Vision Beyond 20/20 - My Model of Vision

An Insight into Behavioral Optometry

There are over 1.2 million nerve fibers that exit through each eye (jonas, 1992) and they contribute to almost 70 % of all the sensory nerves in the entire body. This is why the visual cortex receives majority of the information.

Our visual system is composed of 2 major sub-systems:

1. Focal or central visual process (Parvocellular Pathway).
2. Peripheral or ambient visual process (Magnocellular Pathway).

Central visual system is derived primarily through the macula, which is located on the retina at the central, or the posterior pole of the eye. The macula is densely packed with cone cells in the foveal region. The primary functions of the cone cells are colour detection and detailed resolution. This is also called the Parvocellular pathway (p-pathway). P- Pathway helps us see things in detail with better resolution and also helps us with recognition.

The peripheral area of retina is highly composed of rod cells. The rods occupy greater area than the cones throughout the retina. The rod cells are important for scotopic vision and they are also more sensitive to movements/motion than the cone cells. This is also called Magnocellular pathway (M-pathway). It is the M-pathway or the ambient visual process which links up with and becomes the part of sensorimotor feedback loop at the level of midbrain. M- Pathway helps us with peripheral awareness of our surroundings and also facilitates reading surroundings, visual attention and saccadic eye movements.

We have all been taught that the eye is like a camera as the light passes through the lens to produce an inverted image on the retina, the light-sensitive film at the back of the eye. Retina is connected to the brain and turns the inverted image the right way up and through some magical process, we see!

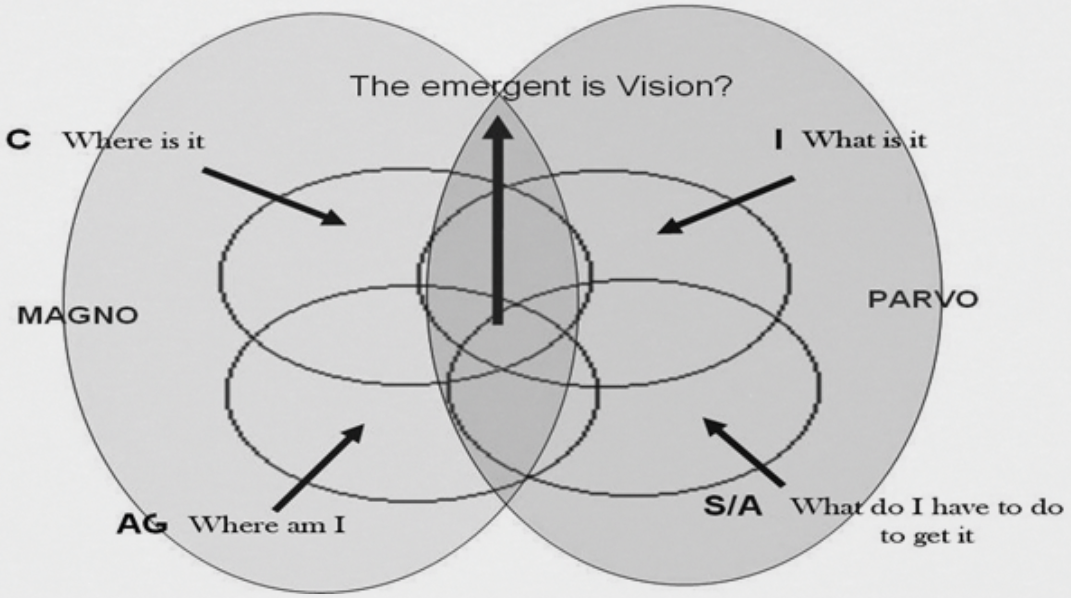
At optometry school, my model of vision was developed to provide an explanation for myopia, hypermetropia, astigmatism, and presbyopia. This model of vision was basic and sufficiently adequate for a typical optometrist to perform refraction and provide a spectacle prescription when needed. A decade ago, when I started my professional journey as practicing vision therapy optometrist and began expanding my knowledge in the field of developmental/behavioural optometry, my model of vision evolved and my understanding about vision changed. It inclined towards understanding the patients' functional difficulties which allowed me to plan and provide appropriate therapy.

My very first patient, an 8-year old boy, visited my clinic with a complaint of difficulty in reading. His best corrected visual acuity (BCVA) was 20/20 (OU) for distance and N6 (OU) for near. Anterior segment and posterior segment were unremarkable. The boy was struggling with reading, writing and learning for 4 years and he was diagnosed with attention deficit disorder (by another practitioner). However, after his functional visual evaluation, I started working on his functional visual skills. After 30 sessions of vision therapy for improving his oculomotor skills, normalizing accommodation and vergence amplitudes, his parents reported a drastic improvement in his reading, tracking, and writing.

Another patient, a 4-year-old boy, who was diagnosed as a child with global developmental delay with nystagmus presented to us with complaints of poor vision in both the eyes with poor motor control and was unable to stand or walk (Pandey, December -2020). I decided to work with him on improving his visual fixation and eye movements, followed by helping with the boy's primitive reflexes by providing visual-vestibular rehabilitation therapies. These therapies finally resulted in improved body balance and a much better body posture and the boy began standing and walking for the first time in his life. This changed my understanding of vision and I could clearly see that vision is more than reading the 20/20 line on a vision chart and also justifies that there is a difference between "vision" and "eye sight".

My present understanding of vision and the model I believe is very much motivated from Dr Skeffington's four circles theory of vision. In the mid-twentieth century, Dr A.M. Skeffington, the founding father of modern developmental / behavioural optometry realised that "vision" plays a much larger part in individuals' lives than simply being able to read a letter chart and then postulated and developed his four-circle concept.

Dr. Skeffington highlighted that vision is an emergent process as it is actually a cluster of interrelated sub senses that works together to create the visual world we experience. He conceptualized vision as emerging from four intimately related and integrated processes or system components as explained below:



The relationship of the magnocellular/parvocellular systems with Skeffington's 4 circles (Shayler, the use of models to help our understanding of vision, 2015)

A. Antigravity: "Where am I?"
B. Centring: "Where is it?"
C. Identification: "What is it?"
D. Speech-Auditory: "How can I communicate it?"

The most important and the major concept in his model was that the understanding of vision requires more than looking at isolated processes or individual structure-function pieces. Skeffington moved the field away from the camera-like understanding of eye toward the framework for multiple, distributed, parallel, and reintegrated processing.

In postulating vision as an emergent process, Dr. Skeffington used terminology distinct from the more familiar visual subcomponents of convergence and accommodation. Let's understand his ideas of four circles below:

A. The Antigravity Process: "WHERE AM I?"

Vision provides us the idea of our reference in space and also allows us to organize things and materials spatially and for this we must first know where we are in space. Vision also plays a vital and active role in controlling our body posture, movements, locomotion, and manipulation function and this particular role is called visual proprioception (Shayler, the use of models to help our understanding of vision, 2015). The very important role of vision in counterbalancing gravitational forces and visually guided movement of our body is also evident and reflected in our clinical tests of gross motor skills of standing and walking balance.

Therefore, the antigravity system depends on many neurological processes which evolves and comes into action and follows the below mentioned sequence:

- Visual system input that aids in the determination of vertical and horizontal frames of reference and the perception of self-motion that comes from optic flow patterns across the retina.
- Vestibular system input through the otolith and semi-circular canal systems of the inner ear gives information about head position relative to gravity and changes in acceleration and deceleration.

- Proprioception system input from the stretch receptors in the muscles that give information on body position.

(A) Bosu Ball- visuo-vestibular training combining with SVI- rotator module.
(B) Balance board training with visual fixation for improving balance (Pandey, december -2020), a part of visuo-vestibular training. These are some of the vision therapy activities we perform which relates to the circle of Anti-gravity process: Where Am I?

B. The Centring Process: "WHERE IS IT?"

The centring process refers to the coordinated movements of eyes, head and body to investigate and explore the environment surrounding the person and is a response crucial to the development and survival of the individual and species (holland, 2008). This particular process of centring describes ocular motility that can be fragmented and described as fixation, saccades, pursuits, and vergence.

Fixation: It is the ability of the eye to keep a steady image of object in space on the fovea. Fixation also serves as a measure of global attention and a patient with reduced attention span may can have difficulty maintaining visual fixation on a task. An accurate fixation is also very important and serves as a prerequisite for accurate saccades & pursuits.

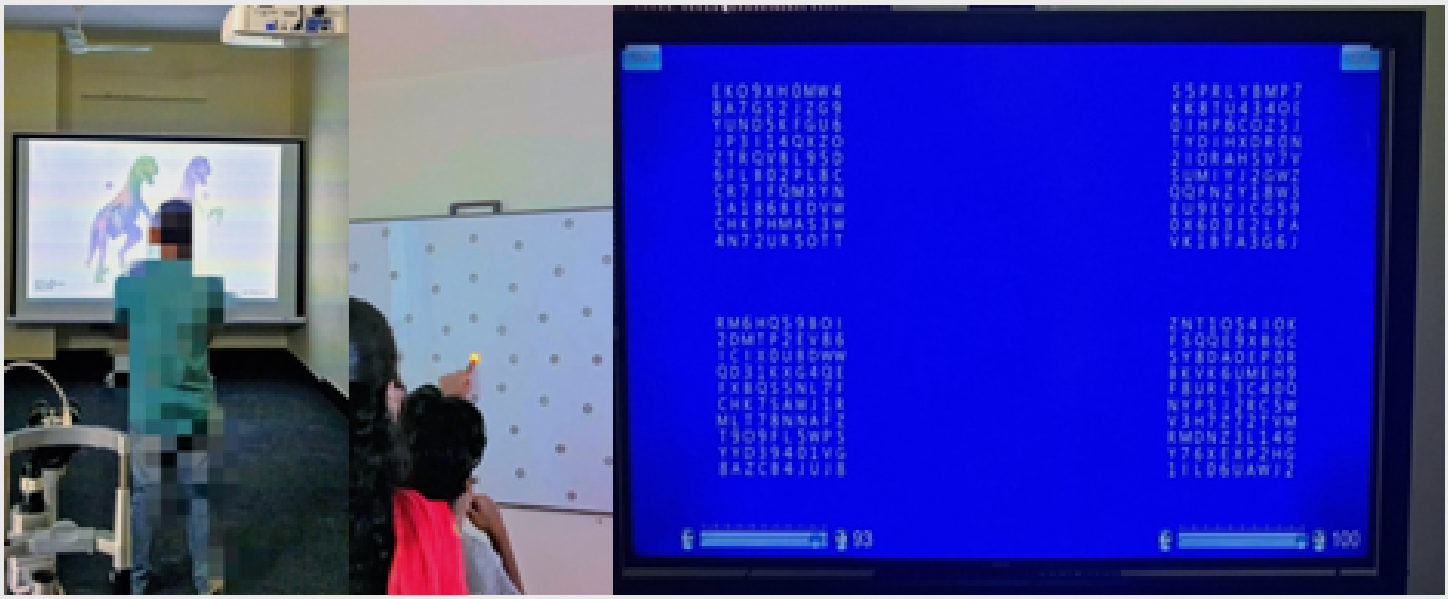
Saccades: Saccades, also called fast eye movements shifts our centre of focus between two or three successive points of fixation in the same direction. Saccades can be further classified into involuntary saccades and voluntary saccades. Involuntary saccades are mostly reflexive in nature and gets stimulated because of sudden changes in the environment for example bright light or sudden sound whereas voluntary saccades are purposefully induced by an individual for example reading is a voluntary saccades.

Pursuits: Pursuits are the smooth eye movements used to track moving objects in space.

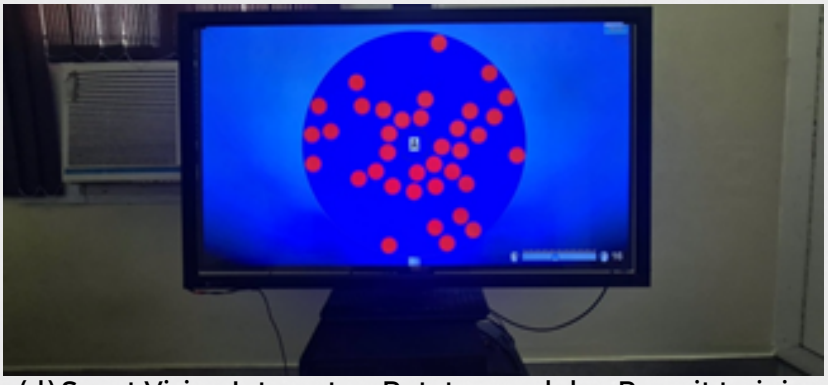
Vergence: Vergence can be subdivided into five subclasses:

- Tonic vergence: normal vergence tone of the neuromuscular system. (Penelope S. Suter)
- Fusional vergence: disparity driven vergence when images fall on non-corresponding retinal points.
- Voluntary vergence: vergence under voluntary control.
- Accommodative vergence: vergence stimulated by changes in accommodation.
- Proximal vergence: vergence stimulated by the nearness of an object.

All of the various components of vergence must be integrated so that binocular fusion is effortless. This frees attention from the act of vergence, allowing attention to be allocated toward other aspects of visual information processing (Penelope S. Suter).



(a)VTS-4 (b) Saccadic fixator. (c) Four corner saccadic chart – Sanet Vision Integrator



(d) Sanet Vision Integrator- Rotator module – Pursuit training

(e) Eye port fixation training – to develop vergence

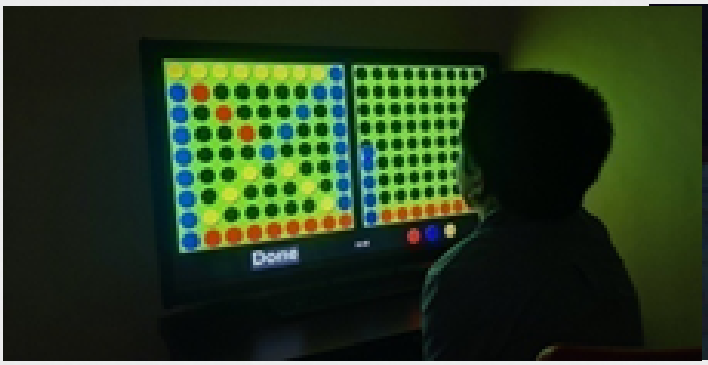
(f) Space fixator

(g) Mac- Donald charts – to improve peripheral awareness

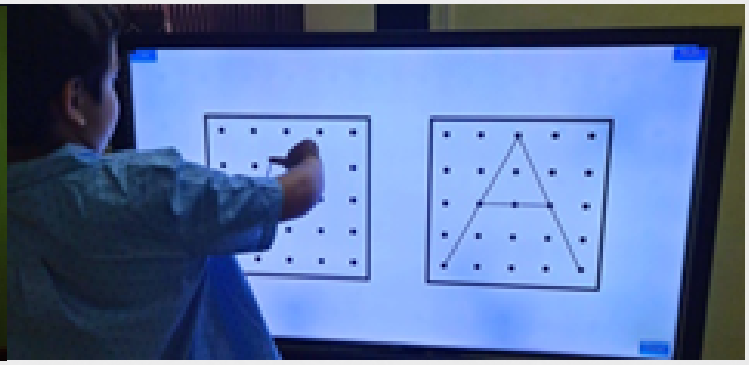
These are some of the vision therapy activities we perform which relates to the circle of centring- Where is it?

C. The Identification Process: "WHAT IS IT?"

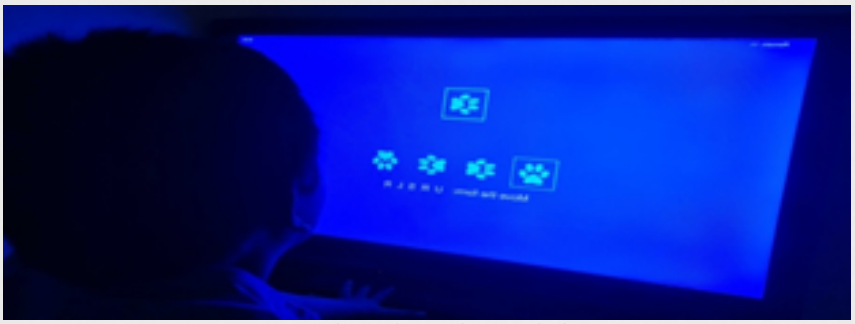
Identification, or recognition of an object, occurs through the recognition of objects through their specific attributes such as shape, colour, size, and texture. Multiple processes are involved, including attention, prior experience with the object, and storage of information, conversion to memory, memory retrieval, association, generalization, and classification. Object vision normally has as its basis stable visual fixation, aided by the ability to attain and maintain a clear image through visual process of focusing or accommodation.



(a)Perceptual Therapy- Pegboard



(b) Visuo motor module - SVI



(c) Perceptual therapy- Directionality training

(d) Parquetry blocks

These are some of the therapies we perform which relates to the 3rd circle – The Identification Process: What is it?

D. Speech – Auditory: Analysis and Communication:

Identification of an object is incomplete until a person is able to label and communicate that which is seen. The communication may be internal, in the generation of visual images or more in the form of auditory analysis to tell ourselves what we are seeing, or speech in terms of conveying what is seen.

(a) Computer Tachistoscope- Audio- Visual Format to train visual auditory integration. This particular vision therapy activity relates to the 4th circle – Speech -Auditory- Analysis and Communication
(b) Computerised parquetry blocks – visual verbal format

Now, I can conclude that Dr. Skeffington's theory on four circles of visual process is very closely standing up with the modern concept of neurological processes of the magnocellular and parvocellular pathways. I can very well relate that antigravity and centring circles are primarily related to the magnocellular processing and are closely associated with visual attention, whereas identification and speech/auditory circles are primarily related to parvocellular pathway mechanism and associated with cognition.
So based on the above theory postulated by Dr Skeffington and my newly evolved understanding of vision, I can now clearly state that there is a difference between eye sight and vision. Where eye sight is more quantitative in nature (20/20) and can be measured using a vision chart whereas "vision" is an emergent process which integrates with all other senses together to give an amazing experience of the world surrounding us which cannot be measured by any one single test.

"Vision is a dynamic interactive process of motor and sensory function, mediated by the eyes for the purpose of simultaneous organization of posture, movement and spatial orientation, for manipulation of the environment and to its highest degree, of perception and thought." – William V Padula

Rabindra Kumar Pandey is the Optometric Director and Proprietor of Caring Vision Therapy and Neuro-Vision Rehabilitation Centre in Chennai, India. He completed his bachelor of optometry and vision science from NSHM school of Optometry, Durgapur/ Kolkata and post-graduation in clinical optometry (M.Optom) from Chitkara School of Health sciences- Chitkara University, Punjab. He is currently pursuing his Ph.D. from CT University, Punjab. He has been an international member of The College of Optometrists in London, U.K, international clinical associate member of College of Optometrists in Vision Development (COVD), Neuro Optometric Rehabilitation Association (NORA), American Academy of Optometry (AAO) and the College of Syntonic Optometry (CSO) and is currently pursuing his fellowship at COVD and AAO.

References:

1. holland, k. (2008, march). www.optometry.co.uk. Retrieved from www.optometry.co.uk.
2. jonas, j. B. (1992). human optic nerve fiber count and optic disc size. investigative opthalmology and visual science .
3. Pandey, R. K. (december -2020). a journey towards 1st step of life- a case report on vision therapy for a patient with global developmental delay and nystagmus. vision development and rehabilitation , 295-303.
4. Penelope S. Suter, L. H. Vision Rehabilitation- multidisciplinary care of the patient following brain injury. CRC press.
5. Shayler, G. (2015). the use of models to help our understanding of vision. optometry and visual performance , 138-150.
6. Shayler, G. (2015). the use of models to help our understanding of vision. optometry and visual performances .