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# Low Vision Rehabilitation

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Additional information is available at the end of the chapter

<http://dx.doi.org/10.5772/58436>

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## 1. Introduction

Low vision rehabilitation has developed along two approaches based on either the education/vocational system or the medical model. In 1999, Massof and Lidoff [1] reviewed the issues in vision rehabilitation from a public policy, service delivery, and funding perspective. They delineate the evolution of services for persons with visual impairment as primarily originating within the education and vocational rehabilitation systems. The end goals from these perspectives would be educational achievement or vocational training and placement. Simultaneously, though, a medical model of low vision rehabilitation also existed within the United States' Veteran's Administration as it historically has provided military veterans comprehensive, in-patient rehabilitation services including visual aids or adaptive devices, instruction in living skills, communication, orientation & mobility (O&M) and more. The objective of the medical model of low vision rehabilitation is to restore function for improved daily living skills. Although the strategies for rehabilitation within the education model and the medical model may be similar, the framework of this chapter is primarily based on principles of the medical model while borrowing valuable insight from the educational model.

Outside of the Veterans Administration but within health care professionals, some version of low vision rehabilitation has developed over the last several decades from a specialty or area of emphasis practiced by a few scattered experts in optometry, ophthalmology, and most recently nursing and occupational therapy. Entry-level skills in low vision rehabilitation have become a required competency for all optometry graduates [2]. It is also a requirement of all U.S. ophthalmology residencies to expose students to low vision rehabilitation.. Even so, low vision rehabilitation remains a field that is difficult to define precisely in that it still faces barriers within reimbursement structures and funding mechanisms [1].

In 2006, some progress in funding models was made as rehabilitation codes were designated by Medicare as applicable to vision rehabilitation. Occupational therapists with their training

in aging and activities of daily living began offering low vision rehabilitation under the order or referral of a physician. Under Medicare definitions, this physician role in most cases is fulfilled by the low vision optometrist or ophthalmologist. Together with occupational therapy, a rehabilitation model similar to physical therapy rehabilitation models has emerged, however, the consensus and uniformity of low vision rehabilitation service provision in the U.S. remains inconsistent. In 2009, Cynthia Owsley [3] performed a large census of non-Veterans Affairs entities that performed low vision rehabilitation in the United States in an effort to describe the characteristics of services, types of providers and profile of patients. The result was the first large scale picture on the state of low vision rehabilitation. Among several findings were that 74.1% of patients had central vision loss with its attendant reading (85.9%) and driving (44.9%) problems. 67.1% were diagnosed with age related macular degeneration (AMD). Notably, the patient complaints were function related. This chapter presents an overview of the low vision rehabilitation field from a functional care perspective with the goal of enhancing the patient's quality of life. The emphasis is on a comprehensive, inclusive and interprofessional approach to the treatment and management of the whole patient related to their visual impairment and their specific functional goals.

## 2. Definitions and model

Every doctor who prescribes minus lenses to allow a myope to see distance objects, or vision therapy to relieve symptoms of convergence insufficiency or cataract surgery to give clearer vision is practicing vision rehabilitation even if not using the term. Indeed, most primary ophthalmic and optometric treatments are designed to restore visual system efficiency and patient functioning, and can surely be considered forms of vision rehabilitation in the broadest sense. Low Vision Rehabilitation, however, emphasizes care for people who have degraded visual function such as visual acuity, visual fields or contrast sensitivity to the point that restoration of previous visual abilities with standard optical corrective techniques like glasses and contact lenses or surgical procedures is no longer possible. The World Health Organization (WHO) provides two definitions for low vision:

1. Low vision is visual acuity less than 6/18 and equal to or better than 3/60 in the better eye with best correction.
2. A person with low vision is one who has impairment of visual functioning even after treatment and/or standard refractive correction, and has a visual acuity of less than 6/18 to light perception, or a visual field less than 10 degrees from the point of fixation, but who uses, or is potentially able to use, vision for the planning and/or execution of a task for which vision is essential.

These definitions are primarily based on measurement of visual abilities rather than the loss of function secondary to the loss of vision. This difference is crucial to the vision rehabilitation of the individual. What is important to one person may be inconsequential to another and treatments based on only visual acuity or visual field may prove unsatisfying for the patient. Therefore, our focus will be on the functional loss of independence when performing critical

and desired activities of daily life (ADL). For our purposes in this chapter we will maintain the World Health Organization definitions and propose an additional definition:

3. Low Vision is a loss of visual function (i.e. Visual acuity, visual fields and/or contrast sensitivity) caused by an organic or non-organic mechanism resulting in a loss of functional ability and quality of life

Our emphasis in this chapter will be on people who developed as fully sighted then suffered an event or series of events that negatively impacted their visual systems. While it is true that infants with Retinopathy of Prematurity, inborn errors in metabolism, trauma, or other sight affecting conditions can be, and are, considered in the low vision field, and the principles in this chapter are applicable to them, the core view for this chapter will include rehabilitation approaches for those who have acquired vision loss in adulthood, rather than on congenital vision loss. With most visual impairment caused by conditions related to aging or present in aging adults, acquired vision loss in older adults presents the most challenge and burden from a social and economic perspective [4].

Low vision rehabilitation is presented as a three-part paradigm to provide a framework for the physician's evaluation and guided rehabilitation process within the medical model to the linking of services available outside of that model but within the valuable educational and vocational system.

Vision Rehabilitation secondary to our above definition is approached herein as a three part paradigm:

1. *Cause* Visual abilities loss and their measures
2. *Effect* How a person functions given their visual status
3. *Impact* How vision loss impacts quality of life (QOL) and the amelioration of Impact

*Cause* refers to the loss of visual ability in the key areas of visual acuity, visual fields and contrast sensitivity and how such losses operate to interfere with optimal eye and vision system performance.

Whereas *Cause* implies a vision dysfunction, *Effect* is related to the level of functional visual ability and performance independence given the associated *Cause*. *Effect* is addressed with standard health history questioning, symptom survey measures of functional independence and observational evaluation of the patient performing a task or series of tasks.

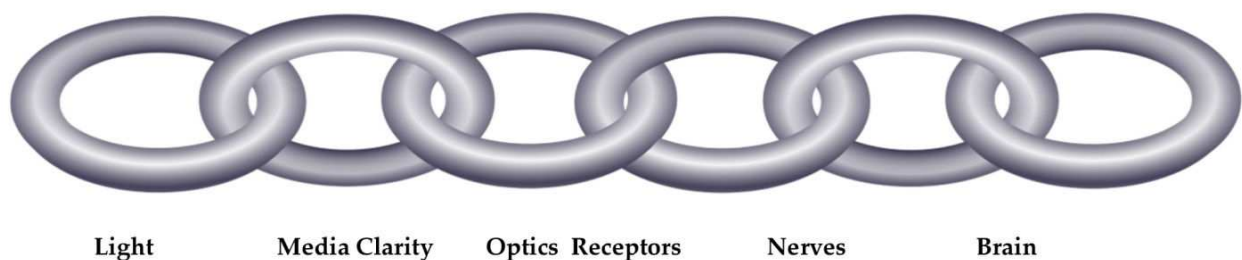
Lastly but quite important, we consider *Impact*, or how the loss of visual function contributes to the degradation of the person's quality of life. This is viewed from a patient reported, subjective evaluation of life status but it is addressed through referral and partnership with a number of providers that may be within or outside the medical system. Whereas the first two, *Cause* and *Effect*, can be addressed within the evaluation process of physician and therapist, the concept of *Impact* can be addressed in a broad fashion with appropriate referrals and education about resources. *Cause*, *Effect* and *Impact*, will be considered herein as overlapping and interconnected in order to effectively practice comprehensive, inclusive and interprofessional low vision rehabilitation.

It should be noted that health care has become increasingly divided into specialties in spite of a number of initiatives to integrate care across and among various disciplines. The sheer volume of knowledge necessary to become expert in just the various specialties of the eye and visual system, let alone the whole human body, strongly mitigate against the interprofessional efforts of universities, governments and non-government groups. As each provider's specific view of the patient becomes more and more limited to the aspect unique of their specialty, the overall view of the wellbeing of the patient can become more at risk of being diminished or lost. While the results of specialty treatments are separately efficacious to the parts they address, there is a danger in viewing the patient as an assemblage of parts. Many patients with low vision report hearing, "nothing more can be done" from the authority they trust when the authority means "I cannot do any more". The critical missing part of the conversation is: "but there may be someone who can." [5]

### 3. Chain of vision

One approach to moderating this potential point of patient vulnerability is by addressing it early in the exam process with the analogy that vision is like a chain. Each link in the chain is necessary for full visual functioning but none is sufficient alone. Therefore, repairing a single link does not make one see if there is more than one issue, but rather removes one barrier to vision. All link weaknesses must be ameliorated and all links must be whole for the chain of vision to be strong.

<b>Chain Link One:</b>	Light
<b>Chain Link Two :</b>	Clarity of Ocular Media
<b>Chain Link Three:</b>	Optical Focus
<b>Chain Link Four:</b>	Receptor Elements
<b>Chain Link Five:</b>	Optic nerve and Pathways
<b>Chain Link Six:</b>	Neural processing and brain associations



**Figure 1.** Chain of Vision

The first link is a sufficient amount of **light** to illuminate the object of regard and mitigation of glare.

The second link is **clear media** which can be compromised by cloudy corneas or lenses.

Third is the sharp **optical focus** of the image. This link is the only one impacted by glasses, contact lenses or refractive surgery.

Fourth are the **receptor elements** of the eye, or the retina which takes the “picture”. Age related macular degeneration and diabetic retinopathy are primary diseases affecting this chain link.

Fifth we have transmission to the brain via the **optic nerve** and related pathways which can be compromised by atrophies, vascular accidents and trauma.

The sixth link is in the **brain** where **neural processing** takes place and associations occur. Stroke, aneurysms and accidents interfere with the chain of vision in this link.

While the Chain of Vision analogy sounds simplistic at first glance, it has proven memorable to patients who commonly believe it requires only glasses or surgery to make them see. Taking a few moments to introduce this model of Chain of Vision can yield multiple benefits downstream. Once the patient realizes all the links must work to see and once the specialist acts on the reality that their specialized treatment for one link is necessary but potentially insufficient for restoration of visual ability, we can work toward improving the patient’s quality of life using the tools and techniques of the Low Vision Rehabilitation field.

Caution:

When considering the *Cause* of loss of vision ability, it is important to remember that the patient is not to be equated with their condition [6]. Regrettably, language frequently betrays a, perhaps unintended though nevertheless real, diminishment of our patients into a single category of disease through our labels. The adjective becomes the noun and the person becomes the condition. It is easy to think of a person as a “diabetic” or “albino” or “strabismic” but in so labeling them, we belittle, in a real way, the totality of the individual in our substitution of their wholeness into a single attribute. A person with diabetes or a person with albinism or a person with strabismus is first and foremost a person. A whole, complete person who has all the hopes, traits, abilities, talents, relationships and fears comparable to any other person. This clarity of differentiation is not trivial for many of our patients as it is language that shapes perception of reality and influences attitudes that direct care and treatment.

#### 4. Cause

As *Cause* refers to the etiology and assessment of vision loss, the measure of that dysfunction on the patient’s function will guide the low vision rehabilitation practitioner’s approach to understanding the *Effect* and to ameliorate the *Impact* on the patient’s quality of life. Although there are many visual capacities explored in a comprehensive low vision rehabilitation exam, this chapter will highlight the three key measurable attributes of (1) visual acuity, (2) visual fields and (3) contrast sensitivity. Visual acuity (VA), or sharpness of vision, is the primary vision attribute measured in assessing visual ability as it directly affects reading and driving. Visual fields and contrast sensitivity are reviewed later in this chapter as they have been demonstrated to correlate with particular patient complaints and functioning such as reading ability, facial recognition, mobility and fall risk.

The two most common causes of low vision in the U.S. are age related macular degeneration and diabetic retinopathy affect all three of the above visual functions [7-9]. Most commonly found in people over age 65, age related macular degeneration primarily disrupts visual acuity and central visual fields. The leading cause of vision loss for those under age 65 is diabetic retinopathy which similarly yields reduced visual acuity but generally with greater contrast sensitivity loss and varying amounts of visual field loss. Though visual acuity is typically easy to measure, the standard in-office charts have been designed for the fully sighted person and the design assumptions underlying them can lead to invalid outcomes when used to measure visual acuity in people with low vision.

#### 4.1. Cause — Visual acuity

There are several types of visual acuity. Therefore, it might be more appropriate to speak of “the visual acuities” rather than just the singular “visual acuity” and review them sequentially to develop a common foundation that provides us good confidence in the validity of our clinical results. Measurements in one category do not necessarily correlate with those of another. Indeed, as there can be significant variances between and among the categories, it is important to identify the type of acuity one is assessing and not compare across psychometric boundaries. We will then examine these systems used to measure and record VA and investigate how the proper documentation can generate useful extrapolations regarding patient performance and treatment choices.

The first type of VA is **Detection Acuity**. This is the “ah-ha” acuity often expressed by subjects with the expression, “look, something is there!” Detection acuity is useful for safe ambulation, scanning for new information sources in the environment, and defense against approaching dangers. It is not, however, much use in the gathering of form details such as reading, driving or facial recognition.

The second category of VA on our list is **Resolution Acuity**, or the ability to differentiate (resolve) a gap or change in an object or image. This allows an observer to tell a letter “C” from an “O” and forms the basis for the Landolt C acuity charts. The patient is to tell which direction the opening is pointing. Multiple presentations of the Landolt C in various orientations quickly yield a high level of confidence in the final result if the patient gets them all correct. Resolution is useful when an observer knows something is there (detection) but cannot recognize any elements. Extracting some details from the image can generate knowledge of space, distance and, in unfamiliar areas, safety. Resolution acuity does not, however, allow the observer to gather detailed or coded (e.g. alphabet) information.

**Vernier Acuity** is generally of more interest to vision scientists than to the clinician. Still, it has found utility in geographic areas where it is important to triage patients with severe cataracts when there are not enough ophthalmic surgeons to meet the need. Screening with vernier acuity can help determine who has macular function sufficient to benefit from cataract removal.

**Recognition Acuity** is the standard of most distance visual acuity test charts. Being able to not only know something is there (detection) and that there are gaps or a space in the image

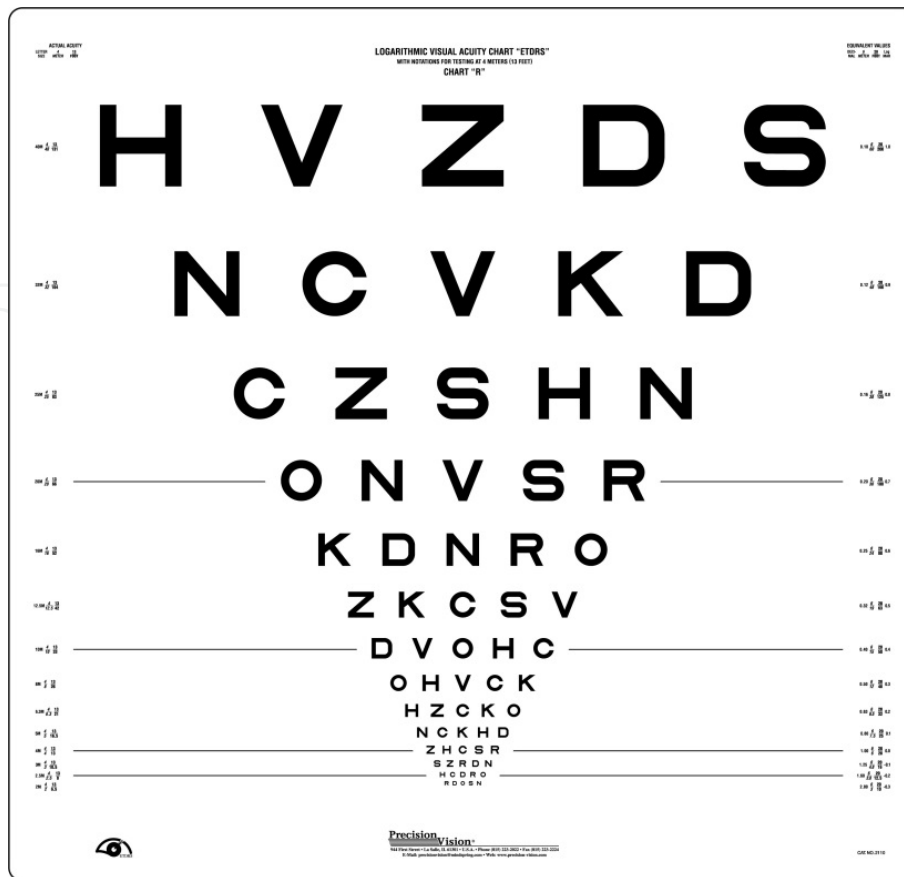


**Figure 2.** Landolt C Resolution Acuity Chart

(resolution), but to identify it with visual cues is the key to reading printed materials and language. This is the core issue for people with the central vision impairment caused by age related macular degeneration or diabetic retinopathy. Poor recognition acuity is the primary motivator for people with macular issues to present for a low vision rehabilitation evaluation. Inability to recognize faces and difficulty reading disempowers the individual leading to dependencies in the demands of modern daily life and, too frequently, less than optimal quality of life. The concept of recognition acuity, unfortunately, is so comfortably familiar to clinicians that its real meaning can become muddled when it is inappropriately used. Therefore, we need a psychometric standard for our results to have useful meaning in low vision rehabilitation.

The first chart incorporating the most significant psychometric principles was the Bailey-Lovie chart, first introduced in the late 1970s [10]. It was developed to address all the significant factors in the measurement of recognition acuity including equivalent readability of the letters, stroke height of letters, equal contour interaction both within and between rows of letters,





**Figure 3.** Recognition Acuity Chart ETDRS

equal numbers of single letters per row and logarithmic progression of test task within and between rows. This last aspect takes advantage of Weber's Law and yields valuable predictive power in choosing lenses, working distance, magnification and telescopes for patients' needs. In the early 1980s, the Early Treatment of Diabetic Retinopathy Study (ETDRS) test chart was developed, largely from the Bailey-Lovie design and has been the standard for Recognition visual acuity ever since. The standardizing of test task equivalence yielded by both these charts gives a high level of confidence in the validity and repeatability of measurements, allowing more accurate and consistent collection of data and a solid basis for comparison of past and future visual performance when tracking the course of the patient's condition and the success or lack thereof in treatment.

Recording recognition visual acuity is optimally done with the Snellen fraction, writing the numerator as the test distance, preferably in the logarithmic progression of distances and letter size read at threshold as the denominator, also in the logarithmic sequence of Just-Noticeable-Differences (JND) (both discussed more fully in the *Cause-LogMAR* section below) while always keeping the units in the same system (English or Metric). When visual acuity is always and only recorded as a fraction with actual test distance over actual letter size measured, all the pertinent visual acuity information is captured and available for use by the clinician.

Refraction is an aspect of visual acuity that requires addressing even if it is too large a topic to explore completely in our chapter context. The phoropter is the instrument developed for refraction of fully sighted patients and serves that purpose very well. It uses small steps of dioptric power to determine the patient's ametropia because the Just-Noticeable-Difference of fully sighted patients is roughly only a quarter of a diopter (0.25D) as found in the phoropter. Partially sighted patients, however, have variable Just-Noticeable-Differences depending on their level of acuity or sensitivity and therefore need an approach based on differential lens steps to accommodate the presenting Just-Noticeable-Difference. This is achieved by the use of a trial frame and trial lens set with techniques adapted to the sensitivity of the partially sighted patient. The whole range of visual acuities and Just-Noticeable-Difference variances can be addressed using the principles of LogMAR progression steps of significance.



**Figure 4.** Trial Lens Set with Trial Frame and hand held Jackson Flip Cross Lenses

#### 4.2. Cause — LogMAR

**Weber's Law** – The change in stimulus which is necessary to evoke a just-noticeable-difference (JND) in sensation bears a constant ratio to the original stimulus from which it was derived.

This broad law of human stimulus perception is deceptively simple in its presentation yet potentially powerful for predicting patient performance with induced changes in stimulus. While Weber's law is not immutable, especially with stimuli at the extremes of the spectrum,

it does provide guidance with stimuli changes that are manifest in the activities of daily life. When considering formed image stimuli measurable by recognition acuity charts, the constant ratio, or logarithmic progression, of Just-Noticeable-Differences is remarkably consistent and reliable over the range of standard measures. Given this characteristic of Just-Noticeable-Differences being a constant ratio, and charts designed with the principles of psychometric integrity and test task equivalence, we have the foundation for using acuity measurements to predict visual performance when we introduce reading lens changes, working distance adjustments or telescopic power variations to the patient, other factors being equal. All that is missing for us to lever the potential power of Weber's Law in predicting patient performance is a starting "original stimulus." Fortunately, we have Robert Hooke, sometimes known as "England's DaVinci." We can thank him for developing an employment test aimed at potential astronomy assistants. Hooke had the assistant candidates count the stars in the Big Dipper. Since one "star" is really two stars (Alcor and Mizar) separated visually by approximately one minute of arc, he declared those that passed had good vision and the stage was set for one minute of arc to be the standard of visual acuity. However apocryphal the story might be, we have our "original stimulus" or minimum angle of resolution (MAR) from which to begin our logarithmic progression for charts, working distances, dioptric lens powers and telescopic magnification: one minute of arc.

Work in the late nineteenth century demonstrated the constant ratio for detecting visual change as  $0.1 \log_{10}$  units. From our starting point of a minimum angle of resolution of one minute of arc, and a Weber's Law constant of  $0.1 \log$  units we can build a table of significance for visual acuity:

LogMAR	MAR (')	VA (English)	VA (Metric)
0.0	1.0	20/20	6/6
0.1	1.25	20/25	6/8
0.2	1.6	20/32	6/10
0.3	2.0	20/40	6/12.5
0.4	2.5	20/50	6/16
0.5	3.2	20/63	6/20
0.6	4.0	20/80	6/25
0.7	5.0	20/100	6/32
0.8	6.3	20/125	6/40
0.9	8.0	20/160	6/50
1.0	10.0	20/200	6/60

**Table 1.** MAR, LogMAR and Visual Acuity

This chart design enables thinking of the steps between the lines as “steps of significance”. These steps can be Diopters (D), working distance, letter size when working at near, or telescopic magnification for distance. At near, a change in one step for diopters necessitates a change in one step of distance, resulting (all other variables being equal) of one step in letter size. As diopters add increases by a step, working distance decreases by a step as does letter size. In the above table, the MAR column can be thought of as the “Steps” column.

Steps	Diopters Add (D)	Working Distance (cm)	Letter Size (M)
Start	2.50	40	2.0
1	3.25	32	1.6
2	4.00	25	1.25
3	5.00	20	1.0
4	6.25	16	0.8
5	8.00	12.5	0.63
6	10.00	10	0.5

**Table 2.** LogMAR Reading Example

When working with telescopic powers, one always begins with best distance refraction and working distance is always infinity. Since the eye by definition has a magnification at distance of “1”, all step changes start from there.

Steps	Telescope Power	Acuity
Start	1.0	20/200
1	1.25	20/160
2	1.6	20/125
3	2.0	20/100
4	2.5	20/80
5	3.25	20/63
6	4.0	20/50
7	5.0	20/40
8	6.3	20/32
9	8.0	20/25

**Table 3.** LogMAR telescope example

One can see the utility in charts built with LogMAR, but before using these steps of significance for treatment choices in the *Impact* section, it is important to examine near visual acuity and reading ability.

### 4.3. Cause – Reading

Near visual acuity and reading ability are different tasks yet sometimes conflated inappropriately thereby becoming a source of frustration for the doctor and patient when expectations of reading ability in the patient's life and near acuity measures from the doctor's office do not align.

Charts properly designed for near visual acuity give results strongly correlated with distance acuity. The rules of building significance for distance ETDRS charts apply for the near charts allowing maximum degrees of freedom in choosing working distance, add powers and magnification. Image 5 shows a single digit near visual acuity chart with a 40cm string that can be used to control working distance. The string can also be folded in half for a 20cm working distance but any distance on the LogMAR scale can reasonably be used.

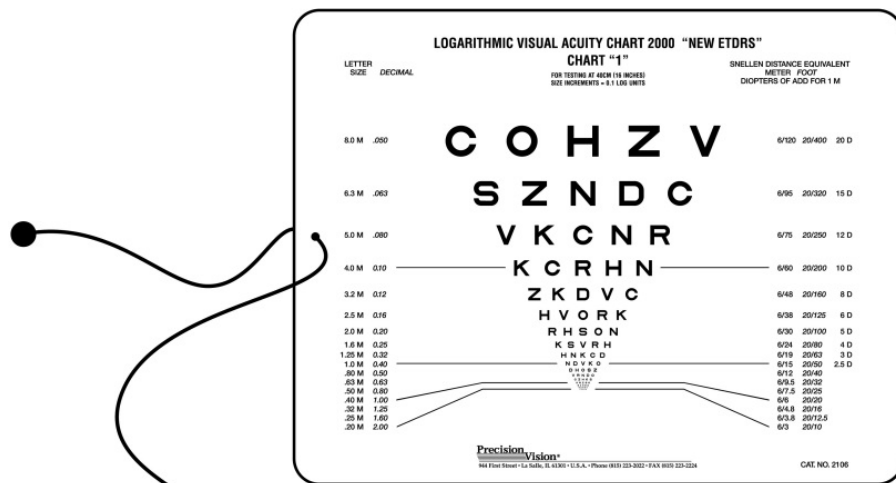


Figure 5. Single Digit near chart

Near Visual Acuity has four common systems of recording, only one of which has the psychometric integrity necessary for our purposes. (1) Reduced Snellen does not capture either letter size or working distance. (2) Point system (n-units) captures image size but not working distance in a useable format. (3) Jaeger or "J" size is not standardized among chart manufacturers and does not record working distance in a meaningful way. Only (4) M-Units recorded as a Snellen fraction of distance in meters over M size provides information in a fashion which can be used in calculating dioptric lens powers and working distances for low vision rehabilitation work.

Example of Recorded M-Unit acuity: 0.4/1.0M means at 40 cm, the patient was able to recognize a 1.0M letter

Once the near single digit visual acuity is determined and recorded in M-Unit fashion, variations in working distance and dioptric lens power can be manipulated to meet patient acuity goals using LogMAR principles discussed previously.

Reading for information, however, is a complex activity of which near Visual Acuity is only one part. Therefore, a reading task requires a more complete description than just acuity. One method that accounts for reading's complexity is the MN Read cards system which incorporates three factors affecting reading performance: (1) Reading Acuity, (2) Maximum Reading Speed and (3) Critical Print Size.



**Figure 6.** MN Read Near Card

Reading acuity (1) is the smallest resolvable print size, similar to near visual acuity. Maximum Reading Speed (2) is the top rate at which a patient can read contextual words for information. Critical Print Size (3) is the smallest print size that the patient can read at maximum reading speed. Combining these three reading components allows a more thorough understanding of

reading in patients with low vision. Additionally, it demonstrates to the patient how their reading is affected by the three factors and that it can be improved with changes in add, working distance and letter size.

A reading test developed primarily for the patient with the central field defects (scotomas) that are commonly found in age related macular degeneration is the Smith-Kettlewell Reading test (SK Read) by Don Fletcher. The test is different from the MN read as it uses words that when combined into a block of a particular size print, the block contains no contextual meaning. This means that reading errors caused by central field defects or scotomas and the corresponding preferred retinal locus (PRL) will be apparent as the patient cannot use context to guess words. Both the reading speed and number of errors are recorded which results in a reading error rate per block of text. The test instructions provide guidance for interpreting the locations of the errors as related to the location of the patient's scotoma relative to fixation. The test can also be used to educate the patient on the impact of central scotomas on reading so that when both magnification and fixation training are included in the final rehabilitation plan, the patient is aware of the complexities of their reading facility and the rehabilitation process.

#### **4.4. Cause — Visual field**

The low vision rehabilitation domain has traditionally divided visual field impairments into the two general areas of central fields and peripheral fields. The type of loss in either area affects patient function in different ways. Peripheral field losses such as overall constriction and hemianopsias can affect mobility and activities of daily life but are a small percentage of total scotomas compared to acquired central field loss as found in age related macular degeneration. Therefore, the emphasis in low vision rehabilitation is properly on central and paracentral loss.

Although it has been well understood that scotomas or visual field defects occur in the progression of many visually debilitating conditions, the understanding of how to best measure the central and paracentral scotoma and relate that measurement to patient visual abilities and low rehabilitation strategies is a newer concept. Traditionally, a central automated visual field or an Amsler grid was considered the test of choice for evaluating the central visual field but both of these tests are problematic when applied to rehabilitation of a patient.

As early as 1987, Timberlake, Peli, and Augliere [12] used a Scanning LASER Ophthalmoscope (SLO) and derived the term preferred retinal locus (PRL) to describe a "single, idiosyncratic retinal area, immediately adjacent to the scotoma, for fixating, inspecting acuity targets, and scanning simple, nonsense-syllable text". They also determined the preferred retinal locus may not be the ideal location for reading text nor was it always situated as close to the fovea as possible. In 1999, Schuchard, Naseer and de Castro determined both that the location of the preferred retinal locus affects visual performance of the patient and the location may shift over the progression of the disease—true especially of patients with a ring scotoma [13]. Additional studies have suggested that the development of a preferred retinal locus occurs within 6 months of visual loss and that multiple fixation locations can be used depending on the visual task.

There are varying opinions about how the location of the scotoma relative to the preferred retinal locus impact reading rates and about how to best train patients to use their preferred retinal locus or to even use a new better positioned trained retinal locus (TRL). For example, Deruaz (2006) [14] asserted that reading requires two conditions (1) detailed discrimination and (2) global viewing (i.e. seeing the whole length or words). A natural preferred retinal locus may only provide detailed discrimination but might be in a location that prevents the second important reading criteria, global viewing (2006). Nilsson (2003) [15] and Deruaz (2006) have successfully selected a new location for the patient, a trained retinal locus (TRL), typically above or below the scotoma for hopes of improving function. Although they achieved short term success in the use of a trained retinal locus or a combination of preferred retinal locus and trained retinal locus for reading, it is unclear how the patient may utilize the trained retinal locus alone or in combination with their preferred retinal locus for activities of daily life in the long term or for improved vision related quality of life (VRQOL).

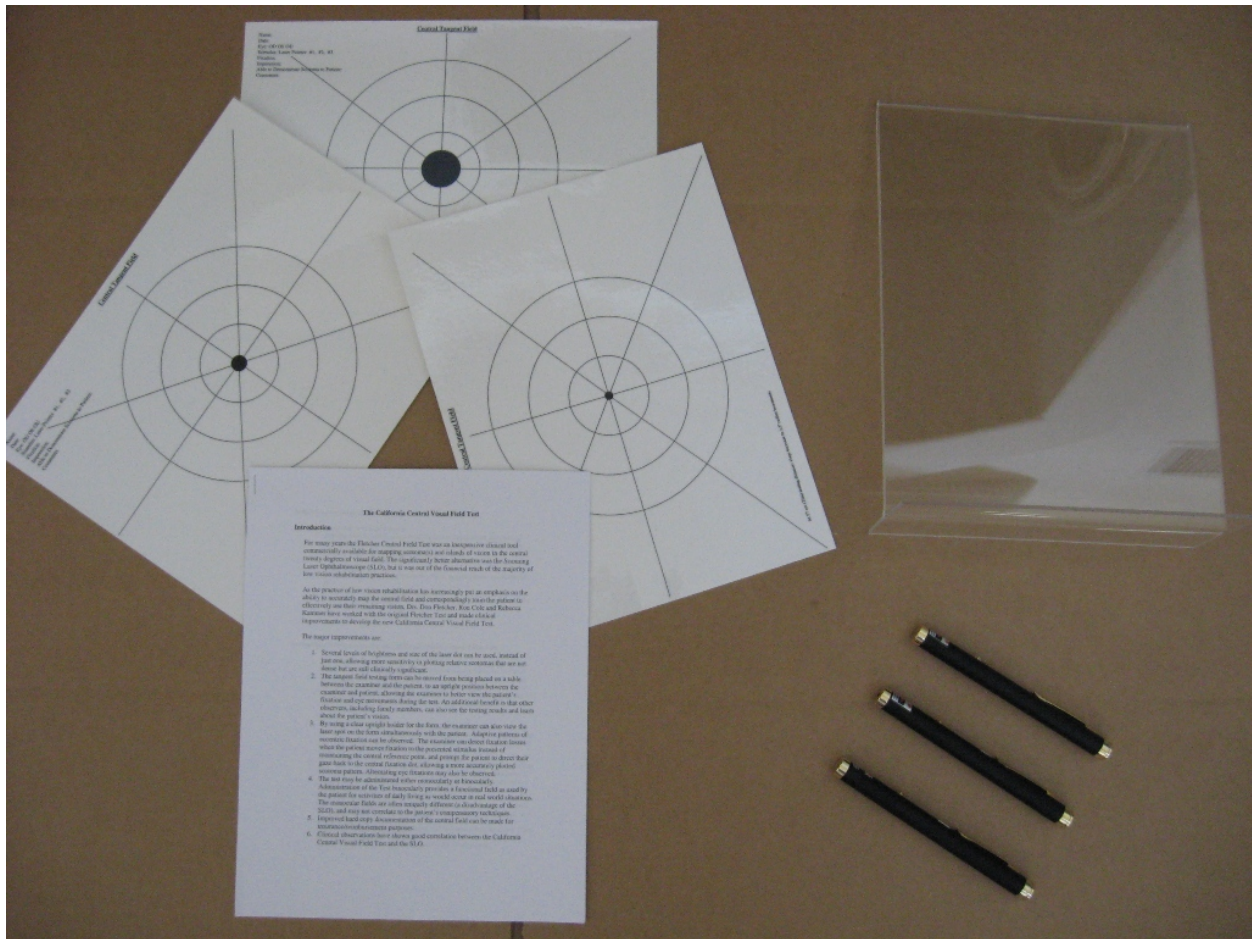
Another rehabilitation approach, training with the existing preferred retinal locus for fixation stability, has been demonstrated to successfully improve reading speed. Most recent literature on scotomas and function support the use of strategies aimed at improving fixation stability with the natural preferred retinal locus strategies [16, 17].

Many clinicians, instead of using any type of perimetry with age related macular degeneration patients, employ techniques such as asking the patient to identify parts of the doctor's face that may be missing or numbers on a clock face that may be absent or difficult to view. These techniques suffer from subjectivity and poor quantification. The patient is an unreliable source to describe the presence of binocular scotomas and the "missing areas" that result. Fletcher found that out of 153 patients with age related macular degeneration who were asked if they were able to see or notice their blind spots, 56% were totally unaware of their presence, and of those patients who did notice something missing they were only able to vaguely describe how objects disappeared. Microperimetry and determination of the patients most commonly used preferred retinal locus is invaluable for modern rehabilitation methods that incorporate training strategies teaching steady eye fixation. [18]

According to Markowitz (2013), the three parameters of macular function that should be assessed during a low vision rehabilitation evaluation are (1) scotoma characteristics, (2) preferred retinal loci and (3) oculomotor control [19]. This can be done through the use of microperimeter or scanning LASER ophthalmoscope to view the fundus while simultaneous projecting viewing targets directly on areas of the retina. Although microperimetry is used extensively in research settings and in a few comprehensive low vision clinics, the cost and time to perform such testing limits their current use in low vision rehabilitation clinics. Until more widespread adoption of microperimetry in low vision clinics occurs, less expensive and time intensive strategies have been recommended such tests as the California Central Visual Field Test (CCVFT) by Fletcher, Cole, and Kammer [20]. The California Central Visual Field Test utilizes three different modified LASER pointers with varying output and beam diameters as visual stimulation. The fixation target is in the center of series of rings printed on letter size paper. The test is positioned at a near distance that allows for simple determination of size of the scotoma in degrees with simultaneous recording of scotoma boundaries directly on the



test. The test is similar to a tangent screen in the utilization of both static and kinetic target presentations and does require the clinician to simultaneously observe both the patient's fixation and record the boundaries of the scotoma.



**Figure 7.** California Central Visual Field Test (CCVFT)

#### 4.5. Cause — Contrast sensitivity

Contrast Sensitivity Function is the third important attribute of visual ability quantified in a low vision rehabilitation exam. The term “Contrast” refers to the difference between the highest and lowest brightness levels of a target. A person’s ability to detect the minimum difference in contrast for a particular size image is designated “Contrast Sensitivity” and the plot of Contrast Sensitivity to object (letter) size is called the “Contrast Sensitivity Function”. Contrast Sensitivity is affected primarily by optics, retinal function and neural processing. Since the most common conditions that cause visual impairment are age related macular degeneration and diabetic retinopathy, poor retinal function is the predominant cause of contrast sensitivity loss in this population.

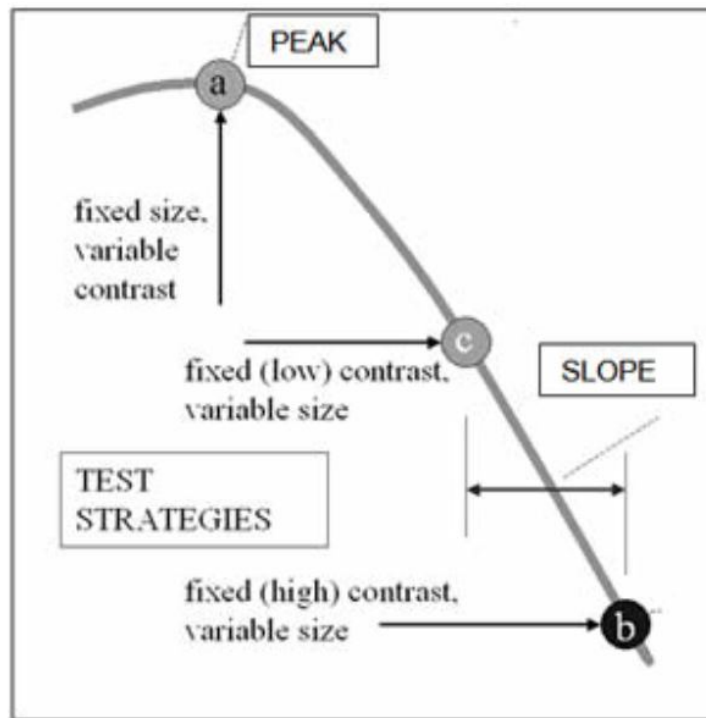


Figure 8. Contrast Sensitivity Curve

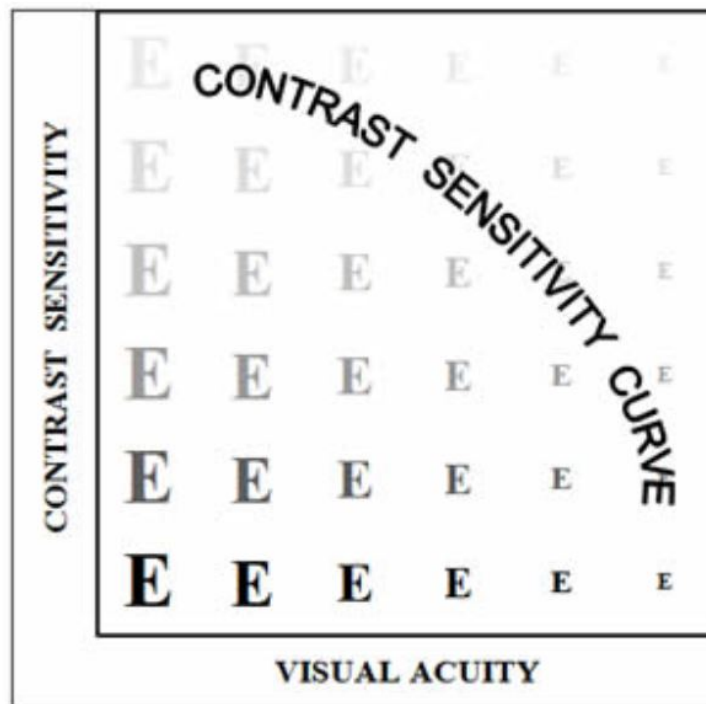


Figure 9. Contrast Sensitivity Curve Illustration

Threshold visual acuity is actually measured on a CSF graph being, in essence, the single point farthest to the right.

Reasonably, therefore, Contrast Sensitivity Function has not been shown to add any prescriptive value beyond standard visual acuity in measures of reading function when using high contrast materials. Activities of daily living such as walking, cooking, and grooming, however, often consist of visual cues with less than optimum contrast that present as various sizes and can cause functional visual difficulties for patients with low vision. In particular, mobility speed and safety are correlated with Contrast Sensitivity Function [21].

In examining the CSF, where visual acuity is along the X-axis and contrast sensitivity along the Y-axis, we find the peak contrast sensitivity for fully sighted people at mid-sized objects. As objects get smaller or larger, contrast sensitivity performance drops off. The CSF curve deviates differentially when retinal function is negatively affected by a condition or disease. Typical contrast measurements might be obtained with high contrast, small letter objects even while the ability to detect larger, lower contrast objects declines. This would be manifest by the ability to read standard vision charts well but subjective patient reports of significant issues in mobility such as not being able to see a curb or step. Functionally, this can lead to increased fall risk. When only considering visual acuity, these functional complaints seem to be out of proportion to the measured acuity, and indeed they are. Only when Contrast Sensitivity Function is considered are the subjective complaints accounted for.

There are several tests to evaluate CSF including sine wave gratings of variable contrast and size, Pelli-Robson or MARS letter triplets of varying contrast, and ETDRS or Text charts at distance or near with varying levels of contrast between presented charts. Each test has its own scoring which makes cross test extrapolation less than satisfactory, but each type of testing yields results that characterize patient complaints unaccounted for by acuity and visual field tests. Loss of Contrast in the higher spatial frequencies (small letters) usually signifies threshold visual acuity loss, while Contrast loss in lower spatial frequencies (large letters) could indicate poor ability to detect large, low contrast items in a path and lead to increased trip hazard and fall risk. Since visual acuity can be a good predictor of higher spatial frequency losses, particular attention regarding CSF should be paid to loss of contrast in lower spatial frequencies. In the past, contrast sensitivity testing was often left to the vision researchers and less commonly addressed in clinical vision examinations. This could be due to the complexity and the time required to complete and interpret testing. New types of charts that enable a quick screening of CSF loss such as the Mixed Contrast Chart by Gus Colenbrander [22] could be used to identify significant defects as well as educate patients and caregivers about the impact of loss.

Losses in the lower spatial frequencies are not generally improved by optical devices, but the attendant functional losses can be ameliorated with techniques and training by qualified professionals such as Orientation and Mobility (O&M) instructors and Occupational Therapists (OT).

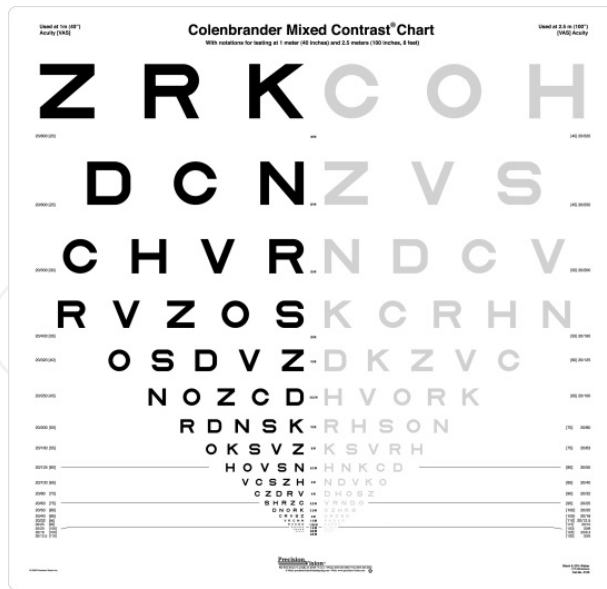


Figure 10. Colenbrander Mixed Contrast Chart



Figure 11. ETDRS Two Contrast Charts

#### 4.6. Cause – Lighting

Lighting is more problematic to quantify than visual acuity, visual fields and contrast sensitivity function, and although it is not a measure of visual dysfunction directly, understanding how it may change the assessment of the other deficits is important. Lighting or illumination is a potentially key factor in ameliorating the *Effect* of the visual condition on function and its *Impact* on quality of life. For patients with significant contrast sensitivity loss, illumination can improve function and effectively decrease the amount of magnification needed to achieve the patients reading goals [23]. In addition, Schuchard and Lei discovered that in patients with relative central scotomas, some patients use different preferred retinal loci locations in high illumination settings for different visual and reading tasks [24]. Compounding contrast sensitivity loss with central scotomas can result in reading impairment to a much greater degree than would predicted by single optotype acuity testing under optimum office conditions. Therefore, evaluating the patient's response to lighting during the low vision rehabilitation exam process is necessary if both contrast sensitivity and the central visual field have been found to be compromised during standard testing of visual acuity, visual field and contrast sensitivity testing.

#### 4.7. Effect – Functional sequelae of cause

Once the *Cause* of the vision deficit is determined and the visual acuity, visual fields and contrast sensitivity parameters measured, it is important to define how the visual deficit affects the patient's function regarding activities of daily life. This is done initially with the standard vision exam history. In a primary care exam, the standard measures of Chief Complaint, Review of Systems (ROS) and Past, Family & Social History (PFSH) are generally adequate. For the patient with low vision, however, these three standard history categories are often insufficient. Vision loss can affect the patient in such a way that they adapt by avoiding an activity and may not even recognize they can no longer perform it or that they even want to. Once accommodation is made, the specific loss of function may not be elicited in a Chief Complaint, Review of Systems, Past Family and Social History profile of questioning. Therefore, in a low vision rehabilitation history it is important to probe in a more comprehensive and systematic manner. Symptom surveys of independence and third party observations of activities of daily living can provide a more complete picture of the *Effect* and give us guidance for effective low vision rehabilitation treatment.

#### 4.8. Effect – Directed symptom survey

Vision specific questions alone do not always address the totality of *Effect* on activities of daily living for the person with a vision loss. A more complete system needs to be utilized for evaluating the patient's level of ability and independence. The Functional Independence Measures (FIM) structure meets these requirements [25, 26]. FIM separately evaluates thirteen tasks on a seven point scale of Independence – Dependence. It is a useful tool to ascertain where a patient is having difficulty performing common activities of daily living, identify those activities a patient has given up on or is avoiding, and to direct the rehabilitation team's ongoing efforts. Functional independence measures can also be used to monitor progress of

the patient's treatment regimen and evaluate care goals. While functional independence measure scaling is necessarily subjective, it is rubric driven around specified criteria to improve validity. Limiting the number of questions and the number of associated scaled responses to each question allows us to glean valuable information regarding activities of daily life objectives in a short time.

The following is a list of thirteen categories for the functional tasks that have been selected to be each graded using a seven point scale of perceived independence/dependence.

1. Cooking
2. Cleaning
3. Grooming
4. Finances
5. Self-Care
6. Ambulating Home
7. Ambulating Out
8. Reading Sustained
9. Reading Spot
10. Other Near Tasks
11. Intermediate Tasks
12. Distance Tasks
13. Technology

These thirteen functional task categories are reasonably self-explanatory and understandable for the patient who ranks each task on a seven point scale with a score of seven being completely independent and a score of one being total dependence. A measure of independence with no helper is only possible at the level of six or seven. Dependence levels are ranked from five to one with subscales for modified dependence and complete dependence. Details for scaling independence are described in Table 4.

After the level of Dependency is established for each of the thirteen categories, we can direct our rehabilitation efforts more rationally in mitigating the *Effect* of the vision deficit on the patient's life. For example, a patient with scores of six and seven in all categories except Sustained Reading needs little attention to distance rehabilitation devices or activities of daily living training. Rather, we should concentrate on reading devices, training and techniques. Similarly, a patient with scores of six and seven in all categories except Ambulating Out will need a referral to the Orientation and Mobility (O&M) member of the rehabilitation team, not new magnifiers. Processing functioning scores at the entrance testing level of our low vision rehabilitation evaluation not only directs the doctor toward the most efficacious avenue to proceed in the exam, but makes the patient aware there might be possibilities for them in

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INDEPENDENT Another person is not required for the activity (NO HELPER).

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**7** Complete Independence - All of the tasks described as making up the activity are typically performed safely without modification, assistive devices (other than standard glasses or contact lenses) and within a reasonable time frame.

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**6** Modified Independence - Activity requires any one or more of the following: An assistive device beyond standard glasses or contact lenses, more than reasonable time, or there are safety (risk) considerations.

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DEPENDENT Another person is required for either supervision or physical assistance in order for the activity to be performed, or it is not performed (REQUIRES HELPER).

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MODIFIED DEPENDENCE - The subject expends 50% or more of the needed effort to perform the task. The levels of assistance required are:

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**5** Supervision or Setup - Subject requires no more help than standby, cueing or coaxing, without physical contact. Or, helper sets up needed items.

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**4** Minimal Contact Assistance - With physical contact the subject requires no more help than touching, and subject expends 75% or more of the effort.

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**3** Moderate Assistance - Subject requires more help than touching, or expends between 50% and 75% of the effort required to perform the task.

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COMPLETE DEPENDENCE - The subject expends less than 50% of the effort, maximal or total assistance is required, or the activity is not performed. The levels of assistance required are:

---

**2** Maximal Assistance - Subject expends between 25% and 50% of effort for task

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**1** Total Assistance - Subject expends less than 25% of the effort.

---

**Table 4.** FIM Independence Rubric

categories on which they had given up or are avoiding. This sets functional scoring apart from standard history taking of Chief Complaint, Review of Systems and Past, Family and Social History and opens up options for addressing aspects in the life of the patient with low vision that are never manifest in fully sighted patients and hence have never become a part of standard history taking in a primary care vision exam. Asking the patient their Chief Complaint or reason for presenting is necessary yet many times inadequate for those with vision impairment. Directed probing at the beginning of the low vision rehabilitation evaluation rationalizes the process for the doctor, opens up the patient to possibilities they might not have considered and prepares the patient for thinking beyond just glasses and magnifiers. As the *Effect* on the low vision patient is qualitatively different from the fully sighted patient, so must the history be.

#### 4.9. *Impact* — Quality of life

*Impact* in our paradigm of low vision rehabilitation refers to how the how the loss of vision and vision related function (*Cause* and *Effect*) contribute to the degradation of the individual's quality of life. Whereas *Cause* and *Effect* can be addressed within the evaluation process of physician and therapist, the concept of *Impact* may need to be additionally addressed in a

broader fashion beyond low vision rehabilitation optical devices with appropriate referrals and education about resources.

Quality of life is a common phrase, but as a precisely definable concept remains elusive. The various conceptualizations of quality of life do, however, generally tend to include objective and subjective measures in a multi-dimensional manner while recognizing individual, societal and economic values. Though details do vary between the various instruments of quality of life measures, the categories essentially overlap and usually include aspects of a person's physical, material, social and emotional well-being. Therefore, rather than a blueprint of precision, quality of life definitions and measurement tools present a more general framework of reference. They are not typically used clinically on every low vision rehabilitation patient due to the time limitations for their administration, but have been used to validate the efficacy of treatment models.

Patient Reported Outcomes (PRO) are being increasingly used by third party and government regulators to assess care quality from the viewpoint of the patient and society. Among these are a number of quality of life surveys that seek to validate treatment efficacy. Khadka, McAlinden, and Pesudovs [27] conducted a comprehensive survey of the field in 2013 and found 121 vision related patient reported outcomes with 48 meeting the quality inclusion criteria for question unidimensionality and interval-level measurement. Of those, only six were related to low vision rehabilitation and one, the Veteran Affairs Low-Vision Functioning Questionnaire was considered highest quality. This patient reported outcome structure was validated in the Veteran Affairs Low Vision Intervention Trial (LOVIT) which reported significant improvement in every facet of visual function outcomes for patients who received low vision rehabilitation treatment. Even so, with 48 questions, it involved a significant time commitment to administer. While the outcomes of low vision rehabilitation have been shown to be positive, the studies point to time constraints as one of the main difficulties in performing current quality of life surveys on every patient. In addition, the current state of quality of life surveys is limited by the fixed question format which does not provide for adaptive questions based on preceding answers, thus limiting the comprehensiveness and individuality of the results.

The World Health Organization [28] broadly defines quality of life as "an individual's perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. It is a broad ranging concept affected in a complex way by the person's physical health, psychological state, personal beliefs, social relationships and their relationship to salient features of their environment."

The Center for Disease Control [29] subsequently added the concept of health related quality of life (HRQOL) in order to parse out those aspects of overall quality of life pertaining particularly to health. Defining, measuring and tracking health related quality of life is intended to be used to improve public health decision-making and allocation of resources.

Vision Related Quality of Life (VRQOL) [30] is a term referring to those parts of quality of life affected by vision. Instruments have been developed that seek to provide guidance in making



economic health evaluations of eye care and rehabilitation programs. These instruments have currently not received widespread clinical acceptance.

A factor impacting quality of life that is commonly seen in low vision rehabilitation practice is that of depression. Renaud and Bedard (2013) completed a review of the literature of studies linking the relationship between quality of life and depression in elders with visual impairment and, as is expected, their findings indicate that better quality of life is strongly related to less severe depressive symptoms. The complexity of psychological evaluation makes it difficult to deconstruct out the exact link with vision loss in seniors, but Eramudugolla, Wood and Anstey [31] showed a significant association between objective indices of visual impairment (visual acuity, contrast sensitivity, visual fields) and functional vision with depressive and anxiety symptoms. This would lead us to encourage primary care practitioners to consider deeper evaluation of depression and anxiety in adults with age related eye disease. Several studies have demonstrated a lack of appropriate screening methods among practitioners while also calling for methods to train low vision rehabilitation practitioners in screening and referral methods [32, 33]. Some leaders have been successful in developing a training program to assist health professionals and rehabilitation professionals in detection but the program has not been adopted in widespread use in the U.S [34].

Another impacting phenomenon for people with low vision is Charles Bonnet Syndrome (CBS). This involves visual hallucinations that many people with binocular vision loss experience, many times, on a regular basis. Some scholars suggest that 30% of persons with ARMD and binocular vision loss experience these [35]. Commonly described as colorful and sometimes dynamic scenes, they do not usually induce an unpleasant experience. The symptoms may decrease over time but in some patients it is an ongoing phenomenon. The exact process causing the hallucinations is unknown but thought by some to be similar to the mechanisms of “phantom limb syndrome”. Others based their theories on functional MRI studies suggesting Charles Bonnet Syndrome results from increased function in certain pathways other than those caused by external visual stimulus [36]. Regardless of the cause, doctors may reassure patients of the benign nature of these hallucinations and that they are unrelated to cognitive decline.

## **5. Interventions and management**

### **5.1. *Impact* — Vision enhancement — Optical**

Vision enhancement by optical and electronic devices have been a mainstay of low vision rehabilitation but modern low vision approaches and advancement in knowledge have supported the evolution of prescribing to include more factors for enabling patients to use the devices and incorporate them in daily life. For example, rather than prescribing optical or electronic devices after an evaluation with a low vision physician, many rehabilitation teams provide basic tools but incorporate rehabilitation methods such as teaching stable fixation with a preferred retinal locus (PRL) in patients with age related macular degeneration prior to

prescribing final devices. This allows for an evaluation of activities of daily life, lifestyle, and cognitive dimensions alongside the low vision physician that supports an integration of the devices by the rehabilitation therapist into daily life. Rehabilitation then becomes an ongoing process where the patient is encouraged to develop lifestyle adaptations over the course of rehabilitation. After several sessions with the therapist, the low vision physician would re-evaluate the patient's progress and prescribe additional devices as needed. In the U.S. a growing trend is for the low vision physician (optometrist or ophthalmologist) to refer to a low vision experienced occupational therapist (OT) who can be supported within the medical model by the Center for Medicare and Medicaid Services (CMS). [37].

Optical vision enhancement devices encompass high dioptric add powers, single vision near point glasses, magnifiers of various types (hand held, stand, illuminated) and telescopes. Unfortunately for our model of psychometric integrity, these devices can be variously labeled with non-standard power and/or magnification descriptors leading to confusion and frustration when attempting to compare patient performance and response. Magnification nomenclature is not homogeneous between companies that manufacture low vision rehabilitation devices and, in addition, are based on different assumptions of working distance. The assumptions are limiting and the various magnification formulae confusing.

The power of lenses and lens systems is most correctly defined with diopters and Equivalent Power ( $F_e$ ) is the standard by which they are most properly described. Eyeglasses for the fully sighted are generally such low power that thin lens formulae give good approximations of Equivalent power ( $F_e$ ). Therefore, office lensometers which measure back vertex power ( $F_v$ ) give results which can be considered correspondent with  $F_e$  when used for the most common eyeglass powers. As lens powers increase to the ranges often used in low vision rehabilitation, the thin lens calculations generate measurement errors that become significant. Using  $F_e$  rationalizes observed lens effects on performance and makes treatment decisions on lens more systematic and rational. Consequently, describing the power of low vision rehabilitation optical devices with  $F_e$  is desirable.

The logarithmic progression of steps of significance in the ETDRS chart design in combination with the standardization of  $F_e$  for describing the power of low vision rehabilitation optical devices means predictions of patient near point performance can be made with good levels of confidence. Since each step on the LogMAR scale is a Just Noticeable Difference (JND), the steps can be thought of as either dioptric power steps, working distance steps or M-Unit size steps. Following is a four stage procedure that leads to performance predictions with changes in working distance, letter size and lens power for near acuity:

**Stage 1-**Measure and Record Visual Acuity in M-Units

**Stage 2-**Set letter size Goal for Performance Improvement

**Stage 3-**Count steps from Measurement to Goal

**Stage 4-**Implement counted steps for both working distance and  $F_e$

0.4	0.5	0.63	0.8	1.0	1.25	1.6	2.0	2.5	3.2	4.0	5.0	6.3	8.0	10.0	12.5	16.0	20.0
-----	-----	------	-----	-----	------	-----	-----	-----	-----	-----	-----	-----	-----	------	------	------	------

**Table 5.** LogMAR steps of significance in JND increments of Diopters, Working Distance and M-Units

Once the Equivalent power needed to attain the patient's goal has been determined, the manner of delivery is chosen. Given that the important factor is the angular subtense of the image on the retina, the dioptric power can be supplied to the patient by single vision glasses, bifocal add, hand held magnifier, stand magnifier or telescope. In choosing between the various power delivery methods, factors other than diopters come into play. These factors include the particular task logistics, the ability of the patient to hold magnifiers steady, spot vs. sustained reading and others.

Low vision rehabilitation single vision glasses and bifocals delivery equivalent power to the eye by traditional means but with much higher dioptric power. The advantage to the patient is both hands are free to manipulate books and objects. The disadvantage is the close working distance. Since the working distance is the reciprocal in meters of the dioptric power and powers over +4.00D make binocular fusion problematic with high convergence demands, low vision rehabilitation glasses tend to be reserved for monocular use. This is in keeping with the common asymmetry in visual acuity found in patients with age related macular degeneration and diabetic retinopathy. Monocular spectacle powers in low vision rehabilitation glasses are prescribed in powers as high as +48.00D

Hand held magnifiers are the traditional means of delivering power for spot reading mail, prices in stores and other time limited near visual tasks. They can be lens power alone with a handle or in combination with illumination. Their advantage is easy portability and general inexpensiveness. The chief disadvantage is the necessity to reserve one hand for manipulation of the device while attempting to hold the object of regard with the other. This makes sustained reading difficult.



**Figure 12.** Hand Held Magnifier Set

Stand magnifiers were developed from hand held magnifiers in order to provide an optimal lens placement from the object of regard. While helping to alleviate the issue of managing lens to object distance, stand devices are bulkier and less portable. They can be found with handles

and illumination, no handles with open plastic stands or in domes. In any form, spot reading is the primary task for which they are used.



**Figure 13.** Stand Magnifier with Illumination

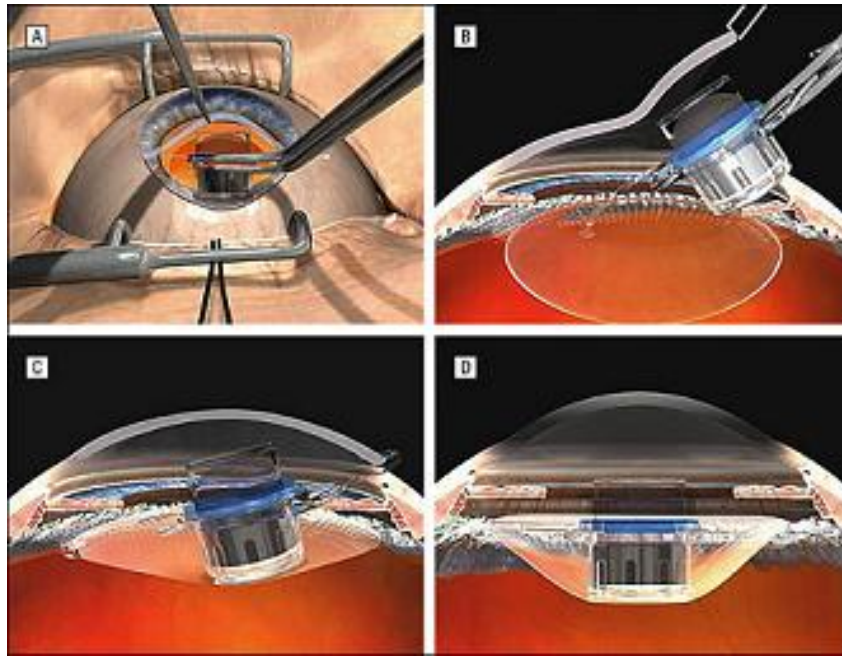
Telescopes have traditionally been prescribed for distance tasks such as reading street signs, taking notes from the board or spotting for mobility. New, closer focusing monocular or binocular telescopes allow television watching, computer viewing and even near point reading with extended length or reading caps on the telescope's objective lens. Telescopes can be hand held for spot use as needed or spectacle mounted for more continuous use. The tradeoff for improving distance visual acuity with any telescope is visual field restriction.



**Figure 14.** Telescope Set

Although all low vision optical and electronic magnification devices have until recently been extraocular, three intraocular devices have recently been developed; (1) the Implantable

Miniature Telescope (IMT, VisionCare Ophthalmic Technologies, Saratoga, CA), (2) Intraocular Lens for Visually Impaired People (IOL-VIP, IOL-VIP System, Soleko, Pontecorvo, Italy), and (3) Lipschitz Mirror Implant (LMI, Optolight Vision Technology, Herzlia, Israel). The IMT is the only device approved for commercial use in the US. It is implanted in one eye only and it enables patients with end-stage age related macular degeneration to see enlarged views at both distance and near. The internal design allows for a larger field of view than external telescopic devices and the rehabilitation program accompanying the implant supports patients' perceptual adaptation to the 2.7x magnified view. The IMT process requires bi-ocular viewing with the non-implant eye used for wide angle general mobility and the IMT implanted eye used for more detailed activities of daily living such as seeing faces, participating in hobbies, and viewing large print on labels. An increased quality of life score at 6 months post implantation compared to baseline has been demonstrated with the IMT. [38]



**Figure 15.** IMT surgical insertion sequence

## 5.2. *Impact* — Vision enhancement — Non optical

Non-optical vision enhancement has traditionally meant lighting and glare control devices and techniques. These entailed dark glasses, hats with brims, and typoscopes or line guides to cut white page glare while giving peripheral clues to maintain position on the line of letters. The benefits of these devices were subjective and their prescription was done symptomatically with no significant psychometric measure beyond observation of improved performance. This does not diminish their utility, however and a good Occupational Therapist (OT) or low vision trainer can identify useful non-optical devices and teach the techniques of their use in short order with good outcomes.

In recent years, the electronic miniaturization revolution which has given the world cell coverage, smart phones, GPS and mobile connectivity tablets for the fully sighted, has also added a great depth to the armamentarium of the low vision rehabilitation practitioner and opened up a whole world of possibilities to partially sighted and blind patients. Accessibility features are imbedded into every smart phone and tablet that allows many more degrees of freedom in accessing information. Global Positioning System (GPS) and mapping programs inform the patient who cannot see street signs or read storefronts just where they are and what businesses are nearby. Directions for walking routes are a few screen swipes away. A quick picture of an approaching bus and a finger gesture that magnifies the photo enables the person to identify the bus number and route. Similarly, menu items can be read independently and people far away recognized unobtrusively. Specialized apps for the patient with low vision are legion, so many in fact that the Braille Institute [39] has an app just to help organize, categorize and find those apps designed for the visually impaired. Some companies have dedicated their whole enterprise to providing tools and devices for these patients. However, the field of electronic accessibility for the partially sighted changes almost daily so any attempt at detailing it is futile. Suffice it to say that annual meetings for doctors and providers for the visually impaired invariably have sessions on the latest advances and the reader should make the effort to keep abreast of the changes in the field in order to provide the best information and treatment to their patients.

### **5.3. Impact – Vision substitution**

When the patient's vision has been reduced to the point that some or all of the functional independence measures are no longer positively impacted by vision enhancement devices, techniques or training, there are still avenues of patient benefit open to the low vision rehabilitation practitioner. That is the field of vision substitution where functional independence can be achieved with devices, techniques and training that do not rely on vision. Some of the more common components of vision substitution are Braille, orientation and mobility (O&M) instruction and audible books. Vision substitution and vision enhancement, however, are not mutually exclusive. In some aspects of functional independence, the patient may perform satisfactorily with vision enhancement while in other functional independence categories they may require vision substitution. An example may be someone who is able to read their mail with high dioptric power devices (vision enhancement) yet is unable to enjoy sustained reading. For them, audible books (vision substitution) are a reasonable accommodation. Additionally, there are devices that provide text to speech or to a file form that allows large viewing on a computer monitor or to a refreshable Braille display. GPS devices without a touch screen empower the functionally blind person with the option of safe, extended and independent travel. Students can quickly receive their assignments electronically rather than having to wait for a Braille transcription. Vision loss no longer has to mean functionality loss when the tools and interprofessional resources of vision substitution are employed by the low vision rehabilitation practitioner. However, this remains an area that has potential not yet fully realized.

## 6. Conclusion

Low vision rehabilitation is a field which is optimally practiced with a comprehensive, inclusive and interprofessional approach involving optometrists, ophthalmologists, occupational therapists, orientation and mobility specialists, social or rehabilitation workers and teachers of the visually impaired. In our paradigm of *Cause, Effect* and *Impact*, diagnosing and treating in the traditional medical model is shown to be frequently inadequate. We need to also look at incorporating the vocational and rehabilitation model. Determining visual ability in *Cause* by measuring visual acuity, visual fields and contrast sensitivity may not sufficiently take into consideration the functional *Effect* upon the patient's independence in their varied activities of daily life. Therefore, the patient history needs to go beyond the standard queries about chief complaint, review of systems and past, family and social history to a more directed functional survey as seen with quantified functional independence measures (FIM). Early interprofessional referrals thus generated can provide crucial input to the development of a rehabilitation plan that is comprehensive and inclusive addressing the *Effect* through activities of daily life and ultimately *Impact* the patient's quality of life. Even when the options for vision enhancement are no longer sufficient for the patient, independence can be achieved through interdisciplinary referrals for vision substitution devices, techniques and training. It is incumbent upon the eye doctor to either provide low vision rehabilitation services or refer to those who can.

## Acronyms and abbreviations

ADL	Activities of Daily Life
AMD	Age-Related Macular Degeneration
CBS	Charles Bonnet Syndrome
CMS	Center for Medicare & Medicaid Services
DM	Diabetes Mellitus
DR	Diabetic Retinopathy
ETDRS	Early Treatment of Diabetic Retinopathy Study
FIM	Functional Independence Measure
GPS	Global Positioning System
HPI	History of Present Illness
HRQOL	Health Related Quality of Life
IMT	Implantable Miniature Telescope
JND	Just Noticeable Difference
LASER	Light Amplification by the Stimulated Emission of Radiation

LogMAR	Logarithm (base 10) of Minimum Angle of Resolution
LOVIT	Low Vision Intervention Trial
LV	Low Vision
LVR	Low Vision Rehabilitation
MAR	Minimum Angle of Resolution
MN Read	Minnesota Reading Charts
NEI-VFQ	National Eye Institute Vision Function Quality
O&M	Orientation and Mobility
OD	Doctor of Optometry
OT	Occupational Therapist
PFSH	Past, Family and Social History
PRL	Preferred Retinal Locus
QOL	Quality of Life
ROS	Review of Systems
SK Read	Smith-Kettlewell Reading Test
SLO	Scanning LASER Ophthalmoscope
TRL	Trained Retinal Locus
TVI	Teacher of the Visually Impaired
VA	Visual Acuity
VRQOL	Vision Related Quality of Life
WHO	World Health Organization

## Acknowledgements

The authors would like to thank Precision Vision of La Salle, Illinois for their generous contribution of images used in this chapter.

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