The Effectiveness of Visual Scanning Training to Improve Functional Performance Poststroke: A Case Study in Eastern North Carolina

By

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Rationale: Although an abundance of research exists regarding overall rehabilitation interventions poststroke, there is a lack of evidence for treatment of visual deficits. Additionally, eye tracking glasses may be used to further understand the effects of visual field deficits poststroke, though no studies have yet used eye tracking in the context of daily occupations. **Purpose**: This study evaluated the effectiveness of component-based, occupation-based, and combined occupational therapy treatment for visual scanning training on improving occupational performance in instrumental activities of daily living. The second portion of the study described the differences in visual scanning tendencies during cooking and driving, between an individual with a visual field deficit poststroke and a healthy control of similar age and gender. **Design**: This study used a case study design with a health control for the eye tracking portion. **Participant**: The participant was a 55-year-old female who had a stroke 7 years prior. **Methods**: One participant with a visual field deficit poststroke underwent three visual scanning treatments – component-based, occupation-based, and combined. The researchers administered the Assessment of Motor and Process Skills (AMPS) and took standardized measures on the Vision

Coach (full field, 60 dots, all red, speed 0, fixator off) at pretest, after the component-based intervention, after the occupation-based intervention, and after the combined intervention to determine the change in occupational performance – measured by motor skills and process skills – after each intervention. After the interventions were complete, the participant completed a cooking tasks and a task on the driving simulator, while wearing the Tobii Glasses Pro 2 eye tracking glasses. **Analysis**: Data from the AMPS was compared between times and to the AMPS standardization sample to determine observable improvements. Vision Coach data was also compared between times. The participant's eye tracking data – duration of first fixation, total visit duration, and heat maps – were compared to a healthy control of the same age and gender. **Results**: With regards to the AMPS and in order of time, the participant scores of motor skills were 1.4 (mild to moderate increased physical effort), 1.8 (questionable to mild increased physical effort), 2.0 (questionable increased physical effort), and 1.8 (questionable to mild increased physical effort). Her scores of process skills were 0.8 (questionable to mild inefficiency), 1.0 (questionable inefficiency), 0.8 (questionable to mild inefficiency), 1.2 (questionable inefficiency). As per the AMPS standardization sample, an observable difference is one of 0.30 logits or more. Comparison of the eye tracking measures and heat maps revealed differences between time spent viewing areas of the visual field, including during two crashes on the driving simulator. **Discussion**: Overall, visual scanning training as a compensatory method was effective for this participant and could therefore be considered by occupational therapists when treating clients with chronic visual field deficits poststroke, with the combined training being most effective. This study also supports the use of eye tracking glasses during occupations to understand visual scanning tendencies between individuals with and without visual deficits.

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Chapter 1: Introduction

Stroke is the third leading cause of death, and approximately 795,000 strokes occur in the United States each year (Benjamin et al., 2017). Of those individuals, approximately 22% have chronic visual field deficits (Ali et al., 2013), which can affect self-care occupations, including activities of daily living (ADLs) and instrumental activities of daily living (IADLs) (Kizony & Katz, 2002). Currently, insufficient research exists surrounding the effects of a visual scanning training on occupational performance in instrumental activities of daily living (IADLs) for persons poststroke. In fact, a great deal of information exists about stroke rehabilitation and treatment, but little of that information focuses on visual deficits (Duncan et al., 2005). Therefore, research is needed to determine best practices for visual rehabilitation poststroke. This case study offers insights as a first step in this exploration.

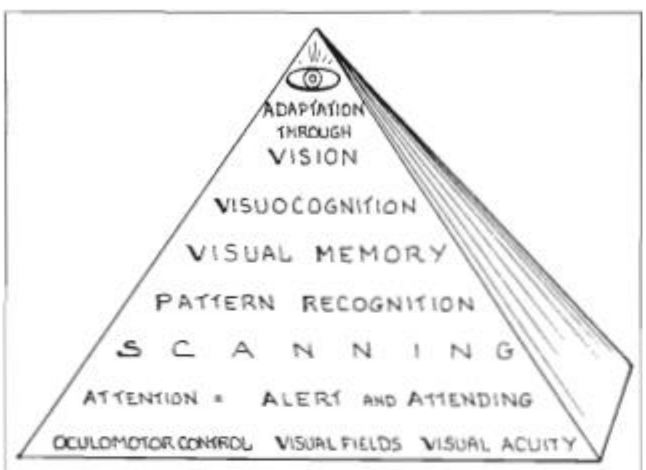
Occupational therapists deliver skilled interventions based on client-centered goals to complete meaningful occupations despite impairments, including visual deficits. Individuals poststroke who have remaining visual field deficits, such as homonymous hemianopia, may need to learn compensatory strategies to improve occupational performance. Out of the three largest rehabilitation fields in the United States – occupational therapy, physical therapy, and speech therapy – occupational therapy is the only profession whose scope of practice includes visual rehabilitation (American Physical Therapy Association, 2015; American Speech-Language-Hearing Association, 2016; Brayman et al., 2014). Additionally, occupational therapy's scope of practice includes IADLs, such as cooking, shopping, and financial management (American Occupational Therapy Association, 2014) of which visual deficits can impact most of these occupations (Phipps, 2013; Schuett, 2009). Therefore, this study is significant for occupational therapists treating persons poststroke with visual deficits in order to improve their function in IADLs. Specifically, the purpose of this study was to investigate the use of a visual scanning training – via the Vision Coach™ – with individuals poststroke to improve motor and process skills, the components of occupational performance defined by the American Occupational Therapy Association, in order improve IADL performance, as measured by the Assessment of Motor and Process Skills (AMPS) (Fisher & Jones, 2012).

Assumptions and Definitions

This study is based on the theoretical theory of Hierarchic Model of Visual Perceptual Processing (Warren, 2013) as an explanation of how visual information is processed in the neurological system. Figure 1 is a visual representation of Warren's model.

Figure 1

Warren's Hierarchy of Visual Perceptual Skill Development in the Central Nervous System (Warren, 1993a)



Mary Warren's Hierarchic Model of Visual Perceptual Processing. Warren's model describes the hierarchy of visual processes that "interact with and subserve each other" (Warren, 2013, p. 596). At the most fundamental level of the hierarchy are basic visual functions –

oculomotor control, visual fields, and visual acuity. These functions then affect higher level functions which build on each other in the following sequence: attention, scanning, pattern recognition, visual memory, visuocognition, and finally adaptation through vision (Warren, 2013).

Stroke. “An acute neurologic dysfunction of vascular origin with symptoms and signs corresponding to the involvement of focal areas of the brain” (Gillen, 2013). It may also be referred to as a cerebrovascular accident (CVA).

Poststroke. The time following a stroke/CVA, including treatment and recovery.

Cortical visual deficit. Disruptions in the visual processing and reception centers and pathways of the central nervous system (CNS). May present as various functional deficits (Warren, 2013).

Visual field deficit. Deficit resulting from “damage to receptor cells in the retina or to the optic pathway that relays retinal information to the CNS for processing” (Warren, 2013). This deficit presents as a loss in processing of or input from area(s) of the visual field of one or more eye.

Homonymous hemianopia. Loss of vision in half of the visual field in the eye, resulting from a lesion along the geniculocalcarine tracts (GCTs), which is the most commonly occurring visual deficit after brain injury (Warren, 2013). Can be complete or incomplete.

Compensatory approach to intervention. Emphasizes “changing the context of the environment or task to enable the client to successfully use his or her current level of visual processing” (Warren, 2013, p. 600).

Remedial approach to intervention. Interventions that attempt “to establish or restore the client’s ability to complete visual processing be improving aspects of visual performance such as increasing the efficiency of visual search or improving visual attention" (Warren, 2013, p. 600).

Instrumental activities of daily living (IADLs). IADLs include care of others (including selecting and supervising caregivers), care of pets, child rearing, communication management, driving and community mobility, financial management, health management and maintenance, home establishment and maintenance, meal preparation and cleanup, religious and spiritual activities and expression, safety and emergency maintenance, and shopping (American Occupational Therapy Association, 2014).

Modality. A technology, tool, or other equipment that is used in interventions.

Participants. Individuals who have undergone screening, met the criteria for participation, and have agreed to participate in the study by signing the informed consent document.

Visual scanning training. A visual rehabilitation technique to improve scanning strategies and compensate for lost areas of the visual field. It is important to note that visual scanning training is referred to throughout the literature by a variety of names, including visual search and exploratory eye movements.

Chapter 2: Review of the Literature

Stroke

Stroke is a major concern in the United States. It is the third leading cause of death, and approximately 795,000 strokes occur in the United States each year (Benjamin et al., 2017). Demographically, stroke is 1.25 times higher in men than women, and the incidence doubles in people over 55 years (American Heart Association, 2010). Risk of stroke also varies culturally. Black individuals are approximately 2.7 times more likely to have a first stroke than white individuals until 85 years of age, though recurrence rates are not significantly different (Howard et al., 2016). Prognosis following stroke depends on a range of factors, including age and possible covariates of age (Luker, Bernhardt, & Grimmer-Somers, 2011). For individuals poststroke, chronic deficits may include motor impairment (Gillen, 2013), cognitive deficits (Gillen et al., 2015), aphasia (Flowers et al., 2016), dysphagia (Mitchell, Bowen, Tyson, Butterfint, & Conroy, 2017), and sensory impairment – including auditory, gustatory, tactile, proprioceptive, olfactory, and visual deficits depending on the location of the injury (Gillen, 2013).

Visual Deficits

Visual deficits are a common complication resulting from stroke. Visual perception, like many other senses, involves a complex interaction between the structures that collect information about the surroundings and the structures of the central nervous system (Warren, 2013). Stroke can directly affect both the cerebral structures that process visual information and the tracts carrying information from peripheral receptors (Warren, 2013). Visual perception is a hierarchy in which higher perceptual function, such as visual attention and scanning, is reliant on the more basic visual functions, such as oculomotor control and visual fields (Warren, 2013), as represented by *Figure 1*. Thus, strokes resulting in visual field deficits – one of the most basic visual skills – can impact the perception and processing of incoming visual information and subsequently an individual's understanding of the environment.

Cortical visual deficits include any impairments resulting from injury to the cerebral cortex. Strokes can result in various cortical visual deficits, depending on the site of the lesion. Strokes of the middle cerebral artery can result in visual field impairment, poor contralateral conjugate gaze, unilateral spatial neglect, and visuospatial impairment (Gillen, 2013). Strokes of the posterior cerebral artery can result in homonymous hemianopia, visual agnosia, cortical blindness, and visuospatial impairment (Gillen, 2013). The exact presentation of impairments will vary across patients, depending on the location, severity of the stroke, and response to early treatments.

Visual field deficits. Visual field deficit describes a collection of conditions that may result poststroke, all of which involve loss of portions of the visual field. Homonymous hemianopia (HH) is the most common visual field deficit poststroke, persisting in 22% of individuals who have had a stroke (Ali et al., 2013). Complete HH is a visual field deficit in which half of each visual field, contralateral to the stroke-affected cerebral hemisphere, is lost (Perez & Chokron, 2015). It is usually due to a lesion of the geniculocalcarine tract from a stroke of the posterior cerebral artery, although a stroke of the middle cerebral artery is also a possible cause (Warren, 2013).

Research in the field of neurology has shown that about 40% of individuals with complete and incomplete HH poststroke spontaneously recover, with about 5% making a full recovery (Zhang, Kedar, Lynn, Newman, & Biousse, 2006). However, the probability of recovery decreases with time and individuals typically do not adapt without intervention

(Bowers, Ananyev, Mandel, Goldstein, & Peli, 2014; Reinhard, Damm, Ivanov, & Trauzettel-Klosinski, 2014; Zhang et al., 2006). Experts have conflicting opinions on whether or not visual functioning can be restored for an individual with chronic HH (Nelles et al., 2009; Pambakian, Currie, & Kennard, 2005; Zhang et al., 2006). *Visual Restoration Therapy*, which aims to restore visual field representation through use of unaffected tracks, has been tested in animals but results are unclear (Ghannam & Subramanian, 2017; Frolov, Feuerstein, & Subramanian, 2017). Thus, use of this technique is controversial and not currently viable for patients poststroke. However, the literature suggests that, despite various severities of persisting visual field deficits, compensatory strategies can be developed, especially with regards to visual scanning (Mannan, Pambakian, & Kennard, 2010; Pambakian et al., 2005). These compensatory strategies, while unlikely to restore visual fields (Zhang et al., 2006), may act synergistically to restore functional performance in daily activities through improvements in higher-level visual functions (Nelles et al., 2009).

Visual scanning. In neurotypical adults (i.e. those without history of central nervous system injury), visual scanning occurs in an organized and efficient pattern using saccades (Warren, 1993a). After a stroke, however, these saccadic eye movements become slower, inappropriately fixated, and inaccurate (Warren, 1993a). Compensation to perform everyday activities with visual deficits may becomes more complex and complicated when the individual has aphasia poststroke, as in this case study. Individuals with aphasia have associated inefficiencies in visual scanning, leading to decreased occupational performance and increased risk for falls (Warren, 1993a).

Impact on Occupation

Cortical visual deficits can have a significant effect on independence and self-care. For example, Buzaid, Dodge, Handmacher, and Kiltz (2013) discuss how visual deficits from another cerebral disorder (i.e., multiple sclerosis (MS)) can affect activities such as meal preparation and mobility. For patients poststroke, the visual deficits can resemble those of MS since both disorders can affect a variety of cerebral areas. Research has shown that homonymous hemianopia specifically impacts activities of daily living (Mennem, Warren, & Yuen, 2012), reading and academic occupations (Schuett, 2009; Warren, 1993a), and driving (Devos et al., 2011; Moss, Harrison, & Lee, 2014).

In general, self-care activities require higher-order visual processes, especially visual attention and visual-contextual memory (Kizony & Katz, 2002), which support accuracy and efficiency in occupational performance. As discussed previously, these higher-order processes are directly impacted by deficits in basic visual functions (Warren, 2013). Therefore, visual field deficits are likely to impact one's IADL occupational performance.

Intervention

Standards of care for poststroke rehabilitation are well established with multiple clinical practice guidelines have been published regarding poststroke care (Duncan et al., 2005; The Management of Stroke Rehabilitation Working Group, 2010). With regards to prognosis, the literature suggests that, although largely more significant changes are made within one to three months poststroke (Simpson & Eng, 2013), smaller but clinically meaningful changes can be made even in the chronic phase poststroke (Eng et al., 2003), including in visual field function (Julkunen, Tenovuo, Jääskeläinen, & Hämäläinen, 2003).

Systematic reviews regarding rehabilitation research for individuals poststroke describe the efficacy of interventions targeting motor deficits, including exercise (Chen & Rimmer, 2011; Stoller, de Bruin, Knols, & Hunt, 2012; van Delden, Peper, Beek, & Kwakkel, 2012), respiratory muscle training (Gomes-Neto et al., 2016), constraint-induced movement therapy (Castellini et al., 2014; Fleet, Page, MacKay-Lyons, & Boe, 2014; Kelly et al., 2014; Nilsen et al., 2015; Shi, Tian, Yang, & Zhao, 2011), orthoses (Braun Ferreira et al., 2013; Lannin, Tyson, & Kent, 2011; Tyson & Kent, 2013), functional electrical stimulation (Howlett, Lannin, Ada, & McKinstry, 2015), virtual reality (Li, Han, Sheng, & Ma, 2016; Pompeu, Alonso, Bordello Masson, Alvarenga, & Torriani-Pasin, 2014), and technology-assisted therapy (Cha & Kim, 2013; Cheok, Tan, Low, & Hewitt, 2015; Norouzi-Gheidari, Archambault, & Fung, 2012; Wu, Yang, Lin, & Wu, 2013). Preliminary support has also been found for complementary and alternative medicine, such as acupuncture (Liu et al., 2015; Najm, 2010; Lim et al., 2015) and yoga (Desveaux, Lee, Goldstein, & Brooks, 2015). Other systematic reviews and meta-analyses have shown efficacy for interventions targeting psychosocial deficits of stroke, including emotional deficits (Hildebrand, 2015), participation (Dorstyn, Roberts, Kneebone, Kennedy, & Lieu, 2014; Morris, MacGillivray, & Mcfarlane, 2014), cognitive strategies (Gillen et al., 2015; Patrick et al., 2012; Stanton, Ada, Dean, & Preston, 2011), and occupational performance (Wolf, Chuh, Floyd, McInnis, & Williams, 2015).

Despite the abundance of literature on stroke rehabilitation, no systematic reviews were found for interventions targeting visual deficits poststroke (The Management of Stroke Rehabilitation Working Group, 2010). Little research exists regarding therapy for visual deficits and researchers found no compelling evidence that a single approach is sufficient (Berger, Kaldenberg, Selmane, & Carlo, 2016). One clinical practice guideline recommends screening for visual deficits but is unclear about specific treatments (Duncan et al., 2005).

In general, the literature supports certain components or techniques that should be incorporated into therapy sessions, independent of the deficits that are targeted. For example, Jellema et al. (2016) reviewed studies that investigated environmental factors qualitatively and concluded that families and other social supports should be invited to participate in therapy sessions. Other reviews found that self-efficacy (Korpershoek, van, & Hafsteinsdóttir, 2011), autonomy (Luker, Lynch, Bernhardsson, Bennett, & Bernhardt, 2015), early supported discharge (Thorsen, Holmqvist, de Pedro-Cuesta, & von Koch, 2005), and a positive therapeutic alliance (Lawton, Haddock, Conroy, & Sage, 2016; Luker et al., 2015) correspond with more positive outcomes. Luker et al. (2015) also found that individuals poststroke report being frequently bored and desire an increased challenge during therapy, though it must be meaningful. The need for collaborative goal setting has been reported, though barriers exist – including time, resources, and requirements of the healthcare system (Rosewilliam, Roskell, & Pandyan, 2011). Furthermore, one systematic review found that altering only one component of training does not create significant increases in functional recovery (Hayward, Barker, Carson, & Brauer, 2014). Therefore, protocols for an entire training, that considers all necessary physical and psychosocial components, are important to develop to yield optimal results in practice.

For visual perceptual deficits, Warren (1993a) suggests using a hierarchical, bottom-up approach to occupational therapy assessment and intervention. Although trends in occupational therapy emphasize using a top-down approach, visual rehabilitation is one area where a bottom-up approach is important to understand the specific deficits and their impact on higher-level functioning (Warren, 1993a). Various visual deficits may manifest similarly in occupation-based outcome measures, so understanding the exact cause of dysfunction for an individual is essential to effective intervention planning (Warren, 1993a). Visual field deficits are considered a basic visual function in Warren's hierarchy (1993a) and thus affect all higher-level visual functions: visual attention and scanning, pattern recognition, visual memory, visuocognition, and adaptation through vision. Since literature suggests the visual field loss likely cannot be restored (Nelles et al., 2009; Pambakian, Currie, & Kennard, 2005; Zhang et al., 2006), this study focuses on compensatory interventions for the higher-level function of visual scanning.

Visual Scanning Training. Patients with visual field deficits demonstrate improved performance on activities of daily living (ADLs) both on objective and subjective measures following compensatory training for visual scanning (Pambakian et al., 2005). Multiple studies support the use of this training technique to improve awareness of and attention to the impaired area of the visual field (Berger et al., 2016; Nelles et al., 2010; Turton et al., 2015).

Vision Board Modality. One potential modality for visual scanning training is a vision board, such as DynaVision™ or Vision Coach™. The literature shows that vision boards can improve motor flexibility, physical energy, and attention in individuals with visual field deficits, such as HH (Klavora, Gaskovski, Heslegrave, Quinn, & Young, 1995; Klavora & Warren, 1998). For example, one study conducted by Klavora and colleagues (1995) conducted a single case experimental study regarding use of DynaVision with an elderly individual poststroke. The intervention consisted of a 16-session training over 4 weeks. Each session involved approximately 25 minutes of training, which included a variety of tasks that targeted the participant's visual field deficits, pacing, and endurance. Training tasks ranged in intensity, with the most demanding protocols involving multitasking. Following the training, the participant improved in response frequency, response time, and visual scanning speed. The results of the study also demonstrated training maintenance effects. Klavora and Warren (1998) also reviewed the existing studies on DynaVision to consider the potential uses of the vision board. These researchers concluded it is a useful tool for visuomotor training, based on approximately nine studies.

Similarly, the Vision Coach – created by Robin Donley, an occupational therapist and optometric vision therapist – allows participants to train their visual scanning skills among other possible benefits, including “visual function, muscular coordination and neuromotor abilities” (Perceptual Testing Inc, 2012). Xi et al. (2014) developed norms for and evaluated the test-retest reliability of the Vision Coach task FF120, using healthy participants. According to Xi et al. (2014), the other popular tool – DynaVision – had very obvious points that therapists would prompt the user to touch, which may act as a cue and confound the results. Therefore, Vision Coach was designed so that it “does not indicate the location of potential targets” (Xi et al., 2014, p. 3). The lack of cues is especially important when using the boards for visual search compensation, since cues would lower the level of difficulty of the training.

Previous literature using the Vision Coach, in which a majority (51%) of participants had a diagnosis of stroke, discussed the utilization of this tool in occupational therapy practice (Hennessey et al., 2016). Participants were patients (N = 470) and occupational therapists (N = 21) in a rehabilitation hospital and its corresponding outpatient clinic (Hennessey et al., 2016). Researchers observed how occupational therapists used the Vision Coach in practice, across a 2-year period (Hennessey et al., 2016). The study highlights the conditions used most often by occupational therapists: using task Full Field 60 (FF60), setting to speed 0, standing while performing tasks, turning off the fixator dot, displaying only red dots, depressing the lights, testing for reaction time, and performing one to three tasks during a session (Hennessey et al., 2016). While these guidelines forming the basis for intervention, Hennessey et al., suggests adapting tasks “to any patient’s specific needs” (2016, p. 17), and noticeable variation existed across circumstances. Therefore, individual characteristics and needs should be considered when using the Vision Coach in a clinical setting.

A recent study by Brooks and colleagues (2017) also used the Vision Coach with healthy drivers, aged 21 to 66 years. Brooks et al. (2017) compared performance on the Vision Coach between age groups – younger (n = 22), middle (n = 15), and older (n = 17) – and with performance on the Functional Object Detection © advanced driving simulator scenario. Results indicate that there is a significant effect of age on Vision Coach performance (Brooks et al., 2017), which was also discussed in Xi et al. (2014). Therefore, timed trials using the Vision Coach should be compared to individuals in a similar age group. However, Brooks et al. does not discuss performance changes over time nor with individuals poststroke.

Additional results indicate that performance on the Vision Coach full field 60 task was significantly correlated with braking and E detection on the driving simulator (Brooks et al., 2017), providing a basis for comparison of Vision Coach data to driving simulator data. The authors concluded that occupational therapists can use both the Vision Coach and driving simulator in assessment and intervention for individuals with cognitive and visual processing difficulties and that data from both tools can be generalized to on-road performance in driving (Brooks et al., 2017). Thus, relationships between Vision Coach and driving simulator performance need to be explored and eye tracking technology may assist with identifying specific deficits.

Brooks et al. (2017) also expanded on the short-term training effect discussed by Hennessey et al. (2016), concluding that training effects last through the sixth trial, though to a lesser degree than is seen in the first through third trials. In the older population, the difference between the first and third trial averages was 5.17 seconds, whereas the difference between the fourth and sixth trial averages was 3.76 seconds (Brooks et al., 2017). Brooks et al. (2017) also discussed qualitative benefits of using the Vision Coach in occupational therapy settings, including client engagement and satisfaction, convenience data for billing, and high levels of customizability. However, no literature currently exists on the long-term training effects of using the Vision Coach.

Training with the Vision Coach. Warren (1993b), a leader in research for occupational therapy in visual rehabilitation, proposes four treatment guidelines for intervention for visual deficits following brain injury, which were considered when selecting the intervention. Researchers determined that the vision board modality theoretically fulfills all four guidelines. The first of Warren's guidelines encourages increasing the participants' awareness of the deficits and then giving them a systematic method to overcome it (Warren, 1993b). The vision board provides this systematic approach through easily manipulated settings (e.g., speed, color, cognitive loading) and repetition of tasks. The second is to "broaden the visual field that the patient scans as much as possible" (Warren, 1993b, p. 62). The vision board requires the participant to scan the full visual field, so not limiting generalization to a confined space such as a single sheet of paper. The third training guideline is to combine the visual experience with tactile feedback (Warren, 1993b). The vision board provides this tactile feedback through depressing a light when it is displayed. The vision board also reinforces visual exploration through auditory feedback when lights are depressed. The final guideline encourages the inclusion of attention to detail within the visual exploration task (Warren, 1993b). The Vision Coach, specifically, provides a possibility for cognitive loading through various letters and numbers printed on the lights. The participant may scan for only letters, numbers, or blank dots to encourage this attention to detail on the lights. Additionally, the Vision Coach has two possible colors for lights – red and green – which can be used simultaneously to encourage participants to search for a specific color. Overall, the vision board modality, especially the Vision Coach, meets Warren's guidelines for rehabilitating visual deficits after a brain injury, such as stroke, making it a promising intervention for occupational therapists.

However, Warren (1993b) also encourages combining this repetitive training with practice of visual skills in the context of occupations because research shows individuals who have experienced brain injury often do not spontaneously generalize skills between contexts. Therefore, research is needed to explore the impact of training with the vision board modality alone and in combination with occupation based intervention.

Eye Tracking. Eye tracking devices have been used in research in the field of psychology to examine social behaviors in children with autism (Freeth, Chapman, Ropar, & Mitchell, 2010), human viewing behavior (Kurzhals, Fisher, Burch, & Weiskopf, 2016), and other areas of interest (Gredebäck, Johnson, & von Hofsten, 2010; Kaminska & Foulsham, 2016; Jared & Bainbridge, 2017). In occupational therapy, research has confirmed the feasibility of using eye tracking to understand the effects of visual deficits on occupations (Kortman & Nicholls, 2016) and have discussed methodology for using eye tracking in driving simulators (Sundin, Patten, Bergmark, Hedberg, Iraeus, & Pettersson, 2012). However, no research has currently been conducted in the field of occupational therapy using eye tracking devices to understand the relationship between instrumental activities of daily living (IADLs) and visual field deficits. Current literature suggests a relationship between eye tracking data and mild traumatic brain injury (Cifu, Wares, Hoke, Wetzel, Gitchel, & Carne, 2015), another central nervous system injury.

Summary

Existing literature demonstrates an insufficiency in research of visual rehabilitation interventions for individuals poststroke (American Heart Association, 2010; Berger et al., 2016; Duncan et al., 2005). Studies in the field of neurology and rehabilitation have demonstrated the effectiveness of visual scanning training for individuals with visual field deficits in improving attention to the affected portions of the visual field (Berger et al., 2016; Bowers et al., 2014; Nelles et al., 2010; Turton et al., 2015), but limited research has focused on the effectiveness of visual scanning training for improving occupational performance (Pambakian et al., 2005) and specifically using a vision board modality (Klavora et al., 1995; Klavora & Warren, 1998; Vesia, Esposito, Prime, & Klavora, 2008). Thus, the current study aims to investigate the effectiveness of individualized visual scanning training, using a vision board modality, to improve IADL occupational performance, as measured by an occupational therapy evaluation (the AMPS) that is sensitive to changes in occupational therapy performance (Fisher & Jones, 2012). Additionally, eye tracking data was collected during cooking and driving tasks to explore of areas for future study. The research questions include:

1. Does visual scanning training improve the occupational performance in instrumental activities of daily living of people with poststroke visual/perceptual impairment as measured by the Assessment of Motor and Process Skills?
2. Is component-based visual scanning training, occupation-based visual scanning training, or a combination of both most effective in improving occupational performance in

instrumental activities of daily living of people with poststroke visual/perceptual impairment as measured by the Assessment of Motor and Process Skills?

   a. What visual training protocols work most effectively with individuals with mild poststroke visual/perceptual impairment?
   b. What recommendations can be made regarding dosage of visual scanning training?

3. How does visual scanning differ between those with a visual field deficit and those without during a functional task (cooking), as measured by eye tracking technology?
4. How does visual scanning differ between those with a visual field deficit and those without during driving, as measured by eye tracking technology?

Chapter 3: Methodology

Design

This study used a case study approach, completing three interventions with one participant and a follow up session after 4 weeks of no intervention to collect data with eye tracking glasses. Each intervention consisted of two sessions per week over a four-week period. The independent variable is the intervention, consisting of four levels: control or baseline, component-based visual scanning training, occupation-based visual scanning training, and a combined intervention with component-based and occupation-based visual scanning training.

The main dependent variables are two measures of occupational performance (i.e., process, motor) based on the *Assessment and Motor and Process Skills* (AMPS; Fisher & Jones, 2012). Data was collected at the baseline (pretest) and after each of three interventions. Follow up data was also collected during the eye tracking portion of the study. The time (in seconds) and hand use (%) during a task on the Vision Coach were collected using a time series data collection method during the first and third interventions. For the third and forth research question, the quantitative variables are percentage of time spent attending to the affected visual field of the participant, percentage of time spent fixated on task objects and environmental spaces, and duration of the first fixation on task objects and environmental spaces. These measures are all at the ratio level of measurement, given as time in seconds and a percentage of total time spent on the task. Qualitative observations provided information about participant tolerance, progression of scanning tendencies, and treatment protocol recommendations.

The researchers submitted two studies for approval to the University and Medical Center Institutional Review Board (UMCIRB) at East Carolina University (UMCIRB 17-001274;

UMCIRB 17-002074) for the visual scanning training and follow-up with the eye tracking, respectively.

Participant

The inclusion criteria were ages of 18-85 years, currently having visual field deficits (e.g., homonymous hemianopia, quadrantanopia, bitemporal hemianopia), and having completed standard of care rehabilitation treatment. Exclusion criteria included having chronic spatial neglect and significant motor or cognitive deficits. The participant was recruited from a support group for people with aphasia at East Carolina University and completed informed consent for each study before beginning the respective study protocol.

The participant was a 55-year-old female with a visual field deficit from a stroke, seven years prior to this study. She was an active member of a support group for people with aphasia at East Carolina University.

Occupational Profile. The participant had good social supports in the area. She had two adult sons who lived in the area, and her parents lived an hour drive away. The participant worked as a nurse prior to having the stroke. She worked at a warehouse after the stroke, but chose to quit this job because the work was very physically taxing.

The participant reported several ADLs and IADLs that are currently difficult for her due to her visual deficits. These occupations included showering, cooking, driving, and grocery shopping. For showering and driving, the participant reported feeling apprehensive and fearful of these occupations, whereas for cooking and grocery shopping, she reported having difficulty searching for objects. Specific to driving, the participant reported having anxiety and described a time when she was in a parking lot and hit a low pole. She said her anxiety came because she never saw it and felt as if she should have seen it. Due to this anxiety, she preferred to only drive at low traffic times. Accordingly, sessions were scheduled between 10:30 am and 2:00 pm whenever possible.

Her current activities included group exercise. The participant stated she took classes three to four days per week for one to three hours each day, including sessions on strengthening, cardiorespiratory endurance, and flexibility. These exercise sessions sometimes occurred within 30 minutes prior to a treatment session.

Motivation. The participant demonstrated high motivation. She has a history of seeking treatment from various departments at East Carolina University, including speech language pathology and occupational therapy. Subsequently with this study, the client was participating in an aphasia support group hosted by the speech language pathology department at East Carolina University. Treating therapists reported the participant consistently demonstrated a positive attitude, despite any difficulties that she encountered. At the final sessions of this study, she asked for additional treatment sessions or if there were any other studies in which she could participate.

Evaluation of Physical and Visual Deficits. While Appendix B illustrates the specific results of all screening evaluations, overall, her physical abilities were generally intact. She displayed minimal deficits in shoulder and elbow range of motion, strength, and increased tone. Hand dexterity was moderately impaired likely due to the tremors in the participant's right fingers.

The participant had mild bilateral visual acuity deficits (20/40), which are fixed by prescription reading glasses. The participant had mild visual field loss past 90^{o} to the right and left of midline. The participant had significant visual field loss in the superior and inferior portions of the right eye and mild visual field loss in the superior and inferior portions of the left eye. These results may have been impacted by her expressive aphasia-related delays in verbalizing perception of visual stimuli. However, the participant's performance on the Vision Coach confirmed the presence of a visual field deficit.

The participant demonstrated a high degree of accuracy in visual scanning tasks, though with an inconsistent scanning pattern, even within a single task. The participant also had mild to moderate cognitive and language deficits, including mild global aphasia.

Instrumentation

Assessment of Motor and Process Skills. The Assessment of Motor and Process Skills (AMPS) (Fisher & Jones, 2012) is an observation-based assessment tool with a top-down, client-centered theoretical basis. The AMPS can be performed in any task-relevant setting and requires no standardized equipment. However, it requires the scorer to be trained and calibrated with the computer software, so that the Rasch analysis can account for the rater's severity (Fisher & Jones, 2012). The AMPS measures two constructs – motor skills and process skills – consisting of sixteen and twenty components, respectively, as identified on the score sheet in Appendix A.

The AMPS was designed to assess the quality of performance in occupations that are typical for the individual being assessed (Dickerson, Reistetter, Davis, & Monahan, 2011), This test is ideal for this research because it uses a many-faceted Rasch analysis to convert ordinal ADL/IADL scores to an interval scale (Fisher & Jones, 2012), making it possible to understand the outcomes as compared to a standardization sample.

The literature shows that AMPS scores remain similar between right and left hemisphere strokes, have no ceiling effect, and provide account of how motor deficits affect task performance (Bernspang & Fisher, 1995). The AMPS has been shown to be more sensitive than the FIM cognitive scales (Fioravanti, Bordignon, Pettit, Woodhouse, & Ansley, 2012) and more elaborate than the Large Allen Cognitive Level (Marom, Jarus, & Josman, 2006). Additionally, the AMPS has been validated across people with and without disabilities (Dickerson et al., 2011), cultures (Goldman & Fisher, 1997; Goto, Fisher, & Mayberry, 1996), gender (Duran & Fisher, 1996), diagnoses (Doble, Fisk, Fisher, Ritvo, & Murray, 1994; Hartman, Fisher, & Duran, 1999), race (Stauffer, Fisher, & Duran, 2000), and for determining the need for community assistance (Doble et al., 1994; Merritt, 2011). Individuals who have had a stroke vary by culture even within a given country (Howard et al., 2016) and often have difficulties in the home (Pound, Gompertz, & Ebrahim, 1999); thus, the AMPS is a useful tool for this population. Overall, the AMPS is shown to be a valid and reliable tool and controls for inter-rater variations (Fisher & Jones, 2012).

Vision Coach. The Vision Coach was designed and developed by Robin Donley, an occupational therapist and optometric vision therapist. It is a black board with 120 lights that appear based on the settings selected. The possible settings include speed (0 to 11), fixator (off, on, active), area (full field, lower field, upper field, right field, left field, lower right field, lower left field, upper right field, upper left field), mode (sequential, reduced field, full field – all with various number of lights), and color (red, green, red/green). The tool includes lights with a full set of upper and lower-case letters and three sets of numbers 1-9. The Vision Coach requires users to depress a light when it appears. The height of the board can be adjusted so that users are at eye-level with the center of the board when seated or standing. Clinicians who are frequent users of the Vision Coach have reported a learning effect and suggest recording data during the third trial or after (Donley, 2017), and research has confirmed this effect (Brooks et al., 2017; Hennessey et al., 2016). Thus, the assessment completed with the Vision Coach included three trials of a task with settings of full field, 60 dots, all red, fixator off, speed 0. The third trial was recorded for data analysis. Additionally, Brooks et al. (2017) suggested that therapists use Vision Coach data, specifically using a full field 60-dot task, to predict on-road driving performance. As such, the results of the Vision Coach have the potential to show possible improvements to occupational performance. The measures of time and hand use on the Vision Coach may be a more sensitive measure of improvement in visual scanning than the AMPS, so both will be considered to understand the usefulness of the interventions for individuals poststroke.

Tobii Eye Tracking. The current study used the Tobii Pro Glasses 2 (Version 1.76, Tobii AB, 2017) to capture foveal movement during the tasks of cooking and simulated driving. The Tobii Pro Glasses 2 are wearable eye trackers with infrared lights surrounding the frames. The infrared lights reflect off the participant's pupils and tracks where the participant is focusing his or her eye gaze. The analyzer software (Tobii Pro Glasses Analyzer; Version 1.79, Tobii AB, 2018) allows users to determine the percentage of time spent on various objects or areas of interest. In this study, gaze data was analyzed during cooking tasks by percentage of time spent fixated on task objects and environmental spaces and duration of the first fixation on task objects and environmental spaces. For the driving task, gaze data was analyzed for two crashes and one four-way stop intersection by the percentage of time spent fixated in selected areas of interest. This data was compared between the case study participant and an analogous healthy volunteer. Notably, the Tobii Pro Glasses 2 do not collect information on peripheral vision, so heat maps represent foveal eye fixations only.

Procedures

Recruitment used a convenience sampling method from local occupational therapy settings (e.g., outpatient clinics, inpatient hospitals, acute care hospitals, and skilled nursing facilities) and stroke survival groups seeking referrals of stroke patients who were completing or had completed standard of care treatment to volunteer. Each volunteer completed an intake survey and screening, ensuring they met the inclusion criteria. A list of screening tools can be found in Appendix B. One volunteer met the criteria and was selected as the participant.

The participant completed an AMPS and Vision Coach assessment at East Carolina University as a pretest and after each of the three interventions. The Vision Coach assessment is detailed under Session 0 in Appendix C. The researcher trained and calibrated to use the AMPS directed, observed, and videotaped the participant the completion of two AMPS tasks in one of the prepared kitchens. The researcher recorded the AMPS scores in a Microsoft Excel (Microsoft Office Professional Plus, Version 15.0) spreadsheet. The researcher reassessed the participant within one week after the first, second, and combined interventions had terminated. The researcher who instructed the participant to complete the two AMPS tasks was the same individual and each time, to avoid inter-rater differences.

Four weeks after the conclusion of the combined visual scanning training interventions, the participant came to East Carolina University for follow up assessment using the AMPS and driving simulator. The participant completed two AMPS tasks while wearing the Tobii Pro Glasses 2. The participant then completed one task on the driving simulator while wearing the glasses.

Intervention 1: Component-based Training. This study used the Vision Coach to conduct the component-based training intervention. The interventions of the study were conducted at East Carolina University in a room dedicated to the Vision Coach. The room had no outside windows, and the one-way mirror to the connecting room was covered to decrease distractions. The room lights were turned on during the treatment.

The participant completed the Familiarization and Baseline Establishment session (session 0, Appendix C) before starting their first intervention using the Vision Coach. This session provided time for the participant to become familiar with the Vision Coach and for the researcher to assess the participant on the Vision Coach, using a task with settings of full field, 60 dots, all red, fixator off, speed 0. The researcher used observations during practice time and the assessment to design the intervention protocol for the participant. The researcher reassessed the participant within one week after the first, second, and combined interventions had terminated.

Sessions of the visual scanning training ranged from 35 to 54 minutes. The first 2 sessions of the component-based intervention were shorter to allowed the participant to acclimate to the Vision Coach and treatment setting. Other sessions ranged from 42 to 54 minutes, based on participant tolerance and fatigue. During the sessions, the researcher guided the participant through a brief, three-trial warm up to familiarize her with the board and the intervention protocol. The session outlines are described in Appendix C. Researchers recorded time, hand use, and additional observations about effectiveness and ease of use for the Vision Coach protocols.

Intervention 2: Occupation-based Training. The participant completed four weeks of an occupation-based IADL training. The sessions took place at East Carolina University in a variety of settings throughout the occupational therapy department, including the simulated apartment, classrooms, and library. The sessions ranged from 45 to 60 minutes. Researchers used a variety of activities to facilitate efficient visual scanning. The session outlines are described in Appendix C. Researchers recorded qualitative observations in a narrative treatment note.

Intervention 3: Combined Training. The participant completed four weeks of combined training. Sessions ranged from and 12 to 15 minutes of training using the Vision Coach and 30-45 minutes of occupation-based training. Activities were similar, though shortened, from the first two interventions. Session outlines are found in Appendix C.

Data Analysis

The two measures of AMPS (motor and process skills) and Vision Coach data (time and hand use) were recorded in a Microsoft Excel (Microsoft Office Professional Plus, Version 15.0) spreadsheet. The participant's demographics were recorded and examined with the outcome measures to consider any confounding variables. To determine differences between interventions and answer the primary research question, the motor and process scores were compared using the AMPS's determination of observable difference. The AMPS scores can be compared using the likelihood of observable and statistical difference between two times (Fisher & Jones, 2012). Therefore, each AMPS measure – motor and process – could be compared between each time (2 x 4 design). These determinations of likelihood are based on mean standard deviation for the standardization sample (0.25 logit on the motor scale and 0.20 logit on the process scale) (Fisher & Jones, 2012). A change is likely statistically significant if the logit value changes by 2 standard deviations (0.50 for the motor scale and 0.40 for the process scale) (Fisher & Jones, 2012). Similarly, based on the minimal clinically significant difference, or MCID, a change is likely observable if the logit scores differ by 0.30 on either scale (Fisher & Jones, 2012). Therefore, the participant may show an observable change without the change being statistically significant. Since the purpose of this thesis is to determine best practice in a real-world healthcare setting, both statistical difference and observable difference will be considered.

Data from the Tobii Pro Glasses 2 was transferred to the Tobii Pro Analyzer. The researchers created an area of interest in the participant's affected visual fields, as determined by the deficits identified at the screening assessment. The percentage of time spent in this area was calculated for the participant and the subject of comparison, and the values were compared. This software also matched eye gaze fixations with objects and visual fields in reusable images, called snapshots. Researchers created three schematics to match gaze points with items and spaces of interest (See Appendix D). Researcher used the same schematics for the participant and the subject of comparison to determine amount of time spent on task objects and spaces during cooking and objects and in the affected visual field during driving. Percentage of time spent on each object and in each space, was calculated and compared between subjects. Additionally, the duration of the first fixation in each space and on each object, was calculated and compared between subjects.

Secondary question outcomes regarding protocols were determined based on researcher observations of difficulties, successes, and trends with various aspects of the Vision Coach protocol.

Chapter 4: Results

AMPS

To answer the first research question regarding whether visual scanning training improves the occupational performance during IADLs of people with poststroke visual/perceptual impairment, the AMPS motor and process skills at the pretest (time 1) and after each intervention were compared (time 2-4). Table 1 lists the results of the AMPS, separated by motor and process, at the four measurement times. Figures 2 and 3 illustrate the outcomes for each measurement time individually by motor and process on a logit scale. When the pretest and posttest are compared, the scores suggest there is observable changes in motor and process skills and a statistically significant change in process skills. Additionally, posttest scores improved to within the age-expected range.

Table 1

AMPS Results

Time	Score	Qualitative Description	Age Range Comparison
Motor Skills			
Pretest	1.4	Mild to moderate	Outside expected range
Post Component-Based	1.8	Questionable to mild	Within expected range
Post Occupation-Based	2.0	Questionable/ Questionable to mild	Within expected range
Posttest	1.8	Questionable to mild	Within expected range
Eye Tracking	1.9	Questionable to mild	Within expected range
Process Skills			
Pretest	0.8	Questionable to mild	Outside expected range
Post Component-Based	1.0	Questionable/ Questionable to mild	Within expected range
Post Occupation-Based	0.8	Questionable to mild	Outside expected range
Posttest	1.2	Questionable	Within expected range
Eye Tracking	0.9	Questionable to mild	Within expected range

Figure 2

AMPS Motor Scores

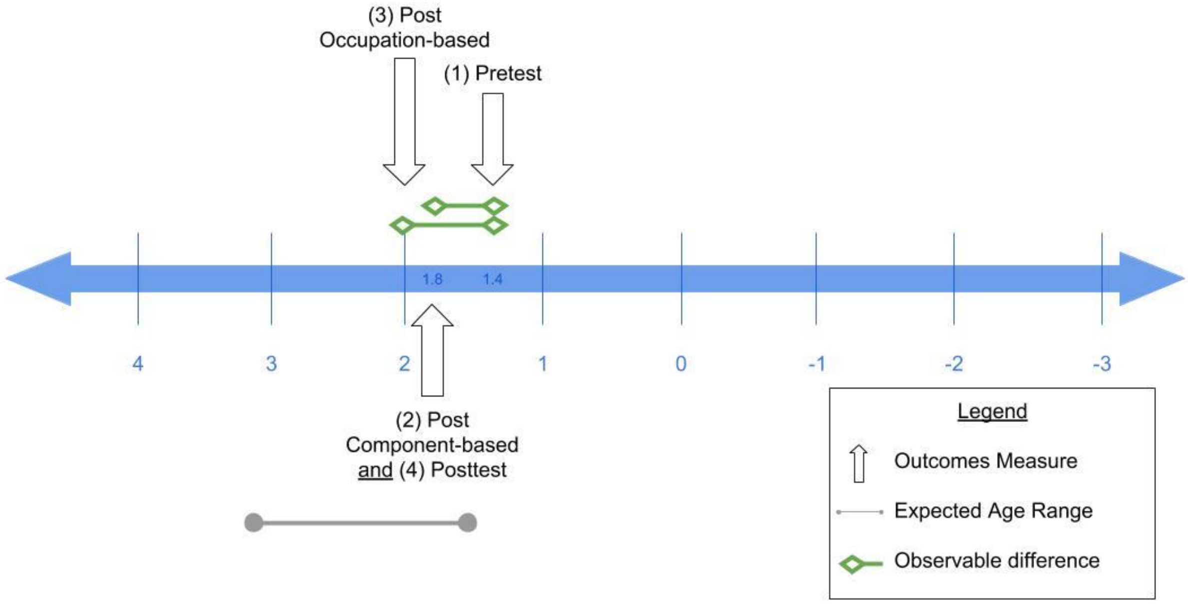
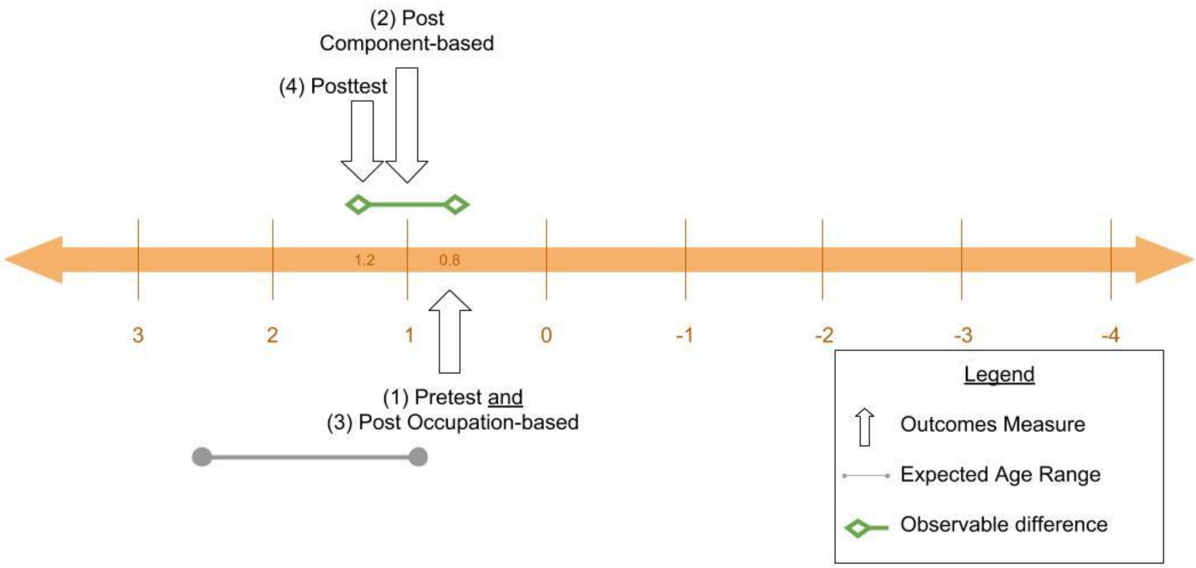


Figure 3

AMPS Process Scores



During pretest assessment (time 1), the participant demonstrated mild to moderate difficulties with motor skills and questionable to mild difficulties in process skills. These logit scores were outside the expected range for her age group, based on normalized standard scores from 213 well adults in the same age group – 50 to 59 years (Fisher & Jones, 2012). Therefore, the pretest scores on the AMPS indicated that occupational therapy intervention was warranted.

After the first intervention (time 2) – component-based training – the participant improved her scores on both motor and process skills. Based on the AMPS standardization sample, the increase in motor score was observable, but not likely statistically significant. Similarly, the increase in process score is likely not substantial enough to be observable in her IADLs and ADLs. Both increases, though, were enough change so that the participant was within her age-expected range.

After the second intervention (time 3) – occupation-based training – the participant improved her motor score while her process score decreased. While neither of these changes were significant or observable when compared with the assessment directly preceding (time 2), the process score fell below the expected range for the participant's age group, returning to pretest level (time 1). However, when comparing the motor score between the pretest (time 1) and the score post-second-intervention (time 3), the increase was observable and likely significant.

After the third intervention (time 4) – combined training – the participant improved her process score, but her motor score decreased (compared to time 3). The change in process score was both observable and likely statistically significant, according to the AMPS standardization sample data. The participant's motor score was the same as the score after the component-based intervention (time 2).

Finally, during the eye tracking assessment of cooking four weeks following cessation of intervention, the participant completed the AMPS with the Tobii Glasses Pro 2. The participant maintained her motor score and her process score decreased (compared to time 4).

To answer the second research question regarding which intervention phase elicited the greatest improvement in motor and process skills, comparison of all outcomes suggests the individual interventions (component-based and occupation-based) elicited a greater improvement in motor skills, whereas the combined intervention elicited the greatest improvement in process skills. The component-based intervention elicited the greatest improvement in motor skills, thought the effect of time is unknown.

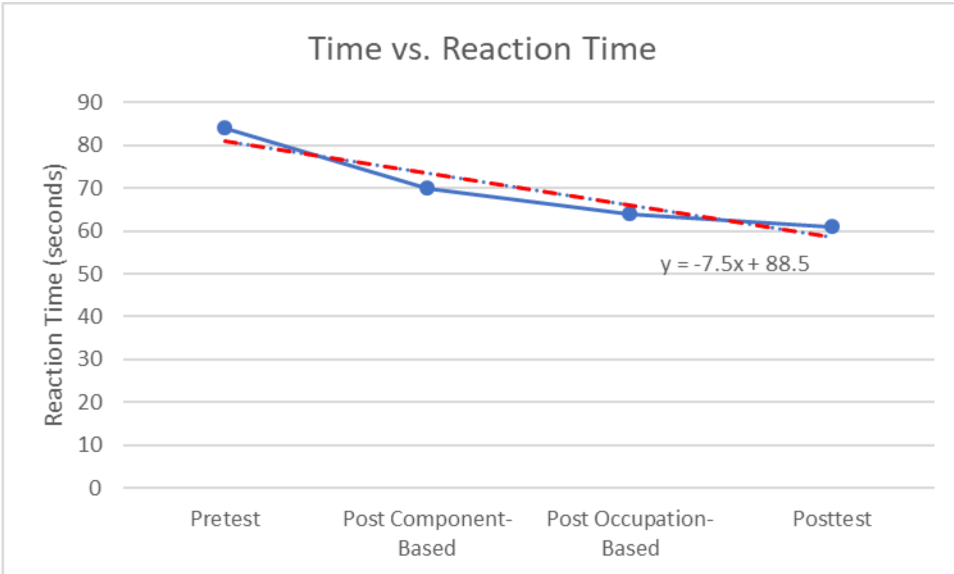
Outcomes from the Vision Coach

Data from the Vision Coach, as well as qualitative observations, were used to analyze the component-based sessions in order to address secondary research questions regarding visual training protocols and dosage.

Time. The total time in seconds of the FF60 task at pretest and end of intervention (a total of 4 times) is graphed in Figure 4. The trend line in this graph has a negative slope, indicating the overall trend was a decrease in reaction time when visually searching and responding to the vision board.

Figure 4

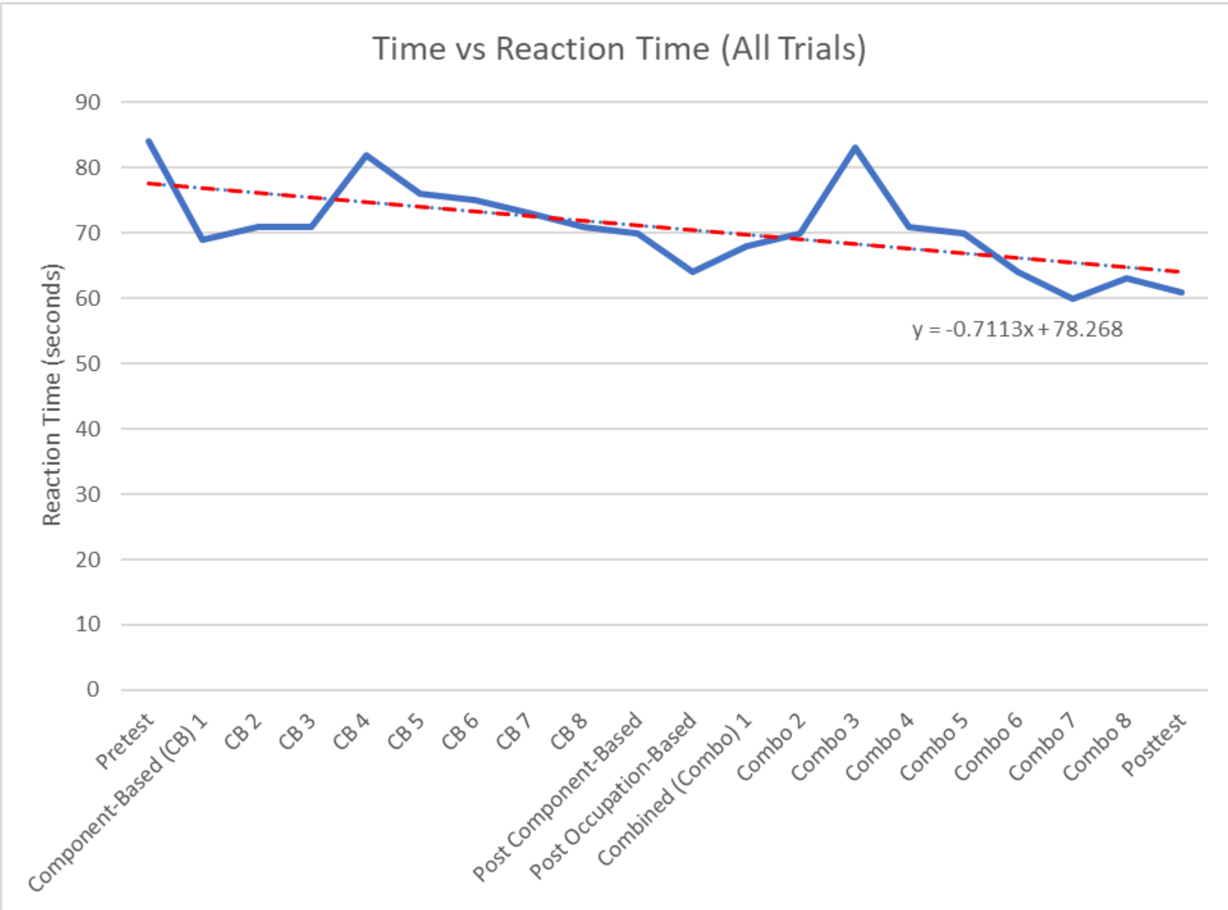
Time versus Reaction Time: Outcomes Assessment Only



In addition, the participant's performance on the FF60 task was measured at each session of the Vision Coach, as shown in Figure 5. Notably, these measures are not standardized so other factors may have influenced individual trials. The trend line in this graph indicates a negative trend though not as steep as the outcome measures alone.

Figure 5

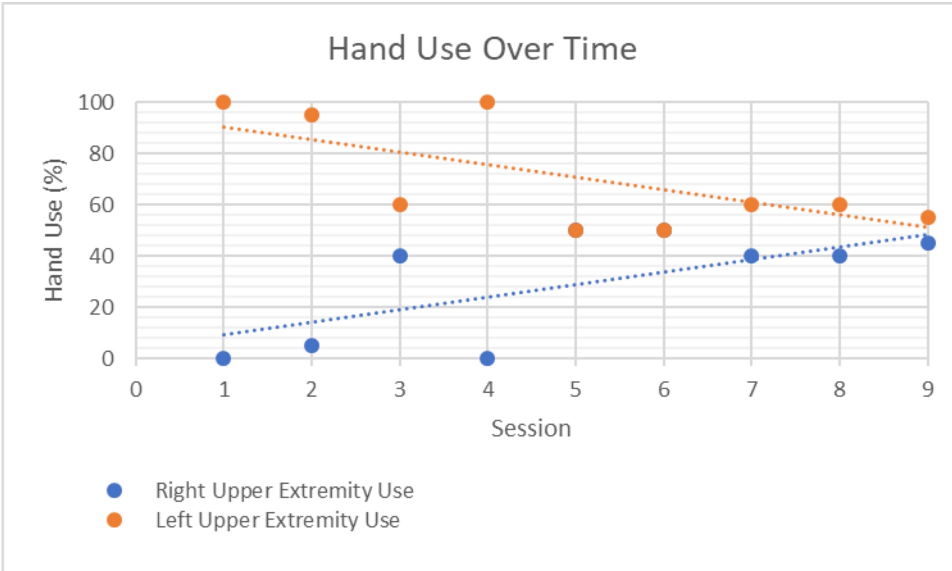
Time versus Reaction Time: All Trials



Hand Use. The participant began the interventions only using the left hand, which was naturally dominant and unaffected by the stroke. With training, the client began to use the hands more evenly, reaching a regular 50/50 pattern (alternating) by the end of the component-based intervention. The relationship between hand use and reaction time on the FF60 task during the component-based intervention can be seen in Figure 6.

Figure 6

Hand Use Over Time[a]



Session 1 is the pretest. Sessions 2-9 are the eight component-based sessions.
[a]At sessions 5 and 6, the hand use was even (50% and 50%), so only one dot is visible.

During the combined intervention, the participant continued to use both hands evenly, although she was trained to use them on the appropriate sides of the board (symmetrical pattern) rather than a pattern of alternating hands.

Qualitative observations. Following each session, treating therapists wrote a narrative note with qualitative observations and the clinical reasoning for specific strategies. The notes supported the outcomes and added descriptions in terms of scanning pattern, hand use/function, fatigue, and exercise. In terms of scanning patterns, the participant demonstrated the importance of client involvement in the development of a scanning pattern. She also appeared to benefit from anchors, though environmental anchors may have provided lasting benefits. For hand use and function, the participant demonstrated some decreased effort over time when using the affected upper extremity with Vision Coach tasks. Additionally, the participant demonstrated more physical and cognitive fatigue with the component-based intervention than with the combined intervention. With regards to exercise, the participant sometimes attended exercise classes directly before the treatment sessions.

Eye Tracking Comparison of Participant and Healthy Control

To explore how the participant's visual impairment affected her scanning ability for IADL tasks as well as driving – answering the final two research questions – data was compared between the participant and a similar-aged individual who has not experienced a neurological injury, using the Tobii Analyzer Pro software. Overall, the researchers determined that the eye tracking glasses are useful to understand the differences in visual scanning tendencies between an individual affected by stroke and a similar-aged healthy control.

Cooking as an IADL Task. To answer the third research question regarding differences in visual scanning between individuals with and without a visual field deficit, results from the two cooking tasks were analyzed as two separate tasks, required by the AMPS. The key elements (e.g., knife, plate) and spaces (e.g., stove, sink) for each task were selected to be as inclusive as possible, since this is the first study of this kind. Dotted lines (cutoffs) indicate objects or spaces that the participant and healthy control visited for more than 10% of the total task time (Tables 2 and 3) or that subjects fixated for 0.30 seconds (Table 4 and 5) or more during the first fixation. During the Eggs and Toast task, the participant viewed both the bread and the eggs for more than 10% of the task, whereas the healthy control viewed only the pan for more than 10% of the total task time. During the Grilled Cheese task, both the participant and healthy control viewed the pan and bread for more than 10% of the total task time.

Table 2

Total Visit Duration – Objects

Eggs and Toast Task					
	Participant			**Health Control**	
Item	**Time (sec)**	**% of Task Time**	**Item**	**Time (sec)**	**% of Task Time**
Bread	49.01	15.84%	Pan	72.99	15.44%
Eggs	37.63	12.16%	Bowl	42.33	8.95%
Pan	25.00	8.08%	Eggs	19.30	4.08%
Butter	13.06	4.22%	Bread	18.06	3.82%
Spatula	12.10	3.91%	Spatula	15.80	3.34%
Utensils	11.06	3.58%	Plate	15.52	3.28%
Toaster	9.82	3.18%	Jelly	14.52	3.07%
Jelly	9.14	2.96%	Juice Bottle	10.90	2.31%
Cup	8.86	2.86%	Toaster	10.78	2.28%
Salt & Pepper	8.44	2.73%	Salt & Pepper	9.70	2.05%
Juice Bottle	5.14	1.66%	Paper Towel	7.32	1.55%
Plate	2.08	0.67%	Cup	5.00	1.06%
Bowl	0.36	0.12%	Butter	4.02	0.85%
Paper Towel	0.34	0.11%	Utensils	2.64	0.56%
Grilled Cheese Task					
Pan	84.65	22.49%	Bread	74.59	17.24%
Bread	59.65	15.85%	Pan	69.09	15.97%
Cheese	17.24	4.58%	Cheese	38.75	8.95%
Cup	15.96	4.24%	Plate	34.23	7.91%
Utensils	15.16	4.03%	Butter	19.34	4.47%
Spatula	7.88	2.09%	Cup	8.58	1.98%
Butter	7.66	2.04%	Paper Towel	6.42	1.48%
Juice Bottle	7.32	1.95%	Juice Bottle	4.80	1.11%
Paper Towel	5.70	1.51%	Utensils	4.62	1.07%
Plate	0.52	0.14%	Spatula	4.58	1.06%

Table 3

Total Visit Duration – Spaces

Eggs and Toast Task					
	Participant			**Health Control**	
Space	**Time (sec)**	**% of Task Time**	**Space**	**Time (sec)**	**% of Task Time**
Counter	83.01	26.84%	Counter	189.47	40.08%
Stove Area	67.21	21.73%	Stove Area	71.47	15.13%
Refrigerator	18.38	5.96%	Refrigerator	41.96	8.87%
Microwave	11.98	3.87%	Sink Area	16.46	3.48%
Drawers	11.88	3.84%	Top Cabinets	15.68	3.32%
Sink Area	8.64	2.79%	Microwave	10.72	2.27%
Top Cabinets	7.98	2.58%	Drawers	7.78	1.65%
Bottom Cabinets	2.36	0.76%	Bottom Cabinets	4.94	1.05%
Trash Can	0.28	0.09%	Trash Can	0.24	0.05%
Grilled Cheese Task					
Stove Area	125.56	33.35%	Counter	135.28	31.26%
Counter	68.13	18.10%	Stove Area	127.84	29.55%
Sink Area	18.64	4.95%	Sink Area	26.68	6.17%
Refrigerator	18.12	4.80%	Refrigerator	16.22	3.76%
Top Cabinets	13.90	3.69%	Top Cabinets	13.58	3.14%
Drawers	10.54	2.80%	Drawers	9.00	2.08%
Bottom Cabinets	7.20	1.91%	Bottom Cabinets	7.56	1.75%
Microwave	3.66	0.97%	Microwave	6.38	1.47%
Trash Can	0.00	0.00%	Trash Can	0.06	0.01%

Table 4

First Fixation Duration – Objects

Eggs and Toast Task			
Participant		**Healthy Control**	
Item	**Time (sec)**	**Item**	**Time (sec)**
Butter	0.66	Spatula	0.32
Paper Towel	0.34	Eggs	0.32
Spatula	0.16	Pan	0.32
Pan	0.16	Bread	0.26
Cup	0.12	Bowl	0.24
Salt and Pepper	0.12	Toaster	0.22
Plate	0.12	Paper Towel	0.20
Jelly	0.10	Cup	0.14
Juice Bottle	0.10	Juice Bottle	0.14
Bread	0.10	Salt and Pepper	0.12
Bowl	0.08	Butter	0.12
Eggs	0.06	Utensils	0.10
Utensils	0.06	Jelly	0.08
Toaster	0.06	Plate	0.08
Grilled Cheese Task			
Cheese	0.60	Plate	0.28
Butter	0.30	Paper Towel	0.26
Cup	0.22	Bread	0.24
Utensils	0.18	Cheese	0.20
Paper Towel	0.12	Utensils	0.16
Bread	0.10	Butter	0.12
Juice Bottle	0.08	Spatula	0.12
Spatula	0.08	Pan	0.06
Plate	0.08	Cup	0.06
Pan	0.08	Juice Bottle	0.06

Table 5

First Fixation Duration – Spaces (Averaged Across Tasks)

Participant		Health Control	
Item	**Time (sec)**	**Item**	**Time (sec)**
Sink Area	0.27	Microwave	0.23
Trash Can	0.22	Sink Area	0.22
Top Cabinets	0.20	Drawers	0.18
Refrigerator	0.17	Refrigerator	0.16
Bottom Cabinets	0.13	Trash Can	0.11
Microwave	0.12	Bottom Cabinets	0.11
Stove Area	0.11	Stove Area	0.09
Drawers	0.08	Top Cabinets	0.08
Counter	0.04	Counter	0.08

Driving Simulator. To answer the final research question regarding differences in visual scanning between individuals with and without visual field deficits, data from the Tobii Glasses Pro 2 was analyzed for one task on a driving simulator. While the complete drive on the driving simulator was recorded, only three critical events were compared in this exploratory examination: a four-way stop, a pedestrian crossing in front of the car, and a car coming head-on in the wrong lane. The four-way stop event was chosen due to healthy control fixations in the participants affected visual field (far right and left), while the latter events were chosen because the participant crashed.

The frequency of the fixations in the affected visual fields – far right and left, inferior and superior regions – was examined and compared between subjects. The participant had no instances of fixation in the affected areas. The comparison subject had one instance of entering the participant’s affected visual fields, during a four-way stop event for 0.08 seconds. The fixation was to the far-right visual field to search for a car coming to the four-way stop. The participant viewed the same spaces on the driving simulator screens, though she turned her head rather than moving her eyes.

Table 6 presents the total visit duration of various areas of interest during the four-way stop event with an associated heat map for this event for the participant (Figures 7) and the control (Figure 8). It is important to note that in these images, the points of view changed as the head turned and observation of the video clearly shows the movement of the head. Therefore, the participant's gaze to the far right and left of the heat map image do not represent the foveal vision entering the area of the visual field deficit but rather the participant's head turned to view these spaces on the driving simulator. Thus, the heat map suggests the participant has learned to compensate for her deficits, although she had fewer fixations in the peripheral fields.

Table 6

Four-Way Stop Total Visit Duration – Ordered by Participant Time

Area of Interest	**Participant**		**Healthy Control**	
	Time (sec)	**%**[1]	**Time (sec)**	**%**
Straight Ahead	2.30	19.95%	5.94	48.45%
Cars Parked on Right	2.13	18.47%	0.00	0.00%
Dashboard	0.96	8.33%	0.84	6.85%
Stop Sign	0.42	3.64%	0.10	0.82%
Far Right Road	0.36	3.12%	1.14	9.30%
Left Road	0.16	1.39%	0.24	1.96%
Far Left Road	0.10	0.87%	0.00	0.00%
Left Mirror	0.00	0.00%	0.60	4.89%
Rearview Mirror	0.00	0.00%	0.00	0.00%

As the participant crashed at two critical events, these were examined and compared to the healthy control, who did not crash. The eye tracking fixations were matched to snapshots of two critical events (pedestrian crash and a head-on collision). Table 7 presents the total time and percentage of time spent in areas of interest for each event and heat maps are for the participant (Figure 7, 9, 11) and the control (Figures 8, 10, 12).

[1] Percent of total time of incident

Table 7

Total Visit Duration

Pedestrian Crash				
Area of Interest	**Participant**		**Healthy Control**	
	Time (sec)	**%[2]**	**Time (sec)**	**%**
Construction Truck (Left)	0.00	0.00%	0.30	3.50%
Parked Cars (Right)	0.40	8.32%	0.46	5.36%
Road Straight Ahead	0.00	0.00%	3.94	45.91%
Head-on Collision				
Area of Interest	**Participant**		**Healthy Control**	
	Time (sec)	**%**	**Time (sec)**	**%**
Cars Close Up/Next To	0.00	0.00%	0.00	0.00%
Cars in the Distance	2.42	90.27%	0.74	16.35%
Road Straight Ahead	0.00	0.00%	1.98	43.73%

Figure 7

Heat Map for 4-Way Stop – Participant

[2] Percent of total time of incident

Figure 8

Heat Map for 4-Way Stop – Healthy Control

Figure 9

Heat Map for Pedestrian Crash – Participant

Figure 10

Heat Map for Pedestrian Crash – Healthy Control

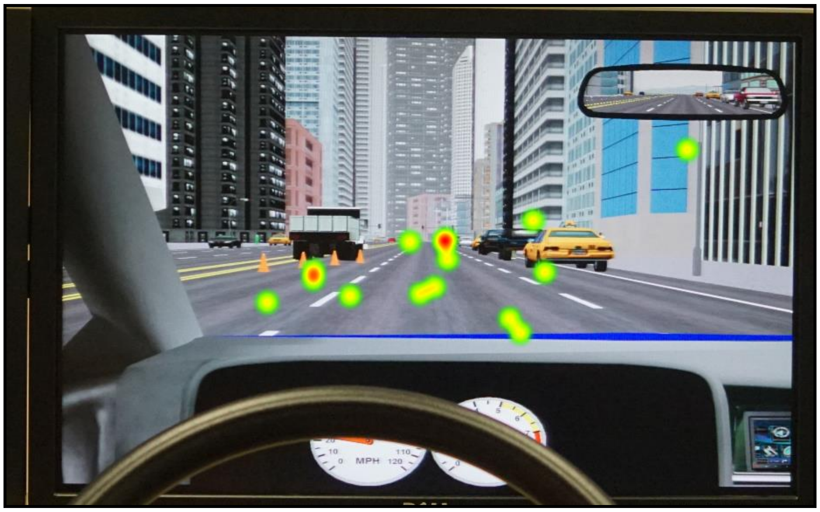


Figure 11

Heat Map for Head-on Collision – Participant

Figure 12

Heat Map for Head-on Collision – Healthy Control

During the pedestrian crash, the participant only viewed the right side of the road (0.40 seconds, 8.32%), whereas the healthy control viewed the left side of the road (0.30 seconds, 3.50%), right side of the road (0.46 seconds, 5.36%), and straight ahead (3.94 seconds, 45.91%). During the head-on collision, the participant only fixated on the cars in the distance (2.42 seconds, 90.27%), whereas the healthy control fixated on cars in the distance (0.74 seconds, 16.35%) and the road straight ahead (1.98 seconds, 43.73%). These differences represent disparate attentions and recognition of hazards.

Chapter 5: Discussion

The objective of this single case study was to explore whether an individual with residual visual deficits from a stroke can improve her visual scanning ability through occupational therapy interventions. Specifically, component-based intervention with the Vision Coach and occupational-based scanning training were used individually and then in combination to improve IADL performance, as measured through motor and process skills of the AMPS as outcomes. In addressing this first research question, results reflected a noticeable change in both motor and process skills resulting from the 12-week intervention program, suggesting that the intervention program improved occupational performance. It is important to note, that as a functional assessment tool (AMPS), the improvement in performance reflects a functional change, not only a change in underlying physical or cognitive skills.

The second research question addresses the two different interventions. One intervention is considered component-based because the visual, physical, and cognitive challenges were based on an exercise tool, not directly related to any functional daily living task. However, the research does indicate that such programs can improve the underlying skills necessary for function (Warren, 2013). The other intervention was occupation-based and therefore embedded in typical daily activities.

Following the component-based intervention, motor skill changes were observed. Changes in motor skills following the component-based intervention are likely due to an increase in right upper extremity use. Due to the nature of tasks and size of the Vision Coach, the participant was encouraged to use both hands evenly to improve reaction time. The use of the right upper extremity increased from baseline primarily because the participant used her right upper extremity only minimally prior to beginning this study.

After the occupation-based intervention, the participant's motor scores increased by 0.2 logits, which is not a significant change based on the AMPS standardization sample. The results may indicate that some minor improvements can be made during occupation-based training that focuses on visual skills. However, these changes are insufficient to see noticeable improvements in daily activities after only 4 weeks of training.

Following combined treatment, the participant's motor skills score was the same as the score after the component-based intervention, and therefore decreased from the measure directly preceding (time 3). It is possible that the decreased time in either of the treatment types – vision board or occupation-based training – detracted from their effectiveness to focus on motor skills. The longer sessions of the separated interventions allowed for time to integrate motor demands and challenges, whereas a short session required the therapist to focus on only the main priority of the session (i.e. visual scanning and learning compensatory methods), which in this study were process skills. Additionally, by the time of the combined intervention, the participant had already mastered using hands bilaterally in an alternating pattern, which is another possible explanation for not observing further changes. However, the participant's motor score was maintained 4-weeks after intervention cessation, as demonstrated by the score during the eye tracking follow-up. Thus, the total effect on motor skills of the 12-week program remained.

Improvements in process skills were only observed following the combined intervention. The researchers suggest that changes in process skills are elicited by a combination of component-based and occupation-based training due to increased opportunity for transfer and generalization of specific skills. Component-based scanning training using a vision board may allow an occupational therapy client to develop necessary foundational skills, whereas the occupation-based training might help the client generalize the skills into daily activities. Since the dependent variable in this study was occupational performance, generalization is likely essential for improving performance in a real-world environment, such as a kitchen as with the AMPS.

However, the participant did not maintain these improvements at the 4-week follow up, when using the eye tracking glasses. Wearing the eye tracking glasses may have impacted her process score during the tasks, though this is unlikely since none of the individual scores were noticeable impacted by the glasses per evaluator report. Therefore, the decreased scores may suggest that longer than four weeks of the combined intervention is needed to maintain the effects.

Thus, it appears that occupational therapy treatment for visual field deficits should include both component-based and occupation-based approaches in order to improve the overall occupational performance impacted by the visual field deficit.

Vision Coach

Data from the Vision Coach showed the participant decreased her reaction time following each intervention. Currently, the literature does not specify a minimal clinically significant difference or minimal detectible change for relating reaction time on a vision board to occupational performance. However, reaction time on a full field task of the Vision Coach has been related in one study to driving performance (Brooks et al., 2017). Therefore, driving may be improved through quicker reaction times due to more efficient scanning.

Time. Each intervention resulted in a decrease in response time on the task of full field, 60 dots, all red, speed 0, fixator off, thus confirming the findings of Klavora, Gaskovski, Heslegrave, Quinn, & Young (1995) that a vision board modality improves response time and visual scanning speed. The component-based intervention appears to have elicited the greatest decrease, but this magnitude might be attributed to training effect, being the first intervention with the Vision Coach. The combined intervention had the least decrease in time, but this decrease may be due to a plateau effect. Her time approached 1 second per dot (60 seconds total), which is a steady and presumably functional pace. Overall, the 12-week program demonstrated observable decreases in response time on the Vision Coach, which a previous study has related to driving performance (Brooks et al., 2017). Due to findings by Klavora and colleagues (1995), this effect on response time is likely to be maintained over time.

Additionally, Figure 4 shows the importance of considering change over time, not individual sessions. The participant increased her time noticeably during some sessions, often due to new strategies being implemented, but still had an overall decrease in reaction time. No previous studies have collected such outcome measures from daily treatment sessions, only from outcome measure assessment (Klavora, Gaskovski, Heslegrave, Quinn, & Young, 1995; Brooks et al., 2017; Hennessey et al., 2016). This data relates to the real-world settings of occupational therapy, where performance may be observed during sessions as well as regular re-evaluations. Thus, this graph provides a comparison for future studies to establish trends in Vision Coach training progression and expected changes in reaction time over the course of therapy.

Hand Use. The participant began the component-based intervention by using the left upper extremity 75-100% of the time. By session six of eight, the participant consistently used the right upper extremity at least 40% of the time when given no specific directions on hand use, with two exceptions. One exception occurred when the directions of the task changed, so it is likely the participant was focused on adhering to the new directions rather than extremity use.

The second exception occurred when completing a task with one eye covered, which the participant indicated made her feel nervous.

During the combined treatment, when no specific hand use directions were given, the participant completed each trial using both hand evenly. During the first few sessions, the participant implemented an alternating pattern of hand use. The therapist found this was creating difficulty for the participant when the dot location forced her to cross to the contralateral edge of the board. Therefore, the participant was instructed to use each hand on the ipsilateral side of the board. Learning and integrating this symmetrical pattern took time, but by session six of the combined treatment, the participant appeared proficient in symmetrical hand use and ultimately became more efficient in her movements to the dots.

Overall, the progression of hand use – moving from alternating to symmetrical – appeared useful for the client to first involve the affected upper extremity and then add an advanced cognitive challenge. The former required only right-left discrimination of her body (intrinsic awareness), whereas the latter required the client to also have good right-left discrimination of her environment (extrinsic awareness). This pattern facilitated the client to complete tasks more quickly, because her left hand did not become fatigued. Thus, the progression may be beneficial for developing cohesive use of both hands during occupational therapy treatment. Previous literature supports the integration of both symmetrical and alternating bilateral arm training into occupational therapy treatment (Lee, Lee, Koo, & Lee, 2017; Lin, Chang, Wu, & Chen, 2009), but has not discussed best methods for progression between these methods. Further research could focus on whether symmetrical or alternating hand use is more beneficial for improving occupational performance and if alternating might support later use of symmetrical hand use.

Qualitative Observations. For the component-based intervention phase, the therapist's treatment notes offer insights into the nuances of using the Vision Coach during occupational therapy treatment.

Client involvement in scanning pattern. The literature supports the use of autonomy and a positive therapeutic alliance for maximizing the benefits of occupational therapy treatment (Lawton, Haddock, Conroy, & Sage, 2016; Luker, Lynch, Bernhardsson, Bennett, & Bernhardt, 2015). In this study, treatment notes demonstrated the importance of this kind of client involvement in developing a consistent and efficient visual scanning pattern. At the first session, the participant demonstrated an inconsistent visual scanning pattern. The therapist inferred that the participant had learned visual scanning patterns before but was switching between patterns, making the scanning inefficient. During the initial sessions, the therapist taught the client a horizontal rectilinear visual search pattern. However, due to the nature of the visual field deficit – more pronounced in the far right inferior and superior – the participant suggested first searching the far right inferior then superior, making the pattern counterclockwise. The therapist incorporated the participant's suggestions, and the participant began to use this one pattern consistently. Thus, participant involvement and trial-and-error for a preferred visual scanning pattern was essential for carryover and consistent, repetitive use of the pattern, which ultimately increases scanning efficiency.

Anchors. The therapist used anchors of a hand on side of Vision Coach board and blue tape dots on the sides of the board as visual cues for how far to scan on the board. The therapist noted how the participant's memory deficits could have impacted the effectiveness of anchoring. Once the visual cues were removed the participant returned to missing dots in the far-right visual field within 2-3 trials. Thus, whenever anchors are used with clients having coexisting memory deficits, as are common following stroke, anchors already existing in the environment that will not be removed or training to use self-anchoring (e.g., moving finger across board until feeling the edge) may be most beneficial.

Hand function. With regards to hand function, at the first five sessions of the component-based intervention, the participant demonstrated moderately increased effort to depress dots with the right upper extremity as compared to the left. Over time, the therapist reported a slight improvement in right upper extremity strength and coordination – as measured by ability to depress the Vision Coach dots – though difficulties were still present. It is possible that these improvements resulted from training with the Vision Coach. However, it is important to note that improving upper extremity strength and coordination was not a focus of the sessions and objective data was not collected.

Fatigue. Fatigue was a major hindrance to treatment during the component-based intervention, improving during the combined intervention. During the component-based sessions, the therapist consistently noted cognitive and physical fatigue at about the midpoint of the session (i.e. 20-25 minutes). This fatigue resulted in ending the session early (first two sessions), ending tasks early, changing treatment plans to exclude more difficult tasks at the end of the session, and one instance of a flexor synergy pattern in the right upper extremity. Additionally, with fatigue the participant requested a lower number of dots or lower speeds for difficult tasks. The participant was often discouraged when performance decreased throughout the session, though her decreased performance was likely due to fatigue. During the combined intervention, cognitive fatigue was not observed. On two occasions, physical fatigue was observed in the right upper extremity. It is possible the physical exertion that led to fatigue contributed to the motor skills improvement observed during the component-based treatment and not during the combination treatment. Future research can further indicate the optimal combination of component-based and occupation-based visual scanning training to maximally improve occupational performance, as well as consider the impact of intertwining the component-based and occupation-based tasks rather than having separated treatment.

Exercise. The participant had a regular exercise routine. She participated in group fitness classes 3-4 days per week for 1-3 hours each day. Some of these classes occurred within 2 hours before the treatment sessions. The effects of exercising before a session with the Vision Coach was unclear. After attending a fitness class that same day, the participant appeared to have decreased physical endurance but also decreased cognitive fatigue. However, the exercise had little perceptible effect on Vision Coach performance. It is important to note that comparison across various tasks and between days is difficult, since tasks were upgraded and downgraded each session. Comparison is largely based on the baseline comparison task (full field, 60 dots, speed 0, fixator off, all red), which was kept consistent each session but does not tax cognition significantly.

Eye Tracking

In order to understand how visual scanning is used in functional performance, the participant's visual fixations were recorded using the Tobii Pro Glasses 2 during two cooking tasks and one driving task, and analyzed compared to a health control's visual fixations. Fixations are defined as instances where a user's pupil gaze stabilizes on an object or space for a specified amount of time, as compared to a saccade where the pupil is in motion. Expert opinion suggests that fixations are linked to cognitive attention and consequently cognitive processing of information in an individual's visual world (Tobi Pro, 2018; Warren, 2013).

Since limited research exists in connecting eye tracking data to occupational performance, it is noteworthy that this study confirmed the feasibility of using the eye tracking glasses during both cooking and driving occupations. This finding is supported by Kortman & Nicholls (2016) for occupations in general and Sundin, Patten, Bergmark, Hedberg, Iraeus, & Pettersson (2012) for driving simulators. Future research can draw upon the methodologies of these studies to design experiments which investigate the correlation between eye tracking metrics and occupational performance.

Cooking. The total time spent in the areas of interest, on average, did not differ noticeably. The differences observed are likely due to individual differences in task completion. Although, data has not yet been published regarding individual differences between healthy individuals, so it is unclear what magnitude of difference is significant. The average duration of first fixation – the first time an object or space is viewed – was similar between the participant and healthy control, with differences ranging from 0.01 to 0.03 seconds for each task and the spaces averaged across tasks. Overall, the participant and control had greater variation in total time spent and duration of first fixation on objects than on spaces. Therefore, future research should focus on the difference between task objects within a sample of health adults and compare to a sample of individuals with cortical visual impairments resulting from a neurological injury or condition. Spaces in the environment may be useful to consider when conducting tasks in a larger or unfamiliar environment, though this is outside the scope of this study.

Cutoff Values. Another significant contribution of the cooking task eye tracking data exploration is the cutoffs seen in Tables 2 through 5 for total visit duration and first fixation duration. Cutoffs were generated based on observations made while analyzing the data. Since this is the first study of its kind, these cutoffs represent a natural separation in the participant's outcomes. For the total visit duration, researchers noticed a gap between objects or spaces viewed for about 15% of the time and the next most visited object or space. Therefore, 10% was selected as the cutoff to account for variation in the values of the healthy control. For the first visit duration, researchers again noticed a gap between objects viewed for more than 0.30 seconds and the next longest first fixation. Therefore, 0.30 seconds was selected as the cutoff.

These cutoffs can be used for future research to expand on the work of Kizony & Katz (2002) regarding how visual attention affects task performance in various brain injury populations. Eye tracking data is thought to be connected to cognitive information processing (Tobi Pro, 2018), since it provides insights to visual attention – a precursor to higher level cognitive functions (Warren, 2013). The gap observed between the most used objects and other objects can be useful to understand what a participant is focusing on most. For example, the participant in this study viewed the eggs longest, approximately 12% of the total task time, whereas the healthy control viewed the pan longest, approximately 15% of the time. These results may indicate that the participant focused more on the eggs themselves rather than the pan as she was stirring the eggs. The healthy control, in contrast, may have focused more on the pan than on the eggs inside it. The reason for this difference is unclear, but researcher suggests this focus may impact performance of the task, especially with regards to preventing mistakes. Further research is needed to generalize and draw substantive conclusions regarding how focus on various objects impacts task performance and where focus should be directed to improve occupational performance during occupational therapy treatment.

Additionally, the cutoff for the first fixation duration can form a foundation for understanding differences in information processing during a task. For example, the participant took double the time to process the butter upon first fixation (0.66 seconds) during the eggs and toast task as the healthy control took to process any of the objects. This difference may indicate the participant had to cognitively process butter longer than is typical for an individual without visual deficits. Further research with larger sample sizes are needed to understand how first fixation duration differs between neurotypical adults and those with visual deficits from a brain injury, as well as how any differences affect occupational performance.

Driving. During observations of simulated driving, the participant's field deficits did not appear to impact her abilities and attention during driving when environmental cues were evident. During the only fixation of the healthy control in the participant's affected visual field – a four-way stop event – the participant viewed the same area of the environment as the healthy control, though with more head motion and less eye movement. The head movements suggest that the participant is successfully compensating for her visual field deficits.

However, analysis of data surrounding the participant's crashes indicate that her visual scanning may still be restricted when there are no cues to alert her for danger. For example, during the pedestrian crash event, the participant did not search the left side and the road ahead whereas the healthy control did. The health control's gaze visited the left side of the road for a small percentage (3.50%) and the road straight ahead for the highest portion of total time surrounding the crash (45.91%). The participant's gaze did not enter these areas of interest in the visual field. Instead, the participant focused her gaze to the right side of the road where cars were parked. It is possible the participant was alerted to the potential danger of these parked cars and watch diligently for one of them to start merging into the road. Her visual field deficit may have made her apprehensive about such an event. However, her attention became fixated on the right side and did not search the left side and road ahead for other potential dangers, therefore missing the pedestrian coming from the left. The healthy control, on the other hand, focused a majority of her gaze straight ahead, looking to the left and right in equal measure to identify hazards as they appeared. This gaze shifting likely contributed to her success in avoiding a crash with the pedestrian. The healthy control likely used her peripheral vision with more confidence than the participant since the health control did not have a visual deficit.

Additionally, during and directly before the head-on collision, the participant again did not shift her gaze as much as the healthy control. The participant continued to look far into the distance of the road, even as the car approached the head-on collision. She did not direct her gaze to view the car coming towards her. In contrast, the healthy control shifted her vision to fixate on the car coming towards her and avoided a head-on collision by moving off the road. The healthy participant also had noticeably more variety in areas of the visual field that were visited (16.35% in the distance and 43.73% at the road straight ahead), whereas the participant spent a majority of the time (90.27%) with her gaze on cars in the distance. This data again suggests that without signs of danger, the participant was less likely to visually scan her environment during driving.

As occupational therapists, safety awareness is an important skill for independence, especially in driving and community mobility. Therefore, further studies exploring the frequency of compensatory visual scanning to the affected side among people with brain injury would be useful to understand how compensatory methods may transfer to driving. Berger, Kaldenberg, Selmane, & Carlo (2016) suggest that visual scanning can be useful in increasing awareness of and attention to the affected visual field. However, while purposeful and sustained attention to the affected area during a cooking task may improve task performance, this compensatory method may increase an individual's risk for a driving accident. For example, compensatory methods used in the kitchen – a stable environment – may include attending more consciously to the affected visual field to notice materials, directions, or cues for danger. However, occupational therapists may be advised to revise this compensatory measure for driving to include consistent scanning of the entire environment rather than focused attention to the affected side, since the environment when driving is dynamic with equally dynamic hazards. As stated above, future research can use eye tracking to further understand how occupational therapy compensatory methods for a stable environment transfer to driving.

Application for Occupational Therapy Practice

Due to the case study design, generalization is limited. However, the following recommendations provide a basis for developing intervention plans to improve visual scanning following a stroke or other brain injury.

Visual Scanning Training. As expected, the participant's visual field loss presentation did not change over the course of therapy (Bowers, Ananyev, Mandel, Goldstein, & Peli, 2014; Reinhard, Damm, Ivanov, & Trauzettel-Klosinski, 2014; Zhang et al., 2006). Therefore, visual scanning training was warranted to compensate for the lost visual fields (Mannan, Pambakian, & Kennard, 2010; Pambakian et al., 2005). These findings confirm the conclusions in current literature.

Overall, it would appear that a program specifically targeting visual scanning compensation to improve occupational performance for individuals poststroke should likely include both component-based treatment to compensate for continuing deficits and occupation-based treatment to promote generalization and transfer of component-based skills. In occupational therapy practice, therapists usually target multiple client factors simultaneously and a combination treatment allows for other skills to be incorporated during the occupation-based part. When visual scanning inefficiency is the main client factor affecting occupational performance or when visual scanning is otherwise being targeted by the therapist, the component-based visual scanning training may provide additional benefits when combined with occupation-based training. This study confirmed the hypothesis of Warren (1993a; 1993b) in using a bottom-up approach in occupational therapy practice for visual deficits, focusing on individual skills first but ultimately integrating developed skills into occupations. For this participant, the occupation-based training was not able to isolate visual scanning. It incorporated higher level skills, such as visual memory and pattern recognition, throughout the interventions. Using component-based training may therefore have isolated the skill of visual scanning, as Warren suggests.

Vision Coach. The Vision Coach was a useful tool for improving this participant's occupational performance. This vision board provided opportunities to improve hand function, cognition, and visual scanning. Occupational therapy practice can benefit from the availability of this equipment, especially with clients who have had a stroke, since nearly 22% of them will have chronic visual field deficits (Ali et al., 2013).

For this tool, therapist observations of participant fatigue and session duration revealed an optimal range for dosage of Vision Coach treatment. During the component-based intervention, sessions lasted approximately 45 minutes, and the participant became fatigued around 25-30 minutes into the session. During the combined intervention, the participant did not become fatigued and seemed energetic at the end of the 15-minute Vision Coach portion. Therefore, the optimal range for visual scanning training using the Vision Coach is likely between 15-30 minutes.

Eye Tracking. Understanding the impact of visual attention on occupational performance can help occupational therapists teach clients the most effective methods for visual attention during cooking tasks to compensate for visual field deficits. In a static environment such as a kitchen, visual scanning which focuses on problematic areas of the visual field may help clients to increase awareness of that part of the environment to decrease the chances of mistakes or hazards. Comparison of the participant and the healthy control revealed visual scanning differences during cooking, though generalization is limited due to the small sample size.

Additionally, safety awareness is an important skill for occupational independence, especially in driving and community mobility. According to the performance of this participant, occupational therapists may consider revising compensatory measures developed within a stable environment for driving to include consistent scanning of the entire environment rather than focused attention to the affected side, since the environment when driving is dynamic with equally dynamic hazards. While it may be beneficial in a stable environment to move the gaze more frequently to the affected side since peripheral information is limited, the dynamic environment and extensive hazards of driving elicit a need for a unique scanning pattern to reduce the chances of an accident. Occupational therapists may find it beneficial to specifically attend to a client's visual fixations during dynamic tasks, especially where the environment is moving around him or her, to better understand how efficient they might be at identifying hazards on the road.

Limitations

Though measures were taken to maximize validity, this study has some limitations. Due to the nature of being a case study, there was only one participant and a healthy control. Therefore, the generalizability of findings is limited. However, since the study is the first of its kind, the case study design allowed researchers to gain in-depth understanding of the impact of various confounding variables. For example, the researchers discovered the possible confounding variables of working out and motivation. The participant exercised before some sessions, which appeared to impact her performance on the Vision Coach tasks. The participant also demonstrated a high degree of motivation to improve her skills, as demonstrated by continued exercise programs and volunteering in university programs. Therefore, the nature of being a case study – while limiting the generalization of results – allowed researchers to identify possible confounding variables that should be controlled for in future studies.

Moreover, the study results were limited by not having a pretest for the eye tracking measures. In future studies, it would be beneficial to record performance using the eye tracking glasses before and after the interventions. This pretest could be an objective measure of how the visual scanning training impacted visual scanning. It could control for other visual skills – such as visual memory and pattern recognition – to definitively determine what types of changes were made by the intervention.

Conclusion

The 12-week program of visual scanning training did make observable changes in occupational performance (motor and process skills). The Vision Coach was shown to be a useful tool for occupational therapists to improve the underlying skill of visual scanning in a bottom-up approach. Additionally, the combined treatment was the most effective for improving the participant's process skills, though the component-based and occupation-based visual scanning training were more effective at improving motor skills when utilized individually. It is also important to note that neither individual treatment – component-based and occupation-based – was sufficient to improve process skills.

Eye tracking data from this study can provide a basis for future research using the eye tracking glasses during occupations. This research can be useful to expand our understanding of visual scanning trends and how those change after a brain injury. The next step is to gather a large data set of typical adults to develop norms for and understanding of typical visual search patterns for comparison to clients of occupational therapists.

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Appendix A: Assessment of Motor and Process Skills Score Sheet

AMPS SCORE FORM (page 1 of 2)

Name: ______________________ OTAP ID number: ______________________

Occupational therapist: ______________________

Gender: ____ Male ____ Female Major diagnosis: ______________________

Birth date: ______________________ Secondary diagnosis: ______________________

Evaluation date: ______________________ Observation number: ____1 ____2 ____3 ____4

Task number: ______ Task name: ______________________

RATE THE PERSON'S QUALITY OF PERFORMANCE (QoP) ON *THIS* TASK:

	No problem	Questionable	Minimal	Moderate	Marked	Inordinate; cannot test
Increased effort	1	2	3	4	5	6
Decreased efficiency	1	2	3	4	5	6
Decreased safety	1	2	3	4	5	6
Assistance provided	1	2	3	4	5	6

GLOBAL BASELINE STATEMENT: ______________________

____

____

RATE THE PERSON'S OVERALL ABILITY TO LIVE IN THE COMMUNITY (Consider everything you know about the person):

____The person can/could live *independently*

____The person needs/should have *minimal assistance or supervision*

____The person needs/should have *moderate to maximal assistance*

NOTES:

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AMPS SCORE FORM (page 2 of 2)

ITEM RAW SCORES

ADL Motor Skills		ADL Process Skills	
BODY POSITION		***SUSTAINING PERFORMANCE***	
1. Stabilizes	4 3 2 1	16. Paces	*Already scored under ADL motor skills*
2. Aligns	4 3 2 1	17. Attends	4 3 2 1
3. Positions	4 3 2 1	18. Heeds	4 3 2 1
OBTAINING AND HOLDING OBJECTS		***APPLYING KNOWLEDGE***	
4. Reaches	4 3 2 1	19. Chooses	4 3 2 1
5. Bends	4 3 2 1	20. Uses	4 3 2 1
6. Grips	4 3 2 1	21. Handles	4 3 2 1
7. Manipulates	4 3 2 1	22. Inquires	4 3 2 1
8. Coordinates	4 3 2 1	***TEMPORAL ORGANIZATION***	
MOVING SELF AND OBJECTS		23. Initiates	4 3 2 1
9. Moves	4 3 2 1	24. Continues	4 3 2 1
10. Lifts	4 3 2 1	25. Sequences	4 3 2 1
11. Walks	4 3 2 1	26. Terminates	4 3 2 1
12. Transports	4 3 2 1	***ORGANIZING SPACE AND OBJECTS***	
13. Calibrates	4 3 2 1	27. Searches/ Locates	4 3 2 1
14. Flows	4 3 2 1	28. Gathers	4 3 2 1
SUSTAINING PERFORMANCE		29. Organizes	4 3 2 1
15. Endures	4 3 2 1	30. Restores	4 3 2 1
16. Paces	4 3 2 1	31. Navigates	4 3 2 1
		ADAPTING PERFORMANCE	
		32. Notices/ Responds	4 3 2 1
		33. Adjusts	4 3 2 1
		34. Accommodates	4 3 2 1
		35. Benefits	4 3 2 1

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Appendix B: Screening Results

Table B1

Results of the Screening Assessments

Assessment	Subtest	Score
Range of Motion (RUE)	Shoulder elevation	Less than normal
	Shoulder flexion	155^{o}
	External rotation	Less than normal
	Finger extension	Shaking, WFL
	All other motions tested	WFL
Range of Motion (LUE)	All motions tested	WFL
Manual Muscle Testing (RUE)	Shoulder scaption	4+/5
	All other muscles tested	5/5
Manual Muscle Testing (LUE)	All muscles tested	5/5
Timed Get Up and Go[3]		7.5 seconds
Modified Ashworth Scale[4] (RUE)	Elbow flexion/extension	1, "catch release"
	Shoulder flexion/extension	0
	Wrist flexion/extension	0
Box and Blocks	Dominant hand (L)	62 blocks
	Nondominant hand (R)	35 blocks

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Assessment	Subtest	Score
Brain Injury Visual Assessment Battery for Adults[5]	Pupillary Function	Normal (bilateral)
	Eye dominance	Left eye dominant
	Acuity: Intermediate Distance	20/25
	Acuity: Reading Acuity	20/40
	Kinetic Two Person Confrontation Test: Horizontal Visual Field (L)	80^o left to 30^o right
	Kinetic Two Person Confrontation Test: Horizontal Visual Field (R)	30^o left to 90^o right
	Kinetic Two Person Confrontation Test: Vertical Visual Field (L)	30^o up to 60^o down
	Kinetic Two Person Confrontation Test: Vertical Visual Field (R)	0^o up (straight ahead) to 15^o down
	Damato Campimeter	2 abnormal blind spots in the L eye (L half of visual field – 35, 48) 3 abnormal blind spots in the R eye (L half of visual field – 18, 41, 43)
	Single Letter Search	92.5% accuracy 1.5 minutes Inconsistent search pattern
	Complex Circles Search	100% accuracy 1.5 minutes Verbal cue given Benefitted from cue Symmetrical rectilinear pattern
	Telephone Number Copy	100% accuracy
	Design Copy	All details drawn 45 seconds Rechecked for accuracy
Cognitive Linguistic Quick Test[6]	Attention	166 (mildly impaired)
	Memory	130 (moderately impaired)
	Executive Functions	26 (WNL)
	Language	23 (moderately impaired)
	Visuospatial Skills	91 (WNL)
	Clock Drawing	11 (mildly impaired)
	Non-linguistic Cognition	38 (mildly impaired)
	Linguistic/Aphasia	42 (mildly impaired)

[5] Warren, M. (1998). Brain injury visual assessment battery for adults test manual. *Birmingham, AL: visAbilities Rehab Services.*
[6] Helm-Estabrooks N. Cognitive Linguistic Quick Test (CLQT): Examiner's Manual. The Psychological Corporation, San Antonio, TX; 2001.

Assessment	Subtest	Score
Canadian Occupational Performance Measure[7]	Occupations	Showering Exercise Searching cabinets Driving Searching grocery store Volunteering Job/Employment Gardening Attending Football Games Hiking

[7] Law, M., Baptiste, S., Carswell, A., McColl, M. A., Polatajko, H., & Pollock, N. (2014). *Canadian occupational performance measure* (5th ed.). Ottawa, ON: CAOT Publications ACE.

Appendix C: Visual Scanning Training Protocol

The following is the intended intervention protocol for the visual scanning training sessions. Prior to each participant's arrival, the researcher will turn on the Vision Coach, modify the board to the correct height, input the correct settings (see below), and prepare a space for the researcher and participant to sit and debrief. The researcher will also schedule the sessions at times when the Vision Coach is not being used by other studies. Below are outlines for the sessions.

Session 0: Familiarization and Baseline Establishment

1. Researcher will explain the Vision Coach functionality and features.
2. The participant will have 5 minutes to familiarize themselves with the Vision Coach. Where upper extremity functioning allows, participants will be encouraged to use both hands and depress the lights fully, using their knuckles if needed. The researcher will decide if balance is adequate to safely complete the tasks in standing. If not, the participant will be allowed to perform tasks while seated, and the Vision Coach height will be adjusted appropriately. The researcher will allow the participant to practice the following, repeating as desired by the participant:
    a. Speed 0, full field, 30 dots, all red, fixator off
    b. Speed 0, sequential, 30 dots, all red, fixator off
    c. Speed 0, sequential, 30 dots, red/green, fixator off
    d. Speed 0, full field, 30 dots, all red, fixator on
    e. Speed 1, full field, 30 dots, all green, fixator off
    f. Speed 1, full field, 30 dots, all red, fixator active
    g. Speed 2, full field, 30 dots, all green, fixator off

3. Simple: The participant will then complete three trials of the speed 0, full field, 60 dots, all red, fixator off. The third trial will be recorded as a baseline. The researcher will record the correct hits, late hits, and time from the Vision Coach output.
    a. Difficult: If this task appears too easy for the participant, the researcher will ask the participant to complete three trials of the following: speed 1, full field, 60 dots, red/green, fixator off, with instructions to only select lights with letters on them, not blank lights or lights with numbers. The third trial will be recorded as a baseline. The researcher will manually record the number of correct hits and late hits, and the time will be recorded from the Vision Coach output.
4. The researcher will provide feedback on the participant's performance and allow the participant to ask any questions.

Session 1-8: Intervention

1. The participant will familiarize themselves with the Vision Coach using the baseline comparison task: speed 0, full field, 60 dots, all red, fixator off.
2. Where upper extremity functioning allows, participants will be encouraged to use both hands and depress the lights fully, using their knuckles if needed. Participants will complete tasks in standing or seated, as determined by the familiarization session.
3. Participants will complete 10-15 minutes of visual scanning training. Researchers will prompt participants to complete the following, based on problem areas identified in the baseline establishment.
    a. Problem: Not scanning the full visual field

       Training option 1: Field of difficulty

Training option 2: First the field without difficulty and then the field of difficulty

Training option 3: Full visual field

b. Problem: Cognitive loading difficulties (following the Difficult baseline task)

   Training: Instructions to press only certain lights (options: lower case letters, upper case letters, numbers, or any specific ranges of these items)

   i. If used multiple times, the task instructions should be novel for each session.

c. Problem: Slow reaction time

   Training: Instructions to move eyes and head to find every dot as fast as possible

   i. The participant should be informed of previous time and told to try and improve the time.

4. The researcher will provide feedback on the participant's performance, noting any new problems identified, and allow the participant to ask any questions.

Final Session: Reassessment

1. The participant will have 5 minutes to familiarize themselves with the Vision Coach. Where upper extremity functioning allows, participants will be encouraged to use both hands and depress the lights fully, using their knuckles if needed. The researcher will decide if balance is adequate to safely complete the tasks in standing. If not, the participant will be allowed to perform tasks while seated. The researcher will allow the participant to practice the following, repeating as desired by the participant:
   a. Speed 0, full field, 30 dots, all red, fixator off
   b. Speed 0, sequential, 30 dots, red/green, fixator off
   c. Speed 0, full field, 30 dots, all red, fixator on

    d. Speed 1, full field, 30 dots, all red, fixator active
    e. Speed 2, full field, 30 dots, all green, fixator off

2. Simple: The participant will then complete three trials of the speed 0, full field, 60 dots, all red, fixator off. The third trial will be recorded as a final assessment. The researcher will record the correct hits, late hits, and time from the Vision Coach output.
    a. Difficult: If this task appears too easy for the participant, the researcher will ask the participant to complete three trials of the following: speed 0, full field, 60 dots, red/green, fixator off, with instructions to only select lights with letters on them, not blank lights or lights with numbers. The third trial will be recorded as a final assessment. The researcher will manually record the number of correct hits and late hits, and the time will be recorded from the Vision Coach output.
3. The researcher will provide feedback on the participant's performance and allow the participant to ask any final questions from this intervention interval.

Table C1

Treatment Sessions Outlines

Session	Task (s) – in order	Time
Vision Coach only (VC) 1	FF60, all red, speed 0, fixator off (x1) FF60, all red, speed 0, fixator on (x1) Right field, 40 dots, all red, speed 0, fix. off (x3; hand use prog.[8]) RF30, all red, speed 0, fix. off (x2; 50/50 hand use, RUE only) Inferior field, 40 dots, all red, speed 0 fix. off (x3; hand use prog.) FF60, all red, speed 0, fixator off (x1)	35 minutes
VC 2	FF60, all red, speed 0, fixator off (x3; hand use prog.) Right field, 40 dots, all red, speed 0, fix. off (x3; hand use prog.) Inferior field, 40 dots, all red, speed 0 fix. off (x3; hand use prog.) Right field, 40 dots, all red, speed 0, fix. off, glasses on (x1) FF60, all red, speed 0, fixator off (x1)	38 minutes
VC 3	FF60, all red, speed 0, fixator off (x3; hand use prog.) Right field, 40 dots, all red, speed 1, fix. off (x3; hand use prog.) Right field, 60 dots, all red, speed 1, fix. off (x3; hand use prog.) Inferior field, 40 dots, all red, speed 0 fix. off (x3; hand use prog.) Inferior field, 40 dots, all red, speed 0 fix. off (x1) FF60, all red, speed 0, fixator off (x1)	54 minutes

[8] Hand use prog. = Hand use progression; directions to use any hand, both hands evenly, and then RUE only across 3 trials

Session	Task (s) – in order	Time
VC 4	FF60, all red, speed 0, fixator off (x3; hand use prog.) Right field, 40 dots, all red, speed 0, fix. off, glasses on (x1) Right field, 40 dots, all red, speed 1, fix. off (x1) Right field, 40 dots, all red, speed 2, fix. off (x3; hand use prog.) Right field, 60 dots, all red, speed 2, fix. off (x2; 50/50 hand use, RUE only) Inferior field, 40 dots, all red, speed 0 fix. on (x3; hand use prog.) FF60, all red, speed 0, fixator off (x1)	52 minutes
VC 5	FF60, all red, speed 0, fixator off (x3; hand use prog.) FF30, all red, speed 0, fixator on (x3; any hand) FF60, all red, speed 0, fixator on (x3; any hand) Inferior field, 40 dots, all red, speed 0 fix. on (x3; hand use prog.) Inferior field, 40 dots, all red, speed 2 fix. on (x2; any hand) Inferior field, 40 dots, all red, speed 2 fix. off (x1; any hand) Right field, 40 dots, all red, speed 0, fix. off (x2; 50/50 hand use, RUE only) FF60, all red, speed 0, fixator off (x1)	43 minutes
VC 6	FF60, all red, speed 0, fixator off (x3; hand use prog.) Right field, 40 dots, speed 0, all red, fixator off, glasses on (x1) Right field, 40 dots, speed 1, all red, fixator off (x1) Right field, 40 dots, speed 2, all red, fixator off (x3; hand use prog.) Inferior field, 40 dots, speed 1, all red, fixator on (x1) Inferior field, 40 dots, speed 2, all red, fixator on (x2; any hand, 50/50) FF30, all red, speed 0, fixator on (x3; hand use prog.) FF60, all red, speed 0, fixator off (x1)	46 minutes

Session	Task (s) – in order	Time
VC 7	FF30, all red, speed 0, fixator off (x3; hand use prog.) Right field, 40 dots, speed 0, all red, fixator off, glasses on (2x; 50/50) FF30, all red, speed 0, fixator on (x3; hand use prog.) FF30, all red, speed 1, fixator on (x3; hand use prog.) Right field, 40 dots, speed 2, all red, fixator off (x3; hand use prog.) Inferior field, 40 dots, speed 1, all red, fixator on (x2; any hand, RUE only) FF60, all red, speed 0, fixator off (x1)	42 minutes
VC 8	FF60, all red, speed 0, fixator off (x3; hand use prog.) FF60 task, speed 0, all red, fixator on (x3; hand use prog.) FF30 task, speed 1, all red, fixator on (x3; hand use prog.) Right field, 40 dots, speed 2, all red, fixator off (x3; hand use prog.) Inferior field, 40 dots, speed 2, all red, fixator on (x3; hand use prog.) FF60, all red, speed 0, fixator off (x1)	50 minutes
Occupation-based only (IADL) 1	Sudoku Puzzle – 3 Activities	50 minutes
IADL 2	Sorting Laundry – 3 Activities	45 minutes
IADL 3	Laundry and Kitchen Activities – 2 Activities	45 minutes
IADL 4	Baking Cookies – 2 Activities	45 minutes

Session	Task (s) – in order	Time
IADL 5	Decorating Cookies – 2 Activities	45 minutes
IADL 6	Mosaic Tile Making – 3 Activities	45 minutes
IADL 7	Mosaic Tile Making (Part II) – 3 Activities	45 minutes
IADL 8	Library Search/Wayfinding – 3 Activities	45 minutes

Session	Task (s) – in order	Time
Combined 1	FF60, all red, speed 0, fixator off (x1) FF60, all red, speed 0, fixator on (x3) Right field, 40 dots, speed 1, all red, fixator off (x1) Inferior field, 40 dots, speed 1, all red, fixator off (x1) IADL: Mosaic Tile Making (Part II) – 4 Activities	15 minutes VC; 30 minutes IADL
Combined 2	FF60, all red, speed 0, fixator off (x1) Right field, 40 dots, speed 2, all red, fixator off (x2) Inferior field, 40 dots, speed 1, all red, fixator off (x1) IADL: Card Making – 2 Activities	15 minutes VC; 30 minutes IADL
Combined 3	FF60, all red, speed 0, fixator off, with guiding tape[9] (x1) Right field, 40 dots, speed 2, all red, fixator off, with guiding tape (x2) Inferior field, 40 dots, speed 0, all red, fixator on, with guiding tape (x1) Inferior field, 40 dots, speed 1, all red, fixator off, with guiding tape (x1) Inferior field, 40 dots, speed 2, all red, fixator off, with guiding tape (x1) IADL: Chopping Vegetables – 4 Activities	15 minutes VC; 30 minutes IADL

[9] "Guiding tape" included two small pieces of tape along each side edge of the Vision Coach (lower quadrants) and one each at the top and bottom at midline. The tape on the side edges provided a visual cue for the participant to see how far out to search in areas of difficulty, where she often missed red dots while scanning initially. The midline tape indicated at what point the participant should use the right hand (on the right side of the board) versus the left hand (on the left side of the board). This supplemented additional instructions given to the client during Combined 3 to use the right hand on the right side of the board and the left hand on the left side of the board to minimize physical difficulty in depressing dots, caused by reaching too far, and increase efficiency while still using both hands evenly.

Session	Task (s) – in order	Time
Combined 4	FF60, all red, speed 0, fixator off, with guiding tape (x1) Right field, 60 dots, speed 2, all red, fixator off, with guiding tape (x2) Inferior field, 40 dots, speed 1, all red, fixator on, with guiding tape (x1) Inferior field, 40 dots, speed 2, all red, fixator on, with guiding tape (x1) FF60, all red, speed 0, fixator on, with guiding tape (x1) IADL: Kabobs – 1 Activity	15 minutes VC; 30 minutes IADL
Combined 5	FF60, all red, speed 0, fixator off, with guiding tape (x1) Right field, 60 dots, speed 2, all red, fixator off, with guiding tape (x2) Inferior field, 40 dots, speed 2, all red, fixator on, with guiding tape (x2) FF60, all red, speed 0, fixator on (x2) IADL: Gardening (Part I, Decorating Pot) – 2 Activities	15 minutes VC; 30 minutes IADL
Combined 6	FF60, all red, speed 0, fixator off (x1) Right field, 40 dots, speed 2, all red, fixator off (x2) Inferior field, 60 dots, speed 1, all red, fixator on (x1) Inferior field, 60 dots, speed 2, all red, fixator on (x2) FF60, all red, speed 0, fixator on (x1) IADL: Gardening (Part II, Planting) – 3 Activities	14 minutes VC; 30 minutes IADL
Combined 7	FF60, all red, speed 0, fixator off (x2) Right field, 40 dots, speed 2, all red, fixator off (x2) Inferior field, 60 dots, speed 1, all red, fixator on (x1) Inferior field, 40 dots, speed 2, all red, fixator on (x1) FF60, all red, speed 0, fixator on (x1) IADL: Cleaning the Home – 4 Activities	12 minutes VC; 30 minutes IADL

Session	Task (s) – in order	Time
Combined 8	FF60, all red, speed 0, fixator off (x2) Right field, 60 dots, speed 2, all red, fixator off (x2) Inferior field, 60 dots, speed 2, all red, fixator on (x1) FF60, all red, speed 0, fixator on (x1) FF60, all red, speed 1, fixator on (x1) IADL: Christmas Decorating – 2 Activities	15 minutes VC; 30 minutes IADL

Appendix D: Eye Tracking Schematics

Figure D1

Spaces Schematic

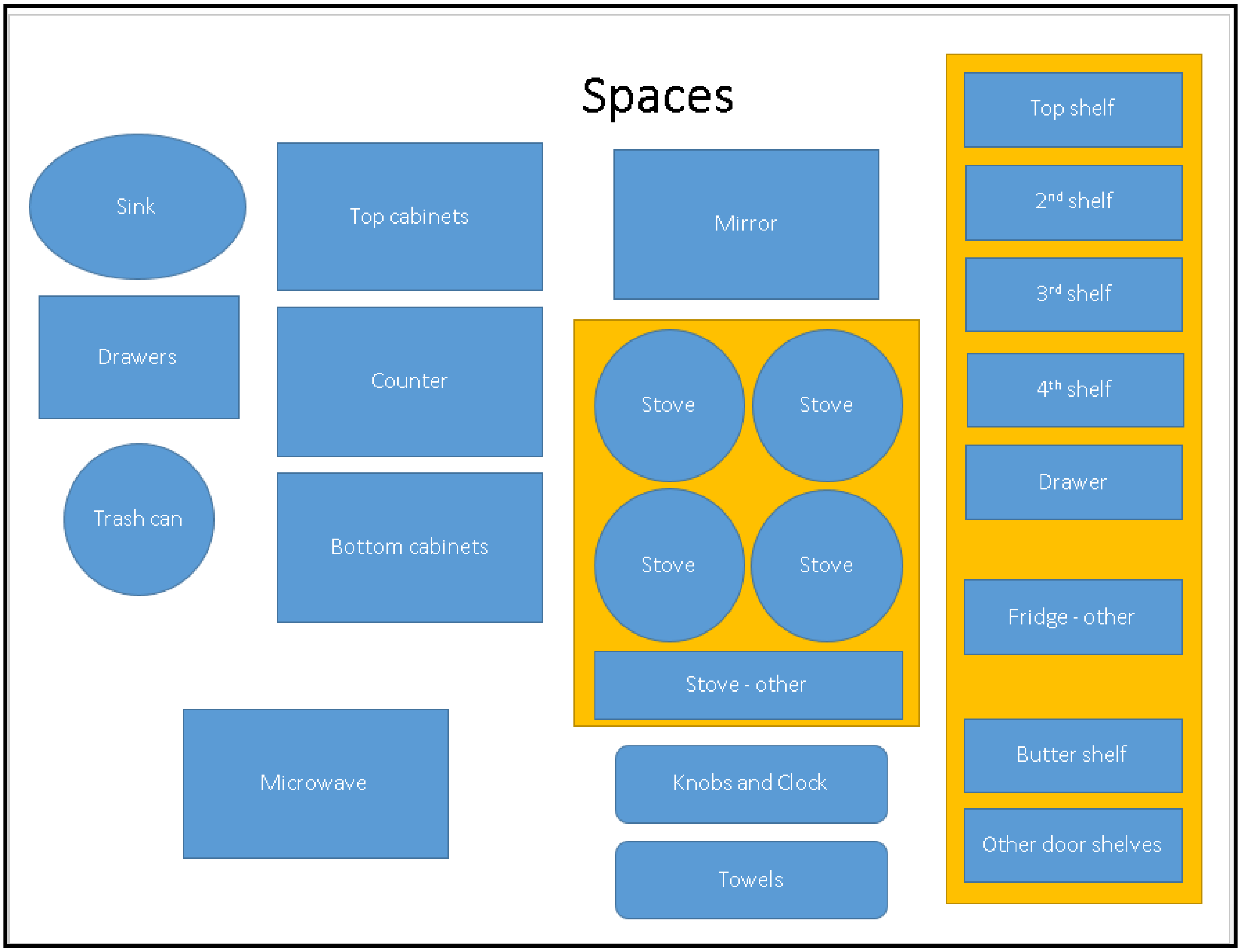


Figure D2

Schematic for Objects in Grilled Cheese and a Beverage Task

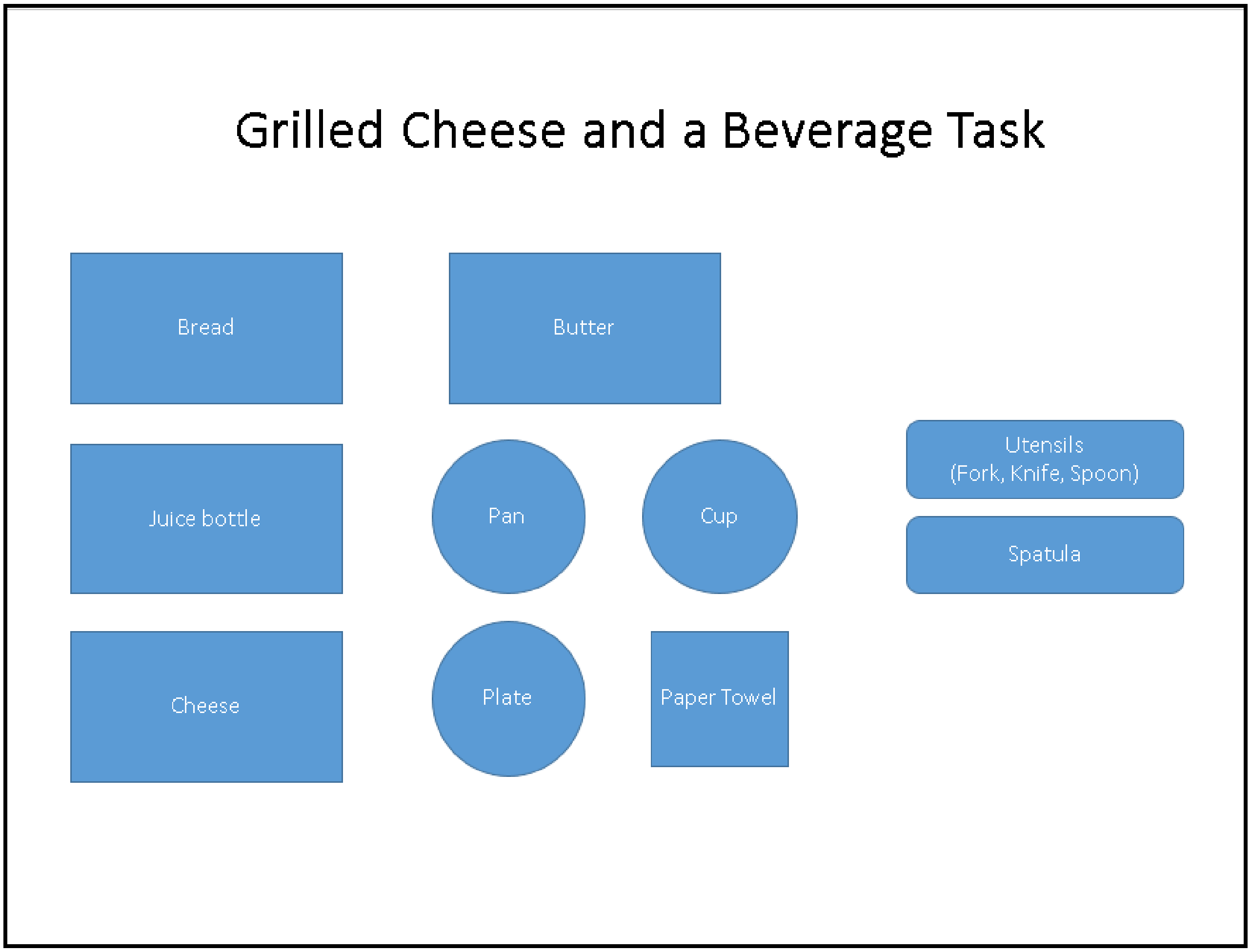
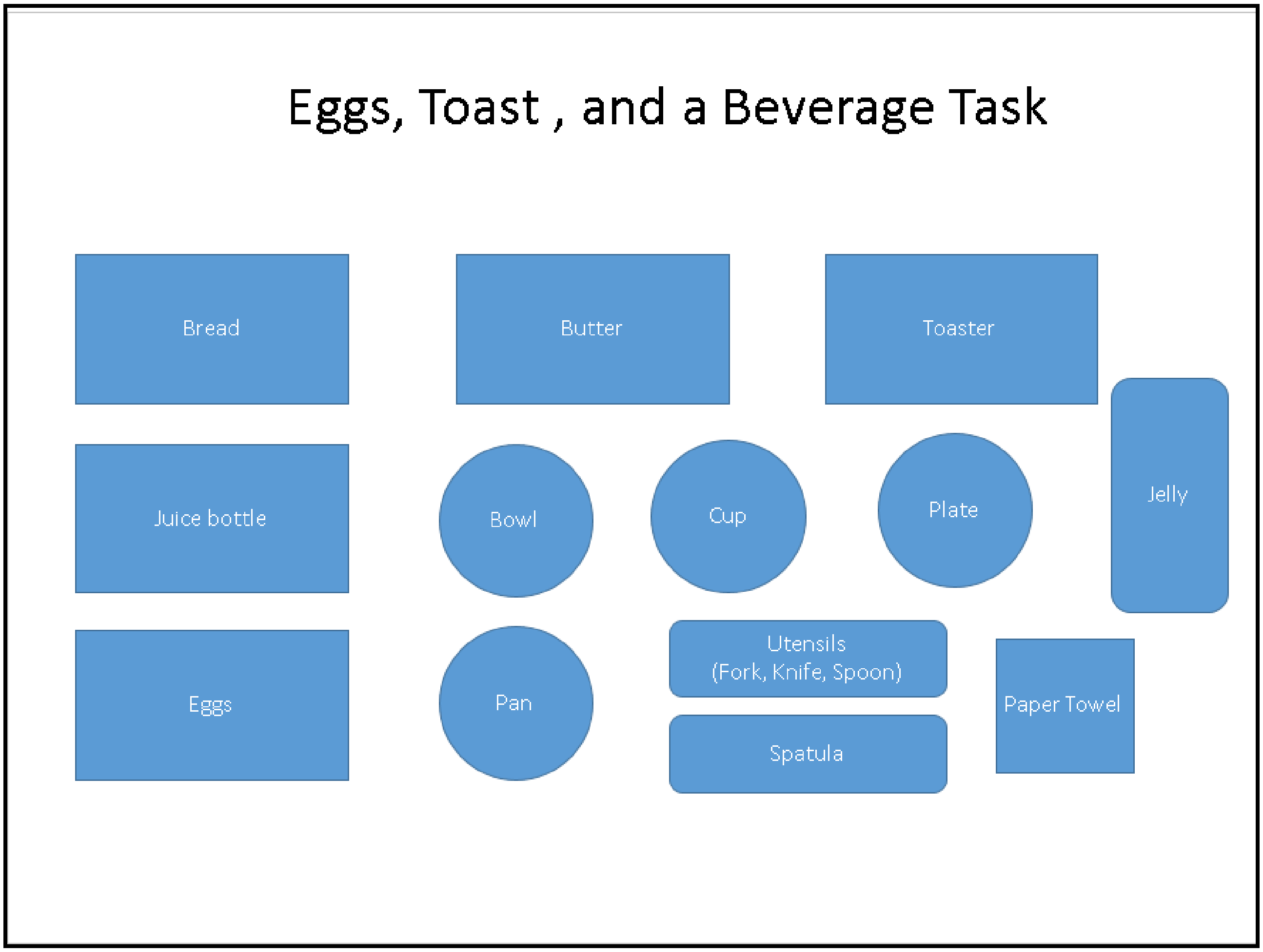


Figure D3

Schematic for Objects in Eggs, Toast, and a Beverage Task



Appendix E: IRB Approval

EAST CAROLINA UNIVERSITY
University & Medical Center Institutional Review Board Office
4N-70 Brody Medical Sciences Building · Mail Stop 682
600 Moye Boulevard · Greenville, NC 27834
Office **252-744-2914** · Fax **252-744-2284** · www.ecu.edu/ORIC/irb

Notification of Initial Approval: Expedited

From: Biomedical IRB
To: Jennifer Radloff
CC:
Anne Dickerson
Date: 7/3/2017
Re: UMCIRB 17-001274
Effects of Visual Rehabilitation on Occupational Performance and Participation

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 7/2/2017 to 7/1/2018. The research study is eligible for review under expedited category #6,7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
AMPS	Standardized/Non-Standardized Instruments/Measures
BiVABA	Standardized/Non-Standardized Instruments/Measures
Box and Blocks	Standardized/Non-Standardized Instruments/Measures
CLQT	Standardized/Non-Standardized Instruments/Measures
Consent Version 2	Consent Forms
COPM	Standardized/Non-Standardized Instruments/Measures
email recruitment_v2.docx	Recruitment Documents/Scripts
MAS	Standardized/Non-Standardized Instruments/Measures
Protocol_Visual Rehab Research.docx	Study Protocol or Grant Application
Range of Motion Assessment	Standardized/Non-Standardized Instruments/Measures
Recruitment Flyer Version 2	Recruitment Documents/Scripts
TUG	Standardized/Non-Standardized Instruments/Measures
TVPS-4	Standardized/Non-Standardized Instruments/Measures

Name	Description
Vision Coach	Standardized/Non-Standardized Instruments/Measures

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418

EAST CAROLINA UNIVERSITY
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www.ecu.edu/ORIC/irb

Notification of Initial Approval: Expedited

From: Social/Behavioral IRB
To: Anne Dickerson
CC:

Date: 10/23/2017
Re: UMCIRB 17-002074
Eye tracking on simulator

I am pleased to inform you that your Expedited Application was approved. Approval of the study and any consent form(s) is for the period of 10/22/2017 to 10/21/2018. The research study is eligible for review under expedited category #6, 7. The Chairperson (or designee) deemed this study no more than minimal risk.

Changes to this approved research may not be initiated without UMCIRB review except when necessary to eliminate an apparent immediate hazard to the participant. All unanticipated problems involving risks to participants and others must be promptly reported to the UMCIRB. The investigator must submit a continuing review/closure application to the UMCIRB prior to the date of study expiration. The Investigator must adhere to all reporting requirements for this study.

Approved consent documents with the IRB approval date stamped on the document should be used to consent participants (consent documents with the IRB approval date stamp are found under the Documents tab in the study workspace).

The approval includes the following items:

Name	Description
AMPS score sheet	Standardized/Non-Standardized Instruments/Measures
Brake reaction timer	Standardized/Non-Standardized Instruments/Measures
consent for ECU students	Consent Forms
Driving Habits Questionnare	Surveys and Questionnaires
Email	Recruitment Documents/Scripts
General consent	Consent Forms
Mazes	Standardized/Non-Standardized Instruments/Measures

The Chairperson (or designee) does not have a potential for conflict of interest on this study.

IRB00000705 East Carolina U IRB #1 (Biomedical) IORG0000418
IRB00003781 East Carolina U IRB #2 (Behavioral/SS) IORG0000418