Dynamic Vision: Vision Therapy through the Anti-Gravity System

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Abstract

In the four circle model, AM Skeffington proposed the idea of the anti-gravity system as one of the building blocks of vision. While the anti-gravity system is highly active in many vision therapy techniques, conditions can be arranged to ensure full engagement. This paper will briefly discuss the tecto-pulvinar pathway and vestibular system and explain how they play a role in vision therapy as it relates to the anti-gravity system. Specific vision therapy procedures emphasizing the anti-gravity system will be discussed.

Key Words

anti-gravity, Bal-A-Vis-X, central-peripheral organization, Hart chart saccades, sensory integration, space fixator, tecto-pulvinar pathway, vestibular system, vision therapy

In school, I remember learning about the incredible detail and complex processes that go into making vision possible. During that time, the concepts focused on the neurophysiology of light and how the information was sent to the brain as useful pieces of life and information. The whole process was remarkable, but I seldom found clinical and real life applicability to what I was learning. I was taught an appreciation for how visual information was sent to specific areas of the brain resulting in visual processes like accommodation, vergence, saccades, pursuits, visual-spatial organization, and visual-vestibular integration. But, what if these visual processes do not function at their most optimal levels? What I wanted to know were vision therapy techniques that could help to turn on these visual pathways and lead to efficient visual processing and purposeful movements through space. I propose to integrate multiple neurological systems into vision therapy procedures to enhance the therapy. The goal of this paper is to provide a condensed explanation of the tecto-pulvinar pathway and vestibular system and integrate them into several vision therapy procedures.

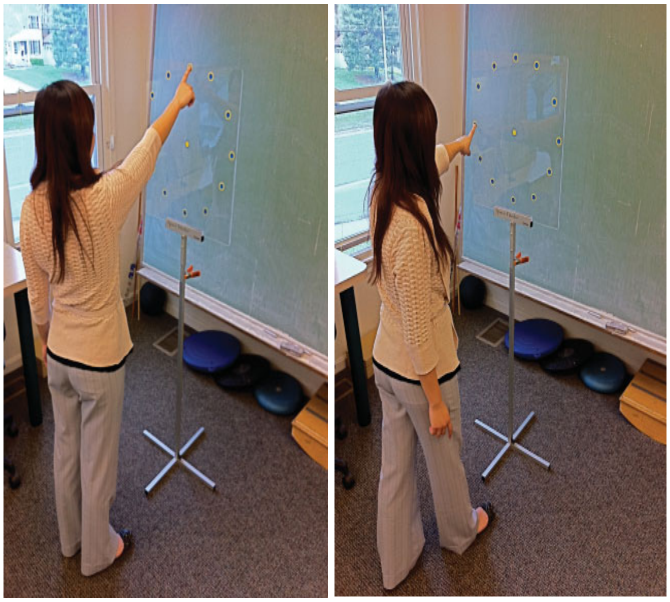
There is little argument that vision is our dominant sense; its integration with other neurological systems and pathways shows that without an efficient visual system, we are at an extreme disadvantage when attempting to derive meaning from our surroundings. These neurological pathways process a wide range of visual tasks to keep our bodies in a state of clarity and equilibrium, as well as process information for all our senses.[1] It is how we integrate this total system that allows for efficient, purposeful vision and movement.

Skeffington proposed his four circles model of vision and explained the importance of gravity on vision. It is described as the 'Where am I' aspect for the person and 'Where is my body in relationship to my surroundings.'[1] We know there are specific neurons that are solely devoted to helping the body maintain balance, posture, and movement through space. The less effective the anti-gravity system, the more energy is required to establish proper balance. This results in less freedom to manipulate visual processes adequately. It has been found that visual input makes up nearly one-third of the sensory information that is used for balance and equilibrium.[2] This can be appreciated by merely standing with your feet heel-to-toe and trying to balance with your eyes closed. An action that is generally easy to perform when the eyes are open, now becomes a challenging task without visual input. Pertinent to this paper are two pathways that contribute to the anti-gravity system and help maintain the stability of the body's visual environment by compensating for the effects body movements have on the position of images on the retina.

A pathway known commonly as the tecto-pulvinar, superior collicular, or extrastriate (reflecting the regions of the brain involved in processing) does not travel to the primary visual cortex (V1) for processing. This pathway relays visual neuronal information to the extrastriate visual cortical areas for processing of orientation, motion, and speed. This visual pathway bypasses the lateral genticulate nucleus (LGN) and V1 completely and coordinates visual-motor tasks, body, and head movements for stability of fixation. This pathway also integrates with the vestibular, tactile, proprioceptive, and auditory systems as well as other areas of the cortex.[3] There is much in common with the magnocellular pathway, which is primarily involved in location and movement of objects with an emphasis on stimuli in peripheral space.

Another system that is highly involved in vision and balance is the vestibular system. The vestibular system serves to stabilize eye position and movement during changes in head position. The vestibular apparatus located in the inner ear consists of semicircular canals to monitor rotational and angular head movements. The orientation of the semicircular canals mirrors the actions of the extra-ocular muscles of the eye. The vestibular ocular reflex (VOR) plays a pivotal role in the vestibular system. It helps to maintain bifoveal fixation by managing compensatory eye movements to head and body movements. Each semicircular canal is connected to one ipsilateral and one contralateral extra-ocular muscle. For the eyes to move horizontally, a signal generated in the horizontal semi-

Figure 1. a) One of the early levels of the Space Fixator sequence being performed using hands only. b) More advanced level now using hand and contralateral foot movement



circular canal goes to the vestibular nuclei in the brain stem. From there it travels to the contralateral abducens nerve (CN VI) nucleus and ipsilateral oculomotor nerve (CN III) nucleus by way of the medial longitudinal fasciculus. This innervation creates a subsequent eye turn to the right in response to a head turn to the left.[2]

For therapy to be at an optimal level, integration of multiple senses and systems must take place. The term sensory integration is defined as the ability of the central nervous system to take in, sort out, and interrelate information received from the body and the environment to allow for purposeful responses.[4] The idea of sensory integration is closely related to the Gestalt concept of Figure-Ground. The primary focus (Figure) is distinguished from, but still integrated with, whatever is peripherally attended to (Ground), thus producing multi-awareness. Proper sensory integration is pivotal for efficient action, and so the collaboration of vision therapy with other therapies can be beneficial. Proper testing is needed to ensure a reliable referral when necessary.[5]

Many patients come to vision therapy practices with visual issues manifesting from disruptions in the anti-gravity system. It is important that we understand this integration between vision and the other senses; this integration is crucial for proper development. Specific procedures can be used and certain conditions can be arranged to elicit the optimal response. The anti-gravity system can be added into vision therapy procedures to ensure integration and increase the degrees of freedom, allowing for full patient potential.

Movement, balance, and auditory stimulation can be incorporated into vision therapy, integrating multiple systems.[6] The manner in which variables in techniques can be manipulated is truly limitless. These procedures are not intended to replace others, but merely to serve as additional ways to arrange conditions differently to create opportunities for learning. Because the scope of this paper is limited, three vision therapy procedures that incorporate the integration of these sensory systems will be discussed.

Space Fixator

Materials: Space Fixator, Translucent Occluder, Metronome

This procedure is deeply rooted in the integration of multiple sensory processes.[7] The incorporation of visual, vestibular, tactile, auditory, and proprioceptive awareness can be accomplished with proper use. You will see an increased ability in the eyes to move quickly, accurately, and efficiently from one target to another. The device is ostensibly designed to be unsteady, but this element creates a need for accurate spatial judgments along the z-axis. This swivel and instability require precise tactile and visual-spatial movement to succeed in the task. A coherence of central-peripheral organization is also stressed in this procedure by requiring the patient both to localize the target accurately and to be peripherally aware of the next target prior to movement. A sense of "leading with eyes and brain" is encouraged to obtain efficiency in saccadic and spatial eye movements. The use of a metronome set at 60 beats per minute for each instructional set requires the patient to direct the body in a rhythmic and coordinated manner. Cognitive loading can be accomplished through simple dialogue regarding the patient's history or even math problems aimed at creating a new demand for the procedure.

The first level of the procedure begins with creating an understanding of peripheral awareness to lead the eyes in movement from point to point along the spatial plane. As the center target is fixated upon, an 'awareness' of the 3 o'clock position should be appreciated before a quick, precise saccade is performed. When efficient central-peripheral organization has been consistently observed, the integration of multiple sensory processing is required for accurate and rhythmic eye movements in conjunction with hand movements along the patterned board (Figure 1a). As the level set increases, efficient eye movements combined with homolateral and contralateral hand and foot movements bring an integration of multiple sensory systems (Figure 1b). Appendix A describes various levels of training with the Space Fixator.

Loaded Chart Saccades

Materials: Letter/Number Chart(s), Balance Board, Metronome

The possibilities for variation and loading are extensive in this technique. To incorporate multiple pathways and systems such as the tecto-pulvinar and vestibular, the addition of a balance board, or movement forward and backward, can be used. It is amazing how much additional cognitive attention is necessary to perform saccades and fixations while keeping a consistent walking pace. A metronome can be added to assist in visual-auditory integration and reinforce the need for coordinated and rhythmic movement and speech. To add cognitive load to the procedure, one could direct the patient to change directions of movement (if multiple charts are used) –clockwise & counterclockwise–upon vowels (Figure 2). The patient could also be instructed to keep a running count of numbers in multiples of three, upon vowels, or any letter predetermined. If the charts contain numbers, the patient could be instructed to raise his right hand on even numbers and left hand on odd numbers. While loading the procedure with different cognitive demands, precise, rhythmic saccades are continually emphasized as the patient reads through the charts. The possibility for

Figure 2. Multiple chart saccades displayed for use with clockwise/counterclockwise sequence

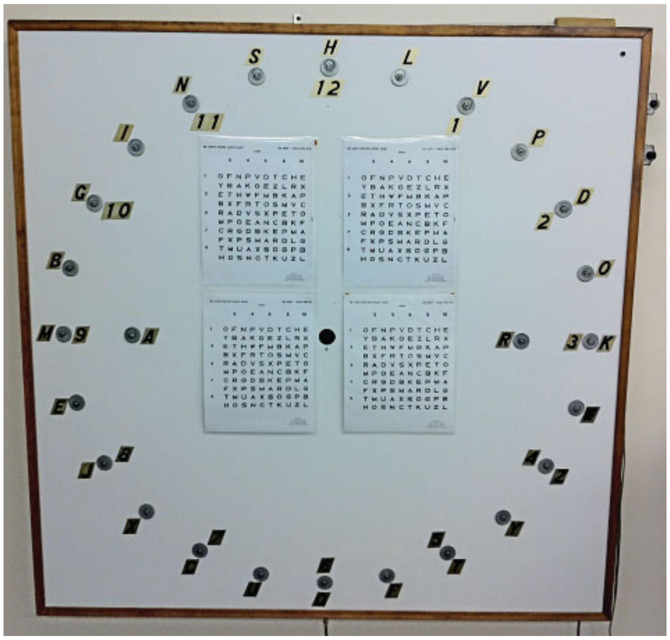


Figure 3. Bal-A-Vis-X performed using two bags displaying accuracy, timing, and visual skills necessary

many variations makes this an effective and engaging activity for the patient.

Bal-A-Vis-X (Balance Auditory Vision eXercises)

Materials: Bal-A-Vis-X set including Information Book and/or DVD set

Sensory integration is at the center of this activity. There are over 300 different exercises listed, each consisting of specially designed ways of integrating the visual, vestibular, and auditory systems for an overall awareness of body movements in space. This is used in occupational therapy settings, and schools, and certainly would be of benefit in vision therapy because of one of its fundamental principles: the eyes are at the forefront in creating smooth movements in space. Each level includes the use of bean bags or racquetballs.

The first level involves two people working together in a self-rhythmic pattern tossing one bag with the right hand, catching it with the left, and clapping the bag over their midline to the right hand before tossing again. Emphasis is placed on the eyes maintaining a steady fixation of the bag throughout the activity. Smooth, accurate pursuits are necessary when tossing and catching, in addition to saccades when the bag is crossed over the midline. The addition of another bag creates a higher demand and requires more accurate timing and synchronizing (Figure 3). The same instructions mentioned above are performed with two bags being tossed simultaneously in the air. The same activities can be done with balls, placing an emphasis on visual space and where to bounce the ball so your partner can easily catch it. The standard pattern is to toss with the right hand and catch with the left, but a direction change of tossing with the left and catching with the right can be used to load. A more advanced level includes the use of three bags or balls and requires efficient central-peripheral organization. The two balls or bags are directed "outside" of the one allowing for an alternate exchange between central attention for the one, and peripheral attention for the two. Because the techniques are very detailed and have specific directives, it is best to refer to the website at http://www.bal-a-vis-x.com/index.htm, where more information on each level set including instructions can be found.

Conclusion

As previously noted, this is merely scratching the surface of what can be done with any vision therapy technique. The possibilities to vary procedures are limitless, and to be able to emphasize elements of procedures for each individual is quite beneficial. To some, the introduction of these procedures may seem unrelated to vision therapy, but that could not be further from the truth. Utilizing balance and movement supports the idea that every human being is a dynamic balancing system and must create and maintain degrees of freedom to balance, first and foremost with gravity. The more efficient and smooth our anti-gravity system, the more efficient our total visual system will be.

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Appendix A.

(Adapted from the work of Robert Sanet, OD)

Level I – Eye Control and Peripheral Awareness

1. Patient stands approximately sixteen inches (40 cm.) away at eye level with one eye occluded.
2. Patient is asked to look at the center fixation target to his left and while using his peripheral vision to locate the 3 o'clock position and then shift his eyes quickly and accurately to that target. The patient is to shift his eyes back and forth between the two fixation targets at five-second intervals with the doctor/therapist observing for over or undershooting.
3. When this step is mastered, the patient repeats all of the above using the 9 o'clock target, and so on until all targets have been completed. The entire sequence is repeated using the other eye.

Level II – Eye-Hand

1. Patient stands approximately sixteen inches (40 cm.) away at eye level with one eye occluded.
2. The following sequence is first demonstrated by the doctor/therapist and then practiced by the patient.
   a) "Look" –patient maintains peripheral awareness of all dots and moves his eyes from the center dot to the 12 o'clock target.
   b) "Ready" – patient maintains fixation and raises right hand to right temple in a "salute."
   c) "Touch" – maintaining fixation, the patient touches the target with the index finger of his right hand, emphasizing an accurate spatial judgment on the "z" axis.
   d) "Back" – patient returns fixation to the center target and right hand returns to the side.
3. Patient continues sequence on all dots in a clockwise pattern. With practice, a metronome set at 60bpm is used and the patient calls out and executes the commands in rhythm with the metronome.
4. Repeat entire sequence using the left hand. Then repeat with left eye, then both eyes.

Level III – Alternate Hands

1. Patient repeats Level II but now alternates hands.

Level IV – Homolateral Hand-Feet

1. Patient repeats all steps in Level II but using a homolateral pattern. When the right hand is used on the "touch" command, the right hand will touch the target and the right foot will step forward touching the toe to the floor; when the left hand is used, the left foot steps forward. On the"back" command, both the hand and foot return to starting position.

Level V – Contralateral Hand-Feet

1. Repeat all steps in Level IV using a contralateral pattern.

Level VI – Change Eye Movement-Homolateral

1. Patient begins in homolateral pattern, alternating hands. When a clicker sounds, the patient completes the sequence for the target he is on, and for the next target changes direction of eye movement (clockwise – counter-clockwise). He will continue with that until the clicker sounds again, at which point he will change eye movement direction again.

Level VII – Change Eye Movement-Contralateral

1. Repeat Level VI using the contralateral pattern.

Level VIII – Change Homolateral-Contralateral

1. Patient proceeds using the homolateral pattern in a clockwise pattern. When the clicker sounds, the patient completes the sequence for the target he is on, and for the next target switches to the contralateral pattern. He will continue with that until the clicker sounds again, at which point he will switch back to the homolateral pattern. The patient does not change direction of eye movement, only the pattern of hand and foot.

Level IX – Change Eye Direction & Homolateral-Contralateral

1. Patient is instructed on how to respond to two different cues:
   a) When the clicker sounds, he is to change the direction of eye movement only.
   b) When the doctor/therapist says "SAME" the patient uses a homolateral pattern, and when the doctor/therapist says "OPPOSITE" the patient switches to contralateral. If "SAME" is said while performing a homolateral pattern or "OPPOSITE" while performing a contralateral pattern, the pattern does not need to a change.

Level X – Peripheral Touch

1. All of the above levels can be practiced using a variation of the "Look-Ready-Touch-Back" sequence. The variation is:
   a) "Locate" – while maintaining fixation on the center target, the patient locates the 12 o'clock target using peripheral awareness.
   b) "Touch" – maintaining fixation on the center target, the patient touches the 12 o'clock target, using peripheral awareness and localization to guide him.
   c) "Look" – patient shifts fixation to target to verify accuracy of touch.
   d) "Back" – arm returns to patient's side and eye returns to center dot.
2. Repeat using eye movement, pattern changes, and verbal cues as described above.