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Abstract

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Approximately one-third of the human brain controls visual anatomy or transmits and registers visual information (Kapoor & Ciuffreda, 2002). Because of this, acquired brain injuries ABI can frequently cause visual impairment. Following an ABI, it is important for visual deficits to be taken into account and addressed during occupational therapy evaluation and treatment.

Although considered a primary sense for obtaining information, vision is often ignored or overlooked in rehabilitation programs. Vision screens should be conducted and collaborations and referrals to a neuro-optometrists made. There is a lack of research regarding the benefits of visual interventions with individuals that are more than two years post-injury. The project looked at benefits of addressing visual deficits in individuals who have experienced a ABI and are five years or more post-injury. A vision program was established at a day enrichment center for individuals' years post-injury. Vision programs were established in collaboration with a neuro optometrist and performed at an inpatient brain injury rehabilitation center. Two different case studies and a pilot study detail the benefits of a comprehensive vision program in individuals who have experienced a traumatic brain injury. A pilot study was conducted to monitor the benefits of development of a program to address visual deficits effecting reading with individuals more than five years post-brain injury. There is potential for ocular motor deficits such as pursuits and saccades to improve with continued training and for improvements in visual deficits to improve performance in activities of daily living.

An acquired brain injury (ABI) is any kind of brain injury acquired after birth, including traumatic brain injury (TBI) and cerebrovascular accident (CVA) (Kapoor, Ciuffreda, & Han, 2004). Traumatic brain injury has become more prevalent with an increase of military service members returning from tours of duty with combat blast injuries and an increased focus on concussive sports injuries (Cockerham et al., 2009). Other common causes of TBI include motor vehicle accidents and falls. Approximately 2.5 million people experience a traumatic brain injury that requires hospitalization each year (CDC, 2010). CVA, or stroke, is the major cause of chronic disability, affecting 700,000 individuals per year (Cohen, Fadul, Jenkyn, & Ward, 2008). Acquired brain injury affects an individual's ability to return to work and increases difficulty of returning to previous quality of life, making it a major health, economic, and occupational concern (Ciuffreda, Kapoor, Rutner, Suchoff, Han, & Craig, 2007).

Approximately one-third of the human brain controls visual anatomy or transmits and registers visual information (Kapoor & Ciuffreda, 2002). Because of this, brain injuries can frequently cause visual impairment. Visual deficits, as a result of brain injury, are often confusing for the individual who sustained the injury and their family members and can affect the rehab process (Ripley, Politzer, Berryman, Rasavage, & Weintraub, 2010). Occupational therapy can assist the person in improving their ability to participate in function independently in all aspects of daily life, including work, self-care, and leisure (AOTA, 2013). Increased awareness of vision problems, and effective assessments and interventions to identify and treat

vision deficits, will assist occupational therapists in helping patients maximize their level of function. The purpose of the project was to increase knowledge in techniques, both remedial and compensatory, that occupational therapists can use to treat vision problems related to ABI. The secondary purpose is to see if there is opportunity for vision problems related to acquired brain injury to continue to be addressed more than 10 years post injury.

Vision Deficits in TBI

All lobes of the brain have a role in visual processing. The primary visual cortex for initial processing vision is located in the occipital lobe (Sutter, 2011). Nerve pathways in the visual cortex lead to higher centers in the parietal and temporal lobes, where meaning is given to visual sensations (Scheiman, 2011). Lesions to the visual cortex and associated areas can produce a variety of visual and perceptual problems. Motion processing takes place in the middle temporal lobe (Sutter, 2011). Processing of spatial organization and visual attention takes place in the parietal lobe. Visual awareness is a result of interactions between the primary visual cortex, posterior parietal cortex, and the frontal eye fields. The cerebellum assists the muscular system in coordinated smooth movements (Scheiman, 2011). Dysfunction in the cerebellum can cause equilibrium, motor control, laterality, reading and speech problems. Because of the large distribution of visual areas of the brain, most TBI patients experience some level of visual dysfunction (Sutter, 2011).

Daily tasks such as showering, dressing, reading, walking, and working may be affected by visual dysfunction. Occupational therapists are qualified to assist in treating vision problems related to brain injury using both vision therapy and low vision techniques. Vision therapy utilizes remedial techniques to improve visual deficits. Low vision is a condition caused by eye disease in which vision is 20/70 or poorer in the better-seeing eye and vision cannot be improved

with eyeglasses (Scheiman, Scheiman, & Whittaker, 2007). Low vision techniques utilize a compensatory approach to teach individuals to use tools that will assist in compensating for visual deficits. Vision therapy and low vision techniques can be used simultaneously during an occupational therapy treatment session. A therapist might assist a patient with brain injury in using the vision they have left or have regained while simultaneously teaching compensatory techniques for deficits that may not be recovered.

Importance of a Vision Rehabilitation Team

A vision rehabilitation team can consist of a physician, an optometrist or ophthalmologist, occupational therapist, nurse, behavioral therapist, family members and patients, and various other members of the rehabilitation team (Ripley, Politzer, Berryman, Rasavage, & Weintraub, 2010). The occupational therapist's role in the team is to be responsible for the initial screening for visual disorders and refer to the interdisciplinary vision clinic. The OT assists in conducting exercises and treatments that were prescribed by the optometrist as oculomotor exercises are patching and incorporate these treatments into activities of daily living (Ripley, Politzer, Berryman, Rasavage, & Weintraub, 2010). Having a vision rehabilitation team for patients with acquired brain injury allows for early assessment and treatment of issues that could affect rehabilitation.

Importance of the Vision Screen

Vision screening conducted by an occupational therapist can help detect unrecognized visual deficits, guide referrals, and help the rehabilitation team better understand patient behavior and performance (Radomski, Davidson, Voydetich, & Erickson, 2009). Individuals with brain injuries are often unaware of their deficits and have not yet attempted complex visual tasks, increasing importance for early vision screening (Raymond, Bennett, Malia, & Bewick, 1996). It

is recommended that visual field, visual acuity, oculomotor function, pattern recognition, and visual attention are all administered as part of a comprehensive visual assessment (Raymond, Bennett, Malia, & Bewick, 1996).

There are not standards in place for vision screens given by occupational therapists to adults with traumatic brain injury, and many existing vision screens have not been standardized on adults (Radomski, Finkelstein, Llanos, Scheiman, & Wagener, 2014). A panel consisting of occupational therapists and optometrists rated various vision tests to compile a vision screening for service-members with traumatic brain injury and made recommendations for assessments to include in a comprehensive vision screening for adults with TBI (Radomski, Finkelstein, Llanos, Scheiman, & Wagener, 2014). The recommended sequence allows for accurate results and factors in the high fatigue level of individuals with traumatic brain injury. The assessment materials cost between \$300-\$900 and can take 5-20 minutes to administer. The assessment has not yet been standardized and may require some shifting in the sequence to be used most effectively with individuals with TBI that are not service members (Radomski, Finkelstein, Llanos, Scheiman, & Wagener, 2014). Because clients' goals often include potential safety hazards, such as returning to driving, work, and living alone, a thorough perceptual/vision screening tool for occupational therapists to administer is necessary (Cooke, Mckenna, & Fleming, 2005).

Oculomotor Dysfunction

Eye movements include motions that shift the direction of eye gaze such as saccades, pursuits, and vergences (Sutter, 2011). They also include movements that steady eye gaze such as vestibular driven movements and fixation. Impairment to eye movements is known as oculomotor dysfunction (Kapoor, Ciuffreda, & Han, 2004). Saccades are quick eye movements

made to change the object of fixation (Sutter, 2011). Saccades are the eye movements used to follow words while reading or change objects of fixation while driving. After suffering a brain injury, individuals often use unsystematic search patterns compared to clockwise circular scanning patterns used by non-brain injured individuals (Raymond, Bennett, Malia, & Bewick, 1996). Individuals with brain injury that have acquired primary saccadic dysmetria will often complain of deficits in their reading skills, this is because the saccades are overshooting or undershooting (Sutter, 2011). A saccadic technique that has been deemed helpful includes holding a page that contains several rows of sentences with a few paragraphs, saccading to the first word in the first line, calling it out, fixating on the word for 3 to 5 seconds, then saccading to the last word in line one, fixating on it, and calling it out (Ciuffreda, Ludlam, & Kapoor, 2009). This technique trains saccades and fixation in a natural context similar to reading and can be graded up by including distractions. Another useful strategy includes holding a flashlight at arm's length from the face and using the eyes to follow the flashlight horizontally, diagonally, and vertically (Markowitz, 2006). These exercises can help train smooth eye movements and fixation. Saccadic training may improve motor performance through practice, through motor learning and neural plasticity of the brain (Kapoor, Ciuffreda, & Han, 2004).

Pursuits are eye movements used to follow a moving object and keep a clear image of it on the retina (Sutter, 2011). Vision therapy is most effective in treating deficits and pursuits when patients are able to monitor any jerkiness in their eye movements (Sutter, 2011). Pursuits can be trained by moving a large target in a slow and smooth manner and grading up to a smaller target while having the patient focus on the target (Ciuffreda, Ludlam, & Kapoor, 2009). This can be graded up by adding a cognitive task or other multitasking.

Convergence insufficiency has been found to be a common oculomotor dysfunction associated with acquired brain injury (Ciuffreda, Kapoor, Rutner, Suchoff, Han, & Craig, 2007). Vergence was trained in individuals with acquired brain injury by teaching visual scanning techniques, visual search of targets, and sustaining vergence during various cognitive demands with participants showing a significant reduction in their primary symptoms (Ciuffreda, Rutner, Kapoor, Suchoff, Craig, & Han, 2008).

Individuals with acquired brain injury often experience reading problems due to a variety of oculomotor abnormalities like saccadic intrusions, jerk nystagmus, and saccadic dysmetria (Ciuffreda, Han, Kapoor, & Ficarra, 2006). When given saccadic training using visual and external auditory feedback over an 11-week period, individuals with acquired brain injury showed improvement in reading ability. Training also carried over to non-reading activities such as improved visual scanning and increased eye contact (Ciuffreda, Han, Kapoor, & Ficarra, 2006). It is important to assure oculomotor training transfers to improvement in activities of daily living by practicing saccadic movements during activities such as cooking and hygiene tasks (Ciuffreda, Ludlam, & Kapoor, 2009).

Accommodative dysfunctions occur when the eyes have trouble sustaining focus on a near point (Sutter, 2011). Symptoms of accommodative deficits like blur and double vision (intermittent diplopia) can affect emulation, driving, and reading ability, and could cause an individual to not want to participate in these occupations (Green, Ciuffreda, Thiagarajan, Szymanowicz, Ludlam, & Kapoor, 2010). Accommodative dysfunctions are often treated with lenses and training is often needed to adjust to the lenses or be able to identify when separate reading glasses are needed (Sutter, 2011).

In strabismus secondary to traumatic brain injury, diplopia causes deficits and spatial judgments, reading, eye-hand coordination, and mobility (Sutter, 2011). Patching is often used to treat traumatic brain injury patients with diplopia, but reduced use of the patching can diminish the chances of recovery (Sutter, 2011). Partial patching or patching under restricted time limits is recommended.

Visual acuity measures the smallest high-contrast detail one can resolve, measured with letters or words (Scheiman, Scheiman, & Whittaker, 2007). This is usually expressed in terms of 20/20 visual acuity, meaning if someone was tested at 20 feet, the smallest letter they could see is large enough that someone with normal visual acuity could see it at 20 feet (Scheiman, Scheiman, & Whittaker, 2007). The Snellen Visual Acuity Chart is the most common way visual acuity is measured. These charts are not recommended for clients with low vision because they do not have smog radiations in the poorer visual acuity range (Scheiman, Scheiman, & Whittaker, 2007). For clients with low vision, a Low Vision Distance Visual Acuity chart is recommended. Traumatic brain injury patients with decreased visual acuity will often benefit from low vision rehabilitation techniques such as increased contrast or a magnifier for reading (Sutter, 2011).

Contrast sensitivity measures how well an image can be distinguished from a uniform field (Scheiman, Scheiman, & Whittaker, 2007). Decreased contrast sensitivity can cause vision to appear cloudy and affect mobility, driving, reading, writing, and almost any activity where identification of form and shape are important (Scheiman, 2011). Poor contrast sensitivity can cause problems seeing objects during night driving or identifying safety hazards that can potentially cause a fall.

Visual Field Neglect

A visual field is how much a person can see when looking straight ahead at the point of fixation (Scheiman, Scheiman, & Whittaker, 2007). In the normal visual field, one can see everything superior of the fixation point about 50 degrees, inferior early about 70 degrees, temporally about 90 degrees, and nasally about 60 degrees. This means that with only one eye open an individual has a horizontal visual field of about 150 degrees and vertical visual field of about 120 degrees (Scheiman, Scheiman, & Whittaker, 2007). The definition of low vision includes visual field, and a person is considered legally blind if the visual field is 20° or less in the better-seeing eye. The ten to twenty degrees central are referred to as the central visual field and everything outside of it is referred to as the peripheral visual field (Scheiman, Scheiman, & Whittaker, 2007). Peripheral visual field loss is the most common field loss associated with acquired brain injury.

Unilateral field loss results from brain injury to cortical areas post optic chiasm, and is often associated with cerebral vascular accident (Scheiman, Scheiman, & Whittaker, 2007). Damage to one side of the brain can lead to blindness in the visual field of both eyes on the opposite side. The blind area is nearly half of the visual field, it is called homonymous hemianopia. If a quarter of the visual field is affected, it's referred to as homonymous quadrantanopia. Homonymous hemianopia and homonymous quadrantanopia can lead to increase falls because of impaired visual awareness of safety hazards (Suchoff, Kapoor, Ciufeeda, Rutner, Han, & Craig, 2008). Reading can be affected, especially in right-sided hemianopia, leading to prolonged fixations and regressive saccades because we tend to read from left to right (Pambakia & Kennard, 1997).

Individuals with acquired brain injury may have visual perceptual impairments such as agnosia, unilateral neglect, constructional skills, and apraxia that are unrelated to cognitive

impairment or severity of injury, and could be more the result of cortical lesions (Mckenna, Cooke, Fleming, Jefferson, & Ogden, 2006). Compensatory visual scanning consists of teaching the client to use quick saccades in their decreased visual field to change habitual eye movement patterns (Scheiman, Scheiman, & Whittaker, 2007). It is important to test for visual field deficits because the brain will often ignore faulty visual input to promote optimal functioning of the sensory system and the individual may be unaware of the deficits (Cate & Richards, 2000).

The lighthouse technique is a visual imagery technique designed for individuals with an acquired brain injury that are experiencing unilateral neglect (Niemeier, Cifu, & Kishore, 2001). Patients are shown a line drawing of a lighthouse and told to imagine a lighthouse when trying to do something that requires him to look both right and left and move their head in both directions. In a comparison study where individuals were trained on tabletop tasks and measured on performance on the Functional Independence Measure (FIM), the lighthouse strategy was found to be effective in ambulation, route finding, and problem-solving (Niemeier, Cifu, & Kishore, 2001). In a case study using the lighthouse technique, an individual who suffered a traumatic brain injury and was experiencing severe left visual and attention was able to improve in a paper and pencil test in a route-finding task after three one-hour sessions training in the lighthouse technique (Niemeier, 2002). While the lighthouse technique appears to be an effective compensatory strategy for unilateral neglect of individuals with acquired brain injury, more research is necessary to assess its effectiveness in reading skills and other activities of daily living.

Deficits in Adaptation

Photophobia is an extreme light sensitivity that is often the result of head trauma (Sutter, 2011). Dark adaptation is a process that causes the visual system to maintain light sensitivity

during the presence of variations in illumination (Du, Ciuffreda, & Kapoor, 2005). Early studies on dark cavitation in individuals with acquired brain injury found that individuals who reported visual light adaptation problems also had reduced light sensitivity (Zihil & Kerkhoff, 1990). More recent studies suggested that the shearing effects of head trauma causes changes in physiology and may place neurons in a hyper-excitabile state, leaving two increased photosensitivity after head injury (Du, Ciuffreda, & Kapoor, 2005). Decreased photosensitivity can reduce a patient's ability to concentrate, emulate, or attend visually causing reduced capability to perform activities of daily living. Compensatory techniques recommended for decreased photosensitivity include use of a brown, gray, or blue tinted lens (Du, Ciuffreda, & Kapoor, 2005).

Warren's Stages of Visual Processing Skills

It has been suggested that the higher-level skills of visual perceptual processing such as visual cognition, visual memory, and pattern recognition depend on integration of lower-level skills such as visual acuity, visual field, and oculomotor control (Warren, 1992). Beginning with visual cognition, each skill depends on integration of the skill before it, meaning visual cognition cannot be maintained without visual memory. A study comparing basic and higher visual functions, based on vision screening and Motor Free Visual Perception test (MVPT) scores with individuals who sustained brain injury due to CVA, found there is a relationship between the two functions (Cate & Richards, 2000). This suggests that low scores on the MVPT may not provide clinicians with the information necessary to assist the individual in adapting to their condition, and that basic visual functions should be screened first in individuals who have sustained a CVA. A deficit in the visual cognitive skills such as figure-ground could be due to a poor scanning pattern resulting from visual inattention in combination with a visual field deficit (Warren,

1992). This further supports the necessity of a comprehensive visual assessment for individuals with acquired brain injury early in treatment.

Low Vision Rehabilitation

Low vision techniques were used effectively in a case study on an individual with a dense scotoma in the visual field, preventing the individual who suffered a brain injury from reading more than 2 to 3 letters at a time (Williams, 1995). The ophthalmologist and occupational therapist conducted a comprehensive low vision evaluation consisting of visual assessment including both higher and lower-level skills, reading, writing, and activities of daily living assessments. Compensatory strategies such as using extra light during reading and writing to reduce the scotoma's effect and maximize contrast were implemented. The client was given saccadic training to utilize return-sweep eye movements to move eyes to a new line of text, and to identify letters and words as fast as they could. Writing tests included tracing and monitoring of pen movement to keep writing in confined spaces. At the end of the eight week training, the client was able to read continuous texts and 112 words per minute, and demonstrate the ability to fill out job applications, insurance forms, and other important job seeking materials accurately (Williams, 1995).

While there have been studies on ways to improve oculomotor dysfunctions and other visual deficits caused by acquired brain injury, there is a lack of studies monitoring their improvement on activities of daily living, such as reading (Welfringer, Leifert-Fiebach, Babinsky, & Brandt, 2011). Reading is one of the activities of daily living most affected by acquired brain injury, because of readings dependence on interplay between saccadic convergence systems as one's eyes move across the line of print (Thiagarajan, Ciuffreda, &

Ludlam, 2011). There is also a need for a standard visual assessment to be used in the rehabilitation setting for individuals experiencing vision problems related to acquired brain injury (Radomski, Finkelstein, Llanos, Scheiman, & Wagener, 2014). There is a paucity of research in the field of occupational therapy regarding treatment of visual deficits in an acquired brain injury population. This project aimed to determine the most effective vision therapy and low vision techniques that occupational therapists can use to treat vision deficits and acquired brain injury population and develop a vision program focused on improving saccadic movements required for reading for individuals who are post-therapy, but still attending a day center. Techniques were conducted as part of a vision rehabilitation team with both optometrists and occupational therapists as community advisors for the project.

Method

The project took place at a brain injury specialty rehabilitation program that treats between 60- 75 individuals for post-acute rehabilitation for ABI. The program includes a day enrichment center that treats 35 additional individuals post-rehabilitation who are receiving ongoing support from the site as part of their assisted living program can spend their day to continue growth through activities, projects and continued therapy programs.

Because of the high prevalence of vision disorders in the ABI population and the effect visual deficits have on activities of daily living, it is important to have a neuro-optometrist or ophthalmologist as part of the rehabilitation team (Fishman Hellerstein & Scheiman, 2011). It is recommended for all patients who have suffered a brain injury to have a vision evaluation completed by an optometrist with extensive experience in vision rehabilitation to establish treatment strategies to address underlying visual deficits (Fishman Hellerstein, Scheiman, Fishman, & Whittaker, 2011).

The site where the project was conducted has close relationships with two separate neuro-optometrists; one in Valencia in which the site transports clients to appointments weekly, and one local. The site stays in close collaboration with both neuro-optometrists and occupational therapists that attend appointments and include the vision therapy exercises, established in collaboration with the neuro-optometrist, into the clients program.

As part of the project clients were escorted to weekly neuro-optometrist appointments, where the occupational therapy doctoral student learned about the prescribed vision exercises, and implemented them in the clinic as part of the clients program. The site conducts a thorough vision screen as part of initial evaluation that includes acuities, saccades, pursuits, convergence, eye alignment, stereopsis and visual field discrimination. The initial evaluation also includes visual perceptual skills testing using the Test of Visual Perceptual Skills (non-motor), third edition (TVPS-3). Scores from both the vision screen and the TVPS-3 are used to refer to the neuro-optometrist and determine visual skills that can be addressed prior to the appointment (e.g., compensatory scanning strategies and eye stretches). The occupational therapy doctoral student learned how to implement both screening tools as well as portions of the Brain Injury Visual Assessment Battery (BiVaba). In order to increase knowledge in treatment of visual deficits as a result of ABI, the doctoral student worked closely with clients who had vision programs, assisting in implementing the vision programs as well as address other problem areas caused by visual deficits. Addressing ADL performance in individuals with visual deficits can be difficult and require an increased knowledge of the visual system. Educational materials were purchased and reviewed to increase knowledge of visual deficits in order to improve overall treatment. Knowledge increased to the point that effective interventions could be produced for clients (See Case example below; Appendix A). The knowledge produced from collaborating

with the neuro-optometrist and others on the treatment team staff will produce benefits in multiple settings with a variety of clients.

Developing a Vision Program for Enrichment Center

The site offers ongoing support and residential care if the impact of their brain injury prevents them from living safely at home. If the intensity of their cognitive, physical or behavioral problems prohibits them from returning safely to their community, clients transition through the assisted living program at the site. Members of the assisted living program have completed rehabilitation and are usually involved in community activities, either through volunteer opportunities or social participation. During the day, clients in the assisted living program are part of the day enrichment center, a program that provides opportunities to participate in activities, games and therapeutic activities. Individuals can stay in the assisted living program years and participate in community activities through the enrichment center program. Most members of the enrichment center are five years post injury or more. Clients in assisted living are re-evaluated every year by all therapies they were previously involved in. There is a nurse on site and staff to take them to medical appointments.

A SWOT analysis was conducted at the enrichment center at the beginning of the project (see Appendix B) and it was determined that a comprehensive vision program would benefit the clients at the center. Many of the clients at the enrichment center are able to work independently and there is not enough staff to allow one to one work with clients, so activities were designed to be performed independently with minimal set up. Clients were trained on the activities so they could initiate and perform with minimal assistance.

Pilot project for Vision Program for Saccades at Enrichment Center

Three clients were chosen to collect pilot data for a potential grant. Pre-test and post information was collected and compared using the Developmental Eye Movement test (DEM) and the letter crossing section of the BiVABA (see Appendix C). Participants were given a vision program appropriate to pre-test data and information from client's case reports. Assisted living clients stay at residential apartments owned by the site, there is staff present at all times and an Independent Living Scale (ILS) is kept on every client ranking their performance and initiation of activities of daily living. Performance of activities of daily living during the pilot project was tracked using ILS scores.

Participant Three was a 67 year old male, nine years post-accident. At time of project, he was completing basic activities of daily living independently but requiring minimum to moderate verbal cues to initiate the tasks. An annual re-evaluation in occupational therapy suggested decreased visual scanning and visual perceptual skills. He presented with decreased visual attention and required maximum verbal cues to remain focused on a task. He frequently perseverated on multiple topics including lying down, using the restroom and eating lunch. During pre-test, he required 4 minutes and 52 seconds to complete the word crossing section of the BiVaba, and required time to be stopped during other portions of the BiVaba letter and circle crossing and the DEM due to walking away during the task. Due to decreased visual attention, Participant Three's program was designed to keep him engaged and increase his visual tracking and attention. He performed wall scans (alphabet and number), card scans, copying of shapes on visual sequential memory module (VSM), and saccadic movements on yardstick (see Appendix C for description of exercises). After six weeks he was able to participate in previously mentioned activities longer and with less perseveration. His ILS scores remained stable during the time of the project, with ADL score out of 61 going up from 47.7 to 49.5 during week 6 of

the project and going back to 47.8 from weeks 10-12. Post test results indicated the probability of improved scanning strategies during saccadic movements, reduced number of errors and faster processing speed.

Participant one was a 63 year old male, 8 years post injury. At the time of the project, he was completing daily tasks with supervision with minimum assistance required for activities of daily living for set up and supervision. He volunteered in the community sorting clothing for a local goodwill. He expressed that he often skips lines during reading activities and he finds reading difficult. His vertical time score for the DEM was 18% below the mean. His program was designed to increase saccadic movements and reduce skipping of lines when reading. He was given wall scans, Ann Arbor Letter Tracking workbooks and saccadic yardstick movements. Participant one completed the workbook monocular. Performance on letter tracking workbook improved by 11 seconds average during week six and 14 seconds by the end of the project, for an overall 25 second improvement. During week 10 of the project, he was given a word find in a five page article and had 76% accuracy finding the target words and 100% performance on three reading comprehension questions. Additional details on Participant Three and his vision program are provided in the case example below.

Participant two was a 36 year old male, 18 years post-injury. At the time of the project, he was completing daily tasks with supervision with minimal verbal cues required. He was participating in volunteer programs in the community and volunteering to clean and lead groups at the enrichment center. Annual re-evaluation in occupational therapy suggested moderate impairments for visual memory, visual sequential memory, form constancy and size discrimination. He expressed wanting to read more, but not always being able to follow what he

is reading. His vertical time score for the DEM was 47% below the mean. His program was designed to increase saccadic movements and reduce skipping of lines when reading. He was given wall scans, card scans, and Ann Arbor Letter Tracking workbooks. The Ann Arbor Letter Tracking workbook is designed to increase the speed and accuracy of saccadic fixation. Each section of the workbook includes two or more paragraphs of what appear to be random letters, clients track each letter in the alphabet individually and the total time required is recorded. Participant two completed the workbook monocular, using both eyes because near distance acuities were recorded as the same in both eyes. Performance on letter tracking workbook improved by an average of 15 seconds at the end of the pilot study. Post test results indicated probable reduced errors and faster reading speeds. During week 10 of the project, he was given a word find in a five page article and had 63% accuracy finding the target words and 75% performance on three reading comprehension questions.

Participant three was a 67 year old male, nine years post-accident. At time of project, he was completing basic activities of daily living independently but requiring minimum to moderate verbal cues to initiate the tasks. An annual re-evaluation in occupational therapy suggested decreased visual scanning and visual perceptual skills. He presented with decreased visual attention and required maximum verbal cues to remain focused on a task. He frequently perseverated on multiple topics including lying down, using the restroom and eating lunch. During pre-test, he required 4 minutes and 52 seconds to complete the word crossing section of the BiVaba, and required time to be stopped during other portions of the BiVaba letter and circle crossing and the DEM due to walking away during the task. Due to decreased visual attention, Participant Three's program was designed to keep him engaged and increase his visual tracking and attention. He performed wall scans (alphabet and number), card scans, copying of shapes on

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Overall Vision Program for the Enrichment Center

Upon completion of the project, the Enrichment Center was given the materials and training to produce vision program that has the potential to improve client's ocular motor and visual perceptual skills (see Appendix D). The Enrichment Center was satisfied with the program and had already begun to implement it at the completion of the project.

Conclusion

Following an ABI, it is important for visual deficits to be taken into account and addressed as part of an occupational therapy program. Vision screens should be conducted and referrals made to neuro-optometrists when needed. The occupational therapist should collaborate with the neuro-optometrist in regards to client's rehabilitation and vision therapy programs. It may be beneficial to continue to address visual deficits in individuals who have experienced a TBI years post-injury. There is potential for ocular motor deficits such as pursuits and saccades to improve with continued training and for improvements in visual deficits to improve performance in activities of daily living.

Case Example: Mark

Mark was a 63 year old male admitted to the brain injury rehabilitation center 8 months post injury. He had a closed head injury with subdural hematoma and intracranial hemorrhage following a fall on icy pavement at his workplace. Mark had a history of Diabetes mellitus, but did not have vision problems prior to his injury. At the time immediately following his injury, he presented with decreased acuities, decreased convergence, poor pursuits and poor saccades. Mark saw a neuro-optometrist during his initial stay and was given an eyeglass prescription and a vision therapy program. He is presently eight years post injury and has been finished with rehabilitation for seven years. He stays at the rehabilitation program as part of their assisted living program, and takes part in the day enrichment center, a program that provides opportunities to participate in activities, games and therapeutic activities. He currently completes daily tasks with supervision with minimum assistance required for activities of daily living for set up and supervision. He volunteers in the community working for a local Goodwill. He still has difficulties with pursuits and saccades and expresses that he would like to read more, but keeping place on the page is difficult. Mark took part in a 12 week, weekly program administered by an occupational therapy student to increase vision programs for individuals' post-injury attending the day enrichment center. Mark was given wall scans, Ann Arbor Letter Tracking workbooks and saccadic yardstick movements as part of an intensive vision program to be completed weekly. Mark's performance on the Ann Arbor Letter Tracking workbooks improved weekly, requiring less cues to complete, and going from requiring two to three minutes to complete a paragraph with three to four errors to being able to complete in one minute without errors. His reading comprehension has improved and he reports less eye strain during his volunteer work and being able to read for longer amounts of time. He says he likes the "challenge" he receives from working regularly with a therapist again. Mark has been left with a

detailed vision program that is currently being administered by trained staff at the day enrichment center. Mark receives yearly re-evaluations from occupational therapy and other disciplines at the site.

Case Example: Raymond

Raymond was a 26 year old male admitted to the brain injury rehabilitation center 14 months post injury. He experienced a brain injury following an assault. He was pronounced dead at the scene, however, vital signs were registered and a Glasgow Coma Scale of 3 recorded in the emergency room. At the time of his admission to the brain injury rehabilitation center, he had been home 5 months because he had achieved maximum therapeutic benefit. At the time of initial evaluation, he had decreased coordination as the result of ataxic movements and visual perceptual deficits. His visual perceptual skills were severely impaired, as measured by the Test of Visual Perceptual Skills, 3rd Edition (TVPS-3). An initial evaluation from a neuro-optometrist revealed a central field loss, decreased depth perception and severe ocular motor deficits. Near and distance prescriptions were prescribed. Recommendations include a combination of vision therapy exercises and low vision techniques. A combination of monocular wall scans, monocular spatial localization using a Dynavision machine and patterned letter tracking initially prescribed. As vision improved, new exercises were prescribed during re-evaluation that took place every 4-6 weeks. New exercises prescribed included metronome tapping, eccentric viewing techniques, enlarged directional arrows and Hart Charts, and insertion of golf tees into a Styrofoam pad to improve eye hand motor coordination. Repetition on the enlarged directional arrows improved performance on the standard size chart. Raymond was initially completing the enlarged directional arrow chart (5x5 inches) with 55% accuracy and average two lines skipped, frequently misnaming left and right directions. Following one month, with repetition 3-4 times a

week, Raymond was able to complete the enlarged directional arrow chart with 100% accuracy without any lines skipped and the standard size chart (1x1 inches) with 85% accuracy and zero to one line skipped. A metronome at 55 beats per minute was introduced to increase the challenge, with Raymond having most difficulty keeping beat when making saccadic movements to the next line. As vision and hand eye coordination improved, Raymond was able to increase participation in activities of daily living such as dressing. When he first came to the site, he required moderate assistance to don a shirt and required shirts to be oriented. Shortly after beginning his vision therapy program he required 15 minutes to don and doff a shirt. Following increased practice combined with vision therapy exercises, he is now able to don and doff a shirt in under a minute.

He continues to work on being able to button fasteners and tie shoes independently. With increased practice and use of eccentric viewing techniques, he is able to complete the first three steps of shoe tying and fasten a button within five minutes with moderate verbal cues for hand placement. He continues to be involved in an outpatient program at the clinic and completes a vision therapy program. His current goals include being able to button his pants and improve his reading and handwriting. He is presently working on saccadic worksheets, metronome tapping and buttoning pants on a table top. He has been given magnified lenses for television watching but trials with a reading magnifier were unsuccessful due to ataxic movements, a closed circuit television demonstration is scheduled.

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Appendix A

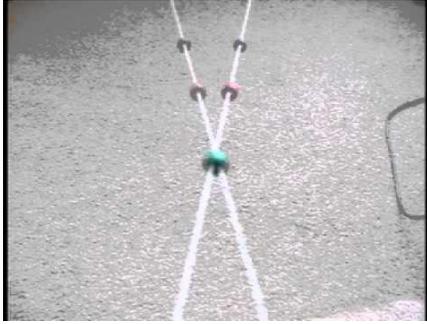
Therapeutic Home Program for Vision Sample

A. Hart Chart

1. Place the large distance Hart Chart on a wall 3m (approximately 10 ft) away.
 2. Hold the small near Hart Chart at 40cm away (arm's length)
 3. Start by reading aloud the first letter on the distance chart.
 4. Move your focus to the first letter on the near chart, make sure it is clear and single, and read it aloud.
 5. Shift to the second letter/number on the distance chart, saying it aloud when it is clear and single.
 6. Continue shifting between the distance and near charts until you have finished all of the letters/numbers.
- Complete five rounds of these cycles, three times per day.
 - Also can read large distance Hart Chart from left to right
 - What to look for: are any lines skipped, are all letters read correct?
 - Once consistently accurate can increase distance

B. Brock String

1. Attach end of brock string to a door handle or tape on wall, bring front bead approximately 12 inches from nose
 2. Look at bead. The goal is to see one bead and two strings emerging from the sides of your face and meeting at the bead , forming a "V"
 3. Once achieved can slowly bring bead closer, feel your eyes aimed at the bead keeping the bead clear and single with two strings crossing at the marble
 4. The goal is to be able to eventually bring the bead up to 2-3 inches from nose, while seeing one bead and two strings aimed at the bead.
 5. If at any time the bead doubles or strings cross in front or behind bead, stop and aim your eyes until strings are emerging from sides once again. If this is not possible, slowly bring the bead away from you until you fuse the bead and then continue to attempt to fuse with bead moved closer
- Use pointer (a pen is fine) to help line string at hole of bead
 - Alternate gaze by alternating direction of string (hold string to left, to right, up, down)



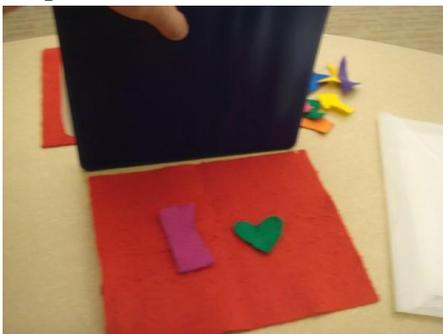
What the brock string should look like visually when properly fused

Visual Sequential Memory Module

1. Place two individual felt pads and assure that both participant and person administering have same shapes and colors



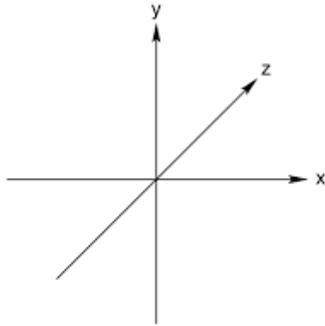
2. Cover your pad, using a binder or folder, and make a design (currently working with 4 shapes)



3. Uncover your pad for 1 second and then recover
4. Once she has made her design, assure that she has right shapes, right colors, that they are in the correct sequence, and that they are in the right position (to where they could fit right over yours) if upside down can cue her that she has a mirror image
5. Show her pad once again for one second, then can give additional feedback while showing her the pad.

Pointer and straw

1. Hold the straw sideways, horizontal and straightened paper clip horizontal in other hand
2. Look straight ahead, bring arms together simultaneously so the clip and straw meet
3. Perform 3 ways, in x axis 10 times each direction, below chest level, chest level, and forehead level
4. Perform 10 times in x,y and z axis

**Lifesaver chart**

1. Place lifesaver chart on flat surface
2. Place a dot directly in the middle of lifesaver circles
3. Complete with both eyes, left eye only, right eye only
4. Complete with chart vertically on wall

Other options:

OKN Drum

In the clinic, she has been using an OKN drum to help with the Nystagmus. This is an app that can be purchased online (<https://itunes.apple.com/us/app/optodrum/id374981098?mt=8>). Have her look down with stripes moving down, have her look up (above eye level) stripes moving up.

Appendix B

SWOT Analysis

SWOT

Analysis

Program idea: Establish a complete vision program for individuals that attend the enrichment center (EC)

<p><i>Strengths</i></p> <ul style="list-style-type: none"> • Will increase independence of clients • Many of the activities needed are already at the site • Promotes ongoing occupational therapy interventions for clients years post-injury 	<p><i>Weaknesses</i></p> <ul style="list-style-type: none"> • Many activities that will potentially be in program require staff to monitor scores, times and provide cues, EC is staffed average of two clients to one staff member • Clients already active in programs in many various disciplines and may become overwhelmed if another is added
<p><i>Opportunities</i></p> <ul style="list-style-type: none"> • Site is supportive of prospective vision program • Clients receptive to more demanding and individualized activities • Clients express wanting to improve their vision to increase participation in reading and cooking activities 	<p><i>Threats</i></p> <ul style="list-style-type: none"> • May require updated technology and materials • Funding does not support an on-site therapist at EC

Appendix C

Pre and Post Test results for pilot project

Assessed both before and after completing 10 weeks of letter tracking workbooks
and personalized visual interventions

Participant 1 Test	Pre-Test Time	Post Test Time	Pre- Test Errors	Post-Test Errors
DEM Test A	21.13 seconds	24 seconds	none	none
DEM Test B	19.95 seconds	27 seconds	none	none
DEM Test C	1 min. 14 sec.	57 seconds	skipped 2 lines	skipped 1 line
BiVABA simple letter cancellation #1001	1 min. 31 sec.	1 min. 8 sec.	missed 13 letters	missed 8 letters
BiVaba Complex Letter Cancellation # 1002	1 min. 33 sec.	1 min. 23 sec.	missed 10 letters	missed 11 letters
Bi Vaba word cancellation #1003	1 min. 31 sec.	1 min 53 sec.	missed 12 word	missed 5 words
Bivaba circles simple # 1004	1 min. 6 sec.	57 seconds	none	none
BiVaba random plain circles crowded #1005	1 min. 2 sec.	1 min. 10 sec.	missed 2 circles	none
BiVaba complex Circle searches #1006	1 min. 25 sec.	1 min. 24 sec.	missed 9 circles	missed 5 circles

Participant 2 Test	Pre-Test Time	Post Test Time	Pre- Test Errors	Post-Test Errors
DEM Test A	35.64 seconds	25.07 seconds	none	none
DEM Test B	28.08 seconds	25.22 seconds	none	none
DEM Test C	1 min. 16 sec.	1 min. 21 sec.	missed 2 letters	none
BiVABA simple letter cancellation #1001	1 min. 13 sec.	1 min. 38 sec.	missed 1 letter	none
BiVaba Complex Letter Cancelllation # 1002	1 min. 30 sec.	1 min. 31 sec.	none	none
Bi Vaba word cancellation #1003	1 min. 40 sec.	1 min. 22 sec.	missed 1 word	missed 1 word
Bivaba circles simple #1004	48 seconds	39 seconds	none	none
BiVaba random plain circles crowded #1005	1 min. 10 sec.	54 seconds	none	none
BiVaba complex Circle searches #1006	1 min. 17 sec.	1 min. 8 sec.	none	none

- Both participant 1 and 2 demonstrated improved scanning strategies during post-test, during pre-test would begin letter scan in middle, during post-test, started all scans left to right

Participant 3 Test	Pre-Test Time	Post Test Time	Pre- Test Errors	Post-Test Errors
DEM Test A	38.28 seconds	33.26 seconds	none	none
DEM Test B	46.2 seconds	36.8 seconds	missed 4 letters	none
DEM Test C	3 min. 21 sec.	1 min. 27 sec.	missed 4 letters	missed 1 letter

- Word cancellations and circle completion attempted but unable to complete accurately due to decreased attention and impulsivity

Appendix D

Vision Program Ideas for Enrichment Center

Wall scan activity

1. Preferably performed in standing, direct that they will flash light on each number 1-26 or letter A-Z in succession. Let them know first letter they will start with and begin time.
2. If cues provided to find next letter or number please describe detail on cues provided, Examples of cues: cues to look to upper left side, cues for next letter in succession, cues to continue activity. Please list cues and number of cues on activity sheet
3. After last number or letter is completed, stop watch and record time required. Record on sheet whether number scan or letter scan performed first.
4. Encourage them to finish task before sitting taking breaks, record cues to continue task and record if break taken (also time and letter break was taken on)

Poker scan activity:

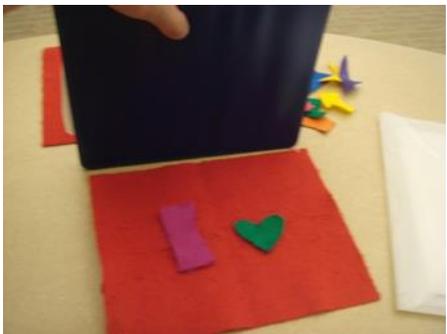
1. Set up table with shuffled deck of cards next to it, instruct that card will be flipped over and they are to find same number and suit on wall, and will continue to find cards
2. Can do practice card before starting time and shuffle back into deck
3. Begin time as first card is flipped, record time

Visual Sequential Memory Module

1. Place two individual felt pads and assure that both participant and person administering have same shapes and colors



2. Cover your pad, using a binder or folder, and make a design (begin with two shapes and gradually increase as accuracy improves)



3. Uncover your pad for one second and then recover
4. Once they have made their design, assure that they have the correct shapes, colors, sequence, and position (to where theirs would fit right over yours) if upside down can cue that they have a mirror image
5. Show pad once again for one second, then give additional feedback while showing the pad.

Letter tracking activity

1. Use Ann Arbor Letter Tracking sheet packets in binder marked "Letter Tracking" begin them with section 1 unless continuing from a previous packet.

2. Set client up with a timer and pen. Instruct that they will be scanning left to right for the letters of the alphabet beginning with "A," once they have found a letter they will search for the next letter in sequence (i.e. b, c, d etc.). Once they find the letter Z, they will stop the timer and record their time (you can record time if assistance is required but seeing the time is a good motivator to continue the activity)

2a. The packet consists of paragraphs made up of nonsense words designed to improve visual discrimination. The learner is to find the first "a" that he comes to in the first line and either circle it or put a line through "a". Then they will go on until he finds the first "b" after the "a" which he is able to circle or put a line through and then the first "c" and so on until they have used all of the letters of the alphabet in sequence. There will be letters in each line that he will need. If the learner goes through an entire line without finding the letter they are looking for, they have made a mistake and must go back and locate the letter they have missed. They will not be able to complete the exercise using all of the letters of the alphabet unless they locate each letter in sequence (Ann Arbor Publishers)

3. Give feedback if any lines were skipped or numbers missed, begin next paragraph in packet.

Example: (Ann Arbor Publishers)

a b c d e f g h i j k l m n o p q r s t u v w x y z

dhoe stil onap cred myf bix mochez togu jod helk pyx wrog zil vuf smolt nik ruz gamp hyb tawp
 vox sanc quork tuk bisy baj pazt wrenk tox dof wabs bulst myzu gand tew bocer fatz gepy bast
 quck gax dich rebaf biz jalf deb setch gek chay hukn mib nep bafil vob chone ply awec croix ah
 strel yabe mez goelp noch fip

Saccadic movements on yard stick

1. Using yard stick with blue, pink, green and orange push pins placed on it, hold yard stick in front of client. Instruct client that you are going to be calling out colors and you want them to move their eyes only to the push pin that correlates with the color you called.
2. Call out colors, note visual attention, overshooting or undershooting (eyes arrive below or above target)
3. Activity can be graded by calling out multiple numbers, flipping yard stick around so colors go opposite direction, turning yardstick vertical so targets are vertical, having them reach toward target after tracking with eyes to additionally challenge upper extremity range of motion.

Hidden Pictures

1. Use hidden picture sheets in binder labeled “hidden picture”, remove packet of Hidden pictures from Highlights workbook. Establish a goal of how many targets should be located in ten minute span.
2. Give client a pen or marker and have them locate targets. Provide hints if needed (“try to find a similar texture in the picture as the item you are searching for”)
3. Following ten minutes, count amount of targets found. Write number on sheet and circle it. Provide extra time for them to locate remaining targets, if possible.
4. Answer sheet provided in back of binder if unable to locate certain targets.