USING A BEHAVIORAL MODEL OF CARE *WITHIN* A LOW VISION REHABILITATION CENTER

■Edward C. Godnig, O.D.

Abstract
Optometrists are increasingly called upon to become team members in rehabilitation clinical settings. The goals of most rehabilitation centers include enhancing a patient's independence and functional agility within society. Vision function plays an integral part in the rehabilitation process. Using Skeffington's behavioral model of vision development and learning, optometrists can develop clinical decision and treatment strategies based upon anti-gravity (locomotion), centering (location), identification (labeling) and speech-auditory (language). This type of model can be effective in developing and coordinating treatment plans within the framework of a rehabilitation team.

Key Words
Skeffington, Four Circles, language, labeling, location, locomotion, low vision rehabilitation, magnification, focal, ambient, communication

A.M. Skeffington, O.D. created a model of vision during the 1940s and '50s that was graphically represented by a four circle Venn diagram to illustrate the holistic, comprehensive nature of vision (see Figure 1).[1] Each circle represents a component in the visual process, and the area of their common intersections represents the total visual process. I propose that this conceptual framework can be used to create a contemporary low vision rehabilitation treatment and training program. This type of rehabilitation care can be defined as a process that enhances the ability of individuals with low vision to maintain independence in activities of daily living by maximizing the use of their residual visual abilities. The most common visual functional conditions adversely affected in this population are; visual acuity degradation, visual field loss, metamorphopsia, ocular motor palsy dysfunction, inadequate binocular fusion, loss of stereopsis, and visual-motor integrative skills.[2] Pathologial conditions most commonly associated with these functional visual losses include age related macular degeneration, advanced glaucoma, diabetic retinopathy, cerebral vascular accidents, traumatic brain injury and retinitis pigmentosa.[3]

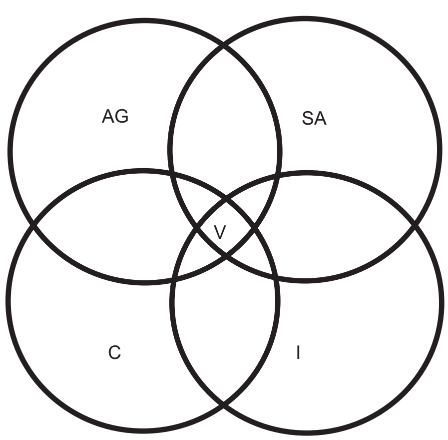

Figure 1. Skeffington Circles.
AG = Antigravity System
C = Centering System
I = Identification System
SA = Speech-Auditory System
V = Vision

Skeffington's four circles

The circle Skeffington termed "anti-gravity" circle, can also be referred to as the LOCOMOTION CIRCLE. This piece of the model answers the question of "where am I?" in space. To begin to answer this somewhat philosophical question, a person must first learn the spatial coordinates of her own body (right, left, up, down directions) in relation to general gross movement patterns in response to the pull of gravity.[4] This learning process follows a developmental hierarchy resulting in the abilities to determine a starting point for judging where other objects are positioned relative to one's self in space. The skills related to the 'ambient' process of vision development dominate this area of vision learning.

Suchoff developed a theoretical construct on how the human organism develops its space world, which elaborates on the Skeffington model.[5] This elaboration hypothesizes that an invariant or zero point be established, followed by bilaterality and self-lateralization (knowledge of self as a two-sided being and knowledge of the difference between the sides respectively). These two physical constructs are a product of child development. Over time, they are projected from self in the interest of the organization and manipulation of the individual's external spatial world. This model of human spatial development further illustrates and supports the visually learned behaviors responsible for developing skills related to Skeffington's locomotion circle.

Skeffington named another circle the "centering," which can be referred to as the LOCATION CIRCLE. This circle is concerned with the set of skills to answer the question "where is it?" in space relative to one's personal perspective and orientation. "It" refers to the object of attention. In order to develop accurate locating skills, individuals draw upon previous visual-motor experiences, as well as other learned experiences of eye position, eye movement feedback from convergence, divergence proprioception and eye-body-mind coordination skills to accurately specify the location of objects in space. The results of highly defined centering skills include accurate oculomotor control, stereopsis, enhanced directional orientation skills and visual spatial memory abilities.

Skeffington's third circle, "identification," can be conceptualized as the LABELING CIRCLE. This set of visual abilities answers the visual question of "what is it?" seeking to determine specific details that require further visual investigation and identification. This area of vision development use the 'focal' set of visual abilities (the central or foveal detail oriented set of visual skills) prerequisite to determining how forms, shapes, colors, sizes, textures and contrast differences combine in the visual recognition of objects. The accommodative system plays an important role in developing the visual recognition ability. Visual perceptual skills, such as visual form perception, visual memory and visualization play important roles in learning to accurately identify and label visual experiences.

More recent neurological research has given specification to the concepts of the ambient and focal visual constructs. There is significant evidence to support the existence of two parallel visual pathways that correspond to the previously discussed 'focal' (labeling) and 'ambient' (locomotion) constructs.[6] Each pathway is selectively sensitive to stimuli that differ in spatial and temporal frequency. The magnocellular pathway (M-pathway), which is related to the ambient or locomotion systems, is more sensitive to large, course visual shapes and forms. It is dominated by peripheral vision, highly sensitive to contrast and a transient response time to visual stimuli. The parvocellular pathway (P-pathway) is related to the focal or labeling systems. It is most sensitive to fine detail (high-spatial frequencies), dominated by central vision, low temporal frequencies, responds while identifying shapes and patterns and responds during and after stimulus presentation. Using the M- and P- pathways as neurological correlates to visual functions of the locomotion circle (M-pathway) and the labeling circle (P-pathway), provides further evidence to better understand the spatial and temporal visual behavioral changes often observed by patients suffering low vision impairments.

The last circle in Skeffington's model is the "speech-auditory" circle, which can be referred to as the LANGUAGE CIRCLE. This segment of the model answers the question of "what do I know about it?" and "what can I tell you about it?" It refers to the object of attention, or what one visually understands. This integrative function is necessary so that humans can share visual experiences and interpretations with others. Integrative language and speech skills, coupled with visual observations, are an integral part of this process of visual learning.

Skeffington's genius was to propose that in order for "VISION" to develop, one needs to combine the development and experiences of all the "Four Circles" such that the sum is much greater than the parts when the components are fully integrated. He realized that this learned process of vision development requires input from all four circles in order to understand how visual abilities are used to efficiently and effectively navigate through our complex world of light and sound stimulation. His model can serve as the basis for designing a low vision rehabilitation model of care.

A LOW VISION REHABILITATION MODEL

Locomotion (anti-gravity)

In the low vision population, many patients have the need to relearn and maximize the visual skills that are related to Skeffington's "anti-gravity" circle. Certain ocular disease conditions, such as advanced glaucoma, retinitis pigmentosa, and cerebral vascular accidents may cause extensive peripheral vision losses, leaving a person with a dramatic inability to move purposely through space. Changes in the ability for people to use their 'ambient' visual system often results in uneasiness in making visual-spatial judgements. Goals of low vision rehabilitation treatment for patients with locomotion instability secondary to peripheral vision loss are to restore a sense of confidence in moving through space accurately and safely.

Some of the optical devices and training protocols employed to promote improved locomotion skills include the use of telescopes and bioptics, orientation and mobility instruction, guide dogs, localization prisms and various visual training activities. For example, Galilean or Keplerian telescopes are used as spotting aids to help patients locate a basic direction or orientation of an object of interest in relation to their own body. Magnifying powers generally range from 2X to 8X, and are designed to stimulate the peripheral retinal cells that provide information regarding spatial orientation of oneself in relation to gravity. Some telescopes and bioptics are designed for a fixed focal length for distance viewing, while others have a variable focus range from infinity to up to a close viewing distance. Some recent telescope designs have an automatic focus control.

A further use of telescopes to improve peripheral vision awareness is to condense or minify visual space such that peripheral awareness can be enhanced using central vision. This can be accomplished by reversing the view through telescopes such that the eye is looking through the objective lens rather than the normal viewing condition of looking through the ocular lens. This reverse viewing condition will result in the minification of objects in visual space, and a relative condensing of peripheral visual space into a more compact size. This method is used only for a select group of individuals who only have central vision function remaining and have lost the use of most of their peripheral vision. This unique application of optics funnels visual images to a central cone of condensed visual space for visual interpretation.

Orientation and mobility instructors are rehabilitation professionals dedicated to teaching new movement and postural skills to the low vision population. These teachers have a dramatic impact on the "anti-gravity" visual skills of a person requiring low vision rehabilitation. Orientation and mobility instructors train low vision patients on various visual scanning and peripheral object detection techniques while moving through space. The use of a white cane or other spatial tracking devices (e.g., GPS device) are aids to help train individuals to use peripheral vision to navigate through space. GPS is an acronym for Global Positioning System and it uses satillite based technology to send signals to a sensor that is able to compute spatial coordinates within a 20-meter accuracy. One such system, GPS-Talk, consists of a specially designed talking user interface, digital maps, a smart GPS antenna and a talking notebook computer.[a] Pedestrians can use this system with a specially designed carrying case.

For patients with hemianopsia, the use of localization prisms are available to help bring spatial awareness from an absent visual field to a functional visual field. The general clinical concept in using localization prisms is that by bending light through a prism in a direction toward functional retina, a person can be trained to periodically fixate through a prism to enhance peripheral visual awareness.

Guide dogs are useful for helping individuals with advanced visual impairment or total blindness learn to navigate through space. The dogs act as visual guides in giving feedback to the person concerning movement strategies of locomoting through gravity dominated space.

In addition to the above mentioned aids, devices and strategies used to help people learn "anti-gravity" locomotion skills, optometric visual training activities can also be adapted for further enhancement of locomotion related visual skills. Rouse and Borsting outlined a sequence of visual training activities based on a hierarchy of visual-motor based development. These increasingly more complex activities can be adapted to meet the demands of the low vision population. The sequence begins by improving the patient's motor memory of the difference between the right and left sides of the body. The training techniques include balance activities, ball bounce, chalkboard activities, and gross eye-hand activities such as bean bag toss. The next goal is to develop the patient's motor planning ability using simultaneous and sequential movement patterns of two sides of the body. The techniques include ball bounce, chalkboard squares, jumping jacks, randolf shuffle and slap tap.[7]

Location (centering)

Within this domain there are other low vision devices and techniques available to train an individual to locate specific areas of visual attention. The LOCATION CIRCLE is often affected by any neurological conditions arising from patholgies of cranial nerves II, III, IV or VI, as well as diseases that affect the retina or other ocular structure that have refractive capabilities. Examples of conditions that have the potential to cause disruption in locating the exact positions of objects in space include cerebral vascular accidents, optic nerve disease, brain tumors and aneurysms, multiple sclerosis, and diabetes.[8] Difficulties in using the extraocular muscles in a smooth and efficient manner may result in faulty feedback information necessary to locate objects in space. Also, any neurologically based dysfunction in organizing and integrating coordination of the eyes-hands-feet-mind skills can greatly impact the ability to locate objects accurately in space. Dysfunctions causing an inability to utilize each retinal receptors 'local sign' (prevalent in retinal disease) cause disruption in localization abilities. The macula area has the local sign of the straight-ahead position when the gaze is straight ahead. Retinal cells on the nasal side of the macula have local signs in the temporal visual field, and all retinal cells on the temporal side of the macula have local signs in the nasal visual field. When macula cells are destroyed, individuals often develop a 'preferred retinal locus,' or another area of the retina (using eccentric fixation) to become the new straight ahead local sign for localizing objects in space.[9]

Examples of low vision devices used to promote improved location skills include microscopes, magnifiers, telescopes, localizing prisms, orientation and mobility instruction and guide dogs.

Low vision microscopes are spectacle-mounted high powered convex lenses. This lens design allows a patient to use the principle of relative distance magnification. Common use of this type of lens allows the patient to bring material closer to eye thus increasing retinal image size. The functional result of increased retinal image size enables the use of peripheral retina to process detail previously available only to central retinal visual processing. Common examples of low vision microscopes include +4, +6, +8, +10, +12 base-in prismatic readers.

Handheld magnifiers are used to increase retinal image size and total magnification by the use convex lenses. Planoconvex or biconvex spherical lenses have ranges of power normally from +4.00D to +14.00D. Aspheric plus lens magnifiers have power ranges from +6.00 D to +40.00 D. These magnifiers are useful in helping low vision patients with central vision loss to establish a new sense of the straight ahead position in space (developing a preferred retinal locus), By developing the ability to discern detail using a retinal location peripheral to the macula area, a new set of directional localization skills may emerge.

Galilean and Keplarian telescopes are commonly prescribed by low vision practitioners to enhance the localization abilities of low vision patients. The recommended order of training a patient to properly use a telescope is localization (finding the object), focusing on object, spotting (using the localization and focusing techniques with proper alignment), visually tracing a stationary object, tracking (following a moving object) and scanning (using a search pattern to locate an object). These learned training techniques enhances the ability to use residual vision enhanced by the magnification of retinal image size made possible by the telescope.

The use of localization prisms and orientation and mobility instruction are also used as potential sources to enhance patients in improving the visual abilities associated with the LOCATION CIRCLE. It is evident from the above that many of the same devices, aids and techniques can be part of treatment strategies in both the LOCOMOTION AND LOCATION components of Skeffington's model. It is the manner and the rationale of the particular rehabilitative intervention that makes it potentially useful in either of these Skeffington circles.

Further enhancement of LOCATION for some low vision patients can be accomplished by techniques designed to re-establish lost or inadequate laterality and directionality abilities. Rouse and Borsting outlined a series of visual training activities that first establish the patient's self-lateralization, by such activities as Simon Says, ball bouncing and following left-right body commands. Once the patient is deemed to have firmly established left-right knowledge of self, techniques focus on projecting the personal left-right concepts into space to enhance directionality. Thus, there are directional mazes and floor maps, where, as the patient traverses them, he calls out the direction of the turn that is necessary. These same concepts are then applied to more cognitively demanding tasks.[7] (p.442-445)

Labeling (identification)

Goals associated with low vision rehabilitation within the third circle, are to find methods of optimizing a patient's ability to accurately and meaningfully understand and interpret visual perceptual attributes such as 'sames and differences,' 'just noticeable differences,' form and shape relationships between objects, and texture and size characteristics of targets of attention. Low vision patients can learn to substitute clear, high contrast visual images with active touch and proprioceptive feedback to form visualization experiences in order to understand and label objects of interest.

Ocular diseases, retinal degenerations, traumas and other visual conditions affecting the use of the central (focal) areas of visual processing impact how well a person is able to identify and derive meaning while viewing a visual image. Conditions such as macular degeneration, multiple sclerosis, and diabetic retinopathy are common examples of ocular conditions that have a direct impact on identifying, labeling and resolving detail and contrast of objects. Accommodation skills are usually disrupted in patients having central vision processing disorders.[8]

Some low vision optical devices used to enhance labeling skills include telescopes, microscopes, magnifiers, electronic magnification systems and large print materials. The principal used to enhance labeling abilities with these devices is that of retinal image magnification, whereby an increased retinal image size is achieved by retinal distance magnification, relative size magnification and/or lens vertex magnification. Increased retinal image size is useful in stimulating peripheral retinal areas that remain functional.

Visual training activities that aid in the learning of improved labeling skills are summarized by Rouse and Borsting. In order to further improve labeling abilities, the low vision patient must be aware of distinctive features of forms, shapes, colors, sizes and orientations of visual objects of interest. The first sequence of abilities within this subset is to improve awareness of similarities or differences among forms using multi-sensory input. Activities used in this training sequence include Parquetry blocks and Winterhaven templates. The next goal is to develop the patient's ability to use only visual cues to find similarities or differences of complex forms. The visual training techniques to enhance this skill include; Geoboard, Parquetry blocks, Sames/Differences and Visual Discrimination.[7] (p. 451)

Language (speech-auditory)

This last of the four circles can be considered, in the context of this article, as the ability of the low vision patient to share their visual experiences with others. The low vision patient must learn to use auditory and speech modes of communication to answer the important questions of 'what do I know about an object of interest?' and 'what can I tell you about it?' If the use of speech is not available for communication, low vision patients may need to learn other means of sharing visual information with others. Sign language, Braille writing, and computer assisted communication devices are other ways to communicate and share visual interpretations with others.

For individuals with functioning auditory and speech capabilities, the integration of vision with these entities becomes paramount to effectively communicate or describe a visual experience. The integration of vision and audition follow an elaborate developmental sequence that is associated with the integration of total sensory input. In this process, eloquently described by Getman, all senses are involved in the exploration of the environment, and initially speech is in the form of babbling sounds. When the hands and eyes are working in unison to dominate the exploration of the environment, vocal noises are integrated with these primary visual experiences. As time goes on, language develops, and accompanying the language process is the highest level of visual development termed visualization (the ability to use one's "mind's eye").[4] (p. 23-31)

Using the developmental model of auditory-vision integration, a low vision practitioner can determine where a person is functioning within this developmental framework, and then design appropriate rehabilitation training exercises to move a person higher along this hierarchy. Examples of activities used to further develop visual based language skills include arranging pictures in proper sequence to tell a story, tap the dots sequence training, and draw a picture and describe the scene.

Examples of devices, aids and technology used to promote improved visually derived communication skills include computer software programs that synthesize speech into text, or text into speech, talking books, sign language techniques and Braille.

SUMMARY

The Skeffington model proposes that vision emerges from the integration of several entities. These include the oriention of the body relative to gravity, the selection of an area of the external environment for visual attention, the ability to derive meaning from this area , and the ability communicate this personal and unique perspective to others. This paradigm can present the low vision practitioner with a framework and plan for rehabilitation.

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Corresponding author:
Edward C. Godnig, O.D.,FCOVD
Director, Low Vision Services
McGreal Sight Center
N.H. Association for the Blind
25 Walker Street
Concord, NH 03301
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