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.

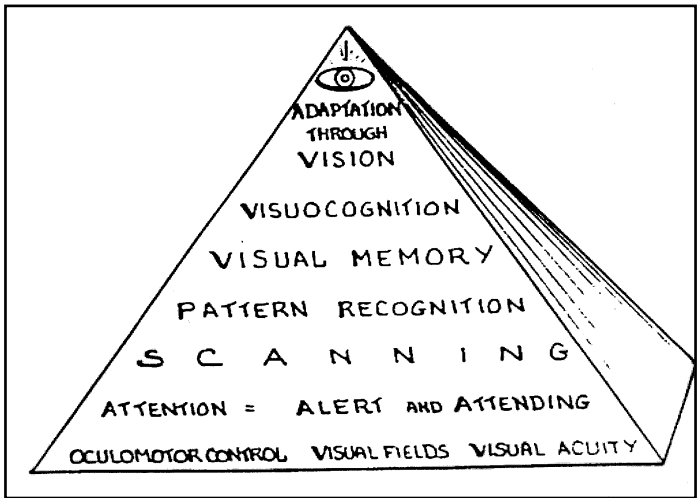

Figure 1.1: The Visual Perceptual Hierarchy. *Illustration courtesy of Josephine C. Moore OT, PhD.*
Working together, these processes enable ***visual cognition***, the highest-order process in the hierarchy.

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.