliminate the diplopia and visual stress. Both eye doctors prescribe occlusion reduce diplopia, but optometrists also use it therapeutically to improve binocular use of the eyes.[48] If you do not have access to an eye doctor in your setting, you can-in collaboration with the rehab team-apply occlusion to restore single vision to the client (see Appendix H). As an OT intervention, you can ONLY use occlusion to eliminate visual stress from the diplopia so that the client can fully participate in activities and therapy during the recovery period. This intervention has no therapeutic purpose other than to eliminate the double image. Consult your medical director when applying occlusion following the same protocol you use to apply a splint or sling.

Two types of occlusion are used to eliminate the second image.[79, 173, 174, 202, 203] ***Full occlusion*** eliminates all of the vision in one eye using a "pirate" patch, a clip-on occluder, or opaque tape to cover the eye glass lens. Pirate patches are often used because they are inexpensive and readily available. However, the client often has difficulty tolerating the patch. The patch eliminates peripheral vision in the covered eye, disrupting normal mechanisms for control of balance and orientation to space. This may cause the client to feel off balance and disoriented when navigating environments. In addition, most clients cannot tolerate long periods of using one eye alone; the working eye becomes fatigued and the person experiences eye strain and headache. To avoid eye strain, the client is usually placed on a schedule to alternate the patch between the eyes. While this reduces fatigue and eye strain, clients often don't adhere to the patching schedule because they don't like covering their dominant eye even for short periods of time. ***Partial occlusion*** covers only a portion of the visual field in one eye-occluding just enough vision to eliminate the diplopia and still allow the client to use the eyes together to complete activities[173, 174, 202, 203] Appendix H describes two forms of partial occlusion that the OT can apply. Partial occlusion provides a kinder, gentler way to achieve single vision without disrupting balance or orientation. The client is often more comfortable and more willing to engage in activities. The main disadvantage of partial occlusion is that the occlusion tape must be applied to a pair of eyeglasses-either the client's prescription lenses or a pair of frames with non-refractive (plano) lenses. "Harry Potter" glasses are an example of inexpensive plastic plano lenses available from Amazon or other retailers.

Regardless of the intervention-occlusion, lenses, or prism-it is important that the OT work with the client and eye doctor to find the best way to manage diplopia and focusing issues so that the client will participate in daily occupations. For example, the OT may advocate for partial occlusion instead of total occlusion for a client who must navigate community environments; or advocate for a prism if the client needs to complete a significant amount of reading.

5.7.1.4 Eye Exercises

Evidence for the efficacy of using eye exercises to restore binocular function and improve oculomotor control following adult acquired brain injury is still limited and inconclusive.[18, 198] However recent carefully planned research studies have shown evidence for the effectiveness of precise exercise protocols to improve vergence and accommodation in persons with chronic mild head trauma.[208, 209, 233, 234] The evidence of effectiveness has only been demonstrated for specific exercise protocols carried out in the OD's practice (e.g., not a generic home program or set of exercises swiped from the internet). As an optometric intervention, eye exercises are not within the OT scope of practice and should only be completed by the optometrist. Read my justification for making this statement *in Opinion: Why You Should Reconsider using Therapy Time to Provide Eye Exercises to Clients with Oculomotor Impairment from Acquired Brain Injury* in Appendix I.

5.7.1.5 Surgery

An ophthalmologist specially trained in strabismus surgery completes this intervention. Surgery is recommended when the degree of strabismus is too large to be reduced with prism or fusional effort, or when a significant strabismic condition does not resolve in 12 to 18 months.[173] The eye surgeon cuts and reattaches the tendons of specific extraocular muscles to physically alter the position of the eye so it aligns with the other eye to create a single image.

5.7.2 OT Role

The OT focuses on enabling the client to participate in necessary and desired daily occupations despite the challenges and discomfort of oculomotor impairment. Persons with oculomotor impairment can independently complete daily occupations but they will avoid participating in activities that cause them to experience considerable visual stress. The conditions that occur with oculomotor impairment including light sensitivity, headache, and blurred vision can persist months to years even in cases of mild TBI and concussion.[37, 146, 216] These co-impairments when combined with visually stressful environmental features like poor or harsh lighting, low contrast, too much clutter and pattern, may cause the client to limit or eliminate participation in enjoyable and meaningful activities. The more stress provoking features the environment contains, the more likely the client will avoid it. The client may stop attending church, lunching with friends, reading books, watching TV, and surfing the internet. Relinquishing important and valued occupations can cause the client to feel depressed and less motivated to engage in daily activities. Ultimately, some clients may experience a debilitating and self-perpetuating vicious cycle often observed in persons with vision impairment wherein depression causes activity limitations and activity limitations cause depression.[118]

5.7.2.1 Education

Oculomotor impairment is short term for most clients-lasting a few weeks to a few months. The typical client can expect to eventually reestablish normal binocular function using prescription eyeglasses if needed. Because it is relatively short-term, eye doctors and members of the rehab team may feel that educating the client about their vision impairment is not important. But oculomotor impairment and co-impairments do persist (see section 5.7.2). For these clients, education on how their vision changed and especially about common co-impairments is very important to prevent the client from avoiding and dropping out occupations. Helping the client understand the cause of their visual stress enables them to take control of it and problem solve ways to reduce stress by modifying the environment and how they complete occupations.

5.7.2.2 Environment and Task Modification

The OT disrupts the cycle of depression (refer back to section 5.7.2) and promotes participation by assisting the client to modify environment/tasks and devise strategies to reduce or eliminate visual stress during activities. Intervention begins by observing how the environment and/or demands of the activity causes or aggravates the client's visual stress. For example, poor quality or glaring light in the kitchen may trigger a headache in the light sensitive client attempting to prepare a meal for the family; glare from this client's computer screen may also cause the client to experience eye watering, eye strain and headache when paying bills or completing correspondence.

The following practical interventions teach the client how to manage their visual stress and improve their self-efficacy and belief that they can control rather than be controlled by their symptoms.

- Work with the client to add contrast, increase size, reduce pattern, and find sources of comfortable lighting to create a visually explicit environment.
- Remove vision dependent steps in tasks to lessen the client's need to constantly use vision to complete activities.
- Add structure to create a consistent environment to reduce searching.
- Work with the client to establish habits and routines that minimize and reduce stress. For example, a client who experiences headache triggered by visual stress when grocery shopping might try shopping for just a few items at a time to reduce the amount of time spent in this stress-provoking environment. Alternatively, the client may prevent headaches by shopping in the early morning when the client is well-rested, and the grocery store is less crowded.
- Recommend that light sensitive clients wear fit-over filters and wide brimmed hats to reduce the amount of light entering the eye when participating in community environments (see section 5.5.2).
- Teach the client to use voiceover and speech-to-text apps on their phone and computer to reduce reading and screen time.

5.8 Intervention for Hemianopia and Visual Field Deficits

Persons with hemianopia generally have trouble completing activities that require either mobility or reading. These two performance skills underpin a significant number of I-ADLS. Slow and inaccurate search of the blind side can cause the client to have trouble navigating safely and engaging in daily occupations in dynamic environments, such as driving, shopping, and participating in community events. The client's challenges in reading result from inability to adapt their habitual eye movement strategy to the shortened width of the new perceptual span. The client experiences reduced reading accuracy and speed that limits participation in occupations like financial management, meal preparation and medication management.

5.8.1 Education

Increasing the client's awareness of the location and extent of the field deficit is a critical aspect of intervention. Most visual field deficits cause at least some permanent vision loss which is why hemianopia is considered a low vision condition. The client must learn to compensate for the vision loss in their daily activities and compensation is rooted in understanding how vision has changed. Unfortunately, perceptual completion (see section 2.4.3) makes it difficult for the client to realize the presence, extent, and boundaries of their field deficit. To successfully compensate, the client must firmly believe that the deficit exists and that the visual input from the blind side cannot be trusted. This level of insight is critical to the client's ability to resume driving and participate in activities outside of the home. Education helps the client develop this awareness and successfully apply compensatory strategies.

5.8.2 Environment and Task Modification

Persons with hemianopia function best in a structured and predictable environment because it reduces the need for constant scanning and lessens stress and fatigue. Examples of beneficial environment/ task modifications for persons with hemianopia include

- Adding color and contrast to the key structures within the environment required for safe navigation and orientation (e.g., door frames and furniture) to ensure the client sees these structures more quickly.
- Using black felt-tip pens and bold line paper to increase the contrast in writing materials, and help client more accurately monitor the pen tip in handwriting.
- Adding a high-quality non glaring task light to make print more visible when reading.
- Adding high-quality, non-glaring ambient lighting in the home and other environments to improve mobility and navigation.
- Reducing pattern in the environment by eliminating clutter and using solid-colored objects enhances the client's ability to locate items more quickly.

Consider recommending these environmental modifications to increase the visibility of the other environments that your client wants to participate in including your clinic, the client's church, office, etc.

5.8.3 Compensatory Visual Scanning Training (C-VST)

Clients with hemianopia have difficulty navigating environments because they do not turn the head far enough, fast enough, or often enough towards the blind field to take in the information needed to stay oriented and avoid collisions. When the inferior visual field is affected, as occurs with a hemianopia, the client may also have trouble monitoring the support surface on the deficit side. This can cause the client to walk slowly and hesitantly, keeping the head down and the eyes fixed on the floor directly in front of them. This strategy prevents the client from colliding with objects, but also limits their ability to monitor the surrounding environment increasing disorientation during navigation. To compensate for these mobility limitations, the client must consciously and regularly search the visual field on the blind side during movement.[60, 98, 104, 176, 177, 242, 272] Specifically, the client must learn to:

- Initiate a wide and fast head turn towards the blind field.
- Anticipate visual input from the blind field by increasing head and eye movements toward the blind field.
- Execute an organized and efficient search pattern of the blind side.
- Attend to and detect important visual details on the blind side.
- Quickly shift attention to search between the central visual field and the peripheral visual field on the blind side.

The efficacy of C-VST has been established in multiple research studies including at least four randomized control trials.[4, 56, 60, 199] A Cochrane review in 2019[176] stated that C-VST had the most evidence of effectiveness for improving visual search. It is an *important* performance skill for everyday living-all clients must be able to locate needed items in their environment and a *critical* performance skill for the client who wants to resume driving. Training focuses on increasing the speed, width, efficiency, and consistency of the client's search of the blind side.[56, 98, 107, 176, 177, 199, 205, 272] There are several types of C-VST interventions

5.8.3.1 Light Boards

Many therapists use large computerized light boards to develop the components of efficient search patterns.[23, 33, 56, 103, 222] The size of the light boards automatically elicits the wide head turn needed to search the blind side. The gaming format challenges clients to give their best effort each time and it responsively increases the skill level to facilitate progress. The devices record and analyze performance to identify deficiencies and help the client improve their performance. Figure 5.3 shows a client using the Dynavision D2[23] to improve visual search. The D2 was one of the first lightboards used in vision rehabilitation. It is no longer manufactured but many clinics still use it. Other lightboards include the Bioness-BITS,[222] Vision Coach,[33] and the NVT.[103] If you don't have access to a light board, you can use a laser pointer projected onto the wall and play "tag" games where the client searches to locate the projected laser dot as quickly as possible.

The goal of visual search training is to enable the client to quickly scan the blind side and search between sides to ensure safe navigation. Training focuses on developing these visual search components:

- Initiation of a wide head turn towards the blind side.
- Increased head and eye movement towards the blind field.
- Initiation of fast head and eye movement toward the blind side.
- Execution of an organized and efficient search pattern that begins on the blind side.
- Attention to and detection of visual detail on the blind side.
- Ability to quickly shift attention and search between the central visual field and the peripheral visual field on the blind side.

Figure 5.3: Client searching for and striking lighted button targets on the Dynavision D2.

5.8.3.2 Dual Scanning Activities

As the client masters the components of efficient visual search, incorporate them into dual task activities that require combining search with ambulation. The goal of this intervention is to train the client to keep the head up and continuously searching the environment as the client walks through it. Acquiring this skill enables the client to maintain orientation and avoid collisions while navigating environments. Intervention activities include:

- Completing extended scan courses (see section 4.5.4) using cards with letters taped onto walls in various locations along hallways.
- “Find red” activities where the client points out every red (or a different color) item in the surrounding environment while navigating towards a destination (like the gift shop).
- “Narrated walks” where the client points out landmarks, objects and changes in the environment while navigating towards a destination.
- As the client’s skill in searching improves, add in community environments. Create “treasure hunt” activities that require the client to find a specific item in designated location in the building or on the campus using landmarks and organized search strategies.

Note: If the client is unable to keep their head up during ambulation, consider trialing the use of a support cane. The cane tip provides additional tactile feedback and may help reduce the client’s desire to fix gaze directly the floor ahead.

5.8.3.3 Activities for Lower Functioning Clients

Not every client has the physical or cognitive ability to engage with dynamic light boards and community environments to improve visual scanning. Lower functioning clients require activities that proceed at a slower pace and place less cognitive demand on search and attention. Occupation-based activities carried out in quiet environments are a good place to start. Activities should emphasize initiating and completing a consistent wide search strategy to locate items on the blind side. Repetition is important. Figures 5.5 and 5.6 show examples of simple games and scan boards.

Figure 5.5: Play solitaire or double solitaire

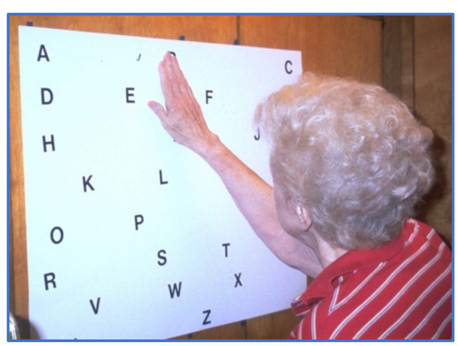


Figure 5.6: Point to letters in order on a poster board taped to wall.

5.8.4 Occupation-Based Community Activities

Combining compensatory visual skills training with occupation-based interventions is an effective way to develop these performance skills.[18, 242] Persons with hemianopia feel least comfortable in dynamic community environments. These environments can trigger anxiety (see section 2.4.3) and the client may respond by avoiding all community environments or relying on someone to lead them through the environment.[102] It is important to take the client into community environments to build confidence and independence. As the client becomes more confident navigating areas surrounding the clinic, introduce occupations in the community like shopping for groceries, mailing a letter or buying stamps at the post office, or walking through a park. To build the client's self-efficacy, carefully grade the challenge to ensure that the client will successfully complete the task. For example, begin with simple challenges like finding a single item in a small shop and expand to more difficult activities like navigating a large grocery store. Assign homework for the client to complete at least one task by themselves between sessions and increase the task demands each week. For example, homework for week one would be for a family member to walk with the client to the church sanctuary and the client goes in and locates a pew and sits down. Week 2 the family member drops the client off in front of the church and the client goes into the sanctuary, locates a pew, and sits down.

5.8.5 Supportive Habits and Routines

Teach the client to incorporate habits and routines that support independence within the home and community.

Supportive habits are especially important when navigating high-risk community environments with people and vehicle traffic, and environments with low contrast features, poor or variable lighting, pattern, and obstacles. The two most important supportive habits to ensure safe navigation are:

1. Stopping before entering an unfamiliar environment and slowly and deliberately scanning the environment to identify potential travel hazards. Common hazards include temporary and fragile displays in stores and low contrast features like curb cuts and other subtle changes in the support surface. This habit helps the client build a mental representation of the space before navigating it which increases the likelihood of success in locating needed items and avoiding obstacles. Successfully navigating a challenging environment increases the client's confidence and self-efficacy and increases the likelihood the client will regularly participate in community environments. It also reduces the client's risk of an unexpected collision and fall. It is a critical habit for every client to learn to ensure safety and participation.
2. Consciously identifying unique landmarks such as a picture on a wall or a change in wall color to assist the client to stay oriented when navigating an unfamiliar environment.

Using *supportive routines* to facilitate the use of compensatory strategies is equally important. Examples of key supportive routines include:

- Shopping at times of day when there are less crowds.
- Choosing well lighted walkways with minimal obstacles.
- Arriving early to social/community events to settle in before others begin to arrive.

Examples of supportive habits and routines that **ALL** clients should use to facilitate compensation include:

- Turning on room lights when navigating (don’t navigate in the dark!).
- Placing task lamps with LED lights where tabletop tasks will be completed *and* turning on the light on to illuminate tasks.
- Structure cabinets, shelves, drawers to find a place for everything and then *return* everything to its place.
- Keep keys or other items in a bowl or on a hanger next to the door.
- Put the lid back on an item after using it (if you knock it over it won’t spill).

5.8.6 The Client Who Wants to Resume Driving

Research shows that persons with hemianopia who have learned to compensate for their field loss can safely resume driving with specific training (see Bowers[30] for an indepth review of driving with hemianopia). Client factors that influence successful return to driving include:

- The statues that govern driving in your state, province, country. Driving with a field deficit may not be permitted.
- The extent of the visual field deficit. The less field loss the better. Clients with quadrantanopia, macular sparing, and relative field loss have more vision to use than the client with a complete hemianopia and dense field loss.
- The presence of co-impairments. Clients with impaired contrast, hemiplegia, neglect, and aphasia are less likely to be able to successfully resume driving.
- The client’s driving record. A client with a history of multiple accidents and citations was an unsafe driver before field loss and will likely be one after.
- The driving environment. Driving in rural areas is easier that driving in a city. Driving on flat, straight wide-open terrain (western Kansas-flat as a pancake) is easier than driving on hilly/mountainous curvy terrain.
- The client’s driving needs. Running a few errands close to home vs. driving to work in rush hour traffic.

Do not refer the client to a driving program until they have mastered compensatory visual scanning in dynamic community settings and fully understand how their field loss affects the ability to use their vision during driving. Driver’s training should focus on minimizing risk:

- Select routes with minimum merges and lane changes.
- Avoid multi-lane traffic.
- Position the car so that evasive maneuvers, if needed, can be made towards seeing side.
- Restrict night and dusk/dawn driving.
- Use wide rearview mirrors and select a vehicle with good rear visibility.
- Restrict driving to just what is needed to complete the task.

5.8.7 Reading

Reading is an important fundamental skill needed to participate fully in daily activities. The inability to read not only reduces the person's ability to complete pleasurable activities but also to acquire information needed to be healthy, safe, and autonomous. Persons with hemianopia often have the language skills but not the visual skills to read. They stop reading because they must put so much effort into seeing words and navigating text. Research shows that, with daily practice and persistence, persons with hemianopia can improve their reading speed and accuracy.[4, 164, 211, 212] Not every client can or will devote the time and energy required to improve reading performance, but every client needs to be able to acquire information normally provided in print form. The intervention goal should be broad: *to enable the client to compensate for the vision impairment to obtain and understand printed information.* You can achieve the goal by improving the client's ability to read printed text or by using technology to enable the client to obtain needed information via another method.

5.8.7.1 Intervention for the Client Strongly Motivated to Resume Reading Print

The primary challenges in reading occur because the client is trying to read using a saccade strategy designed for a wider unrestricted perceptual span. To improve reading speed and accuracy, the client must adapt their saccade strategy to the new perceptual span created by the hemianopia. This is a demanding task that can be extremely frustrating for the client. Provide a structured home program focused on daily periods of short practice. Evidence-based interventions to improve reading are being developed [164, 212] but currently many require special equipment and significant practice time which reduces their feasibility as an OT intervention. I have used the following two step intervention for many years to assist clients to put in the practice time required to improve their reading performance. Depending on the client's progress, Step 1 is usually completed while the client is still receiving therapy and Step 2 as a long-term home program following discharge.

Step 1: Begin with search and find exercises that require the client to locate, and mark designated letters, numbers, or words on worksheets (see Figure 5.7). Use pre-reading exercises such the Warren *PreReading and Writing Exercises for Persons with Macular Scotoma* (available as a free resource download on www.courses.visabilities.com or purchase the Wright and Watson *Learn to Use Your Vision Reading Workbook* Large print word and number search books and crossword puzzles are also excellent practice materials and are widely available in stores. The low cognitive requirements of these exercises enable the client to focus on perfecting the saccade strategy needed to move the new perceptual span across the page. The client completes these worksheets daily, devoting 20-30 minutes each day.

Modifications like drawing a bold red line down the margin of the text will assist the client with a left hemianopia to find the beginning line of text or a client with a right hemianopia find the end of the line of text. Clients with difficulty staying on the line of text, or moving from line to line, may benefit from using a ruler or card to maintain their place. These modifications improve accuracy but reduce reading speed. They should NOT be permanent modifications; the client should relinquish them up as reading performance improves.

Step 2: As the client's ease and accuracy improves, switch to an occupation-based approach to transition into reading continuous text. Assist the client to select a large print book on a familiar topic or by favorite author and instruct them to read a chapter a day. The large print format reduces the density of the text, requiring less saccade precision, and the familiar subject matter reduces the cognitive demands on the client. The client should continue reading books daily until reading becomes less taxing-this could take several months to a year.

As the client's saccade pattern changes with practice, a client who wore bifocals prior to the hemianopia may have trouble seeing clearly through the reading portion (bottom of the lens) due to its restricted field of view. The client may need to be fitted with single lens reading glasses or possibly executive line bifocals to provide a wider field of view.

3M

Cross out the designated letter everytime it appears in the line

a bcdheaghfaeslgagachtarubaqofsat

b cdhbhuierboputybuiondblkiubyuine

c ghtdcopoacehjuehjcdcjashuciopacf

d ghjendeuiwdilldjkdjdlkwerbduiodqw

e ceoauchjebnhydecoiceeasopevbgn

f yuijptfjklipfurtyfxvnbfttujiklpiterijwe

g htygjklmpjechgjygeopghgeicbopygi

h qwbhjkbkpvbsxefguhrthjkihqwsbhjh

i qwiojlibhingbfhiopwjjecntuijkllilawjk

j turijklmngifhrgjjtityruvbiwerjoilgyiih

k qwekigfznvbtklopilklikhtgyrgkiiheui

l uimenlkiopjlfrtltryewlmngoplkjtlnvhl

Figure 5.7: PreReading exercise sheet from the *PreReading and Writing Exercises for Persons with Macular* Scotoma (free download). The client is instructed to cross out all of the letters on the line that match the designated alphabet letter on the left side of the page (e.g., a, b, c,).

5.8.7.2 Key Interventions for **ALL** Clients with Reading Limitations

Assistive devices and technology enable clients to acquire information without reading. The OT assists the client to determine the best device, app, and software to meet their needs.[52] Begin by modifying accessibility features on devices the client already uses (e.g., smartphone, computer, iPad).

- Adjust the brightness and background color of the screen.
- Enhance the size, color, and boldness of text, icons, and cursors.
- Train the client to use built-in features, such as zoom, voice-over, and speech to text.
- Locate apps and software that will enable the client to complete a specific task using voice commands.
- Train the client to use talking devices. Examples include talking glucose monitors, scales, blood pressure meters, watches, clock, calculators, and food scales.

Train the client to use internet-connected virtual assistants (e.g., Siri, Echo etc.). Program the device to perform functions such telling the time, outside temperature, and weather forecast, ordering items, dialing the phone, and setting the thermostat or a timer. Remember that training is critical-be sure to provide instruction on how to use all apps, software, or devices to ensure the client can use them to meet their daily needs.

Require that the client "teach back" instructions on using all new devices. Teach-back is an evidence based and effective method for ensuring that a client understands the instructions they have received.[97] Before ending the session, ask the client to repeat back or demonstrate what they learned. For example, the client repeats back the instructions for using the voice over feature on their phone. Observing the client repeat instructions provides an opportunity to review and reinforce important steps. Older adults need at least two teach back sessions to consolidate their learning of new information: one immediately following instruction and one two weeks later.[119]

Whenever possible try to eliminate the need for the client to read and write-for example set up automatic prescription refills from the pharmacy (while you are at it-alert the pharmacist that the client needs large print labels). Set up automatic bank payment for regularly recurring bills like water, electricity, gas, and the internet.

5.8.8 Handwriting

Increase the client's handwriting legibility by teaching the client to slow down and monitor the pen tip as the hand moves across the page into the blind side. Activities that require the client to trace lines and shapes help them learn how to position the paper and pen so that the pen tip stays visible on the line (see Figure 5.8). The Warren *Prereading and Writing Exercises for Persons with Macular Scotoma* provides practice sheets to improve handwriting legibility (available as a free resource download on www.courses.visabilities.com. Other occupation-based activities include practice filling out a blank check and check register, addressing an envelope, and filling out a form (collect sign-up inserts from magazines to use for practice).

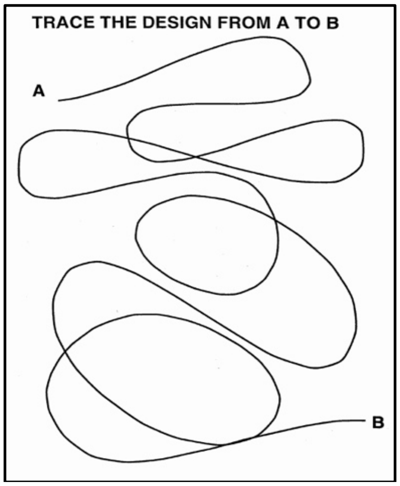


Figure 5.8: Prewriting Exercise Sheet from the *PreReading and Writing Exercises for Persons with Macular* Scotoma (free download). The client is instructed trace the line from A to B

5.9 Neglect

Persons with neglect have trouble locating and using resources from the environment to complete daily activities. Performance limitations may include difficulty locating items on the left side in daily tasks,[10] sustaining attention long enough to complete an activity,[245] dividing and shifting attention between tasks,[245] and rapidly and accurately assessing situations in dynamic environments.[275] Generally, the more dynamic and ambiguous the environment, the greater the limitations the client will experience due to the increased demands on visual attention.[29, 245]

The goal of OT intervention is to enable the client to use their attentional capabilities to complete needed daily activities. The OT intervention focuses on creating an environment that supports attention, improving the client's ability to compensate for inattention when searching tasks and environments, improving the client's ability to sustain attention to task completion, and developing habits and routines that reduce visual stress.

5.9.1 Chronic vs. Acute Neglect

The incidence of visual spatial neglect averages between 50-70% in the early stages of recovery from a right hemisphere brain injury.[83, 107, 244] Fortunately, most neglect resolves during the first year of recovery and is significantly diminished by three months post injury in most persons.[83, 120, 61, 244] Disruption of the pathways that connect the frontal, temporal, parietal and occipital lobes to each other may account for the initially high incidence of neglect immediately after injury and the good potential for recovery.[65] Person's whose neglect persists beyond three months may have significant and chronic deficits that reflect structural rather than pathway damage within the brain.[120]

5.9.2 Education

Education is a key component of intervention process as the client must develop insight into how neglect has changed their visual search and attention before they can learn how to reorganize visual search to compensate for neglect.[130, 228, 229] Education begins during evaluation by using cuing and feedback to alert the client to deficiencies in their search pattern. During intervention the OT can use the client's difficulties or mistakes as "teachable moments" to improve insight into capabilities and limitations.[123, 130, 228]

5.9.3 Environment and Task Modification

The most powerful tool in the OT toolkit is to create an environment that **facilitates and supports attention.** The key question to ask when planning the intervention is "How can I modify the task/environment to help the client use their current attentional capability more effectively to complete occupations?" Then focus on modifications that reduce demand on the client's visual attention to help them use their limited attention capabilities. The most important modification is to eliminate and minimize features that place stress on visual processing. The components of this modification include:

- ***Reduce pattern***. This is the most important modification as dense pattern forces the client to use more selective attention to locate desired objects.[70] The client may not be able to sustain the mental effort needed to sift through lots of pattern and subsequently views the environment as filled with "visual noise" rather than meaningful objects. Reducing distractors has been shown to improve effectiveness of the search pattern in persons with neglect.[55, 112, 161]

- ***Increase the visibility of features that trigger prediction and sequencing***. Remember that the neocortex initiates and guides actions by predicting what is going to happen, verifying it through sensory feedback, and modifying as needed (see section 1.2).[14] The process begins with detecting and recognizing the environmental feature that will trigger memory and unlock the sequence. A visible and explicit environment makes it easier for the client to recognize key features and create a meaningful context for action.[70] Research has shown that making targets more explicit elicits an efficient and faster search pattern in persons with neglect by creating a "pop out" effect that grabs the person's attention.[55, 70, 112, 161] For example in a hospital setting wrap a piece of bright orange fluorescent tape around a call button cause it to pop-out against the bed sheets and railing.

- ***Strategically add task lighting to spotlight the components of an ADL task*** helps the client focus attention to complete the task (see Figure 5.2). Green et al.[94] found that adding a task lamp to spotlight the components of a grooming task enabled clients with neglect to perform the task more quickly and independently resulting in an improved FIM score.

- **Add structure and organization**: Finding a place for everything and keeping everything in its place is the final critical piece in creating an “attention promoting” environment.[70]

5.9.4 Compensatory Visual Scanning Training

Compensatory visual scanning training (C-VST) has a sufficient level of evidence to be considered a practice standard for interventions aimed at reducing the effect of spatial bias on the client’s search pattern.[46] VST is a top-down compensatory approach that employs the higher-level functions of language and cognition to help the client learn and employ a structured search pattern that begins on the left side of a visual array and progresses left to right.[18, 83, 88, 178, 129] This structured pattern helps the client compensate for the tendency to restrict visual search to the right side and increases the symmetry of the search pattern. You can use a variety of activities, and occupations to provide practice using this compensatory pattern.[123, 242] Use these guidelines to select an optimal visual scanning task:

- ***Select activities that require the client to search as broad a visual space as possible***. To help the client learn to initiate and complete a wide visual search, make the working area of the activity large enough to require the client to either turn their head or change body positions to accomplish the task.

- ***Select activities that require the client to interact physically with the target***. Attention is more focused when the person must act on what is seen.

- ***Select activities that require conscious attention to visual details and careful inspection and comparison of targets***. To facilitate selective attention, require the client to consciously study objects to identify their relevant features. Games such as solitaire, Connect Four, checkers, and dominoes have these qualities. Large piece puzzles, word or number searches, crossword puzzles, adult coloring books and crafts such as latchet hook, knitting and paint by number also require selective attention. Encourage the client to recheck their work to make sure that critical details are not missed.

- ***Select activities that require the client to sustain attention***. Several influential researchers believe that the inability to stay on task underlies neglect and contributes to its chronicity, and that rehab focused on sustaining attention can reduce neglect behaviors.[185, 223, 235, 237, 245] Interventions that employ continuously challenging and interactive activities have been shown to increase alertness and the ability to sustain attention.[223, 235, 245] Fast-paced light board and video games that use a go-no-go format are examples of activities that challenge the client to sustain and shift attention.[235 ,245] All instrumental ADLs require sustained attention and most also require the client to interact with left and right space. Activities with these qualities include:
    - Large (outdoor) versions of popular games: checkers, Connect 4, chess, tic tac toe (check out good ole Amazon to see the selection).
    - Light boards (see section 5.8.3.1) provide many wide, interactive games.

- Low-cost games include scatter sticky notes of various colors over a wide wall and instruct the client to locate and group them by color or playing laser tag-where client uses a laser pen to “tag” a laser dot that you project onto the wall.
- Occupations that require physical interaction with a wide visual space including planting, watering, and weeding flowers in a garden, cooking, cleaning, and laundry.

5.9.4.1 Visualization

Niemeier[158] demonstrated that clients with severe chronic neglect could be taught to search left space using a visual imagery technique called the “lighthouse strategy” (p. 40). The intervention placed a simple line drawing of a lighthouse in the client’s line of sight to act as a visual cue. The client was instructed to look at the image and imagine searching like a lighthouse to scan widely from left to right. All rehab staff cued the client to imagine being a lighthouse before completing an activity. Study participants required various amounts of rehearsal to learn the strategy and a statistically significant improvement in search performance was found following the training. The findings were replicated in a second study that showed statistically significant improvements in route finding, navigation (with or without a wheelchair) and problem-solving tasks.[159]

5.9.5 Sensory Input Strategies

Sensory input strategies use a bottom-up approach that alters sensory input into the brain to reduce rightward spatial bias and increase attention to the left.[83, 90, 160, 172] Yoked prism adaptation is currently the most widely used sensory input intervention.[83] Multiple studies, including several randomized control trials, have been published on the use of this intervention in patients with neglect.[83] For the intervention the client wears strong prisms (embedded in an eyeglass frame) while completing a task that requires monitoring of the hand such as placing or painting an object. The prisms shift the image of the task items toward the right side. To successfully complete the task, the client must learn to shift towards the left to compensate for the rightward shift of the items. Repeatedly completing tasks while wearing the prism results in increased attention to left space after the prism is removed. While most studies show increased attention to the left some show inconsistency in the lasting effect of the shift. Further research is needed to establish the best protocols to achieve an optimal outcome.[61, 83, 88, 130]

Small studies have shown that applying galvanic vestibular or optokinetic stimulation, neck muscle vibration, transcranial magnetic stimulation and using constraint-induced therapy with patching can increase orientation towards the left side in persons with neglect.[83, 88, 125, 178, 272, 276] More research is needed to determine the most appropriate clinical application of these interventions before they will be used widely in rehabilitation.[88, 125, 252]

5.9.6 Occupation-Based Intervention

Using occupation as the intervention helps you select emotionally relevant and meaningful activities. Emotions tell the brain to "pay attention-this is important" and valued and practiced activities enable the client to tap into expertise to reduce effort and fatigue.[74, 102, 130, 181, 203] The effectiveness of using occupation to improve attention is supported by a body of research showing that engaging persons with neglect in emotionally relevant and motivating activities increases attention to the left side.[26, 102, 130, 163, 203, 204, 229] Tham et al.[229] found that participation in everyday activities that were personally relevant and meaningful made it easier for clients with neglect to learn compensatory search strategies because the client was interested in using the strategy to complete the task. Klinke et al.[130] confirmed the importance of using daily activities in a qualitative study on persons with chronic neglect. Participants reported that it was easier to attend to concrete and meaningful tasks, and tasks that held high emotional relevance. For example, one participant reported how much easier it was to hold her baby and prepare formula for her than to make coffee (which she did not drink) and hold a coffee cup. Participants also reported that it was easier to apply compensatory strategies when using familiar items to complete the task.[229] Activities that place too much demand on attention can exacerbate spatial bias in persons with neglect.[29, 245] To avoid overwhelming the client, grade the activity to provide the "just right" attentional challenge. For example, start with preparation of a simple breakfast and progress to a four-course meal. Occupations that incorporate both sides of the body like playing musical scales on a piano or listening to music played through headphones have also been shown to reduce neglect.[20, 27, 42, 105] Delivery of the intervention is also important. Tham and Kielhofner [228] and Klinke et al.[130] found that nurturing and positive responses from staff and family increased the participant's motivation to learn compensatory strategies to increase awareness of the left side.

5.9.6.1 Provide Explicit Instruction and Outcomes

Persons with neglect respond poorly to ambiguous situations because they put more stress on working memory.[55] To reduce stress provide complete and simple directions and an explicit outcome. For example, instead of instructing the client to "*put the cookies on the baking tray"* say *"place 12 cookies on the tray"* and instead of *"brush your teeth"* say *"brush your teeth for 10 counts."*

5.9.6.2 Repetition is Important

Repeatedly applying the compensatory left to right search strategy under varied circumstances, helps to generalize it as a performance skill that can be applied to new situations.[123, 238] Ensure that the client consistently uses the pattern with all ADLS. For example, to select clothes from a closet, search for items in a refrigerator, or shop for groceries. Utilize cafeterias, gift shops, and office areas within your facility and surrounding restaurants and shops to expose the client to more demanding visual environments.

5.9.7 Metacognitive Approaches

The metacognitive approach is an effective intervention for clients capable of using language and cognition to focus attention.[46] The intervention uses a reflective, problem-solving approach that requires the client to plan, execute and evaluate the successful completion of a task. An example of a metacognitive approach is to require the client to first describe the steps to putting on a shirt, then state each step out loud while donning the shirt and conclude by reviewing whether the shirt was donned correctly. Tham et.al.[230] used a metacognitive approach to improve ADL performance in with participants with chronic neglect. They found that teaching the participant to consciously reflect on how to proceed before beginning (to plan the activity) and continue to consciously reflect while completing the activity (to monitor performance) increased the likelihood of a successful outcome. An OT intervention-the *Cognitive Orientation to Occupational Performance (CO-OP)*-has been used extensively to facilitate occupational performance in persons with neurological conditions[204] and specifically shown to improve performance in persons with mild TBI.[3, 46, 57, 58, 110]

5.10 Complex Visual Processing

In everyday living, complex visual processing is applied to solve a problem, formulate a plan, and make decisions about specific situations. The OT's understanding of the client's visual processing limitations gathered from assessments and observation is helpful, but it can't predict how the client will actually perform within the context of a practiced and valued occupation. Typically, tasks that require complex visual processing also demand complex cognitive processing. The person relies not just on vision, but on a variety of sensory input and memories to determine the right course and complete the task. A client who is very experienced in completing a complex task is quicker to recognize the salient features of the visual scene and recall and formulate a successful plan when performing within the familiar context of the occupation.[150] For example, an experienced driver who has lived in the same area for many years would likely perform more competently when driving the familiar roads he traveled a hundred times than in the artificial context of a driving simulator. Because of the contextual nature of complex visual processing, the best way to determine whether a client can complete a complex occupation is to observe their ability to accomplish the tasks required for the occupation. For example, if the client is a teacher, the OT should assess their ability to develop lesson plans, teach a lesson, grade a paper, or other aspects of the job. Providing the intervention in the actual environment (e.g., at the teacher's school) is optimal but not always possible. In this case, the OT should simulate as closely as possible the client's natural context for the task. This requires some creativity and effort, but it is the best way to provide a fair assessment and determine whether the client can resume the desired occupation. This is also the justification for using an on-the road assessment to determine the client's ability to resume driving instead of a battery of neuropsychological tests or a driving simulator.

5.11 Final Thoughts on Intervention

Everything we do as human beings involves sequencing actions over time to accomplish our goals. The brain links incoming visual input with past experience to unlock the context for an action and predict what is going to happen next. The process begins with detecting and recognizing the task/environmental features that will trigger visual memory and unlock the sequence. Brain injury or disease that disrupts visual processing creates gaps in the visual information sent to the brain. The quality of a person's occupational performance decreases because the brain receives inaccurate or insufficient visual information to guide actions. The need for OT intervention depends on whether the visual impairment prevents the client from successfully participating in needed and desired daily living activities.

Assessment is the first step of intervention. The framework for assessment and intervention rests on the concept of a hierarchy of visual processing levels that interact with and sub-serve one another. Because of the unity of the hierarchy, a process cannot be disrupted at one level without an adverse effect on all visual processing. To understand how the client's vision has changed and more importantly, how well the client is able to use vision to complete daily activities, OT assessment must measure performance at all levels of the hierarchy and especially the foundation visual functions: acuity, oculomotor control, visual field, and visual attention. For example, left hemianopia may cause a client to miss objects in the left visual field, creating the impression that the client ignores the left side-a characteristic of neglect. In this case, assessment needs to answer the question of whether the client has normal attentional capability but poor ability to compensate for the hemianopia, or left neglect compounded by the presence of a left hemianopia.

The OT role is to ensure that the client participates in daily occupations. The most powerful tool in the OT toolkit is to use modification to create a visible and explicit environment that facilitates the client's ability to use vision to complete occupations. Improving person-environment/task fit reduces the stress caused by vision loss and increases participation in daily occupations. There is no guarantee that the client's visual capabilities will recover, and much more research is needed to determine the most efficacious interventions to restore visual processing. Instead of focusing on a cure, the OT must maximize the client's ability to use their current visual processing to successfully complete valued occupations, keeping in mind that engagement in daily activities also promotes neuroplasticity within the brain and improves health related quality of life.[63, 206, 229, 252]

The team approach is critical to achieve an optimal outcome. The client benefits most when a team approach is used to address vision impairment from brain injury. The optimal rehab team includes optometrists, ophthalmologists, and vision rehabilitation specialists. These professionals provide a different perspective and skill set that can help the client use their vision more effectively. Seek out these professionals and advocate for multi-disciplinary teams.