Feature Article: Optometric Vision Therapy for Visual Deficits and Dysfunctions: A Suggested Model for Evidence-Based Practice
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Editor’s note: To preserve the international flavor, we have elected to utilize the authors’ Australian English spelling, which differs in some respects from their American English counterparts. Owing to the length of the article, we have incorporated a brief content outline as a preview.

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Abstract

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ABSTRACT

Evidence from neural science supports a neuroplasticity thesis where the development and rehabilitation of functional neural pathways can be facilitated by management of biological factors, central processing and environmental interactions. Healthy eyes and clear sight are not themselves sufficient for efficient functional vision. How a person uses vision determines their operational skill. Efficient functional vision requires dynamic interactions between and within visual receptive and reflexive biology, acquired neural networks that serve basic visual inspection processes and visuo-cognitive operational patterns driving top-down visual – spatial analysis and problem solving.

This presentation is a review and discussion of evidence-based practice (EBP) principles that we utilise in clinical neuro-developmental and rehabilitative optometric vision therapy (OVT) for selected visual deficits and dysfunctions.

OVT services, like other collaborative therapies such as cognitive behavioural therapy, speech therapy and occupational therapy, must progressively adapt to new knowledge and advancing technology through EBP. Clinical services directed at treatable neuro-developmental and acquired dynamic functional vision problems require the application of an emerging set of principles resulting from systematic logic and EBP related to the art and science of case analysis, practice management and OVT delivery.

INTRODUCTION

Contemporary neural science, visual science and clinical research have advanced the understanding of functional vision efficiency and the treatability of specific aspects of visuo-motor and perceptual organisation. The emerging science of the mind has recently combined with visual science, innovative laboratory technologies adapted for clinical measurement and consequential systems for management that are applicable to optometry. Neural science and innovative technologies are for vision care providers ‘disruptive’ because their use and application extends clinical services beyond the usual defect/dysfunction construct. Our goal is to detail the evidence-based practice (EBP) and applicable principles related to neuro-developmental and rehabilitative optometric vision therapy (OVT).

Historically, early vision therapy philosophies were based on visual biology and reflexive physiological optics. This produced “orthoptic” procedures that were applied to the patient. These early procedures included lens prescriptions, occlusion, and stimulation procedures to initiate ocular calisthenics, fixation reflex, fusion reflex and diplopia awareness responses. The early concepts of visual function were linear input --> black box --> output in nature. They can be characterised as a bottom-up perspective, as vision was considered something that happened “to” a person. The eyes were viewed as optical systems that responded relatively instinctively and were not greatly influenced by the mindset or cognitive functioning of the viewer. With the realisation that binocular vision was an intrinsic psychic faculty and that voluntary mental effort could play an important role in the treatment of selected strabismic patients, top-down models of visual function began to emerge. Early behavioural views of vision have needed to adapt and shift perspective to clinically apply the new paradigm. Neural science now supports a functional neural developmental and rehabilitative plasticity construct where biological factors, central processing and environmental interactions contribute. Additionally, the neural basis for self-directed visual inspection, working
memory, procedural memory, motor learning and perceptual learning has become better understood.

Both top down and bottom-up processes are now known to influence human neural development, neuro-cognitive operations and functional vision efficiency. Research\(^5\) has added understanding to how executive control comes to gain voluntary management over important aspects of visual inspection. Under natural viewing conditions our eyes are continuously moving and jump from place to place making about 3 fixations per second. Eye movements provide spatial exploration while fine detail and feature analysis requires accurate and stable fixation. The quality of static vision clarity is measured by visual acuity but the quality of *dynamic vision* is not. Dynamic vision requires coordinated organisation of eye movement, fixation hold, and attention to detail. The quality of a person’s dynamic vision can be measured by procedures that use dynamic stimuli. The subject must process the time order and the content of the incoming spatial and feature related neural messages to gain ‘meaning’ from functional vision.

Dynamic functional vision abilities develop as each person learns to integrate their visual inspection and processing systems. Their optomotor cycle\(^10\) then assists in the self-directed management of when to look, what to look at, how to analyse and understand what is viewed, when to leave a target, and where to go next. Basic neuro-developmental aspects of top-down visual inspection (optomotor and perception) are acquired as functional neural assemblies connect attention processes, the ‘where am I’ and ‘where is it’ magnocellular streams, and the ‘what is it’ parvocellular stream to respond to frontal lobe based executive control.\(^12\) The development of this frontal lobe component is essential for efficient fixation stability and saccade generation during general visual inspection. Functional neuro-developmental deficits involving fixation stability, binocular stability, saccadic organisation and subitizing can be identified and now objectively assessed.

Traditionally only aetiological distinctions between adverse environmental factors, biological *defects* and behavioural *dysfunctions* could be made. Essentially, the optometrist sought to understand positive and negative environmental influences on child health and welfare, child development, functional vision and school readiness. Clinical assessment then moved to defect analysis by objective measurements of structure, aspects of eye health, neurology and physiology, and then the use of observational assessments to psychometric performance tasks to identify dysfunctions.

As neuroscience added to the neuro-developmental understanding of functional vision, research measurement technology was adapted for clinical use. Since 2002, clinical identification of basic neuro-developmental optomotor and perceptual *deficits* has been possible.\(^12\) The ability to make an aetiological clinical distinction between reported adverse environmental factors, and diagnosable defects, deficits and dysfunctions has resulted.

Measurement technology can now objectively assess basic neuro-developmental functions of optomotor and perception. Delayed acquisition of the functional neural circuitry for age appropriate fixation stability, binocular stability, dynamic vision, saccadic organisation and selected perceptual thresholds can be clinically diagnosed and such deficits can be effectively treated.\(^13\) Additionally, the application of criterion referenced progress assessments of these deficit biometric markers can track the OVT progress during delivery. While much of the speculation of early VT theorists has been validated, a more focused and structured approach to OVT delivery can now emerge.

**An Evolving Approach to Optometric Vision Therapy (OVT)**

Optometric Vision Therapy (OVT) can be defined as the art and science of therapeutic experiential interventions appropriate for
diagnosed functional vision deficits and / or dysfunctions. The goal of OVT is to achieve optimal visual performance, comfort and efficiency. During the OVT process, each patient gains a greater understanding of, and operational control over, their functional vision applications.

In general terms, OVT goals are achieved by the application of a sequential therapeutic intervention designed to address the specific treatable functional vision neuro-developmental issues, remediate visual inspection and perceptual deficits and dysfunctions or to facilitate visual rehabilitative neural plasticity.

Initially OVT may need to address under-developed functional neural organisation of sub-cortical collicular, multi-sensory, pathways that provide spatial orientation. Calibration deficits within or between the vestibular, somatosensory and visual maps that support ‘where am I’ non-conscious processing can be addressed.\(^{18,19}\)

Basic visual inspection optomotor ‘where is it’ deficits are then addressed by therapeutic procedures that require the visual direction and control of general mobility. When appropriate, visually directed fine discriminative activity is added – such as having the small muscles in the fingers reaching for grasping and manipulation tasks. Typically, these skills are coordinated with or in response to accurate visual inspection. In other words, visual inspection and body movement controls develop and learn to work in combination to produce coordinated actions. The term visuomotor skills is often used to describe this visually directed behaviour. Specific attention to the basic aspects of voluntary eye movements (optomotor control) and perceptual accuracy then occurs.

After basic optomotor ‘where is it’ and perceptual ‘what is it’ deficits are remediated, OVT procedures then develop visual abilities and capacities. The focus now is to efficiently apply general visual inspection to relevant performance tasks and problem solving activities. The

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| Assessment | FixTest, Express Eye, CountFix, FonoFix |

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**Table 1: Factors that Compromise Functional Vision Efficiency**
optometrist’s primary goal when implementing OVT is to treat diagnosed visual deficits and dysfunctions limiting the patient’s functional vision efficiency that are not totally addressed by other methods. It is for the patient, a guided learning and self-discovery opportunity directed at developing the functional neural pathways required for an improved functional vision accuracy, capacity, endurance and automaticity. The OVT treatment plan, prognosis and probable duration can be predicted by careful analysis of the presenting symptoms and signs, and confirmed by the comprehensive functional vision assessment. This prediction is based on the assumption that the patient will engage and comply with the OVT plan.

Patients do not often present to an optometrist asking for OVT. They frequently present however, with visually related symptoms that are not successfully resolved by traditional defect related care alone. Specifically, the application of neural science, the laws of visuomotor perceptual learning and cognitive developmental principles are used to achieve these goals. Simplistically, as Hebb theorised – ‘Cells that fire together, wire together.’ Thus repetitive applications of neural pathway activation within a planned sequence of related experiences are used to direct, establish, consolidate or restore functional neural networks. Remediation of the specifically diagnosed visual deficits and dysfunctions is conducted with experiential and instruction procedures that ensure patient engagement.

Twenty-plus years ago basic visual science had confirmed the importance of the dual interactions of bottom-up processes and top-down controls with research that demonstrated the importance of proximal cues to the operation of accommodation and convergence functions. Since then, what has been termed ‘new science of mind’ has been introduced within many fields including; neural science, visual science, psychiatry, developmental psychology and clinical optometry. Mindful awareness can be therapeutically applied during top-down OVT to visuo-spatial ‘where am I, where is it and what is it’ procedures.

Evidence-Based Practice

Evidence-based practice (EBP), defined as the integration of best research evidence, clinical expertise and patient values by Sackett has gained considerable interest and influence during the last decade and can be expected to remain an evolving approach to clinical decision-making and treatment delivery.

EBP and basic principles applicable to the neuro-developmental and rehabilitative OVT perspective are provided by fields including mind science, neuroplasticity, visual science, cognitive development, perceptual learning and educational psychology. While OVT must be tailored to the needs of each individual, specific operational best-practice principles apply and underpin all case management.

The three essential components of EBP (Figure 1), provide context for discussion of basic principles applicable to neuro-developmental and rehabilitative optometric case analysis, practice management and OVT delivery. We will therefore divide the balance of our presentation into three major parts:

Part 1: EBP Principles Related to Best Research Evidence and Theory
Part 2: EBP Principles Derived from Clinical Expertise and Expert Opinion
Part 3: EBP Principles from Patient/Caregiver Perspectives
PART 1: EBP PRINCIPLES RELATED TO BEST RESEARCH EVIDENCE AND THEORY

Optometry graduates in Australia, USA and Canada are prepared as primary eye-care health practitioners. To quote Anderton …‘evidence-based practice is appropriate for all aspects of optometry but it may be most useful in the selection of treatments with topical therapeutic agents and in optometry’s growing public health role in the detection and management of sight-threatening disease’. Randomised controlled clinical trials have become commonly equated in treatment-centered care to ‘evidence-based medicine’. This is appropriate when researching treatments for things are ‘done to the patient’ such as drug or surgical trials.

Patient-centered care involves ‘doing things with a patient’. How things are done now become important. It is not just ‘what is done’ that is the determinant of patient-centered outcomes. Nursing, speech/language therapy, occupational therapy, special education, educational psychology, education, and cognitive behavioural therapy all share the challenge OVT has in conducting patient-centered research.

The EBP Principles derived from Best Research Evidence and theory will be discussed under the following headings:

a. Science Of Mind and Neural Plasticity.
c. Dynamic Functional Vision.
e. Functional Vision and Cognition.

Science of Mind and Neural Plasticity

Neuroscience has established that neuro-developmental processes contribute to the functional organisation of brain circuitry and neural assemblies. Basic neural science and related research on the complex molecular neurobiology of neural network development, plasticity, and rehabilitation has resulted in what Kandel called A New Science of Mind. A neuro-developmental and rehabilitative multidisciplinary perspective to clinical interventions has been found to be applicable in many clinical fields including mental health care, clinical psychology, speech pathology, special education and optometry.

Top-down executive control processes of the mind have been shown to be the basis for the aspects of skillful optomotor and perception behaviour and that these aspects of efficient functional vision have milestones. Innovative measurement technology enabled objective assessment of the developmental milestone markers that show how well a patient can control their eye/head/body movements for stable visual inspection, selective attention and span of perception. Non-culturally biased performance markers have been compared to age/grade expected responses to identify functional deficits. The diagnostic bio-marker measurement and treatment technology has facilitated the application of mind science related management to OVT. The basic holistic neuro-developmental and general rehabilitative perspective provided by the new science of the mind can be succinctly summarised to four points:

1. Mind emerges from the structures and functions of a living brain. As the master regulator for neuro-endocrine, autonomic, immune, and neural-integrated circuitry systems, the brain is the key organ of stress reactivity, coping, and recovery processes.

2. Neural networks are formed into functional circuitry by experience dependent processes. Mal-adaptation can result from lack of appropriate and timely experience, toxic stress, and poor social support. On the other hand, beneficial adaptations can result from appropriate, timely experiences, and support that directly shapes the genetic expression process. Repetitive experience is needed to maintain, strengthen, refine, and...
elaborate neural circuitry on which the mind functions depend.

3. The mind is enriched by a number of developed processes such as memories, procedural learning, perception and cognition. These emerge from complex interactions between genetic and environmental factors.\textsuperscript{56,57,58}

4. The mind has a lifelong capacity to re-organise and learn new tasks. Neuroplasticity refers to the capacity to change the wiring of neural networks in response to maturation and experience. Positive changes in functional neural complexities are more likely to result when the social and task experiences engage attention, operate at an achievable but challenging level of demand, provide positive reinforcement to quickly recognise success, utilize task delivery that motivates repetitive interaction, and is sequentially moved in small steps from simple responses to more complex integrative behavior.

**Neuro-Developmental Aspects of Functional Vision**

Since the foundational longitudinal research report on vision development by Gesell, Ilg, and Bullis,\textsuperscript{59} the understanding of the dynamics of both the sensory and motor contributions has been elaborated. In the context of our discussion, key elements of neuro-developmental research occurred following the discovery of express saccades in 1983\textsuperscript{60,61} as laboratory research went on to further study optomotor and perceptual development. Full details of this research, conducted at Albert Ludwig University of Freiburg can be viewed at www.optomlab.com. Within that site, a brief summary of evolving research along these lines is provided.

1. Developmental milestones have been established for dynamic vision, fixation stability, binocular stability, pro–saccade reaction times, anti-saccade reaction times, anti–saccade error percentage, subitizing, and auditory–spatial decoding.

2. Basic neuro-developmental optomotor and perceptual deficits can be co-morbid with poor school performance, dyscalculia, dyslexia and ADHD.

3. Neural plasticity principles apply to basic optomotor and perceptual processes, as deficits in these typically respond to specific treatment procedures even when the student has co-morbid conditions such as dyslexia or ADHD.\textsuperscript{7}

4. Basic optomotor and perceptual learning transfers to aspects of education. Performance deficits diagnosed with FonoFix clinical procedures can be co-morbid with dyslexia.\textsuperscript{6,8}

5. Clinical equipment and assessment procedures from optomotor and perceptual research tools and data have been developed.\textsuperscript{12}

The specific focus of these assessment procedures is to study in detail the functional organisation of the optomotor cycle. This is achieved by technology that objectively measures specific optomotor and perceptual bio-markers that are unavailable to direct observation. By electronically recording both right and left eye timing, movement symmetry, and saccadic organisation as the eyes move from light to light the clinician can study more basic optomotor operations than that addressed by, for example, the Visagraph (http://goo.gl/TxZ8h2)\textsuperscript{62} analysis of fundamental reading eye movements.

It is now evident that it may never be too late to influence the functional wiring of the brain. There is neural plasticity that can take place at all ages as new tasks are learned. The older person, however, can expect that longer practice time and greater commitment will be required for rewiring. Case studies on subjects with diagnosed post trauma vision syndrome and the expected symptoms have shown functional vision rehabilitation can assist many to relearn functional vision behaviours that were lost following TBI events. Unlike the child with neuro-developmental visual deficits, adults with
acquired neural damage can recruit undamaged procedural memory that is still stored. During rehabilitation the therapeutic strategy is to recruit available procedural memory circuitry and facilitate the available neurons in the region of damage to re-establish functional connectivity via axonal and dendritic sprouting and synaptogenesis where new synapses are created. During OVT neural plasticity can be encouraged by having the patient engage in top-down processing that requires the prefrontal cortex (executive control) to utilise and access the visual processes that have been impaired.\textsuperscript{9,39,40}

Research has reported on visual neural plasticity induced by optomotor learning, perceptual learning, and biofeedback experiences. Clinical and laboratory research has typically centered on four identifiable groups of subjects:

1. **Convergence Insufficiency Syndromes (CIS):** These near point visual inspection dysfunctions seem to have a neuro-developmental deficit, a fatigue related AC/A dysfunctional breakdown or a combination aetiology. CIS can present with associated basic optomotor deficits and symptomatic Learning to Read issues. Others present with Reading to Learn, quality of life issues related to small print, reduced ability to sustain and comprehension. Clinicians have for many decades considered CIS to have an excellent prognosis from OVT.\textsuperscript{63,64,65} Recently the efficacy of active OVT for CIS AC/A rehabilitation has been confirmed by multi-centred randomised control studies.\textsuperscript{66-71} Active OVT is now the standard of care for this condition.\textsuperscript{72}

2. **Specific Learning Disability (SLD/ Dyslexia):** While this condition is generally considered to be a life-long constitutional defect (possibly genetic) that results in compromised language related processing, other co-morbidities such as treatable neuro-developmental optomotor, perceptual and binocular stability deficits can exacerbate the condition. The text *Visual Aspects of Dyslexia*\textsuperscript{6} provides a recent review of this complex debate.

3. **Post Trauma Vision Syndrome (PTVS):** The visual sequelae that can follow even mild head trauma and neurological injury may have a severe impact on the person’s quality of life. Clinical rehabilitation has applied Hebbian theory and neural plasticity concepts to facilitate the neural potentials in the region of damage and to re-establish functional conductivity.\textsuperscript{9,39,40}

4. **Amblyopia:** Amblyopia is a disorder that results in an otherwise healthy visual system from deprivation of the necessary neuro-developmental visual experiences early in life. Amblyopia typically results from refractive and/or strabismic conditions. The neuro-developmental visual deficiencies that result from deprivation were traditionally thought to be irreversible after the first decade of life\textsuperscript{73-76} as it was assumed that the developmental maturation windows for all aspects of vision were then closed. Amblyopia is characterized by several functional abnormalities in spatial vision\textsuperscript{77-80} including reductions in visual acuity (VA), contrast-sensitivity function (CSF), and vernier acuity as well as spatial distortion, abnormal spatial interactions, fixation instability, and impaired contour detection. In addition, amblyopic individuals may suffer from binocular abnormalities such as impaired binocular stability, stereo acuity, binocular rivalry, visual projection and abnormal binocular summation. The loss of these functional vision processes is thought to result from the abnormal operation of the neuronal networks within the primary visual cortex, particularly of orientation-selective neurons and their interactions that result from deprivation of the necessary neuro-developmental visual experiences early in life.
Perceptual learning procedures have been found to improve visual grating discriminations, stimulus orientation judgements, motion detection, texture discrimination, time to perceive randot stereograms, vernier acuity and object recognition with many amblyopic patients. These studies were designed to train specific perceptual processes by efficiently stimulating their neuronal populations and promoting self-directed spatial interactions and self-correction. Active OVT for selected patients with amblyopia is well documented and supported by case studies.

To summarise, OVT can provide those patients who have been specifically diagnosed with treatable neuro-optometric deficits and performance dysfunctions, the opportunity to improve these aspects of their functional vision efficiency. The efficacy of optomotor interventions, motor learning and perceptual learning has been addressed with the visual aspects that can be co-morbid with dyslexia, dyscalculia, ADHD and amblyopia. Clinical reports have provided details on the use of OVT for post trauma visual rehabilitation. Scheiman and Wick provide an excellent review of assessment, management and prognosis for the clinical management of binocular vision disorders of heterophoria, accommodation, fusional vergence, or ocular movement control. Scheiman and others have shown that OVT is the treatment of choice for convergence insufficiency.

Dynamic Functional Vision

Contemporary visual neuroscience has built upon Harmon’s notes on a dynamic theory of vision based on what is now known regarding the role of brain-mediated visual pathways and networks.

Vision in this context is a constructive process that emerges from eye, brain and ocular motor dynamic cyclic feedback/feed-forward loops. Figure 2 provides a simplified model of dynamic functional vision and the neural bottom-up and top-down relationships between eye, brain and ocular motor processes.

The complex and dynamic interactions between eye, brain and ocular motor processes involve both reflex responses and purposeful visual inspection. The retina in each eye codes the relative spatial distribution of incoming light components and also detects movement of any part of the image. The processing within the brain requires the comparison and integration of this information from the other sensory systems to form a composite representation of the environment. The images of the two eyes are fused to form a single percept, and comparison of the minute differences in the images from each eye also provides direct information about three-dimensional depth. Analysis of the relative size, overlapping contours, and relative motion parallax provides further clues to the structure of the environment. The visual perception and interpretation of the environment is tempered by the information from other sensory systems and a person’s experience. These perceptual and cognitive processes lead to a motor response in reaction to environmental input. When attention is directed toward a component of the environment, top-down cortical control directs the eyes to fixate on the object of interest, to filter bottom-up distractions, to hold stable fixation for detail analysis and then release.

The eye is where the sensory coding of light distribution and change on the retina can initiate
basic reflex responses. Additionally, the person can direct purposeful looking and tell the eyes to seek a specific light distribution. Anatomy provides a constricted macular zone for clear sight and precise binocular alignment.

The brain is where objects in our environment are localised by two different visual processes. Sub-cortical “where am I” magnocellular processes provide orientation and a spatial map where objects are egocentrically localised and the cortical “where is it” magnocellular processes perceptually analyse spatial relationships between objects via a retinotopic perspective. The processing of information from the two eyes into a unified single visual percept is dependent on retino-cortical neurology. The higher cortical centres provide top-down selective visual attention and are engaged during the conscious decisions for “what is it” processes. The parvocellular stream carries neural coding related to fine form and texture to conscious perception, further inspection, analysis and recognition.

The koniocellular stream carries the neural coding related to colour; this pathway serves the red, green and the blue/yellow systems that colour our visual experiences (Fig. 3).

The primary visual cortex is interconnected by the dorsal and ventral streams with the posterior parietal cortex and the infero-temporal cortex. A critical function of the parietal cortex is to spatially localise neural responses that enters from constantly moving eyes, to mediate attention shifts and to select the next objects or features for further attention. The “where am I” and the “where is it” streams provide information that the ocular-motor and skeletal motor systems can use for movement and the spatial localisation of “what is it” features.94

The top-down and bottom-up neural pathways connect mind-eye and eye-brain. Basic sub-conscious organisation is provided by the bottom-up, often sub-cortical, reflex responses. These psychoptical reflex responses serve to alert, orientate and protect. Top-down higher cortical centres of the brain orchestrate the purposeful visual inspections critical to complex tasks such as reading. During visually directed performance, bottom-up neural flow can be filtered by top-down selective attention. The motor outflow systems can then be integrated to manage purposeful fixation stability, pursuits, saccade eye movements, and the accommodation-convergence synkinesis.95 Precise aiming of this spot provides the sharpest point of visual acuity or clarity of sight. The areas of the retina away from the central macular or fovea are less sensitive to detail; consequently peripheral visual acuity is less sharp.

Figure 3: Major neural streams to Brain from Retina.  

Stable fixational engagement facilitates motor, optomotor and perceptual feedback loops for accurate accommodation95 and accommodative/vergence synkinesis.96 To obtain a complete picture of the visual field, it is normal to perform between 3-5 saccades, or snapshots per second. Saccade control is the ability of aiming the eyes to fixate and see a particular point. These movements are not random. This is illustrated by the eye movement recording taken while the subject was viewing the photograph in figure 4.97 The person studies fine detail by precise sensory inspection and feels the spatial relationships of these features by optomotor activity.
Form perception is highly dependent on efficient sequential visual inspection. Number, letter and sight word recognition are all influenced by the optomotor control that enables the eyes to reach out, take hold, attend to detail, and then release so they can move to the next point of interest. Seeing (sensory) and eye movement (motor) feedbacks from contour analysis are connected by each person into our unique features ring or sequence of images each having a specific spatial location. An example of how the feature ring for the letter ‘A’ could be learned is shown in figure 5.

The stability of gaze control is a complex challenge to the visual system. The ability to select one item amongst several is a further development. In order to change the direction of sight quickly and accurately the stability of gaze control has to be finely integrated with the visual optomotor functions. The top-down optomotor cycle (see Figure 6) links eyes, brain and ocular motor processes.

Eye movement control, like other aspects of motor control, can result from three different functional neural loops:

1. Express Saccades. These are fast reflex eye movement responses to startle or threat. Fixation stability, binocular stability and the frequent of express saccades (reaction time of about 100 ms) provide neuro-developmental bio-markers. Persistent reflexive optomotor responses are disruptive to purposeful activity and the building of motor memory dependent features rings. Normal development of voluntary optomotor top-down responses is expected to modulate and selectively suppress most bottom-up reflexive express saccades.

2. Slow Regular Saccades. Conscious, voluntary saccades emerge as the mind comes to use visual inspection processes to extract meaning and understanding from the visible environment. Voluntary optomotor actions are initially dependent on active involvement of the conscious mind. Thinking time makes the response much slower than the reflex. A saccade reaction time that exceeds 200 ms is the bio-marker for this unskilled but task directed level of neuro developmental organisation.

3. Regular Saccades. Task specific automatic optomotor responses provide the basis for efficient visual inspection. With practice optomotor and perceptual responses learn to become more efficient and micromanagement delegates some control to acquired neural assemblies. Saccade reaction times of 150-200 ms are the bio-markers indicating that neural networks have organized to support and shorten reaction time for skilled movement patterns. That is an optomotor and perceptual memory scheme, which has reduced demand on conscious attention. Schemata are built for simple tasks before they can become available for more complex use. Saccadic organisation changes are first recorded for basic tasks such as Express Eye and Fix Test procedures before they can be applied to tasks with higher cortical demand such as Visagraph readings.
Saccade control enables the eyes to move selective visual attention quickly from one point of interest to the next, and to briefly hold each fixation steady for attentional engagement with a perceptual snapshot. To obtain a complete picture of the visual field, a normal adult has to perform between 3-5 saccades and fixations (snapshots) per second. Sensory and motor details are captured into feature ring experiences. The brain organises the constantly moving visual information from visual inspection so that it appears to us as an unbroken stable image. It also uses saccades and saccadic suppression to selectively filter detail that would be counter-productive to the construction of a stable visual world.

**Visual Science and Functional Vision Development**

Severe environmental neglect and sensory deprivation of young children such as unmanaged amblyogenic factors can result in major neural developmental delay. Healthy neural development of aspects of functional vision results in part from self-directed behavioural interactions.

Optomotor and perceptual deficits can result from a delayed interconnection of the functional neural circuitry required to move visual inspection performance developmentally from impulsive reflex responses, to slow self-directed novice behaviour, and then eventually to reasonable fast semi-automatic and skillfully sustained operations. In early primary grades, optomotor and perceptual deficits are impediments that can challenge access to the learning to read curriculum. Indeed a visual inspection pattern that displays a high frequency of reflex express saccades suggests that the student will not be in a state of engaged attention during many of the fixation periods.6,7,8,17 For students in later grades and young adults, functional vision aspects related to reading to learn can go undetected unless specifically clinically assessed.

Structured guidance strategies are applicable and useful during the delivery of many human services such as child psychiatry,99 cognitive behavioural therapy,100 occupational therapy,101 education,102 speech pathology,103 low vision, special needs,104 and orientation/mobility.105 Structured guidance principles can also be used during OVT to improve selected visual inspection and visuo-cognitive problems. The developmental processes relating to visual inspection and visuo cognition begin early and take place for most people mainly as social interactions.

Foundational child development theories such as Piaget and Vygotsky have intertwined into contemporary developmental psychology and educational theory.106-108 Piaget explored the developmental aspects of child thinking, cognition and problem solving as they interacted with their environment. His schemata theory assists us to understand child thinking109 and to identify,110-112 the thinking patterns that can present. Vygotsky explored the role of an adult or more capable peer on task performance. The Vygotsky ‘Four Stage Recursive Loop’ construct,113-114 has been adapted to OVT (Fig. 7) as it provides a bridge between cognitive developmental narrative, neuroscience and functional vision care child development theories.

**Stage One: Performance is often Reflexive but modulated by social interactions.**

Before children can function as independent agents they must rely on adults or more capable peers for outside regulation of task performance. The amount and kind of outside regulation a child required depends on the child’s age and the nature of the task. During the earliest periods of development, the child may have a very limited understanding of the situation, the task, or the goal to be achieved. Only gradually does the child come to understand the way in which parts of an activity relate to one another or to understand the meaning of the performance. The performance a child demonstrates to an assessment procedure reflects the child’s independent self-organisation relative to the processes challenged. This performance can be expected to improve if the assessment procedure...
was to be repeated after some coaching. Their assisted performance would set the level of potential that is available. The difference between the self-dependent performance and the assisted performance defines what Vygotsky called the Zone of Proximal Development (ZPD). This is essentially the achievable but challenging task demand level and where new functional neural assemblies for learning will occur. Seeking this ZPD guides OVT planning and delivery during stages 1 and 2.

Assistance of performance has been described as scaffolding and is achieved with the adult selectively assisting the child by a coach directed instructional set. The clinical application of this will be discussed later.

Stage Two: Performance can be self-directed but is supported by coaching, timely guidance and positive reinforcement.

During the transition to Stage 2, the child will have now taken over some tasks without assistance from others. However, this does not mean that the performance is fully developed or automated.

Once children begin to direct or guide behaviour with their own speech an important stage has been reached. A major function of self-directed speech is self-guidance and its developmental origins have to do with early social experience and which increases under task circumstances involving obstacles and difficulties. Self-control may be seen as bridges between help by others and fully automated, fully developed capacities.

Impulsive children with deficient self-control are taught to instruct themselves before and during a variety of performance tasks. Children also employ self-directed vocalization, reminding themselves to go slowly and be careful as an example, to assist performance under conditions of stress and task difficulty. A major function of self-directed speech is self-guidance, which remains true throughout lifelong learning.

Self-talk is encouraged by initially having the child speaking out load and telling themselves...
what to do next. As the content and task relevance improves usually so does task performance. Later on the child will be asked to use sub-vocal self-talk. The ability to use sequential planning and related self-talk is more than instrumental in skill acquisition, it is itself an aspect of cognitive development.

Stage Three: Performance has become automated into functional neural assemblies or schemata.

Once all evidence of self-regulation has vanished the visual tasks they then are executed smoothly, efficiently and are integrated with other activities. It has been internalized and automated into functional neural assemblies. Assistance from the adult or self is no longer needed. Indeed assistance would now be disruptive. Vygotsky, Piaget and Greenfield all emphasise that performance at this third stage can now operate at a distance from the social and mental forces. The conscious mind is free from most task management duties and can attend to other aspects of higher order thinking and comprehension.

Stage Four: Performance can regress to require conscious self-directed management.

Schemata breakdown, the fourth stage of Vygotsky’s loop, also called de-automatisation, constitutes a part of the normal developmental process. Schemata breakdown can result as a neural organisation mal-adaption. They may be triggered in fragile systems from factors such as excessive demand, fatigue, cognitive overload, adverse health conditions or stress. They may also be due to environmental changes, aging or individual stress, major upheavals or physical trauma. This general developmental principle applies to functional vision.

Loss of visual inspection automaticity can compromise single, clear, comfortable and efficient binocular vision and distract attention from the task. Acquired visual inspection dysfunctions, that is, functional vision schemata breakdown, can interfere with cognitive operations and processing of visible data. Transitory visual dysfunctions occur regularly and most can be resolved by rest and self-directed recursion through Stage 2. Making self-talk external is a form of Stage 2 recursion that can be effective in restoring competence. Further retreat or remembering of visual bio-feedback procedures may be required. Clinical issues arise in functional vision when self-direction responses are insufficient to restore required operational integrity. A symptoms checklist such as the Appendix 1 ‘Functional Vision Efficiency related Survey’ can help to identify clinically significant acquired visual dysfunctions. The rehabilitation of acquired visual deficits and dysfunctions has excellent prognosis. Clinical intervention will consider refractive care, visual ergonomics and/or guided therapeutic OVT intervention with Stage 1 and 2 recursions.

Functional Vision and Cognition

Dynamic interplay between internal processes occurs before and during complex visually directed behaviour. Theory of Mind principles, as applied by cognitive science, inform us that people are cognitive beings with internal processes such as mental states, beliefs, motives, memories, feelings and intentions that are not always accessible to others but often guide internal processes triggering behaviour. From an understanding of the neural basis of perceptual and optomotor learning, the functional vision cycle (see Figure 8) operates to provide visually directed action, detail analysis and cognition. Top-down processes tell the eyes what to look for, manage selective attention and link perceptions to cognitions; while bottom-up processes provide an egocentric spatial anchor. Science has presented us with nine major internal processes in this repetitive functional vision and cognition cycle that operate to produce a product such as a written report. Each of these can be described as follows:

1. Sensation: The basic, immediate stimulus on sense organs.
2. **Perception:** Both top-down (voluntary experience that a stimulus such as light, sound or touch elicits on a sense organ.-motor learning) and bottom-up (reflex) processes can contribute to *looking*. The development of optomotor and perceptual abilities involves learning from experience as attentional weighting is selectively applied; stimulus imprinting feeds memory and differentiates salient features; and unitization groups the basic neural operations into function neural assemblies. This allows accurate inspecting, interpreting, organizing and some basic elaborating on the raw materials of sensation to occur.

3. **Selective Attention:** The active cognitive selection of a limited amount of stimuli from the vast amount available from all the senses, in memory and through the cognitive processes.

4. **Visual Attention:** Selective visual attention enables us to attenuate irrelevant stimuli, while focusing on the relevant stimulus. Selective visual attention links perception with cognition.

5. **Working Memory (WM):** This, sometimes called short-term memory, is the cognitive process that connects central executive control with the linguistic and the visual-spatial domains\(^{115-117}\) (see Figure 9). WM is responsible for holding and manipulating transitory information while the dynamic mechanisms associated with the retrieval of details about past experiences are activated.

6. **Schemata:** A schemata, also called a cognitive structure, develops as functional neural networks come to connect basic optomotor, perceptual and/or cognitive experience into simple stored memory. With repetitive use, error correction and gradual elaboration, these functional neural pathway connections become the basis for transferred applications and skilled performance. Long-term maintenance also is facilitated by self-directed repetition and error correction. Schemata can be explicit (motor and procedural) or implicit (facts, details and declarative). Inadequate functional vision schemata development and/or schemata breakdown may contribute to functional vision problems.

7. **Cognitive development:** Age-related neural organisational changes that occur as mental activities come to manage processes such as attention, perceiving, learning, thinking, action and remembering.

8. **Cognition:** The activities of knowing and the thinking processes through which the central executive’s knowledge is acquired.

9. **Behaviour:** Convenient term for all the reactions of the person which are mediated by the neuro-muscular system.
A behaviour movement pattern is simply a definable formed response to a specific situation (motor learning). Developmental milestones are revealed by outward movement patterns of behaviour during controlled testing. Behaviour now alters the stimuli and the functional vision cycle repeats.

10. **Product:** In this context product refers to the external consequence of behaviours that remain. These external products from task are typically measurable in some way such as through reading comprehension tests, spelling tests, math tests or handwriting assessments, written assignments, driving tests and academic exams.

**Principles of Learning**

The principles of perceptual learning have been emerged from extensive research. Goldstone\(^{118}\) has conceptualized how the four sub-mechanisms below contribute to perceptual learning.

1. **Attentional weighting:** Perception becomes adapted to tasks by increasing the attention paid to important dimensions and features.
2. **Imprinting:** Special receptors are developed that are set for specific stimuli.
3. **Differentiation:** Stimuli that were once indistinguishable become cognitively separated.
4. **Unitization:** Tasks that originally required detection of several components are accomplished by detecting a single construct.

Ahissar’s\(^{119}\) reverse hierarchy theory of visual perceptual learning links behavioural findings of visual learning with physiological and anatomical data. Essentially, the reverse hierarchical theory asserts that perceptual learning is a top-down guided process, which usually begins at high-level areas of the visual system. When these processes are inadequate or do not suffice, the perceptual learning processes are reversed to involve less complicated input levels. Functional vision deficits and dysfunctions may thus be triggered by repetitive performance failure, fear of failure and stressful performance anxiety. Multi-sensory learning strategies and structured guidance on “challenging but achievable” tasks can provide a better signal-to-noise ratio for perceptual learning. The principle that feedback is a critical variable of motor and perceptual learning is supported by research.\(^{19,25,120,121}\)

Key principles of general learning, that have been identified by educational psychology\(^{122-125}\) are also applicable to the instructional components of OVT. Typically active learning requires selective attention, detailed analysis and interpretive responses.\(^{126}\) While there are significant differences in content and purpose between the learning activities that occur in a classroom and OVT procedures, OVT finds common ground in the science and practice of eight principal areas with which we’ll conclude Part 1: readiness, exercise, effect, primacy, retention, intensity, freedom and goal setting.\(^{127}\)

1. **Readiness:** This implies that a physically (biological), mentally and emotionally (mind) and behavioural organisational status provides a prerequisite for learning. The degree of self-understanding, self-organisation and self-confidence can modulate a child’s willingness to engage with OVT instruction. Readiness learning is incremental and experience dependent.\(^{128-130}\) Individuals learn best when therapy procedures are achievable but challenging; and do not learn well if they see no reason for learning, find the task unrewarding, too difficult or frustrating. Getting patients ready to learn, creating interest by showing the value of the subject matter, providing continuous mental or physical challenge, and providing positive feedback are all usually the therapist’s responsibility. If patients have a strong purpose, a clear
objective, and a definite reason for learning something, they make more progress than if they lack such motivation. In other words, when OVT tasks engage patients at their zone of readiness to learn, the therapist/patient collaborations become most productive.

Since OVT includes active motor learning and perceptual learning process, patients must have adequate rest, health, and physical ability. Basic needs of individuals must be satisfied before they are ready or capable of learning. OVT patients who are exhausted or in ill health cannot learn much. If they are distracted by outside responsibilities, interests, or worries, have overcrowded schedules, or other unresolved issues, patients may have little interest in learning generally and OVT in particular.

2. Exercise: Humans learn to do by doing. Things most often repeated are best remembered. Educational studies have shown that students learn best and retain information longer when they have meaningful multisensory practice and repetition. The key here is that the OVT practice must be meaningful and address the processes of visual inspection and basic visuo-cognitive operations.

Human procedural and declarative memories are fallible. The mind can rarely retain, evaluate, and apply new concepts or practices after a single exposure. OVT patients do not learn complex procedural tasks in a single session. They learn by applying what they have been told and shown. Every time practice occurs, learning continues. These include visualisation, recall, manual drill and physical applications. All of these serve to create the functional vision schemata related to learning habits. The therapist repeats important procedures at assigned intervals, and provides opportunities for practice while making sure that this process is directed towards the automaticity of efficient functional vision.

3. Effect: Each learner brings their own power to produce results to the instruction setting. The competency of the evolving self (Domain 2 of visual thinking) and the emotional state can have a direct relationship to motivation. The importance of effect is that OVT learning usually occurs in a social context and is strengthened when accompanied by a pleasant or rewarding feeling and that learning is weakened when associated with an unpleasant feeling, anxiety or anger. Positive reinforcement is more apt to lead to success and motivate the learner so the therapist should recognize and commend improvement. Whatever the learning situation, it should contain elements that affect the patients positively and give them a feeling of satisfaction.

One of the important obligations of the therapist is to set up the learning situation during OVT in such a manner that each patient will be able to see evidence of progress and achieve some degree of success. Experiences that produce feelings of defeat, frustration, anger, confusion, or futility are unpleasant for the patient. If, for example, a therapist attempts to use advanced procedures on the initial engagement, the patient is likely to feel inferior and be frustrated. This can impressing upon patient the difficulty of the OVT tasks and can make future task involvement difficult. Usually it is better to avoid starting a procedure that has a possibility for failure, but to start with procedures that are achievable. The achievable task can then modified to gradually increase its level of difficulty.
and then modulated up and down between easy and difficult. This removes the risk of failure but also gives a sense of achievement to the patient who demonstrates an improved performance at the difficult level. They experience that although the task was difficult, it was within their capability to understand or perform. Every learning experience does not have to be entirely successful, nor does the patient have to master each procedure completely. However, every learning experience should contain elements that leave the patient with some good feelings. The patient’s progress and chance of success is definitely increased if the OVT experiences are pleasant and rewarding.

4. Primacy: It has been observed that things learned first create a strong impression in the mind and that these impressions are often difficult to erase. The consequence is that our first meaningful engagements often create a strong, almost unshakable, impression. For the optometrist and the patient this means that what is taught must be developmentally appropriate the first time. For example a student who came to pencil and paper tasks before they have developed the finger/thumb dexterity required may adopt the developmental thumb grip and write with primarily wrist manipulation. In such cases the therapist will have a difficult task replacing such practiced bad habits.

The first experience should be positive, functional and lay the foundation for all that is to follow. The therapist must present subject matter in a logical order, step by step, making sure the students have already learned the preceding step. If the task is learned in isolation, is not initially applied to the overall performance, or if it must be relearned the process can be confusing and time consuming. Preparing and following a sequential treatment plan facilitates correct delivery of the therapeutic experiences and instructions.

5. Retention: The things most recently learned are best remembered. Conversely, the further a patient is time-wise from instruction on new strategies, actions or understanding, the more difficult it is for them to remember. For example, it is fairly easy to recall a telephone number dialed a few minutes ago, but it is usually impossible to recall a new number dialed last week. The closer the instruction and application therapy is to the time of actual need to apply such organisation, the more apt the patient will be to utilize this new approach successfully.

Retention of learning is enhanced by practice and the meaningfulness of the changed behaviour and knowledge that results. Imagery, spacing of learning, metacognition and generative processes can aid recovery past experiences from long-term memory storage.130,131

Frequent review of instructions and application therapy is required to establish the functional neural assemblies in the mind the material covered. OVT planning should recognize the principle of retention when planning the home practice procedures. The therapist repeats, restates, or re-emphasizes important points at the end of a session to help the patient and home assistant remember the required instructional set.

6. Intensity: This implies that the patient will learn more from their multisensory real life self-directed experiences than from passive observation of others, a video or from verbal instruction only. The more intense the experience on the instruction material, the more likely it will be internalised and
retained. A sharp, clear, vivid, dramatic or exciting learning experience has more therapeutic impact than a routine or boring experience. In most cases, a child can get more understanding and appreciation of a movie by acting out the story then by passive viewing alone. Likewise, the patient is likely to gain greater self-organisation and understanding of tasks by performing them rather than merely observing others perform or to be told what to do. For example, a child with convergence insufficiency syndrome and unable to voluntary converge is not likely to be successfully treated by the therapist demonstration their voluntary convergence or by just telling the child to cross their eyes.

The more immediate and dramatic the OVT is to a real situation, the more impressive the procedure is upon the patient. Real world applications that integrate procedures and tasks that the patient finds achievable but challenging will require them to move from business as usual and to apply greater self- management and attention to specific detail.

The goal is to have the task make a vivid impression on them. OVT instruction can benefit from a wide variety of instructional aids that aim to improve realism, motivate learning, or challenge the patient. Therapists should emphasize important points of instruction with gestures, showmanship, and voice. Demonstrations, skits, and role-playing do much to increase the learning experience of patients. Examples, analogies and personal experiences can also make learning come to life.

7. Freedom: Things freely learned are best learned. Conversely, the more a patient is coerced, the more difficult it seems to be for them to learn, assimilate and implement the strategies and processes addressed during therapy. Compulsion and coercion are counter-productive to personal growth. Since learning is an active process, patients must have freedom; freedom of choice, freedom of action, freedom to bear the results of action. These are the three great freedoms that constitute personal responsibility. If no freedom is granted, a patient may have little interest in the OVT process.

8. Goal Setting: The principles of Goal Setting Theory and fostering a “Be the best that you can be” student mind set are applicable to this discussion. As the student’s life journey progresses new challenges arise. These can be related to ability, skill, the use and control of instrument, a procedure, a problem-solving strategy or anything that may help us to learn or gain something. A starting point goal is needed to motivate and to maintain active engagement with learning. For the OVT patient their goal may relate to something they wish to obtain such as comfortable and efficient visual inspection. Older children and young adults are often motivated to eliminate or significantly reduce eyestrain, blur or other visual distress; others to improve their slow, sloppy or disorganised visually directed performance. Younger children are often more motivated to just please their parents and to show them how they can improve the product of functional vision processes. Young children may only be able to understand OVT as a way of helping them with their writing; keep their eyes on task and learn letters but their parents must appreciate that OVT is not academic education but a treatment for deficits and dysfunctions of the developing functional vision processes that are related to school readiness; learning to read or reading to learn.
PART 2: EBP PRINCIPLES DERIVED FROM CLINICAL EXPERTISE AND EXPERT OPINION

Beyond research, components of evidence-based practice are derived from clinical expertise and expert opinion, identifiable as four essential principles.

**Principle 1: OVT can address many diagnosed functional vision deficits and dysfunctions that are not responsive to other approaches.**

While there is a wide range of approaches to OVT care, three broad perspectives can be identified. The conceptual scope of each approach is represented as changes in area in Figure 10.

1. **The Traditional Perspective.** A mechanical optics and bio–physics, bottom-up approach emphasizing defects.
3. **The Behavioural Perspective.** A neuro-developmental/rehabilitative approach emphasizing deficits in addition to defects and dysfunctions, with OVT as a specialty service.

The traditional approach equates vision to clarity of sight and uses the scientific principles of biology and physics to underpin the clinical care of refractive errors, systemic and ocular health issues, and defect detection within the neuro-visual pathways and physiology. The visual process is conceptualised essentially as a ‘bottom-up’ response with little influence from the conscious mind. Weak muscles, anatomical defects, genetic conditions, trauma and pathology are the commonly assigned aetiologies for visual problems. It is a medical defect perspective that provides limited opportunity for OVT intervention, and this view is well represented in professional literature.\(^{137-141}\)

Contemporary is an extended professional scope indicative of a broader understanding of functional vision.\(^{142}\) This is a body/mind or hardware/software construct. The contemporary perspective considers aspects of binocular vision as dynamic, modifiable behaviour and functional vision abilities to be the product of our inherited potentials, our past experiences, and current visual information. This perspective opens opportunities for management of visual experiences by selective occlusion, prism compensation, AC/A manipulations, therapeutic contact lens use, or simple fusion exercises. It provides an excellent orientation for most primary care optometrists, but can be limiting for the assessment and management of patients needing vision therapy.

The behavioural approach has emerged to serve the needs of helping patients with functional vision issues through OVT. Behavioural optometrists have a long history of using performance tests for developmental and perceptual assessments and to identify visual dysfunctions and developmental delay.\(^{143,144}\) With these procedures the optometrist observes behaviour in relation to psychometric tasks as they are performed and graded. At its cutting edge, the behavioural perspective includes both the traditional and the contemporary but then expands to include neuro-developmental deficit analysis and management to defect and dysfunction considerations.

A person’s general functional efficiency is largely determined by their self-directed sensorimotor
interactive experiences and depends on a complex interaction of innate factors and learned skills. During novice performance, conscious decisions are significantly involved in planning and managing appropriate visual responses. Later, with skilled performance, pre-programmed automatic mechanisms for action and thinking free the conscious mind from the mechanics of the task. OVT therefore recapitulates development through the acquisition of an increasingly more complex repertoire of task-specific automatic processes.

Principle 2: A neurodevelopmental and rehabilitative model of dynamic functional vision guides assessment of the need for OVT.

OVT is most commonly offered to symptomatic patients with treatable functional vision deficits and/or dysfunctions. (Sample Adult Symptom Survey: see Appendix 1). The neuro-developmental and rehabilitative OVT for visual deficits and dysfunctions may require multi-disciplinary contributions. A narrative of efficient functional vision that results from cascading interactions between three areas: the Visual Biology/Physics; Visual Inspection Schemata; and Visuo-cognitive Schemata has been clinically useful (Table 2).

Area 1: Visual biology and physiological optics. The comprehensive functional vision assessment starts with ruling out defects of optical structure, physiology, neurological integrity and general health. The clinician considers family history, patient history as well as current symptoms and signs and seeks relevant data from other professionals. This is then followed by detailed assessment of areas including clarity of sight, integrity of eye optical structures, ocular motor integrity, and visual fields. The initial goal is to identify and manage or co-manage all clinically significant defects that could limit functional vision.

Area 2: Visual inspection schemata. This is the specific clinical domain of optometry. After an age appropriate assessment of accommodative, fusional vergence and ocular motilities has been conducted, most operational dysfunctions will be identified. At least three parallel processing streams serve visual inspection and project to multiple areas in the brain. In brief, two cortical systems, the “where is it” and “what is it” streams develop in a two-way interaction with the sub-cortical orientation “where am I” system. These cortical systems show a staged development with the “where is it” stream being most vulnerable during development. Behavioural milestones depend on the emergence of visuomotor functional neural networks that are called modules by Atkinson and Braddick who state that these modules first develop as specific networks and then later become coupled for integrated behaviour. The development of spatial attention is considered to be intimately linked with target selection and planning in this visual-motor functional system.

Area 3: Visuo-cognitive Schemata. Our ability to extracting understanding from visual experiences emerges as perceptual learning, mindful awareness and problem solving operations develop.

OVT is an opportunity for each patient with treatable visual deficits and dysfunctions to explore their self-organisation and visual capacities as they develop functional neural circuitry. The interconnection of simple reflex pathways, motor learning, perceptual learning, cognitive development, and memories into a fast response functional neural network is termed schemata. Schemata development moves from simple to more advanced and then finally to the stage where efficient functional vision is integrated into skilled performance on required tasks. The neural network circuitry that support each schemata are formed by processes that include the formation of cell bodies, selective cell death, the growth of axons and dendritic processes, as well as the formation of functional synaptic connections and the elimination of unused synapses. Repetitive experience can have the effect of incorporating the task specific neurons and synapses into a strong functional
neural circuitry. Building such schemata provides the neural base for task related functional vision automaticity.

Principle 3. Assessment of visual inspection schemata is informed through biometric technology.

Our assessment of visual inspection schemata is built around a clinical model of optomotor and perceptual learning. This model provides the basis for diagnosis of optomotor and perceptual deficits, and provides a scientific foundation for this objective approach to OVT intervention. Table 2 provides an overview of general visual inspection schemata as a cascading interaction of the three areas described in Principle 2 above.

Our premise is that accommodative and/or vergence dysfunctions tend to occur with basic optomotor performance deficits. Overuse of voluntary controlled corrections for convergence or accommodation deficits, fatigue and pain avoidance, and adverse visual ergonomics are examples of factors that may contribute to dysfunction. Breakdown in the form of de-compensation or avoidance of visual inspection skills can follow efforts to cope with high demand in the presence of co-morbid defects and/or deficits, reflected in optomotor biometrics. Optomotor biometrics are layered onto vision dysfunction theory, research and clinical management, topics well covered by optometry and vision science texts authored by Press, Suter & Harvey, and Scheiman and Wick.

Technology and Clinical Protocols of Basic Optomotor Biometrics

Basic optomotor and perceptual neuro-developmental assessments are currently facilitated by four equipment units. Conceptually these assessments and related treatment technology require a paradigm shift for many and the understanding of the neuro-developmental perspective. There are texts that provide a detailed understanding of the research base and clinical applications of this clinical technology. A brief overview of the assessment equipment is provided below.

The FixTest (Photo 1) is used to assess the quality of dynamic vision at near. Under natural viewing conditions about 3 fixations are made each second. Visual processing has to operate fast enough to keep the time order of the content of incoming neural messages and their spatial locations apart. The perception of fast changing retinal images requires a dynamic cooperation between the “where is it” and the “what is it” processes. The FixTest procedure uses a small visual stimulus (T) that changes in orientation every 200ms. This challenges the patient’s control of fixation stability, accommodative stability, pro-saccade and anti-saccade operations and visual spatial perception. They have to keep watching the targets so that at the end of the series the orientation of the last stimulus can be indicated by pressing an arrow key. This procedure can be performed monocularly or binocularly to provide clinical information about quality of basic near dynamic vision accuracy. Three assessment procedures are used to collect five data groups:

1. Fixation: Fixation stability is measured when the ‘T’ stimuli are all presented at the same place on the display.
2. Jump-C; Jump: The pro-saccadic control is measured by two tasks. Both require the subject to jump the fixation of their eye ‘toward’ the peripheral queue to fixate on the last stimuli.
3. Anti-C; Anti: The anti-saccadic control is also measured by two tasks, both requiring the subject to jump their fixation ‘away from’ the peripheral queue and then to fixate on the last stimuli.

The percentage of correct dynamic vision responses to all the FixTest procedures has been shown to vary with age, as previously discussed.

Data from normal subjects aged 8 to 16 years has been compared to an age-matched group

Table 2: Functional Vision – a cascading interaction of three areas.

<table>
<thead>
<tr>
<th>Area 1</th>
<th>Visual biology/physics: Defect Management.</th>
<th>Health, clarity of sight, integrity of genetics, neurology, structure, physiology, biology, etc.</th>
<th>Multi-disciplinary</th>
<th>(Co-management)</th>
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<tbody>
<tr>
<td></td>
<td>A. Basic Dynamic Vision Deficits</td>
<td>Adverse adaption within vergence, accommodation, ocular motor, sensory fusion, endurance and visual attention processes.</td>
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<td>B. General Inspection Dysfunctions</td>
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<td>C. Task Specific Applications</td>
<td>e.g Measurable visual components related to reading.</td>
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<td></td>
<td>A. Two processing modes</td>
<td>Global knowing and Linear “sequential” analysis.</td>
<td>Multi-disciplinary</td>
<td>(Co-management)</td>
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<td></td>
<td>B. Three domains:</td>
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<td></td>
<td>Domain 1 – Sensorimotor</td>
<td>Me/It thinking</td>
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<td>Visual spatial -</td>
<td>laterality/directionality.</td>
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<td>Visual analysis - JND’s, sorting, matching, classification.</td>
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<td>Visual motor integration – General/discriminative movement, spatial manipulations and timing Graphic thinking.</td>
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<td>Visual auditory integration – Visually directed action to beat, visual/verbal match, RAN, auditory/spatial thinking, FonoFix verbal/spatial thinking.</td>
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<td>Domain 2- Evolving Self</td>
<td>Me thinking</td>
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<td>Mindful awareness for:</td>
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<td>Self awareness</td>
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<td>Body construct</td>
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<td>Self motivating</td>
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<td>Etc.</td>
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<td>ExpressEye (Self-correction)</td>
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<td>Domain 3 - Problem Solving</td>
<td>Me/You thinking</td>
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<td>Mindful awareness of others.</td>
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<td>Empathy</td>
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<td>Stages</td>
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<td></td>
<td>Input - actions, reflexes</td>
<td></td>
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<tr>
<td></td>
<td>Output - self discovery, spatial Exploration</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1. Sensorimotor; (Intrinsic Curiosity drives Visuo-Motor Complex)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2. Pre-operational; (mobility)</td>
<td></td>
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<td></td>
<td>3. Concrete; (Intuitive Physics)</td>
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<td>4. Formal; (Deductive Reasoning)</td>
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<tr>
<td></td>
<td>Output - the &quot;actual&quot;</td>
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<td></td>
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<tr>
<td></td>
<td>Output - invariance, conservation, logic</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Input - the &quot;possible&quot;</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Output - hypothesis testing, creative imagery, Thinking about thinking.</td>
<td></td>
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</table>
diagnosed with dyslexia. Approximately 40% of the dyslexic group were found to have co-morbid dynamic vision deficits. Figure 11 shows age related normative data and the data spread within the dyslexic group for each of the sub-components of the FixTest assessment.

**ExpressEye Equipment and Analysis Software**

The ExpressEye system (Photo 2) is used with older children and adults to assess and diagnose for optomotor deficits. Calibration, fixation stability, binocular stability, saccadic organization, and self-correction factors are measured. The instrument is a head mounted eye-movement recording device that uses three mini-lasers positioned in the box above the head to provide the fixation stimulus.

Infra-red sensors are positioned just below the eyes to collect the data required to study basic mind/eye organisation. 1000 readings per second for each eye over 16 minutes is recorded and available for microanalysis.

**ExpressEye Data Collection**

Four procedures are used during the ExpressEye assessment:

- **Calibration:** The organisation and control of the body, head, and eyes is typically developed sufficiently by the age of seven to enable instrument engagement and computer software calibration. Calibration is essential for fixation stability, binocular stability, pro-saccade and anti-saccade assessments. Failure to calibrate with a normal healthy eight-year-old or older is considered to be a performance marker for a probable orientational ‘where am I’ deficit.

- **Fixation:** The ability to hold steady fixation on a laser light spot projected on a blank screen at one meter from the head mount has normative age expected data. Unstable fixation attention hold correlates with frequent intrusive saccades. This is a basic aspect of the optomotor cycle (figure 2), where magnocellular and

---

**Figure 11:** Comparison of Dynamic Vision results.

**Photo 2:** ExpressEye.
parvocellular pathways integrate with selective visual attention to hold fixation.

- **Pro-Saccades:** These saccadic movements are *towards* the stimulus and make limited demand on voluntary fixation release control. Imagine standing before a person, holding the index fingers of each hand raised to eye level, about 30cms apart. Instruct the person to look at your nose. Ask them to observe when one of the fingers moves, then look from your nose to the moving finger. This saccade movement *towards* the target is the pro-saccade. Data on pro-saccades as a function of age are given in Figure 12.

- **Anti-Saccades:** Now the saccade movements are away from the stimulus and this imposes a higher demand on voluntary optomotor control. Repeat the task above, but now instead of looking at the moved finger gaze is directed to the finger that did not move. A saccade must be made to move fixation away from the moved finger. This consciously controlled eye movement away from a stimulus is an anti-saccade. Data on anti-saccades as a function of age are given in Figure 13.

**ExpressEye Data Analysis**

Digital recordings of all fixation, pro-saccade and anti-saccade procedural responses are available for computer analysis and for graphic inspection of all or selected movement pattern responses. Set protocols are used to measure and analyse response times, control accuracy, binocular stability, and error profile for fixation, pro-saccade and anti-saccade tasks. The clinician then compares each patient’s performance profile with established norms.

- **Fixation Stability:** A marker for fixation instability is a statistically significant frequency of fixation drift from the target light with quick return intrusive saccade recoveries. The age-expected fixation stability for this procedure is determined by counting the number of error saccades (intrusive saccades) per trial.

- **Binocular Stability:** Recording the relative velocities and synchrony of actions for each eye as they make saccadic movements from one laser light to another enables the assessment of the optomotor aspects of binocularity during the eye movement and saccadic suppression. The symmetry of eye movement actions and timing between fixations to each spot of light is an index of dynamic binocular optomotor stability.

- **Saccadic Organisation:** Response times provide markers for saccade responses. There are three saccade groups of interest when assessing neuro-developmental status. Express saccades utilise a reflex pathway without frontal lobe involvement. They are classified by rapid responses, which occur around 100ms after the stimulus. High frequency express saccade
patterns are typically accompanied with many errors and poor self-correction. The next are the slow voluntary saccade responses, which occur 200ms or more after the stimulus. Finally, fast skilled saccades are marked by their response time of 150–190ms. These saccade response time markers are used to determine the deficit diagnosis and also to monitor optomotor learning during the acquisition of saccade control.

Response Times are used as markers to identify 3 Levels of motor control:
1. Express saccade – 100ms (reflex control–Stage 1, Vygotsky Recursive Loop).

Self-Correction: The number of errors and response patterns to errors during the simple ExpressEye procedure provides markers that relate to self-correction responses. This data provides a window into an aspect of visuo-cognitive development, the evolving self. The optomotor developmental changes that are typical as a person progresses from pre-school to advanced reading to learn abilities show that the trend is for the developmentally immature to:
1. Start with poor fixation hold, lots of intrusive saccades and/or reflex express saccades with poor accuracy, and limited self-correction.
2. Move to good fixation, hold and release, and use slow voluntary saccades that show improved accuracy and some self-correction.
3. Eventually demonstrate limited express saccades and a mix of fast and slow voluntary saccades with good accuracy and fast, accurate self-correction.
4. Following good saccadic organisation, the next step is to develop attention shifts for form analysis of detail covered by a single fixation. These attention shifts are required for the scanning of short-term memory imagery as with the CountFix procedure.
5. Finally task specific schemata for reading eye movements emerge as is detailed in the developmental table for the averages for measurable components of the fundamental reading skill \[63,64\].

From data analysis of recorded responses to ExpressEye assessment procedures, patterns of neural organisation, response accuracy, self-correction and reaction times are identified. Saccadic response times, for example, could cluster around the express saccade 100ms and indicate a reflexive behaviour; or be at 200ms or more and indicate a slow conscious unskilled operation. Skillful saccades enable the response times to cluster around 150ms. A developmental aetiology, where the required neural connections have not been acquired, is proposed for the cases with optomotor deficits without vision defects and a history of slow school readiness/learning to read. Some cases with later onset visuomotor dysfunctions have also been found to have optomotor deficits indicating the possibility of a breakdown of previously developed functional neural assemblies.

ExpressEye performance responses of age matched normal students (control) have been compared to students diagnosed as dyslexic. Systematic deficits with anti-saccade performance, but not pro-saccade responses were co-morbid with many students also diagnosed as dyslexic, ADHD and/or dyscalculia. The percent of uncorrected errors for anti-saccade procedures for controls and dyslexic students aged 8 to 20 years is illustrated in Figure 14.

Treatment for basic optomotor deficits has been shown by laboratory studies to be generally effective (about 85%).\[8,150,151\] Figure 15 illustrates the changes in the percentage of uncorrected anti-saccade gap responses for a group of dyslexic students aged 8 to 15 years; the before treatment data is above the after treatment data collected by ExpressEye procedures.
A high frequency of reflex ‘express’ saccades suggests impulsive optomotor cycle organisation and that the student may not be in a state of engaged attention during the fixation period. Infrequent express saccade suggests a reflective ‘over hold’ optomotor cycle pattern. The communication of a patient’s ExpressEye performance on the initial assessment and on the graduation assessment can be graphed on age expected ‘marker’ data as shown in Appendix 2.

The diagnosis of a visual perceptual deficit related to how a number of presented circles are immediately seen. ‘Subitizing’ requires the psychometric comparison of a student’s CountFix visual tachistoscopic ‘where is it’ response profile with normative data. CountFix assessment can discriminate between normal control students and students classified as having dyscalculia. Additionally, the basic visual perceptual deficit processes related to the ‘where is it’ subitizing analysis of dot patterns does respond to treatment.

FonoFix: Equipment and Analysis Software
The FonoFix procedures have been designed to assess aspects of auditory discrimination and “where is it” analysis that does not rely on language processing.

The FonoFix assessment has five procedures and each of these procedures involve many trials. Each task trial starts with listening to sound patterns and to analyse specific features that can be spatially understood as going up; going down; going to my right or going to my left. Each trial is concluded when the subject presses the arrow that represents their answer.

The FonoFix procedures assess:
1. Intensity: While the subject is wearing earphones, two white noise sounds are presented sequentially. The first sound will differ in intensity from the second sound. When the first sound is lower in volume and the second sound higher in volume, the arrow up is to be pressed to indicate difference between the two. When the first sound is higher in volume and the second sound lower in volume, the arrow down is to be pressed. The task starts with an easy to discriminate difference in auditory volume (what is it) and establishes that the subject can perceive the “where is it” relationship in time between the two stimuli. The procedure then moves on to determine the subject’s perceptual threshold. The task concludes when a 50% error rate occurs.

2. Frequency: Two sounds with different frequencies are presented. When the first sound is a high frequency and the

![Figure 14: Anti-saccade data for controls and dyslexics.](image1)

![Figure 15: Training effects of CountTrain.](image2)
second a lower frequency, the change in frequency relationship is going down. When this frequency relationship is reversed, it is going up. The appropriate arrow key is pressed by the subject to indicate choice. The task again starts with an easy to discriminate ‘what is it’ difference and then alters to determine the subject’s threshold for the perception of ‘what & where’ analysis. The task concludes when a 50% error rate occurs.

3. Gap Detection: Two white noise sounds are presented. In the middle of one of these sounds a short gap of no sound occurs. This sound pattern observation requires auditory discriminations and directionality understanding. A sound pattern can be represented as “------ --- ---” where the gap is located in the last heard sound; the arrow pointing right is then pressed. When the gap is located in the first sound, the arrow on the left is pressed. The task again starts with an easy to discriminate difference and then alters to determine the subject’s threshold. The task concludes when a 50% error rate occurs.

4. Time Order: Two very short sounds of different frequency are presented and the difference between the two gradually reduced. When the first tone is a lower frequency and the second a higher frequency the up arrow is pressed to indicate that the sound frequency was going up and vice versa. The time order task again starts with an easy to discriminate difference and then alters to determine the subject’s threshold. The task concludes when a 50% error rate occurs.

5. Side Order: A short white noise is presented to one ear and after a short time break another equal sound is presented to the other ear. Sound that seems to start in the right ear and finish in the left ear is represented by the arrow pointing left. When the sound that seems to start in the left ear and finish in the right ear the arrow pointing right is pressed. Side order tasks start with an easy to discriminate difference in time between the first and the second sound. The procedure then moves on to determine the subject’s perceptual analysis threshold for the analysis of “where am I” and “where is it”. The task concludes when a 50% error rate occurs.

Auditory–spatial perception deficits have been shown to improve with treatment. One reported success rate for the volume, frequency, gap detection and time order is shown in Figure 16; and evidence for transfer of improved auditory–spatial perception to an educationally related spelling accuracy task is shown above.

Figure 16: Development of Auditory Discrimination.

Principle 4. OVT baseline data and procedures are scaffolded onto optomotor and perceptual functions.

Functional vision projection (FVP) is the ability to organise for binocular visual inspection and analysis of virtual space stereogram targets.
and then to respond to the understanding of this projected construct. Systematic study of the child’s visual projection responses to virtual space and selected targets in a Brewster stereoscope was initially reported as an aspect of vision development by Gesell et al.\textsuperscript{59} Over the years the series of cards have been modified into a general use series and an extended test series. The stereogram cards present sensory and motor challenges to the observer’s binocular organisation. Some of these stereogram cards are shown in Appendix 3. FVP cards have various optomotor and perceptual complexity and have been used to progressively and selectively probe how the person uses their functional vision.

The FVP screening assessment is rarely clinically useful for children under the age of 5 years, but for older patients it offers an exceptionally fruitful portal for quantitative and qualitative clinical appraisal of top-down processes. Table 3 builds on the work of Gesell et al.\textsuperscript{59} to provide a contemporary understanding of the developmental response related to the FVP stereograms\textsuperscript{152-163} and provides typical performance achievements that are found in young adults with single, clear, binocular,

<table>
<thead>
<tr>
<th>Age</th>
<th>Expectation</th>
</tr>
</thead>
<tbody>
<tr>
<td>21 mths</td>
<td>Too complicated for this age. Typically only peers in.</td>
</tr>
<tr>
<td>24 mths</td>
<td>Now shows some engagement.</td>
</tr>
<tr>
<td>2.5 years</td>
<td>Typically makes some response, names one or both animals, pig/dog.</td>
</tr>
<tr>
<td>3.5 years</td>
<td>Identifies both animals easily. Asked to touch—points to lens.</td>
</tr>
<tr>
<td>4 years</td>
<td>Quickly identifies both animals. Touch, may get to card surface.</td>
</tr>
<tr>
<td>5 years</td>
<td>Now more exploratory. May use right eye to look through left lens, etc. Pointer typically needed for Vertical and Horizontal posture. 2 ball response often given. Sign posts - may get to 5 or 7 with pointer, by pointing. Rejects repetitions\textsuperscript{110}</td>
</tr>
<tr>
<td>6 years</td>
<td>Most cards give information, but &quot;pointer&quot; may be needed. 3 balls usually. Sign posts - expect 6-7 OU, R &amp; L. 3D - 5 to 2 balloons, colour naming, but no SILO. Fine stereo 2-5 of 12, some may get to 8/12. Randot often seen. Binocular rivalry - may now be measurable, typically more rapid and Piecemeal than the adult.\textsuperscript{111-115}</td>
</tr>
<tr>
<td>7 years</td>
<td>Vertical and Horizontal posture easy and stable. 3 balls and stable. Sign posts 8-9 correct OU, R &amp; L. 3D - 5 to 2, colours named, some get SILO. Fine stereo 6-7/12 (some get all), Randot -- correct response expected. Other cards have variable success. Reflect individual organisation and engagement with visual detail.</td>
</tr>
<tr>
<td>8 years</td>
<td>3 balls stable. Sign posts - 10/10 OU, R &amp; L. Verbal responses solid. Further cards, good data from most, may fatigue and children often report. Responses reflect personal spatial organisation. Internalisation of fusional vergence control typically poor and repeats avoided.</td>
</tr>
<tr>
<td>9 years</td>
<td>Expect stable binocularity and ability to organise virtual space. Precision and crisp awareness of detail and spatial relationships. Neural development for binocular rivalry reflects endogenous attention and aspects of optomotor efficiency.\textsuperscript{116-118} Usually stereoscope responses now reflect similar spatial organisation as real space tests.</td>
</tr>
<tr>
<td>12+ years</td>
<td>Internalisation of fusional vergence control variable. Adult expectations. Binocular rivalry emerges from the cortical mechanisms of 3D vision\textsuperscript{119} is modified by experience 120 and rate decreases as a function of age.\textsuperscript{121}</td>
</tr>
</tbody>
</table>
We generally conduct Visagraph assessment\textsuperscript{164} to identify task specific visually related reading dysfunctions after OVT has remediated basic optomotor and perceptual performance deficits and dysfunctions. Good readers can integrate sequential visual inspection with language processing and do this with minimal demand on their conscious attention. Maximum attention can then be directed to comprehension enhancing strategies. Ciuffreda and Tannen cite clinical guidelines for for the assessment of the measurable visual inspection components that relate to reading.\textsuperscript{62} Expected Visagraph performance for each grade level is shown in Table 5.

The final stage of the “reading to learn” OVT program may then include activities such as Moving Window reading, tachistoscopic procedures, controlled reader and trombone reading. OVT is directed at ensuring that general dynamic visual efficiency can also be applied to reading tasks.\textsuperscript{165-168}

### Visuo–Cognitive Schemata Assessment (Area 3 referenced in Table 2)

Neuro-developmentally, it can be argued that basic attention driven optomotor and perceptual factors are fundamental to the acquisition of more complex visual inspection and visuo cognitive
This construct addresses the functional vision aspects of the interactive relationships between three domains.

Domain 1: Sensorimotor thinking emerges from experiences that generate melit thinking as the person comes to understand and relate self to the environment. This domain includes the psycho-physiological constructs that relate to visual-spatial analysis, visual-detail analysis, visual-motor and visual-auditory integration aspects during motor and perceptual learning. Essentially this is visual information processing, and it is well detailed in various texts. The expressiveEye procedure provides objective assessment of some basic optomotor and perceptual functions essential to the visual aspects of the evolving self. Calibration for the normal child over 8 years of age is primarily dependent on their self-awareness and then the self-organisation of body, head and eyes to specific spatial postures. Additionally, the neuro-optometric assessment of fixation stability, binocular stability, saccadic organisation and perceptual processes provides objective data on basic self-awareness, self-organisation, self-correction responses to error, and attention application. Other observations related to the evolving self can be made during each of the procedures of the functional vision assessment battery.

Domain 2: The Evolving Self emerges as me thinking generates a self-understanding and organisational base for receptiveness, natural curiosity and responsiveness to others. Aspects of this psychosocial domain that relate to OVT include self-awareness, self-organisation, self-correction, self-confidence. The expressiveEye procedure provides objective assessment of some basic optomotor and perceptual functions essential to the visual aspects of the evolving self. Calibration for the normal child over 8 years of age is primarily dependent on their self-awareness and then the self-organisation of body, head and eyes to specific spatial postures. Additionally, the neuro-optometric assessment of fixation stability, binocular stability, saccadic organisation and perceptual processes provides objective data on basic self-awareness, self-organisation, self-correction responses to error, and attention application. Other observations related to the evolving self can be made during each of the procedures of the functional vision assessment battery.

Domain 3: Problem Solving involves itit thinking as specific detail is related to other factors. This domain is philosophical in that development occurs as an understanding of truths and principles emerge. The competency of this domain can be assessed clinically by observation of problem-solving during an inventory of Piaget’s developmental tasks and/or a psychometric assessment by a pattern-matching test such as the Raven’s Progressive Matrices. Raven’s matrices require the student to visually identify pattern sequences, to analyse spatial location (the “where”) and feature characteristics (the “what”) within a pattern to identify the missing element that completes a pattern.

Data Applications for Progressive Monitoring and Case Management

During OVT delivery basic optomotor and perceptual performance are monitored and trained by the FixTrain, CountTrain and FonoTrain procedures. These three training units are similar to the FixTest, CountFix and FonoFix assessment units. The major difference is that unlike the assessment units, the training units can be set to run a level of demand that the patient would find achievable but challenging. Other aspects of top-down functional vision development are monitored as required with stereoscopic procedures and perceptual task scores.

FixTrain:

The FixTrain procedures use a small visual stimulus (T) that changes in orientation every 200ms. This challenges the patient’s control of fixation stability, accommodative stability, pro-saccade and anti-saccade operations and visual spatial perception. The patient watches the target continuously so that at the end of the series the direction of the ‘last’ stimulus by pressing an arrow key. These procedures can be performed monocularly or binocularly.

CountTrain:

The CountTrain procedure is similar to the CountFix testing protocol. However, the task is now set at a level appropriate for the patient’s ability.

FonoTrain:

Each of the five subsets of the FonoFix assessment are able to be trained with the FonoTrain. Training levels start where the patient has a reasonable level of success, typically at or about the 75% level.
Aspects of selective attention and interactions between the bottom-up and top-down mechanisms can be functionally manipulated, modulated and directed during OVT. Bottom-up processes enable fast reflexes and impulsive responses such as eye/body movements to a startle, vestibular ocular reflex (VOR) and optokinetic reflex (OKN) responses to hold fixation on a target and doll’s eye pursuits during head rotations and righting reflex. The righting reflex, also known as the labyrinthine righting reflex, is initiated by the vestibular system and corrects the orientation of the body when it moves from its normal upright position. The perception of head movement involves the body sensing linear acceleration or the force of gravity through the otoliths and angular acceleration through the semicircular canals. Ocular motor related reflexive responses use a combination of visual, vestibular and somatosensory inputs to make postural adjustments. Attention and motivational modulation of the input responses are used for basic efferent motor memory calibration. Such survival alerting processes and reflex responses are sub-cortically organised. They have aspects that are calibrated/recalibrated by experience and provide a ‘where am I’ spatial locus with an egocentric multisensory spatial map.

The responses to yoked prism, isometric vergence prism, AC/A manipulations and motivational manipulation indicate that neural comparisons and adaptive calibrations occur as the person experiences visual challenge and altered feedbacks from expected posture (memory) and their actual perceived posture. Sensory integration adapts to best resolve for the difference. This is the bottom-up aspect of functional vision that may need to be addressed at the early stage of an OVT program.

Bottom-up OVT can use traditional orthoptic techniques and adaptive responses such as those explored by the Held effect, Veagan effect, accommodation/convergence synkinesis to activate and exercise reflexive neuromuscular and sensory fusion responses. Sub-conscious calibration of the multi-sensory “where am I” reflexes and then the acquisition of re-calibration adaptability to challenge lenses that manipulate inter-sensory relationships between visual, somatosensory and vestibular can be used during OVT. When required such activities can assist in the refining of reflexive spatial orientation calibrations and the gaining of a flexible adaptability. Bottom-up reflexes include reflex fixation, express saccades, OKN, fusion reflex, blink, VOR, startle reflex and righting reflex.

Top-down OVT utilizes tasks that require conscious visual inspection and self-monitoring. Biofeedback is used to assist the patient to gain an awareness of how they control their own eye aiming and eye focus. Top-down visual processes are dependent on the functional neural assemblies that serve to provide executive control over selective attention, search, analysis and visually guided behaviour. The higher cortical brain centres become actively engaged when the person decides to searches for specific detail, analyse spatial context (“where is it”) and identify salient features (“what is it”), rapidly match naming to features such as color and form., and contemplates the experience for understanding.

Basic optomotor and perceptual markers include measurements that relate to fixation stability, binocular stability, saccadic response times, saccadic accuracy, saccadic error scores, self-correction responses to saccadic errors and subitizing. General visual inspection progress will be demonstrated by improved accuracy, faster responses, self-correction of errors, capacity to sustain and the ability to generally apply these inspection skills to new circumstances. Accommodative and optomotor demand is sequentially advanced for example and could start with monocular viewing from a chart at far to a chart at near then move to on/off and a moving lens challenge, a +/- flipper lens challenge, a mental minus and beyond.

OVT typically addresses the required aspects of visual inspection and visuo-cognitive...
operations in a developmental sequence. In the final stages of the OVT plan, both general and task specific visual inspection involve cognitive loading as the patient engages in problem solving, text reading or other visuomotor-perceptual challenge. The focal vision operational mode with heightened top-down processes is required for learning, reading, writing and accessing much of the academic curriculum.

A sample therapeutic stream is as follows:

1. **FVP:** Binocular rivalry, VO Star, Cheiroscopic trace, Vectograms (range, float, pointer).
2. **Optomotor cycle:** FixTrain for fixation stability, dynamic vision, saccadic organization, anti-saccade response time and accuracy.
3. **Rapid automatic naming:** charts, stroop procedures, CounTrain, visual processing speed, tachistoscope.
4. **Auditory/spatial integration:** FonoFix, auditory-visual integration.
5. **Voluntary accommodation:** Mental plus, mental minus, SILO.
6. **Voluntary vergence:** Brock string, convergence fusion, divergence fusion, thumb fusion, binocular projection awareness, aperture rule.
7. **Visuo-motor adaptions:** AK arrow procedures, Kraskin squinchel.
8. **Visual-spatial manipulations:** Laterality, chalkboard procedures, key pegs, tootie launch, directionality, Harry’s blocks, geoboards.
9. **Visual imagery:** Button bag, blind box, touch induced imagery, form emergence, chalkboard visualization, typewriter bunt.
10. **Problem solving:** Sorting, matching, classification, conservation, cogs, logic.
11. **Reading related visual performance:** Controlled reader, Vision Builder, Reading Plus.

During OVT therapeutic interventions, patients need to assimilate both bottom-up and top-down experiences. Aspects of both bottom-up & top-down visual processes can be addressed during a single OVT procedure.

Consider the following example:

**Optomotor Therapy Level 3 (Procedure 2 – Station Chalkboard. Level 3 - Alphabet Soup).** This procedure requires visually directed integrative performance and aims to develop basic schemata for skillful application of semi-conscious visual inspection and spatial organisation. It has been preceded by Level 1 (visually directed general movements for “where am I”/“where is it” thinking) and Level 2 procedures (self-directed visual inspection for “where is it”/“what is it” analysis.).

**Materials:** Charts (simple to complex); magnetic letters or Post-It notes; head torch; laser light.

**Procedure:** A letter chart is placed on the magnetic white board at eye height for the patient. Around this the magnetic letters on the board are randomly placed. The therapist asks the patient to put the head torch light on a letter on the chart and asks them to say the letter (or alternative, shape/numbers/symbols) while keeping the head torch light on this area of the chart. While holding head and thus head torch still, the eyes scan outside the chart to find the corresponding letter. Once this has been located within the scattered letters the patient is then to indicate the location by putting the laser light on the required letter. Subsequently the letter is now in the alphabet soup. Finally the head torchlight is moved slowly and accurately to this magnetic letter and the patient says a word that starts with this letter. An appropriate instructional set and Socratic dialogue can be combined with loading modulation and VT Rx.

An essential component of EBP is data documentation. A sample OVT record sheet that we use is provided in Table 6.
PART 3. EBP PRINCIPLES FROM PATIENT/CAREGIVER PERSPECTIVES

The third and final part of Sackett’s approach to evidence-based practice illustrated in Figure 1 incorporates principles related to patient/caregiver perspectives. We conclude our model with seven organizing principles essential to this aspect of care.

Principle 1. OVT management aims to provide high-quality patient-centered services.

The purpose of therapeutic OVT for the patient is to address the treatable problems that are limiting, distressing or otherwise problematic. The clinical goals of the patient/parent and the practice must be realistic and related to the treatable condition. It must be recognised that the evidence base for OVT will not make the decisions, it can only guide people to make their decisions.

Initial presenting complaints as related by parents, teachers or the patient are rarely described or understood in terms of an operational visual deficit or dysfunctional processes. More often at the initial presentation of a patient treatable reading to learn related
functional vision processes will report concerns about visual inspection clarity, stability, or comfort. The younger students with functional vision deficit or dysfunctional processes related to learning to read may report little or no visual symptoms. More typically slow progress with learning to read or spell is reported alone with some observed visual performance issues at school such as reversals, poor attention to detail, sloppy handwriting or poor tracking.

The early primary students that present for an eye examination to confirm that all is okay are a special challenge for the optometrist. For a large group of these students they will have healthy eyes, clear sight and no visual defect. Within the group a sizeable proportion (about 20 - 30%) will be found to have clinically significant issues beyond any ocular defect, as they present with neuro-developmental optomotor and perceptual deficits and/or visual dysfunctions related to learning to read. Parent and teacher questionnaires can disclose the cases experiencing slow progress with measurable educational performance product outcomes such as reading age, writing, math, and/or spelling delay. Observable signs of neuro-developmental issues with functional vision processes may not be reported. It may be necessary for parents to observe their child during the functional vision assessments before the frustrations associated with visual tasks are apparent. They need to understand how functional vision process issues can induce problems including poor visual attention to detail, reversals, spatial confusion, slow to copy far/near, asthenopia, eye strain, intermittent double vision and reduced access to the educational curriculum.

Principle 2: OVT is a goal-oriented and diagnosis-focused intervention.

The patient’s (and parent’s) goals are oriented around their awareness of, attitude to and motivation to address the visual issues they experience.

The patient's problem is typically expressed as symptoms in a QOL questionnaire and then later refined and written down as their goals at the start of OVT. The optometrist uses these tools to illustrate the functional vision problems and help the patient/parent to understand how these deficits or dysfunctions are limiting their ability to perform to potential.

Both parents and patients are asked to detail the three major goals that they wish to achieve from OVT. These goals should revolve around functional vision related symptoms/signs.

Summary of the steps:
1. Establish the presence of performance limiting visual problems.
2. Demonstrate the patient’s visual problem as a disruption of a process.
3. Discuss the relationship between processes (internal functional vision network cycle) and product (educational or performance outcomes).

Principle 3: OVT requires sound therapeutic alliances and collaborations.

The therapeutic relationships that commonly operate during the delivery of OVT are between the optometrist and therapist, and between the patient and the home assistant. The therapist/patient relationship is an ongoing process that is readily accomplished with most patients as the therapist demonstrates good coaching, accurate understanding, positive reinforcement and empathy and the patient becomes aware of measurable progress.

Home assistant/patient. This is primarily motivated by love and nurturing. For the short time of OVT home practice they are asked to be a developmental coach where they supervise and report on the child’s performance.

While the optometrist is professionally responsible for the OVT, in many practices aspects of delivery are delegated to a qualified vision therapist. The duties that are assigned include:
1. The vision therapist implements the optometrist’s plan, makes observations and records performance details.
2. The vision therapist empathetically works to build the therapeutic alliance and collaboration with the patient. Demonstrations, coaching and guidance techniques are used to empower the patient. Positive reinforcement is provided by showing the patient that they can control focus and eye aiming and that practice makes the control more accurate and easier.

3. The vision therapist demonstrates the authoritative developmental guidance approach to coaching and discusses how to apply this during home practice. Other suggestions are also provided to help the home assistant build therapeutic alliance and collaboration with their child. Socratic dialogue is provided, such as asking the patient about their feeling and observations involving during the procedures.

4. As the vision therapist demonstrates and reviews the assigned home practice, a therapeutic alliance and collaborative relationship is fostered between the vision therapist and the patient.

Working with young children requires special considerations, which we summarize here through thirteen guidelines.

1. Work on the floor with small children when necessary. Contact with the floor helps some children to improve control of their eyes, attention, and body.

2. Touch, but respect the child’s response. Some children are uncomfortable with being touched. Watch for the child’s response and ask if it’s ok. Children may learn better when touched as touching expresses empathy and caring. It helps the wiggly child control his body and attention.

3. Use time to motivate. Set a small task and ask ...‘How long will it take you to...? (use timer or count). Can you decide/complete/do ... before I count to...? If patient is visibly tiring set a time limit, “We are going to do this ... more times or for ... more minutes”).

4. Lead, don’t push against resistance, which is likely to lose the child’s engagement. Modify, redirect, or change the instructional set. Use some of the other motivating techniques. Suggest if they work with you on this, they can choose or get to do something they’ll want to do. If the child is unwilling to co-operate, as a last resort, tell them that they can choose to leave that task for now.

5. Be in charge and confident. The child may test the therapist but they needs to know who is the boss. If the child tries to take charge explain that they need to help the therapist in their role, which is being the teacher. Arrange for the controlling child to have some choices.

6. Stay “cool!” If the therapist loses of their cool, the child is in control. Kids can read feelings and they love to push “buttons“. With some aggravating kids, it helps if the therapist reminds themselves that are the adult.

7. Encourage positive self-talk and self-coaching. Discuss the positive words. I can ... I want to ... I am getting better ... I like ... I’m smart ... I’m capable ... I’m learning ... I did a good job ... (clarify negative words which “we won’t use in here”) I can’t ... I’m not good at ... I’m stupid ... I don’t like ...

8. Give choices. The therapist should encourage decision making within the child’s boundaries. “Do you want to do (this) or (that) first“? “Which stool/book/pencil would you like to use?”

9. Allow child some control. “Your turn on the switch... push the button...plug in the cord”.

10. Set boundaries. Establish the rules/expectations which should be reasonable, definable, enforceable and consistent. What’s the rule? Rules and boundaries
make children feel secure. Rules enable freedom. Help the child understand this.

11. Encourage listening. Whenever the child says “what?” ask “what did I say?”
good, you’re a good listener, you heard everything I said … you heard everything
I said except … Look at me and listen carefully and I’ll repeat it.”

12. Acknowledge feelings. “I see you are upset; do you want to talk about it?”
“You’re tired … but we’ll do it just … times”. “I know this is boring, but we have to do it.”
“I’ll set the timer for … minutes.”

13. Watch for learning plateau. Take a break when performance levels plateau or
diminish. Help the child observe how learning continues during these breaks.

Therapeutic engagement at the Zone of Proximal Development (ZPD)

Earlier in Part 1, on the section addressing Visual Science and Functional Vision Development,
we introduced the concept of the ZPD within stage 1 of Vygotsky’s Four Stage Loop (see Figure 7).
This is a crucial component to therapeutic engagement. The patient with an excellent secure
attachment relationship and playful engagement with assigned procedures will reach their potential
faster. This basic principle has become a core feature of EBP among the performance-guiding
professions. The importance of therapeutic visual engagement is supported and informed by the
literature on saccadic organisation \(^{115,181}\) and goal setting, task motivation and self-management
theory.\(^{182}\)

Distinct parenting styles and parent-child attachment relationships have been described\(^ {183}\)
and are categorized as follows:

1. Authoritarian parenting (high demand; low responsiveness) emphasizes blind
obedience, stern discipline, and the controlling children through punishments,
which may include the withdrawal of parental affection.

2. Permissive parenting (low demand; high responsiveness) is characterized by
emotional warmth but a reluctance to set boundaries and enforce rules.

3. Uninvolved parenting (low demand; low responsiveness) is similar to permissive
parents in the failure to enforce standards. But unlike permissive parents, uninvolved
parents are not nurturing and warm. They provided the child food and shelter, but
not much else.

4. Authoritative parenting (high demand; high responsiveness) is a more balanced
empathetic developmental parenting approach. Parents now expect children
to meet certain behavioral standards but also encourage their children to think for
themselves and to develop a sense of autonomy.

Parent/child attachment relationships based on the child’s response to their caregivers
can be classified as:

1. Secure attachment style is demonstrated by the child when they can use caregiver
attachment as a safe base to explore their environment and are comforted by
physical contact with their caregiver when upset.

2. Avoidant attachment characterised by the child’s lack of distress when separated
from their attachment figure and seems to avoid interacting with caregivers.

3. Ambivalent/resistant attachment is where the child tends to cry when separated
from the caregiver but then continues to cry and be unresponsive upon the return
of the caregiver even when comforted.

4. Disorganised/disoriented attachment is demonstrated by not responding in any
systematic way with their caregiver.

OVT procedures that aim to engage the child at an achievable but challenged level (Vygotsky’s
ZPD)\(^ {113,114}\) The authoritative parenting style and
a child with a secure parent/child attachment provide the best dynamics for home practice.
When the activity level is set too high, home
practice can become frustrating, anxiety inducing, unachievable and then quickly rejected by the child. OVT progress is more rapid when the home assistant can authoritatively direct activities, modulate the level of demand to achieve the ZPD to positively reinforce and rejoice in each of the patient’s personal best performances.

**Principle 4: Engagement and compliance that is complementary between office therapy and home practice procedures facilitates transfer of learned skills.**

The OVT treatment plan requires the repetitive home practice of selected procedures between visits to the office or clinic. The clinic visits set up conditions so that activities are achievable but challenging. At the various office visits three procedures are usually assigned for home each week. Thirty minutes of supervised instruction (10 minutes for each procedure) is required for ideally five days each week. The optometrist/therapist demonstrates how each assigned procedure is to be conducted and provides written instructions.

These instructions designate specific requirements such as instructional set, viewing conditions, methods to modify the task demand and the process to be emphasized. Computer software may be assigned when appropriate to reduce demands on the home therapist and facilitate engagement and compliance through feedback.

A daily diary is provided for the home assistant to record a running account of the home practice for the optometrist/therapist to review at the next clinic visit. At the initial OVT visit, the home assistant is given orientation and basic instruction on the key aspects of OVT delivery. A summary of this “Instruction for Home Practice” is provided below.

“6 P s” for the Home Practice Delivery (Guidance for the home assistant)65

1. Patience. The home assistant must appreciate that performance changes can be rapid, but are more usually slowly achieved with persistence and regular practice.

2. Positivity. Positive comments from the home assistant during practice build motivation, sustain involvement and foster the progression to the next level of task difficulty. Alternatively negative comments from others can destroy the moment and may make the child unwilling to participate. The home assistant is instructed to focus more on the positives, and not to overemphasize the negatives.

3. Planning. This involves deciding who will be the home therapist, where the training will be conducted, when it will be conducted and, how record taking will be done. The home assistant determines a suitable location and time of day. It is best conducted in a quiet environment, away from distractions, interruptions and siblings. The selection of a suitable time requires consideration of both the home assistant’s other roles and responsibilities and the child’s needs.

4. Partnership. It is emphasized that the home assistant is in partnership with the OVT clinic and the home practice is a vital part of the therapy program. The optometrist/therapist provides the treatment plan, the basic therapeutic experiences and guides the home assistant in the implementation of the home practice OVT procedures. Communication between the home assistant and the optometrist or vision therapist is essential for on-going management.

5. Process. The home assistant is made aware of various processes or skills that are to be coordinated to perform any of the assigned VT procedures. An analogy is given in terms of golf: improving performance is facilitated by coordinating a number of interactive processes, including the grip, posture, a balanced interaction of the two sides of the body, motor planning, and eye/hand coordination. Facilitating the control and sequential organisation of each of the related processes contribute to skilled
performance of the targeted behaviour. The same paradigm is then applied to the patient's visual dysfunction.

6. Practice. The need for task or procedure repetition in order to develop automaticity in executing the task is a key aspect in successful VT. Some find demands of replication boring and seemingly unrewarding. However, this is the time that the child should develop the awareness of his ability to increasingly gain control, expend less effort and energy, and master the particular procedure.

**Principle 5: OVT includes time projections to completion, incorporating goals, and monitored through progress evaluations.**

This time related principle requires that standard OVT interventions be wisely planned, time limited, therapeutically focused, developmentally appropriate and that regular criteria referenced procedures probe performance progress and monitor for expected change.

**Treatment Duration**

Projected treatment duration for patients with accommodative and vergence dysfunctions can vary widely with complexity of individual cases. The published set of guidelines from the American Optometric Association provides data from pooled clinical experience evidence-base.184

Relating our personal clinical experience below, we refer to sessions - with each session being 60 minutes in duration.

1. Given good compliance and engagement, uncomplicated optomotor and perceptual deficits and mild dysfunctions can be expected to plateau at or near age expected after 14 to 16 treatment sessions. Typically these are happy, healthy children who are smart at everything except school. They are in early to mid-primary grades and are unable to perform to their potential. Symptomatically, they experience visual performance difficulties related to attention to detail, spatial confusion, form perception, tracking and visual memory as they strive to learn to read, write, calculate and spell.

2. After the student has learnt to read they move on to reading to learn. A portion of the “learning to read” OVT patients require additional “reading to learn’” OVT sessions as they move up in grade and print size decreases, content becomes more demanding and the volume of reading increases.

3. Complicated OVT cases occur when defects, deficits and dysfunctions co-exist. The OVT management and delivery is more complex for these patients and additional sessions are anticipated as progress is demonstrated through measurable performance changes. OVT can now be a journey taken in steps of 10 OVT session units, pending progress, and with planned breaks between units.

With young children, a diagnostic trial period of 2 to 4 therapy sessions may be appropriate for evaluating a child’s maturational readiness and social ability to engage with clinic sessions. If the child is unable to engage, home practice activities may be introduced as a helping measure while waiting for the child’s readiness for OVT.

**Early Discharge**

When it becomes apparent that the patient cannot, or will not, engage with OVT, a reappraisal of the case details is required. Early OVT discharge may be triggered by:

1. Patient related factors such as refusal to wear prescribed eyewear, to do home practice, or to follow the rules of the OVT clinic and therapy directions.

2. Improper or inadequate home support or home practice related factors. When the patient is a child, and home practice cannot be supervised and developmentally directed, OVT progress will be affected.

3. Lack of expected progress could be due to another co-existing but undiagnosed
condition. An update on general health and wellbeing may be confirmed by an appropriate referral, for example to a paediatric or educational psychologist for assessment. OVT may be put on hold while other opinions are sought.

Principle 6: Criteria for completion or graduation should be established.

The OVT plan must include graduation criteria. Patterns of response to OVT can vary. The majority of cases, about 80 percent, with uncomplicated neuro-developmental optomotor and perceptual deficits, along with visual inspection and visuo-cognitive dysfunctions, respond reasonably fast at the start and then slow down towards the later sessions when the visuo-cognitive dysfunctions are being addressed. A small number of cases may either respond very quickly or require additional time. The quick responders reach their plateau before the predicted time and can graduate early in contrast to slow but steady responders for whom additional sessions may be indicated.

Regression to past dysfunctional behaviour, or schemata breakdown is a future risk to recently acquired visual skills. We explain and demonstrate to graduating OVT patients how to self-assess basic visual abilities and explain the need to clinically assess the maintenance of their new visual efficiency. Graduating OVT patients (or their parents) have experienced how functional vision performance can be modified by their active experiences. It is not hard for them to appreciate that newly acquired abilities can regress if they are not compliant with the doctor’s recommendations, as noted below in Principle 7.

Graduation from active OVT clinic sessions occurs when the developmental deficit/dysfunction markers related to the initial diagnosis have plateaued and their application to functional vision efficiency demonstrated. In the context of the developmental and rehabilitative loop (see Figure 7) a patient has reached a plateau or Stage 3 with respect to age/grade functional vision developmental milestones. With applied self-direction and the application perceptual-motor learning principles, further skills development and application can be expected.

Principle 7: OVT graduation moves the patient to planned follow-up and self-managed maintenance.

After active OVT has concluded, 3 or 4 three-minute procedures are assigned for weekly self-assessment and to refresh motor and perceptual memory. Performance regression is possible but usually easy to rectify when identified early. The patient is advised that regression toward pre-therapy visuomotor behaviour may result from illness, excessive fatigue, or non-use of prescribed therapeutic eye wear. The purpose and importance of follow-up, visual ergonomics, Rx support, and ongoing self-assessment is explained.

A scheduled follow-up review is made for about 4 – 6 months after the post OVT assessment. In addition to primary eye care the functional vision status is reviewed and maintenance activities are now reconsidered and perhaps modified. Lens and/or prism requirements as well as visual ergonomics are revisited. The longer the new visuomotor behaviour has been effectively used, the less likely regression becomes. An annual review may now follow, but each case must be individually assessed relative to further follow-up.

SUMMARY AND CONCLUSION

Evidence-based practice (EBP) leads to structured and personalised optometric vision therapy (OVT) interventions informed by mind science, innovative measurement procedures and management strategies. We have presented the basis for a model used successfully in clinical practice, predicated on the following points:

1. Evidence-based practice and principles related to neuro-developmental and rehabilitative optometric perspective guides OVT diagnostic optometric work-up procedures, the personalised treatment plan and therapy
delivery for functional vision deficits and dysfunctions.

2. Treatment delivery, timing, mode of delivery, procedure selection, zone of proximal development (ZPD) modulation, therapeutic support and activity loadings can be managed through EBP principles and practices. OVT is structured around an individualized plan to address the diagnostic entities and the patient's goals and, to be most effective, typically involves weekly clinic sessions. An individualized plan is based on the initial assessments, reports from other professionals, diagnoses, Rx, optometric goals and the patient's functional vision problems. An estimation of the probable number of treatment sessions. The plan is continuously monitored and adjusted as required during the course of active OVT delivery.

3. Principles common to many therapeutic disciplines guide the vision therapist/optometrist team. These principles also provide the vision therapist with a structure and a therapeutic purpose to patient coaching. The instruction of the home assistant regarding supervision of home practice is by direct instruction, demonstrations and written handout.

4. OVT is dependent on the patient's therapeutic engagement. Clinical management should address the patient's compliance, progress, interests and readiness. Advancement toward therapeutic goals is monitored and documented through progress evaluations at designated intervals.

5. Time-related factors are critical to effective OVT management. Appointment times, duration of time engaged on any specific procedure, frequency and duration of task avoidance, and home practice compliance are some of the factors that are individually considered. Progress monitoring and compliance data is collected by specific routine procedures. The optometrist reviews weekly clinical performance data, therapist notes and home diary, providing an indicator of home practice engagement.

6. OVT graduation is followed by self-management of visual ergonomics, and appropriate self-assessment. If required early recognition of modest regressions can be self-managed by an active home maintenance plan monitored through scheduled clinical follow-up assessments.

Regarding office-based OVT sessions, we noted that neural network building through rehabilitation treatments occurs via instruction and positive feedback used to foster self-directed engagement. An appropriate, personalised sequence of instruction and Socratic-like questioning supports treatment delivery. OVT delivery is individually planned for each subject to include both bottom-up and top-down factors. The therapist provides structure to the patient as they explore and reflect upon self-guided, visually directed experiences. Response analysis of these experiences, purposeful self-correction and problem solving develops the synaptic organisation required to improve functional vision efficiency.

The clinical management of basic neurodevelopmental deficits in functional vision is complicated when deficits and dysfunctions are co-morbid with other performance limiting conditions. However, basic optomotor and perceptual deficits can be objectively diagnosed and successfully treated even when co-morbid with conditions such as dyslexia, or attention deficit disorder/attention deficit hyperactivity disorder (ADHD). Successful treatment transfers to educationally-related quality of life outcomes.

ACKNOWLEDGEMENT

We thank Keith Masnick Ph D. for editorial advice and assistance with the organisation of references.


42. Merzenich M. Growing Evidence of Brain Plasticity. 2004; Available from: http://goo.gl/LFw1ug


52. Horner RH, Carr EG, Halle J. et.al. The Use of Single-Subject Research to Identify Evidence-Based Practice in Special Education. Exceptional Children. 2005; 71:2:165.


Please rate each question. How often does each behaviour occur?

<table>
<thead>
<tr>
<th>Question</th>
<th>Never</th>
<th>Seldom</th>
<th>Occasionally</th>
<th>Frequently</th>
<th>Always</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. CLARITY OF SIGHT AND FOCUS CONTROL (/20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Near viewing (~ 40cms) blurs - not clear, even with lenses</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Intermediate (~ 70cms) blurs - not clear, even with lenses</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Distance vision blurs - not clear, even with lenses</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Clarity of vision changes or fluctuates during the day</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Poor night vision/can’t see well to drive at night</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>2. EYE LUBRICATION (/16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eyes feel dry, itchy, scratchy or sting</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Often “stare” into space without blinking</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Have to rub the eyes a lot</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Crusty lids, discharge or excessive eye watering</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3. VISUAL COMFORT (/20)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eye discomfort/sore eyes/eye strain</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Headaches or dizziness after using eyes</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Eye fatigue/very tired after using eyes for extended time</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Feel “pulling” around the eyes</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Avoidance of visual tasks relieves symptoms</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>4. BINOCULAR STABILITY (/16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double vision - especially when tired</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Have to close one eye to see clearly</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Print moves, swirls, jumbles or blurs</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Visual attention is slow to adjust place to place, near to far</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5. BINOCULAR DEPTH PERCEPTION (/16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clumsiness/accident prone/misjudge position of objects</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Lack of confidence walking/stairs/escalators/driving</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Difficulty judging distance - oncoming traffic, balls, escalators</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Poor handwriting (spacing, size, legibility)</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>6. LIGHT SENSITIVITY (/16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Episodic migraine/headaches with visual disturbance; light sensitivity</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Normal indoor lighting is uncomfortable - too much glare</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Outdoor light is too bright - have to wear sunglasses</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Sensitive to and disturbed by flickering lights</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>7. SPATIAL ORIENTATION (/16)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Side vision distorted/objects move or change position</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Tend to bump into objects in your “side vision”</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>What looks straight ahead, isn’t always straight ahead</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Avoid crowds/can’t tolerate visually “busy” places</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>8. READING (/24)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Short attention span/easily distracted when reading</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Difficulty/slowness with reading and writing</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
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<tr>
<td>Poor reading comprehension/can’t remember what was read</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Confusion of words/skipping words during reading</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Difficulty sustaining reading comprehension/visual comfort</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Lose place/have to use a finger to keep the place when reading</td>
<td>4</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
</tbody>
</table>

Functional Vision Efficiency Rating = (______/148 x 100/1) = ________
Appendix 2. Documenting ExpressEye assessment results.

1. Percentage of Express Saccades.
   Initial examination 5% (over 'hold')
   Post OVT examination 10%

2. Binocular Instability (BIndex)
   Initial examination 61%
   Post OVT examination 10%

3. Pro-Saccade Mean Response Time ms & Age expected.
   Initial examination 286ms
   Post OVT examination 212ms

4. Task 2 Anti-Saccades: Mean Percentage of Errors.
   Initial examination 38% error
   Post OVT examination 14% error

5. Mean Reaction Time Anti-Saccade: Gap
   Initial examination 348ms
   Post OVT examination 240ms

Red – Initial Examination (14/1/09) Blue – Post OVT Examination (31/12/09)
Black vertical line indicates patient age.
Appendix 3. ‘Functional Vision Projection’: Sample Stereogram Cards

Distance.

1. 2. 3. 4. 5. 6. 7. 8. 9. 10. 11. 12. 13. 14. 15. 16. 17. (continued)
Near.