MANUAL IN VISION REHABILITATION

Learning material for students at the German Jordanian University

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الجامعة الألمانية الأردنية
German Jordanian University

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List of Abbreviations and Acronyms

LV: low vision

MDVI: multiple disabilities with visual impairment

RE: refractive error

RP: retinitis pigmentosa

VA: visual acuity

VI: visual impairment

WHO: World Health Organization

PART I FUNDAMENTALS OF VISION REHABILITATION

1 INTRODUCTION TO VISION REHABILITATION

Vision Rehabilitation (VR) aims at enabling persons with visual impairment (VI) to increase their participation in society and improve their quality of life. In this manual, we refer to persons with VI as blind (no light perception) or LV (low vision, a person who is retaining some useful vision).

1.1 Prevalence

Worldwide, the prevalence of visual impairment (VI) varies greatly from country to country, and exact numbers are rarely available (typically only where extensive services are offered). In most places, the number of persons with VI is estimated using surveys or censuses made in the same country or neighboring countries.

Two key factors affecting the prevalence of VI are the age and the socio-economic status of the population. Table 1.1 shows the prevalence of VI defined as visual acuity (VA) below 3/60 or 0.05 by age group. As people get older, they have a much higher risk of having a VI because of the higher incidence of trauma and of age related diseases such as cataract, glaucoma, diabetic retinopathy and macular degeneration.

Table 1.1 Global prevalence of VI in the total population. *VI is defined as visual acuity below 0.05 or 3/60 and the data are presented in % by age groups. From Resnikoff et al.(2004).*

Age groups	< 15 years	15 – 49	≥ 50 years
Range	0.03 to 0.12	0.1 to 0.2	0.5 to 9

The large variation within each age group reflects the geographical differences in accessibility to health care: regions with poor eye care services have higher prevalence of VI due to preventable diseases such as cataract (Fig. 1.1).

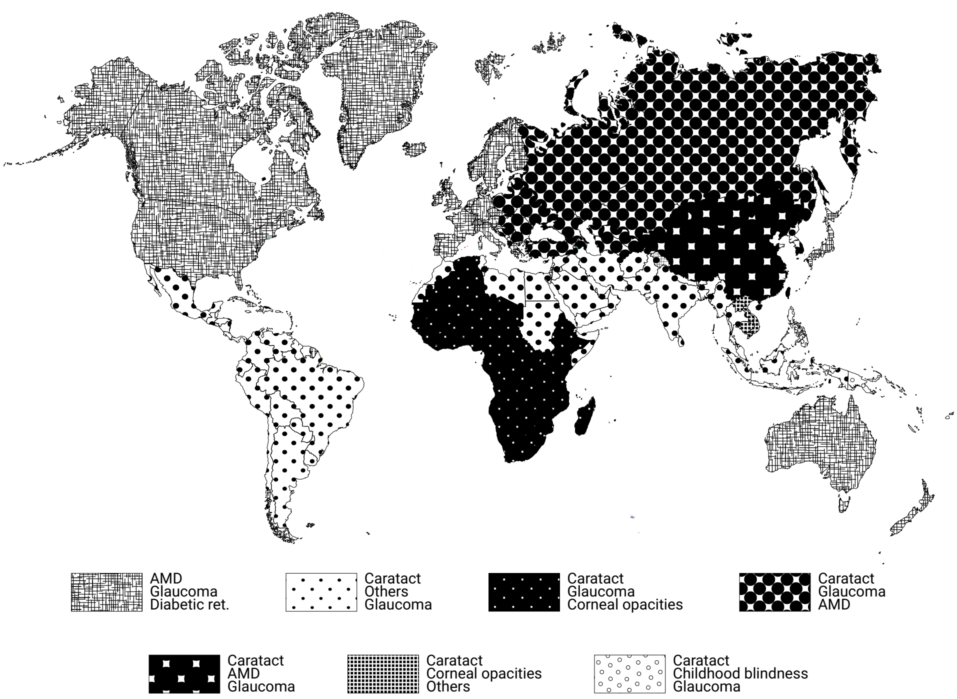


Figure 1.1 Main causes of visual impairment worldwide. *The map is based on the data published by Resnikoff and colleagues in 2004, using the WHO division of regions. The eye diseases are listed in the order of their prevalence. The term "Others" refer to not one of the eight main causes (cataract, glaucoma, AMD, corneal opacities, diabetic retinopathy, childhood blindness, trachoma and onchocerciasis).*

1.2 Rehabilitation services

Ideally, persons with VI should be referred to VR services by their ophthalmologists to insure that the medical aspects of the condition is being managed (Fig. 1.2). The services needed vary greatly from one person to another and depend on a number of factors including the daily activities, age, onset of the condition and amount of residual vision if any. The rehabilitation process takes place in three steps:

I. **The person with disability requests a service.** Often, persons with VI don't fully understand the benefits of VR. In addition, persons who are angry or waiting for a cure are less likely to use a device or learn a new skill. As a result, a large part of the first meeting at the rehabilitation may be dedicated to talking with the person with VI and the family.Rehabilitation works best when the person with disability has accepted the condition and identified goals to achieve.

II. **The abilities and needs of the person are assessed.** The outcome of the rehabilitation relies largely on the quality and relevance of this assessment.

III. **The intervention program is developed and implemented.** In VR, we consider four approaches to intervention:

1st: **Restitution.** Restoration of lost functions, for example the correction of refractive errors.

2nd: **Substitution.** Provision tools that substitute for lost function such as a white cane for persons with blindness to locate objects on a walking path while or a magnifier for a person with LV.

3rd: **Adaptation.** Making environmental adaptations to facilitate visual task such as hand rails or tactile surfaces in front of stairs going down, or improving visibility of the surrounding with better lighting and contrast between objects.

4th: **Compensation.** Teaching techniques and skills to replace vision for example Braille to replace print reading or visual skills to make a better use of the existing vision.

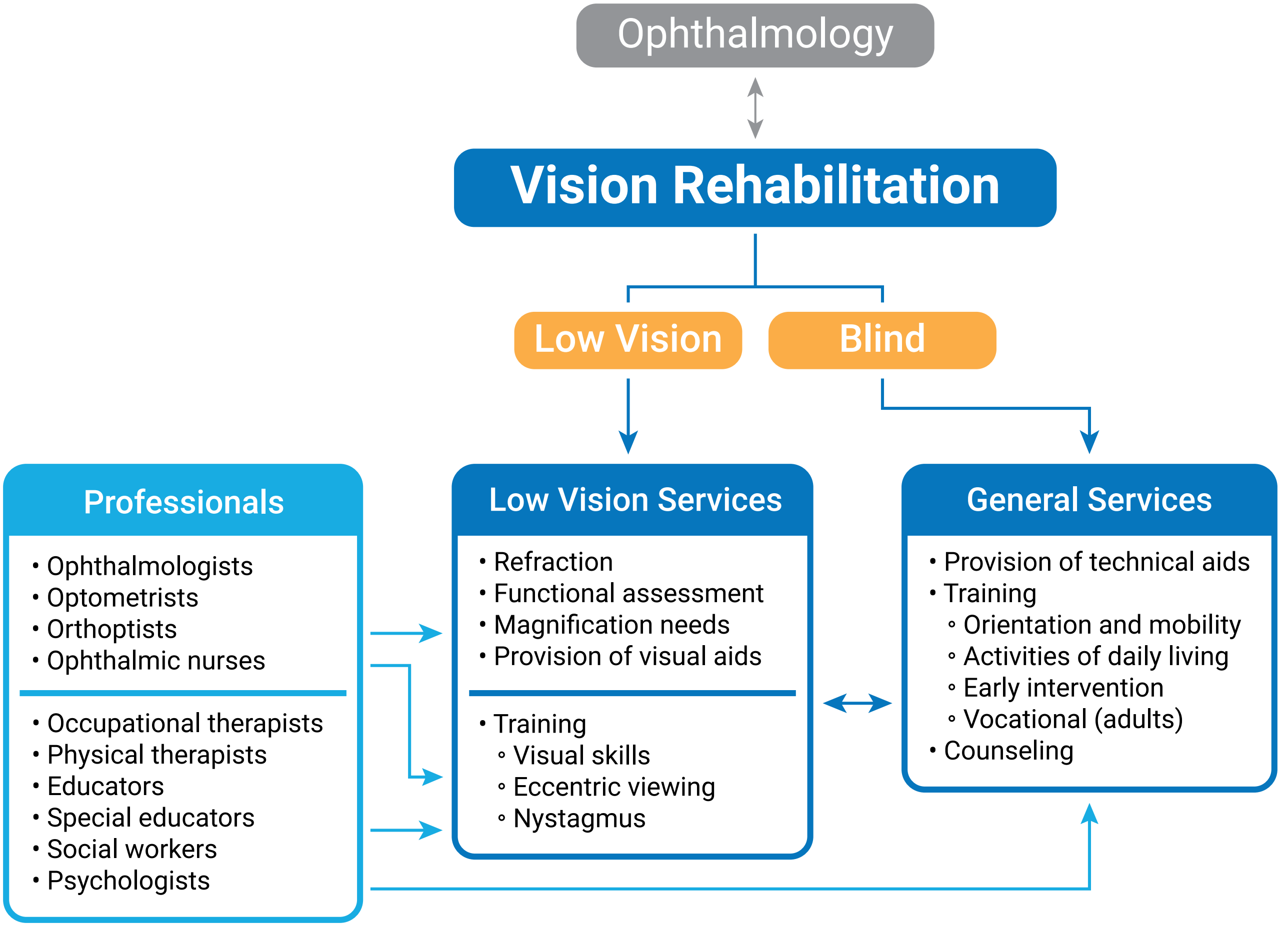
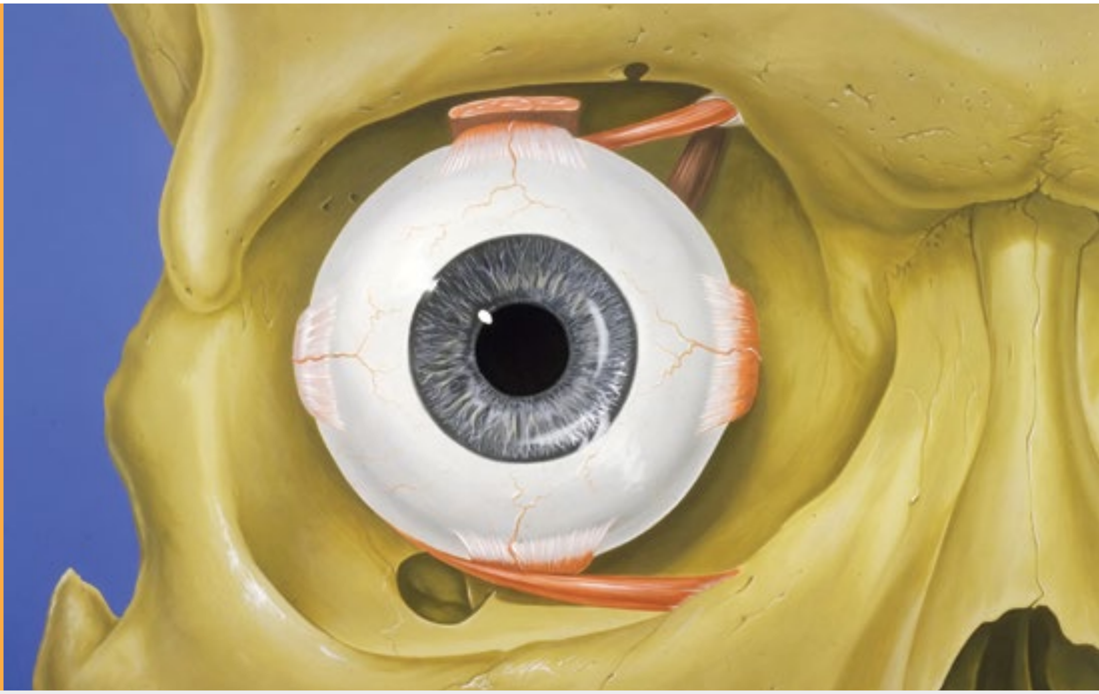


Figure 1.2 Vision Rehabilitation Services. *Diagram showing the relation with ophthalmology and the professionals involved.*



PART I FUNDAMENTALS OF VISION REHABILITATION

2 THE VISUAL SYSTEM

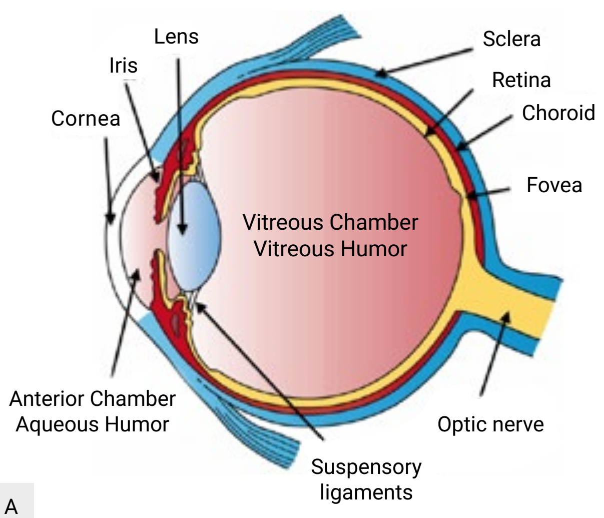
To understand the consequences of the most common causes of VI, it is essential to have a basic understanding of the way the images are formed in the retina and interpreted by the brain.

2.1 The structure of the eye

The eye is made up of three basic layers described from outside to inside (Fig. 2.1). The outer layer of the eye ball is composed of the cornea (front) and the sclera (white of the eye). While the cornea needs to be clear to let the light enter the eye, the sclera is a tough outer layer that serves as an anchor for the six pairs of oculomotor muscles. These muscles control the rotations of the eye in the orbit through the amplitude (how far to go) and direction of movement (which way to go).

The middle layer of the eye includes 1) the iris, which controls the size of the pupil and the amount of light that enters the eye, 2) the ciliary body, encircling the lens and adjusting its refractive power and 3) the choroid, which supplies oxygen and nutrition to the retina. The retina forms the inner layer of the eye and its integrity is essential to the formation of a clear image in the brain.

In addition to the structures mentioned above, the eye is filled with liquids. Two of these areas are particularly important to understand VI: the aqueous humor of the anterior chamber, which nourishes the lens and also regulates the intraocular pressure (IOP) and the vitreous humor, a clear jelly substance between the back of the lens and the retina, which accounts for the size and shape of the eye.



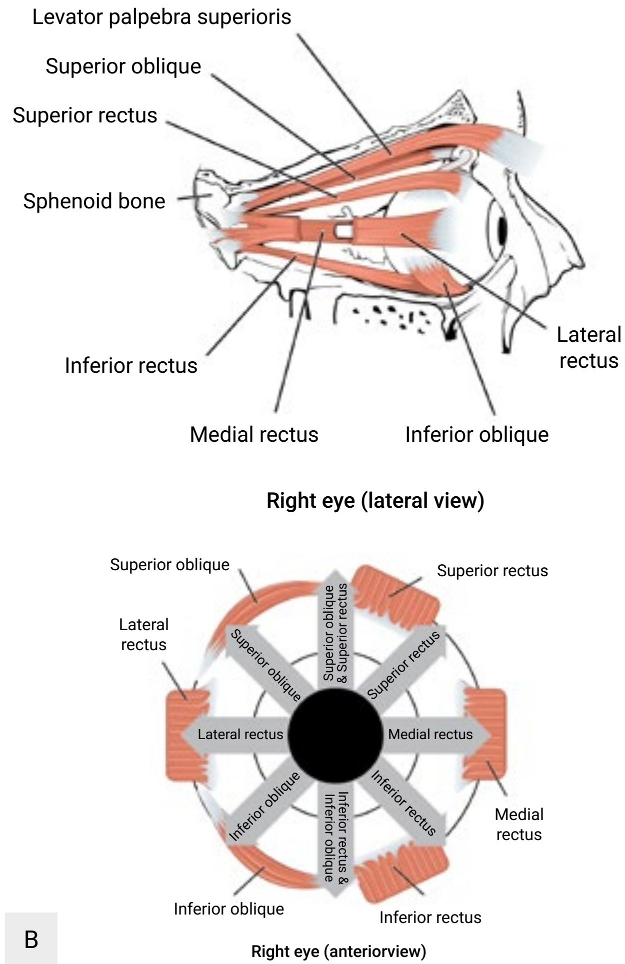


Figure 2.1 The eye *A) Schematic representation of the eye with the main parts. B) The eye muscles. Left: lateral (side) view of the right eye; right: anterior (front) view of the right eye Illustration: A) "Three Main Layers of the Eye" Artwork by Holly Fischer via Wikimedia Commons. B) "The Extrinsic Eye Muscles" by OpenStax College licensed under CC BY 3.0.*

2.2 Optical properties

Good vision requires that light successively travels through five structures: 1) cornea, 2) aqueous humor, 3) pupil 4) lens and 5) vitreous humor. Light rays going across dense surfaces are bent by a process called refraction (Fig. 2.2). Two of the eye structures are particularly important in changing the trajectory of the light: the cornea, which provides more than half of the refractive power of the eye (around 40 D) and the lens (18-20 D when relaxed and looking far).

The shape and size of the eye ball also affects the quality of the image falling on the retina. If the focused image falls behind the retina, the person has hyperopia (or hypermetropia) and if it falls in front of the retina, the person has myopia. In addition, the cornea (or less often, the lens) can be unevenly curved. This irregularity causes a distortion of the image between two focal points which is called astigmatism (see also Section 5.1).

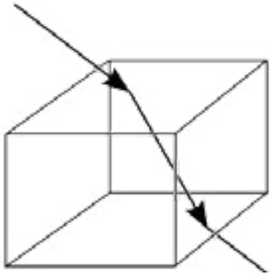


Figure 2.2 Refraction of light. *Light rays change direction when contact with a surface. Refractive errors are discussed in Chapter 5. Illustration: "Light matter refraction" by Klaus-Dieter Keller licensed under CC BY 3.0.*

2.3 Image formation on the retina

The retina is a highly specialized neural tissue. At its center lies the macula, a yellowish area approximately 2 mm in diameter with a few blood vessels and a high density of retinal cells (Fig. 2.3). The center of the macula contains the fovea (0.2 mm in diameter), where the retina is the thinnest and the visual acuity the highest.

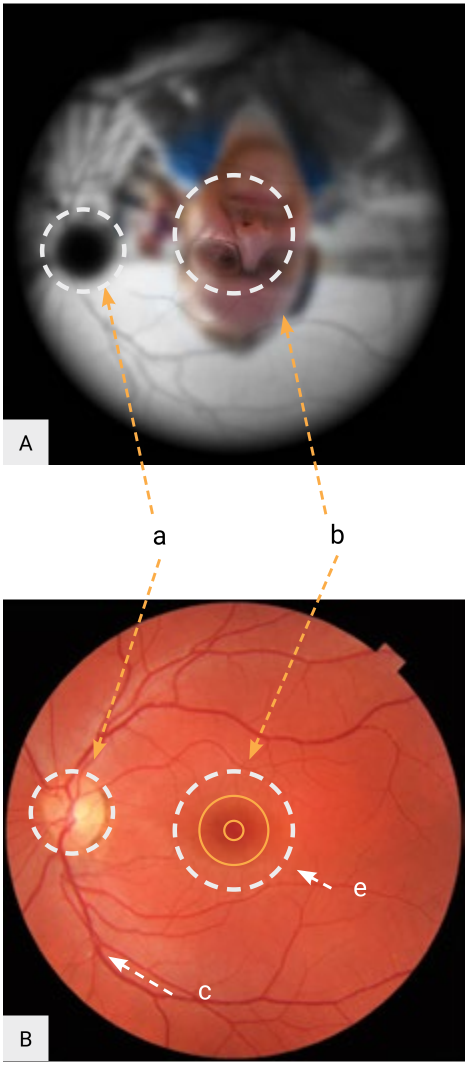


Figure 2.3 The retina. *A) Illustration of image as 'seen' by the retina independent of optic nerve and striate cortex. It takes into account fall off of color vision and acuity away from fovea (proportional to difference in cone density between fovea and periphery), subtle interference of blood vessels and the blind-spot. B) Photography of the interior of the eye, opposite to the lens (fundus). Small letters: a) optic disk, b) macula, c) retinal blood vessels, d) technical landmark found on the upper temporal part of a fundus indicating that the figure is of a left eye, e) fovea. A) "Retinal Image" by Ben Bogart licensed under CC BY-SA 3.0 derived from CC BY 2.0 licensed image by Stig Nygaard. B) "Fundus photograph of normal left eye" by Mikael Häggström licensed by CC0.*

The retina is covered by a pigmented epithelium that absorbs the light and decreases the reflection that would reduce image quality. It contains three layers of cells (Fig. 2.4). The **photoreceptors** (rods and cones) are located below the epithelium and are the only cells sensitive to light: they transform the light rays into impulses then transmit this new signal to the bipolar cells and other interneurons to process the information and make it converge to ganglion cells. Finally, visual information exits the retina with blood vessels at an area called the optic disk, where there are no photoreceptors and therefore no vision. This is the **blind spot**.

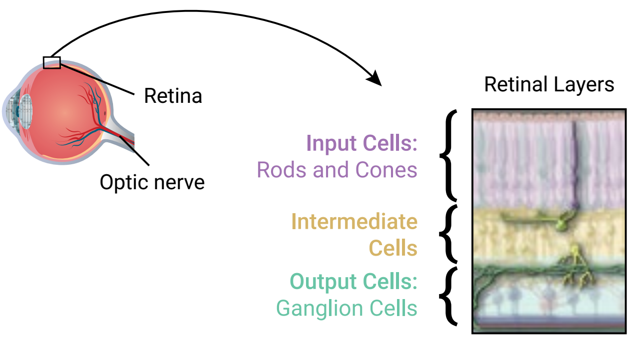


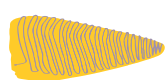
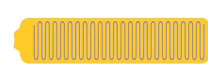
Figure 2.4 Retinal layers. *The photoreceptors form the top layer of the retina (close to the capillaries) while the ganglion cells are at the bottom (close to the vitreous humour). Illustration: "Retina h1 (1)" by National Science Foundation licensed in Public domain.*

There are two types of photoreceptors, the rods and cones (Table 2.1). Understanding how their properties affect the acuity, color, and adaptation to light is a key to grasping the consequences of retinal diseases.

The difference in visual acuity between the center of the retina (high) and the periphery (low) is largely due to the distribution of cones in the fovea (Fig. 2.5).

The properties of the visual field can be explained by the position of the photoreceptors in the retina eye: those from the nasal retina (near the nose) receive light rays from the lateral part of the visual field of the same side, while photoreceptors from the temporal retina (side of the head) receive light rays from the central part of the opposite visual field. As a result, the image of each hemifield is formed by the signals sent by the photoreceptors in the nasal retina on the same side and the temporal retina on the other side (Fig. 2.6).

Table 2.1 Comparisons between cones and rods.

Property	Cones	Rods
Shape (outer segment)		
Types	3 (blue, red, green)	1
Ratio	1 (6 million in each retina)	20 (120 million in each retina)
Response to light	Less sensitive (need lots of light)	Very sensitive (work at low light)
Distribution and density	Mostly central and high density	Only periphery and low density
Convergence to ganglion cells	Low (as low as 5 cone cells / ganglion cell)	High (100 or more rod cells / ganglion cell)
Visual acuity	High	Low

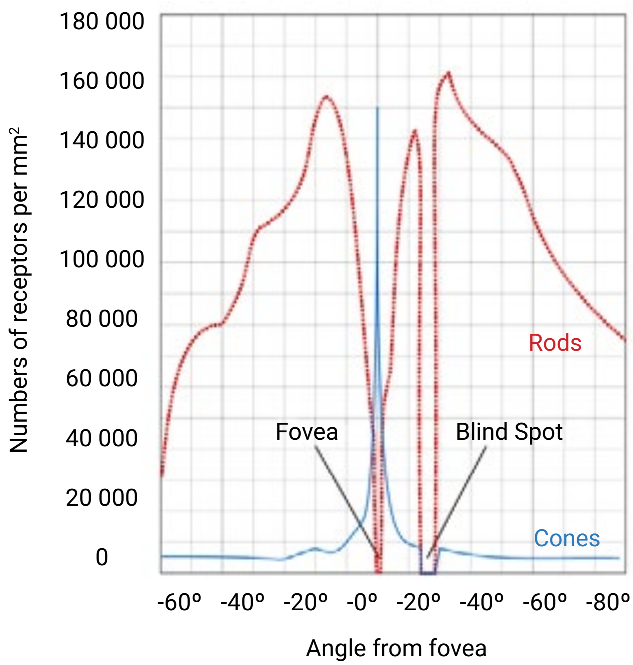


Figure 2.5 **Distribution of the photoreceptors in the retina.** *The majority of the cones are located in the fovea, while the rods are found in high numbers all over the retina except in the fovea. Illustration: "Human photoreceptor distribution" by Cmglee licensed under CC BY-SA 3.0.*

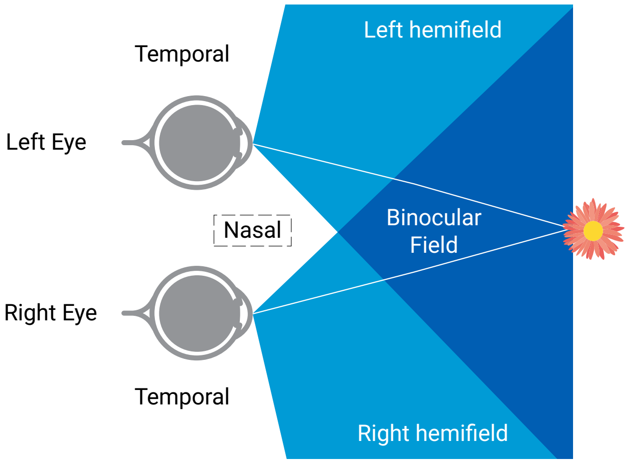


Figure 2.6 **The visual field.** *The contribution of each part of the retina in the visual field. The left hemifield is produced by the joint images of the left nasal and right temporal retinas.*

2.4 From eyes to cortex

The pathways of the visual information from the eyes to the visual cortex are illustrated in Fig. 2.7.

Soon after entering the brain, the left and right optic nerves split in two at the optic chiasm in order to bring together the images of each hemi-field: information from the nasal retinas crosses the midline to join the fibers of the opposite optic nerve forming the optic tract. As a result, the right optic tract contains information from the left hemifield and left optic tract contains information from the right hemifield.

The major target of the retinal ganglion cells travelling through the optic tract is the lateral geniculate nucleus (LGN) of the thalamus. After processing, the visual information leaves the LGN to form the optic radiations which reach the primary visual cortex (also called striate cortex or VI). It is there, in the back of the head, that the visual information from each eye is combined to create 3D images (binocularity). This is possible because all along the visual pathways, the information remains spatially organized so that neighboring cells in the retina feed information to neighboring parts of the LGN and the arrangement is maintained in the visual cortex.

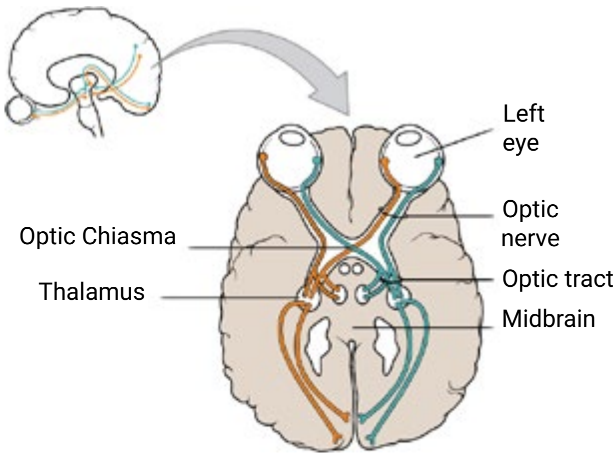


Figure 2.7 **The visual pathways from the eyes to the primary visual cortex.** *Information from the nasal retina crosses at the optic chiasm. Illustration: "1204 Optic Nerve vs Optic Tract" by OpenStax College licensed under CC BY 3.0.*

The consequences of lesions of the visual pathways (from the eye to the primary cortex) on the visual field are summarized in Table 2.2 and Fig. 2.8. Because of the large amount of visual information collected in the fovea, the central visual field occupies a disproportionately large area of the visual cortex compared to the peripheral retina. For this reason, a lesion of the visual cortex can spare some of the central vision (foveal sparing).

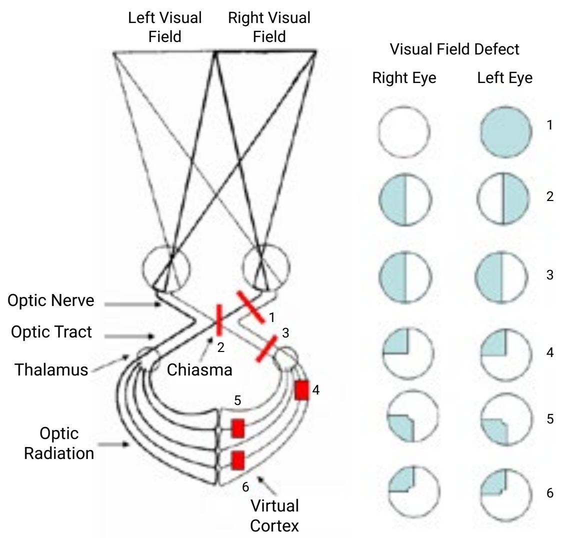


Figure 2.8 Consequences of lesions in the visual pathways. *1: If the right optic nerve is cut, the left eye provides a visual field of around 110°. 2: A lesion at the level of the optic chiasm impedes the fibers from the nasal retina of each eye, causing nonhomonymous hemianopsia. 3: When the optic tract is severed, the visual field defect is called homonymous hemianopsia. 4: A lesion of the Meyer's loop: homonymous superior quadrant anopsia. 5 and 6: homonymous inferior and superior quadrant anopsia respectively, with foveal sparing. Illustration: "Hemianopsien" Albert Kok by licensed in Public Domain.*

Table 2.2 Effects of lesions in the visual system. *The table shows the visual losses resulting from complete lesions. People with vision loss as a result of trauma might have only partial losses (see also Fig. 2.8).*

Location of the lesion	Loss	Remaining visual field
Optic nerve (unilateral)	± 60° of the visual field on the side of the lesion	120° of the opposite eye (90° ± 30° near midline)
Optic chiasm	Temporal visual field from both sides (bitemporal hemianopia)	90° Central
Optic tract (unilateral)	90 ° (hemifield) opposite to the lesion (homonymous hemianopsia)	90° on the side of the lesion
Optic radiation (unilateral)		
Visual cortex (unilateral)	90 ° (hemifield) on the side of the lesion with or without foveal (macular) sparing	None or central 5-10°

2.5 Visual processing

a) Visual cortex

When leaving the primary visual cortex, the visual information forms two pathways (Fig. 2.9).

- **The ventral pathway** (vision for perception) which transmits visual information relevant to the recognition of shapes and faces. If this pathway is damaged, patients develop visual agnosia characterized by difficulties identifying objects or people.
- **The dorsal pathway** (vision for action) which deals with information related to the spatial relationships between objects, the speed and direction of movement, as well as binocular disparity. Patients with damages to the parietal cortex have visual ataxia: they typically have poor eye-hand coordination but no difficulty identifying objects.

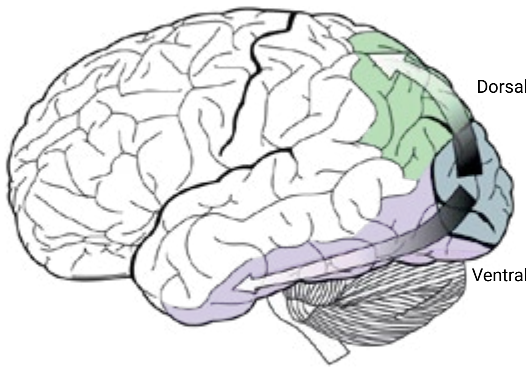


Figure 2.9 Secondary visual pathways. *The visual information in the primary visual cortex is further proacessed in the ventral pathway (vision for perception) and the dorsal pathway (vision for action). Illustration: "Ventral-dorsal streams" by Selket licensed under CC BY-SA 3.0.*

Exactly how these two pathways work together remains unclear. In some case the problem can occur in isolation such as prosopagnosia (poor face recognition, Fig. 2.10).

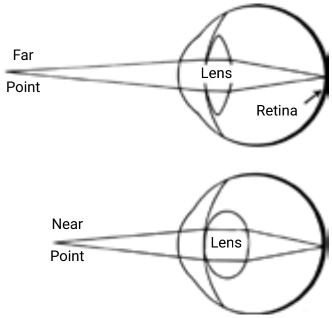
Figure 2.10 Simulation of prosopagnosia. *Even though their visual acuity is normal and they can see facial features, people with prosopagnosia have problems recognizing one person's face from another.*

People with a number of these higher procession functions impaired are said to have a condition called cerebral visual impairment (CVI). Visual processing problems can be present at birth or caused by circulatory failure or trauma. Most people affected have issues with both pathways as well as other parts of their brain or have developed compensatory strategies.

b) Visual perception

In addition to the secondary visual pathways, the brain uses other strategies to understand what we see. Examples are shown on Fig. 2.11-20 and Table 2.3. Most of these tools are not available for persons with LV, since they cannot see well at distance. However, those who lost their vision late in life may be able to interpret what they see using some of these cues and their visual memories.

Figure 2.11 Accommodation. *The lens is thin when looking at a far point, and thick when looking at near. Illustration: "Accommodation" (PSF) by derivative work of Zirguezi licensed in Public Domain*



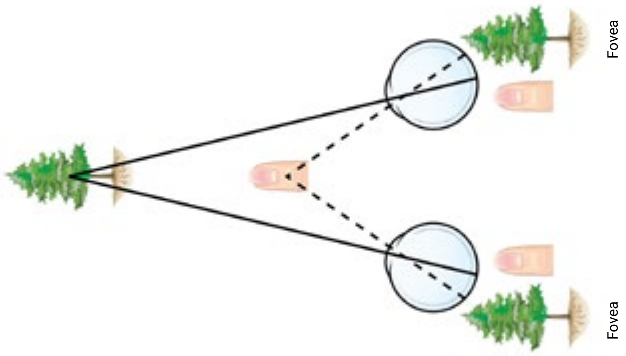


Figure 2.12 Retinal disparity. *The images of far objects occupy more nasal parts of the retina than near objects. Illustration: "1423 Retinal Disparity" By OpenStax College licensed under CC BY 3.0.*

Figure 2.13 Linear perspective. *Converging lines gives information on depth and distance. Photo: Yaser Al-Saghriji.*

Figure 2.14 Framing effect. *Photo: Forced Perspective in front of Jupiter, Baalbeck by Akehs licensed CC BY-SA 3.0*

Figure 2.15 Texture gradient. *The further away the texture, the higher the density. Photo: "wall" by 218146 1280 licensed under CCO Public Domains.*

Figure 2.16 Effects of lights and shadows. *Our brain assumes that the light comes from above, giving a drawing the impression of being in 3D. Illustration: "Optical-illusion" by 37034_1280 licensed under CCO Public Domain.*

Figure 2.17 Figure and Ground. *Rubin's Vase: Depending of the viewer, the image can either represent two faces or a vase. Illustration: "Rubin2" By John smithson 2007 licensed under Public Domain.*

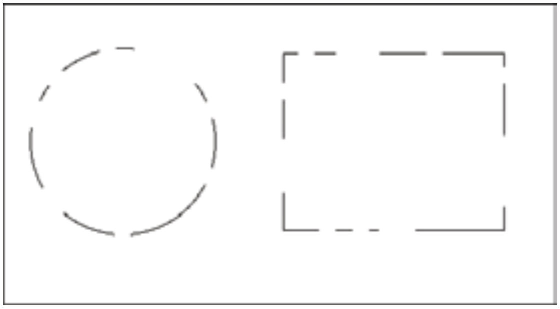


Figure 2.18 Visual closure. *Our brain continues the lines to complete the forms. Illustration: "Gestalt ley de cierre" licensed in Public Domain.*

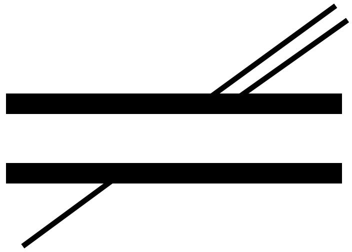


Figure 2.19 Continuity. *Without thinking, we automatically imagine the missing part of the line.*

Figure 2.20 Camouflage. *Nature uses the principle of continuity. Photo: "camouflage" by Tawny Frogmouth licensed under Copyrighted free use via Wikimedia Commons.*

Table 2.3 Examples of visual cues used by the brain of people with normal sight to identify what is being seen. *There is a certain amount of redundancy or overlapping, so that more than one mechanism can help interpret the image. Only a few of these cues may be available to persons with LV because either of their inability to see at far distance, their poor visual acuity, and the limited visual experiences.*

Goal	Source of information	Required abilities
Locate the object	Accommodation	To register the shape of the lens: thick if the object is near, thin if it is far. See also Fig. 2.11.
	Retinal disparity	To compare the position of the images on each retina: temporal is the object is near, nasal if it is far, on the left nasal and right temporal retinas if the object is on the left side, and on the right nasal and left temporal retinas if the object is on the right side. See also Fig. 2.12.
	Linear perspective	To analyze the size of the images, knowing that near objects create bigger images than distant objects, and the direction of lines, where convergence gives the impression of depth and distance. See also Fig. 2.13.
	Framing effect	To compare the object with the surrounding, here again assuming that near objects create bigger images than distant objects. See also Fig. 2.14.
	Texture gradients	To compare density of patterns in a surface: the denser part is usually closer to the viewer, and the density decreases as the surface is moving away. See also Fig. 2.15.
	Light and shadows	To observe the position of the shades assuming that light comes from above. See also Fig. 2.16.
Follow	Motion parallax	To compare the movement of the images on the retina with a fixation point, for example when sitting by a window and watching cars passing.
	Optic Flow	To analyze the changes in the visual field. When sitting in a moving vehicle, for example, objects far away appear stable while those close to the viewer are moving.
Identify	Closure	To complete the figures or shapes when parts are missing. See also Fig. 2.17.
	Figure and Ground	To recognize the object and isolate it from its background. See also Fig. 2.18.
	Continuity	To imagine the missing lines (Fig. 2.19) or continue the pattern (Fig. 2.20).
	Grouping	To group objects to give a meaning.

Table 2.4 Comparison between the information used and processed by the retina and the higher brain centers for a given situation. *Table provided by A. Colenbrander.*

Retinal image	Mental model
Changes constantly	Stable
Eye-centered	Environment centered
2-dimensional	3-dimensional
Strictly visual	Multi-sensory
Visual search driven by attention shifts	Affected by attention shifts
Ends at field limits, scotomas cause gaps	Extends around us, no gaps, information adds up in memory
Motion parallax	To compare the movement of the images on the retina with a fixation point

c) Visual information not for perception

A fraction of the retinal projections bypasses the LGN and projects to deep regions in the brain to control unconscious activities including: 1) biological rhythms such as sleep and wakefulness, 2) size of the pupil and certain eye movements (Fig. 2.21) and 3) eye and head movements to bring a point in the image onto the fovea.

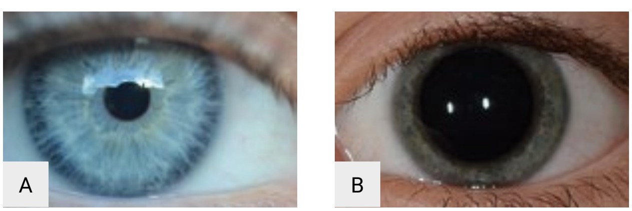


Fig. 2.21 Pupil reaction to light. *A) When the retina is exposed to bright light, the pupils constrict. B) On the other hand, the pupils widen at low light, to let the retina is exposed to bright light. Photos: A) "eye-800766 1920" and B) "child-529522 1920", both CC0 Public Domain.*

d) Development of vision

When a child is born, his visual system is still immature and the visual acuity is relatively poor. To develop fully his vision, the child needs a visually rich environment (visual stimulation) and a well-functioning visual system which includes: a clear optical system, appropriate responses of the pupil and the lens, coordinated eye muscles, the image falling on the retina (corrected refractive error), well-functioning retina, optic nerves, visual cortex and secondary visual areas.

Fig. 2.22 Visual stimuli in infants. *A) Movement attracts attention. Here, a seven-week old baby is following a moving object. B) Infants are often attracted to shiny bright objects with strong contrast and bold colors. Photos: A) "Infant vision" by Allofthe airatonetim licensed under CC BY-SA 4.0. B) "Infant looking at shiny object" by Mehregan Javanmard licensed under CC BY 2.5.*

PART I FUNDAMENTALS OF VISION REHABILITATION

3 IMPAIRED VISION

Problems in the visual system can have a variety of consequences on the vision of the persons affected. This chapter will focus on the most common causes of visual impairment and their signs and symptoms.

3.1 Common eye problems

The most common causes of VI in the Middle-East as encountered by the services users of the Vision Training Center at the German Jordanian University are listed in Table 3.1. Figures 3.1 to 3.4 show some examples.

Table 3.1 Common eye diseases leading to visual impairment in the Middle East. *Listed in alphabetical order.*

Disease	Part of the eye affected	Effect	Stability	Medical Treatment
Albinism	Retina: macula underdeveloped, absence of pigments	Low VA, photophobia, nystagmus	Stable	None
Age related macular degeneration DRY (ARMD)	Macula: progressive degeneration	Central scotomas	Gradual loss	No cure. Stop smoking and change in diet may help.
Age related macular degeneration WET (ARMD)	Macula: progressive degeneration	Central scotomas	Rapid loss	Anti-VEGF medication and laser.
Cataract – Congenital, senile, traumatic	Lens: clouding	Blur, faded colors, sensitivity to glare	Stable if treated	Replacement by intraocular lens (IOL) implant
Coloboma	Iris, retina, eye lid, disk: failure in the development of the eye	Variable from person to person	Stable	None
Corneal dystrophies	Cornea: lacks of transparency from birth	Overall blur	Stable or progressive	Corneal transplant
Corneal opacity	Cornea: loss of transparency caused by chemicals, trauma or ulcers	Overall blur	Stable	Corneal transplant
Diabetic retinopathy	Retina: uncontrolled growth of blood vessels	Variable from person to person and from day to day	Variable	Laser photocoagulation, drug or diet control diabetis, Anti-VEGF injections
Glaucoma / congenital	Eye ball: raised intra ocular pressure that also affects the optic nerve	Initial loss of the peripheral field, corneal opacity at late stage	Variable	Drops for life/ surgery
Glaucoma primary open angle	Nerve: changes associated with raised IOP	Gradual and progressive field loss. Often effects periphery initially	Decline if no treatment. Possible slow decline with treatment	Drops to lower IOP; surgery
Glaucoma / acute angle closure	Sudden painful onset of high IOP that causes a corneal edema	Overall blur	Stable if treated	Surgery to open angle and increase drainage
Keratoconus	Cornea: thinning and bulging out	Central distortion of images	Gradual	Rigid contact lenses, surgery

Disease	Part of the eye affected	Effect	Stability	Medical Treatment
Lens subluxation	Lens: misplacement	Variable	Stable	Surgery
Microphthalmos	Whole eye: developmental failure	Variable	Stable	None
Optic nerve atrophy	Optic nerve: damaged	Low visual acuity	Stable or progressive	None
Optic neuritis	Optic nerve: inflammation of the nerve sheet	Vision loss over hours to days, colour desaturation	Rapid initial loss. Possible slow partial recovery	Corticosteroids during the acute phase
Phthisis Bulbi	Eye ball: disorganization of the structures	No vision	Stable	None
Persistent Hyperplastic Primary Vitreous (PHPV)	Vitreous: developmental failure	Variable from person to person	Stable	None
Retinal detachment	Retina: separation of the retina from the epithelium	From peripheral loss only (if treated immediately) to total and permanent loss.	Rapid initial loss of vision. Stable if treated	Surgery to close tears and reattach retina. True ocular emergency
Retinopathy of prematurity (ROP)	Retina: uncontrolled growth of blood vessels. Associated with retinal detachment	Permanent loss at late stages	Stable if treated	Laser for early stages
Retinoblastoma	Retina: tumor	Variable from person to person	Stable when tumor is treated	Treatment of tumor. May lose the eye
Retinitis pigmentosa (RP)	Retina: rods more affected than cones	Peripheral loss, night blindness, central scotomas	Gradual loss	None

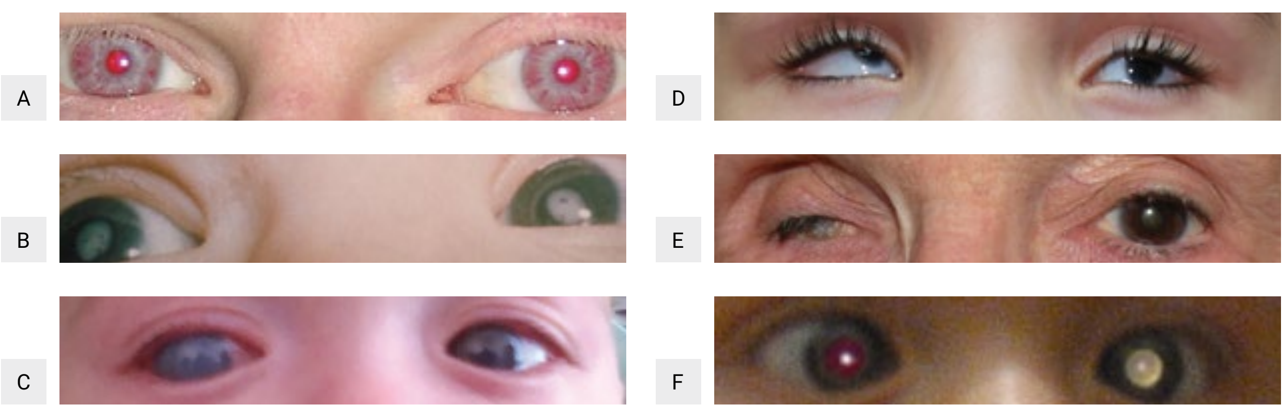


Figure 3.1 Examples of eye defects (pairs). *A) Albinism. B) Bilateral cataracts. C) Buphthalmus developed due to congenital glaucoma. D) Bilateral microphtalmia. E) Phthisis bulbi, right eye due to complication of eye surgery. F) Retinoblastoma in the left eye (white reflection). Photos: A) "Eyes of a person with complete OCA1 (Albinism)" by Karen Grønskov, Jakob Ek, and Karen Brondum-Nielsen licensed under CC BY 2.0. B) "Cataracts due to Congenital Rubella Syndrome (CRS) PHIL 4284" by httpphil.cdc.gov licensed in Public Domain C) "Buphthalmus (or hydrophthalmus) developed due to congenital glaucoma" by Michalgoback licensed under CC BY-SA 4.0. E) "Phthisis bulbi, right eye due to complication of eye surgery" by Jmarchn licensed under CC BY-SA 3.0. F) "A child with a white eye reflection as a result of retinoblastoma Rb white eye" by J Morley-Smit licensed in Public Domain.*

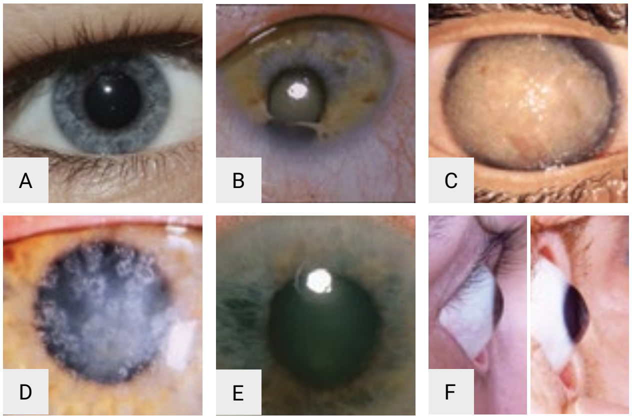


Figure 3.2 Examples of eye defects (single). *A) Normal eye. B) Coloboma The patient was a 67-year-old male with congenital coloboma of the iris bilaterally (only the left eye is shown). C) Corneal dystrophy, gelatinous type. D) Corneal dystrophy, granular type. E) Acute angle-closure glaucoma which is a sudden elevation in intraocular pressure. F) Left: Keratoconus; Right: normal cornea. Photos: A) "eye-421782_1920"licensed under CC0 Public Domain. B) "Coloboma" by National Eye Institute licensed in Public Domain C) "Gelatinous drop-like corneal dystrophy 1" by Klintworth GK licensed under CC BY 2.0. D) "Granular corneal dystrophy type I" by Klintworth GK CC BY 2.0. E) Acute Angle Closure-glaucoma by Jonathan Trobe, M.D. - The Eyes Have It. licensed under CC BY 3.0. F) "Keratoconus eye" by Indiana University School of Medicine, Department of Ophthalmology licensed under CC BY-SA 2.5.*

Figure 3.3 Examples of retinal fundus. *A) Normal. B) Age related macular degeneration (AMD). Note the drusen or white spots C) Diabetic retinopathy. D) Optic nerve atrophy. E) Optic neuritis. F) Retinitis pigmentosa. The peripheral part of the retina is more affected (darker). Photos: A) "Fundus photograph of normal left eye" by Mikael Häggström licensed under CC0. B) and C) "Intermediate age related macular degeneration" and "Diabetic macular edema" NEI by United States licensed in Public Domain. D) and E) "Optic nerve atrophy" Transactions (1865, 14592004469) and "Optic neuritis Intense Inflammation of the Optic Nerve" (Papil-litis,1910, 14741358166) by Internet Archive Book Images. F) "Fundus of patient with retinitis pigmentosa, mid stage" by Christian Hamel licensed under CC BY 2.0.*

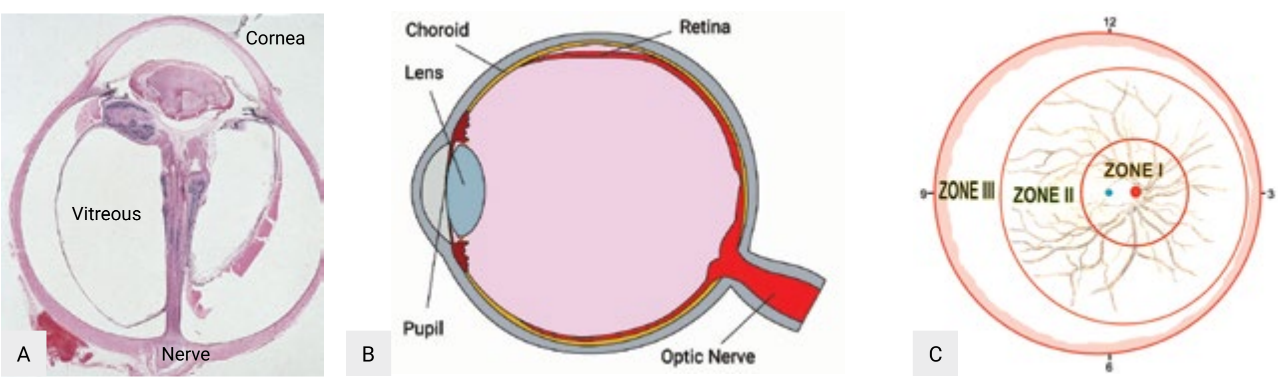


Figure 3.4 Diagram of the retina showing the zones of eye diseases. *A) Persistent hyperplastic primary vitreous (PHPV). B) Retinal detachment. C) Diagram of the retina showing zones of progression of retinopathy of prematurity. Illustrations: A) "Persistent hyperplastic primary vitreous" by The Armed Forces Institute of Pathology (AFIP) - PEIR Digital Library licensed in Public Domain B) "Human eye cross section detached retina" by Erin Silversmith from an original by en UserDelta Gderivative work RexxS, Aibdescalzo. C) "Zone1.2.3" by Kusamura N licensed in Public Domain*

3.2 Heredity

VI can be present at birth (congenital) or appear later in life (acquired). The causes can vary: the vision loss can be due to trauma, infections, heredity or aging. Hereditary eye diseases are most often of the autosomal recessive type: the child is affected because both parents are carriers of the defective gene (Fig. 3.5).

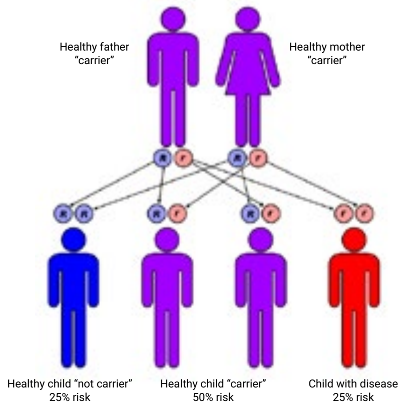


Figure 3.5 The mechanism of inheriting an autosomal-recessive disease. *R is the healthy gene and r the faulty gene. Illustration: "Avtosomno-rezesivne" by Vysokinskyi licensed under CC BY-SA 4.0.*

3.3 Signs and symptoms

Because of their poor vision, the eyes of persons with a VI may deviate from normal. The most common symptoms are described below (see also Chapter 10).

a) Nystagmus

These are rhythmic oscillations of the eyes in their orbit. They usually develop early in life in children with VI but can also appear later on. The amplitude of these oscillations may vary with the gaze positions and decrease by correcting the refractive error or providing tinting of the glasses for individuals with photophobia.

b) Strabismus or squint

It occurs when the eyes are fixating in different directions (While the good eye is fixating, the poor eye can look inward, referred to as esotropia, or outward called exotropia (Fig. 3.6A to C).

This can happen if one eye is stronger than the other (lazy eye) or as in the case of persons with VI, if only one good eye has fixation.

c) Eccentric viewing

Persons whose macula is damaged (central scotoma) use the peripheral retina so their best vision is 'sideways'. This usually causes the visual acuity to be below 0.05 (Fig. 3.6D).

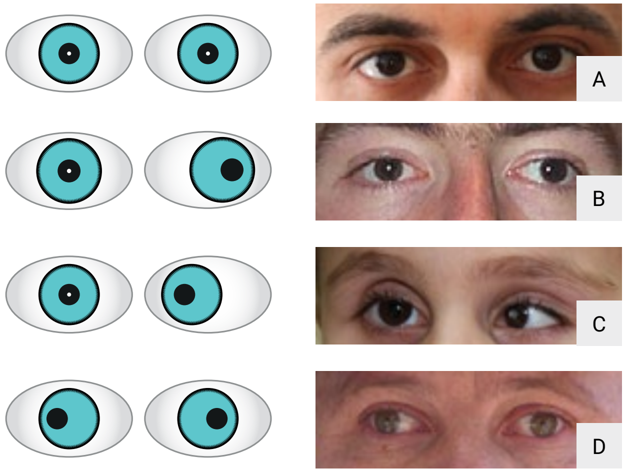


Figure 3.6 Strabismus and eccentric viewing. *A) Normal gaze: both eyes are fixating in the center. B) Exotropia. When the subject looks at the light, the reflection is in the center of the pupil in the right eye but not in the left eye, where the pupil is sideways. C) Appearance of Esotropia. A child with no light perception in the left eye, and the pupil is inward. D) An adult with a central scotoma looking at the camera. Photo: B) "Strabismus"by Montrealais licensed under CC BY-SA 3.0.*

3.4 With other disabilities

Some of the eye conditions listed in Table 3.1 can occur as part of a wider syndrome such as Retinitis Pigmentosa (RP) in Laurence-Moon-Biedel or Usher Syndrome (with hearing impairment). On the other hand, visual issues are common children with certain congential conditions such as Down Syndrome, CHARGE Syndrome, rubella, cerebral palsy or complications of prematurity. In children with multiple disabilities and visual impairment (MDVI), less strategies are available to compensate for the VI, and in turn, the poor vision decreases the possibilities to compensate for mental, physical or other sensory disabilities. The consequence on the child's ability to communicate, interact and learn can be dramatic.

3.5 Visual prosthesis

The visual system is very complex and consequently, very difficult to fix once injured. It is possible to replace blurred cornea or lenses by clear ones, but once the retina or the optic pathways are damaged, the vision lost cannot be restored. There are around a dozen research groups worldwide currently working on the issue and progress is very slow.

Retinal implants currently seem the most promising option (Fig. 3.6). Electronic chips are implanted either above the retina (epiretinal) or below it (subretinal) in the poorer of the two eyes. For these implants to be useful, the visual pathway needs to be intact and therefore trials have been mainly with persons affected by RP. In the Argus II project, the epiretinal chip is connected to a camera (which captures the images) and a processing unit via telemetry. In another approach, subretinal chips are coupled to light-sensitive diodes that stimulate the surviving retinal cells to amplify the light. For updates on these projects, see the respective websites: : www.secondsight.com and www.retina-implant.de.

There are numerous issues related to artificial vision. The devices tend to be cosmetically poor, and so far, the quality of the vision restored is very basic, possibly allowing a person to perceive light or basic high contrast shapes. The long term consequence of brain implants are still unknown: electric charges may lead to ionic exchange, chemical changes, overheating, biocompatibility, waste, contact with blood, etc.

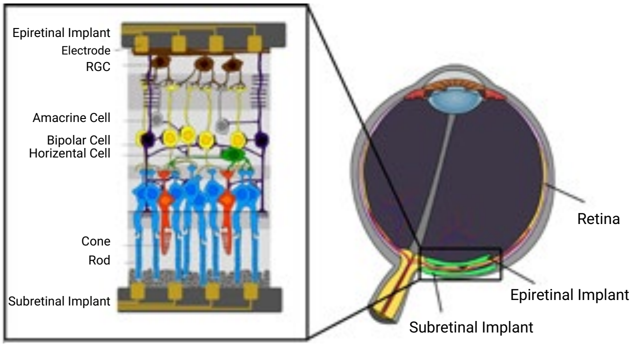


Figure 3.6 Retinal implants. *They can be inserted surgically either under the epithelium (subretinal) or above the cell layer (epiretinal). Illustration: "Retinal implant eye implant small" by Mbuerki licensed under CC BY-SA 3.0.*

4 OTHER SENSES

Persons with VI spontaneously use their other senses to collect informatio. Knowing their general functions can help understand how people with VI can optimize their use.

Touch, taste, proprioception and balance, the near senses, provide information related to the body while vision, hearing and smell are considered far senses (like vision), give cues on the environment. The brain processes the information collected by the other senses in a similar way it does for vision (Fig. 4.1). For example, when you hold an apple, the touch receptors responsible for pressure transmit the information to the part of the thalamus responsible for touch, which then processes it and transfers it to higher brain centers.

4.1 Hearing

When vision is poor, hearing is invaluable to allow the person to communicate with others and collect information about the environment. In some syndromes such as Ushers, or with aging, it is not uncommon that both vision and hearing are impaired so it is critical to optimize both senses.

Persons with hearing impairment are affected in their ability to communicate with others and therefore to access learning about the world around them. Like with vision, the range of hearing abilities necessary to carry on different tasks varies widely (Fig. 4.2). Mild and moderate hearing loss may go unnoticed, while persons with severe hearing impairment will have no or poor speech and typically use sign language.

If the hearing loss is different in one of the ears from the other, their ability to locate sound is impaired.

Like magnifiers increase the size of the image, hearing aids amplify the sounds (Fig. 4.3). They vary in size, power and circuitry and in all cases amplify human voices and decrease the background noise. For people who can only obtain little or no benefit from conventional amplification, the other option is to receive a cochlear implant, which stimulates the auditory nerve inside the cochlea. With hearing aids or cochlear implants, persons with congenital hearing impairment also need support to learn speech and language. Other management strategies include hearing tactics (lip reading) and environmental changes (vibration signals instead of door bells or tactile traffic lights).

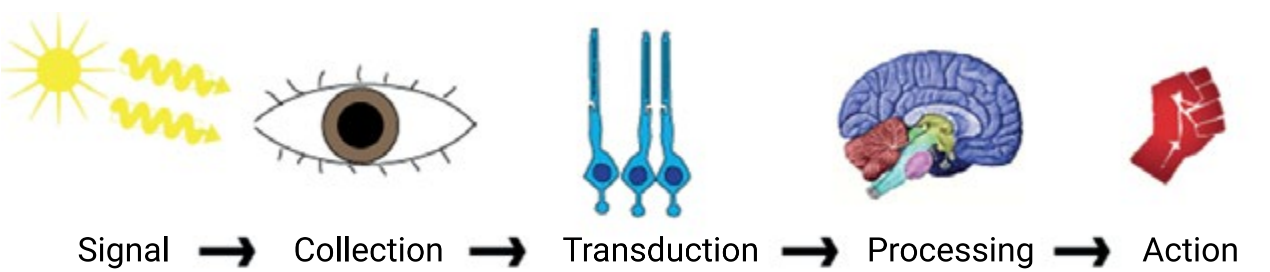


Figure 4.1 The organization of the sensory systems. *Hearing, touch, smell, taste and balance function in way similar to vision: the information reaching the organ is transformed into nerve signals that the brain can interpret and use to make decision. Illustration: "Sensory Processing" by Thomas.haslwanter licensed under CC BY-SA 3.0.*

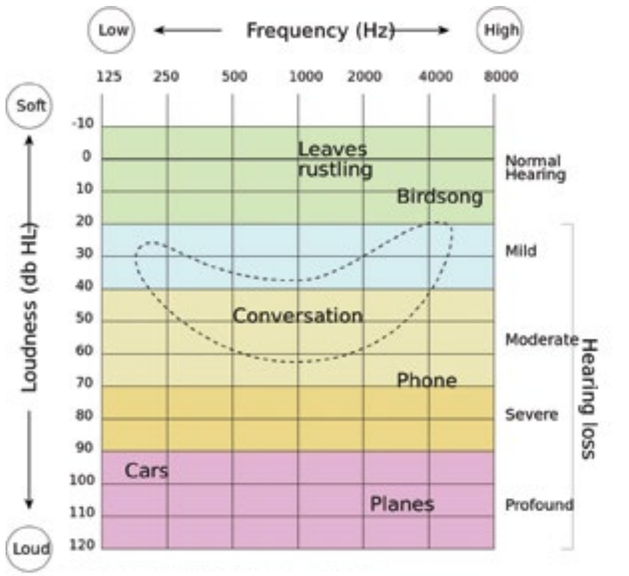


Figure 4.2 **Hearing spectrum.** *The graph show the lost functions associated with each level of hearing loss in decibels (db). Illustration: "Fig. 67" by Thomas.haslwanter licensed under CC BY-SA 3.0.*

A

B

C

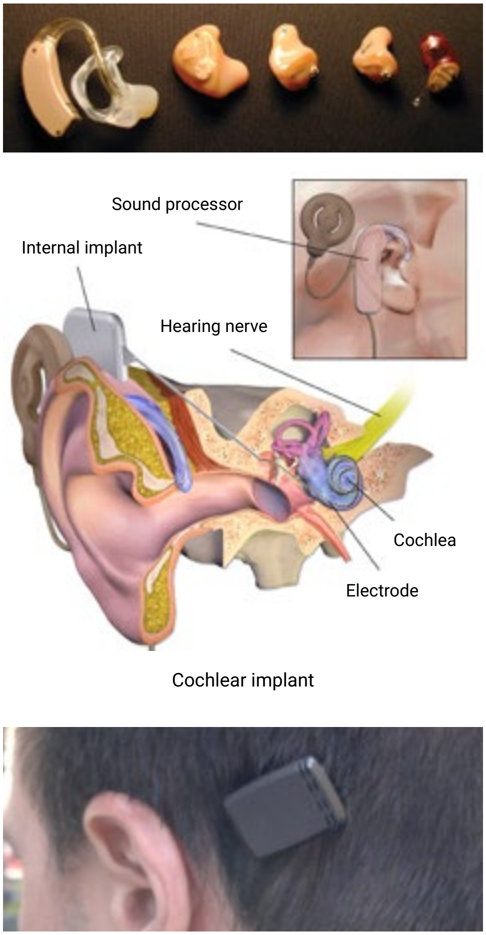


Figure 4.3 **Hearing aids.** *A) Traditional hearing aids are external devices that are introduced in the ear. B) Cochlear implants and C) Bone-anchored hearing aid (BAHA) involve surgical procedures. In the cochlear implant, an electrode is inserted in the cochlea to receive the signals from the sound processor and transmit them to the hearing nerve. In the BAHA, the sound processor anchored to the skull converts sounds into vibrations which are then sent to the inner ear. Illustrations: A) "Traditional hearing aids" by ikesters licensed under CC BY-SA 2.0. B) "Blausen 0244 Cochlear Implant 01" by Bruce Blaus licensed under CC BY 3.0. C) "BAHA sound processing device in place" by Chaosdruid licensed under CC BY-SA 3.0.*

4.2 Touch

The brain contains a map of our skin so that when it comes in contact with another surface, we can locate the area of the body being stimulated and evaluate the pressure applied. Different parts of the body have different sensitivity (thresholds) to touch so that the finger tips are better at detecting pressure than the palm of the hands (Fig. 4.4). When touch is combined with purposeful movement, it is referred to as haptic perception.

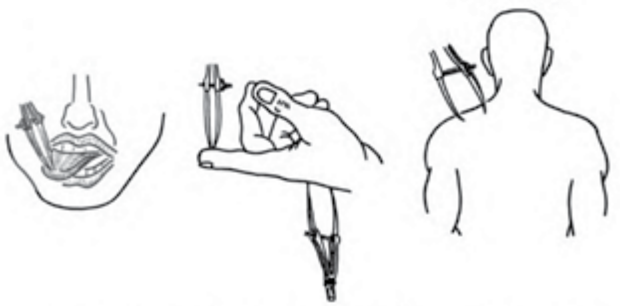


Figure 4.4 Sensory thresholds. *Example of results when two points are applied on the skin. The minimum distance between the points so they can be felt like two (and not one) varies with locations on the body. Illustration: "A functional approach to neuroanatomy 1960 (Lawrence 1960 8.11)" by House, Earl Lawrence. Pansky, Ben. licensed in Public Domain.*

4.3 Proprioception

The sense of body position, proprioception, is provided by three types of receptors: 1) in the muscles responding to passive stretch, 2) in the muscles responding to the tension in the muscle and 3) in the nerve fibers (axons) responding to changes in the angle, direction and velocity of the movement in a joint. When vision is impaired, the importance of proprioception in controlling movements, posture and equilibrium becomes critical.

PART II LOW VISION REHABILITATION

5 REFRACTIVE ERRORS

When vision is normal, distant light rays converge to a sharp focus on the retina; the person has emmetropia (Fig. 5.1). It is estimated that in 20 to 30% of the general population, the images entering the eye do not focus on the retina: they have a refractive error (RE) which, when corrected, gives the person normal vision.

5.1 Types of refractive error

Uncorrected RE has a direct impact on visual acuity (VA): the further the light rays focus the image from the retina, the poorer the VA without correction. It is estimated that uncorrected RE represent up to 18% of the case of VI in the world. Persons with LV are just as likely to have a RE as the rest of the population so before thinking about magnifying the retinal image, it is important to be sure the RE is corrected. The functional vision assessment should be done with the person wearing the best correction for their refractive error.

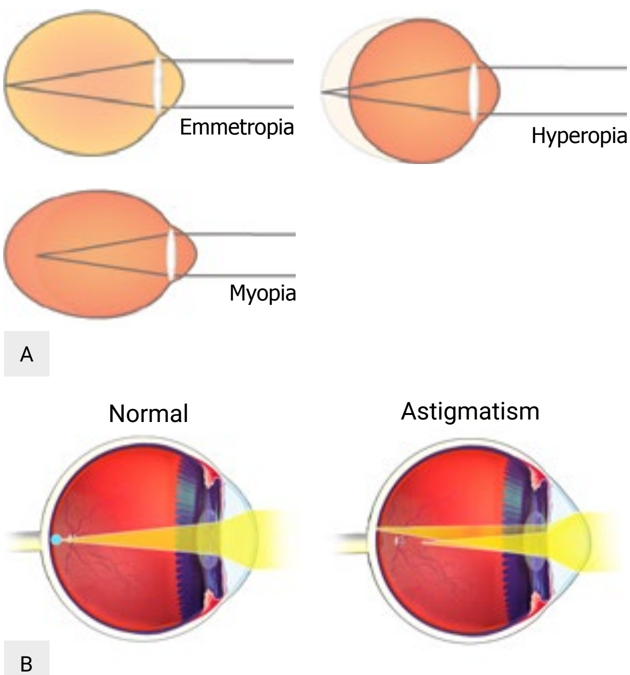


Figure 5.1 Refractive errors. *A) Graphic representation of emmetropia (the image is on the retina), Hyperopia (the image falls beyond the retina) and myopia (the image is formed before the retina). B) Graphic representation of astigmatism (the vertical and horizontal light rays do not converge in the same point). Illustrations: A) "Differ between eye errors" by Drsrisenthil licensed in Public Domain B) "Astigmatism (Eye)" by Bruce Blaus licensed under CC BY-SA 4.0.*

a) Myopia

Short-sightedness occurs when parallel rays of light converge to a focus in front of the retina. This happens when the eye is too long or the focal power of the eye is too high and often develops during adolescence. Myopia can be corrected with minus powered lenses. In a myopic eye, the vision in the distance is blurred but objects at a short distance in front of the eye can be seen clearly.

People with low vision who are also myopic will be able to use their refractive error to see a near object. They use less accommodation (see also Section 2.2) and can hold objects closer if they remove their distance glasses (Fig. 5.2A).

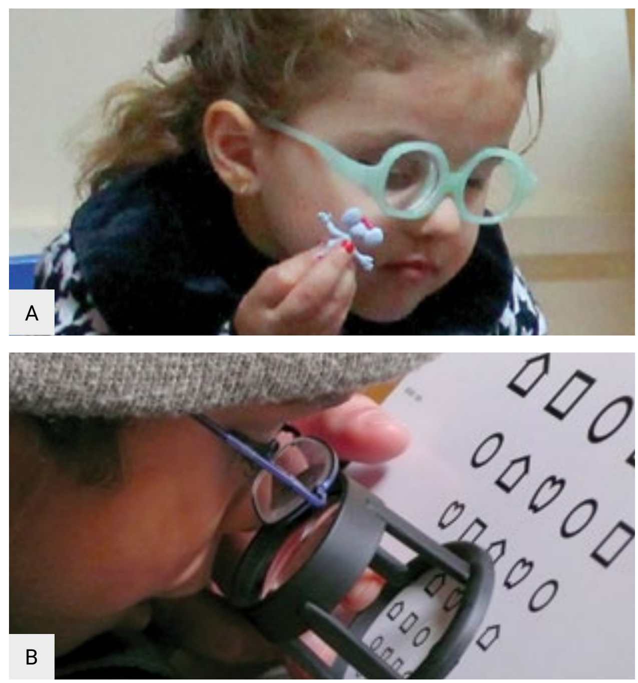


Figure 5.2 Low vision and refractive errors. *A) A child with high myopia looks under her spectacles to see the details of a toy. B) A child with astigmatism prefers to look through a magnifier with his correction.*

b) Hyperopia

Long-sightedness is another type of refractive error. In this case, parallel rays of light converge to a sharp focus behind the retina because either the eye is too short or the focal power is too low and is common in young children. Hyperopia can be corrected with plus lenses. Without corrections, the person sees better at far than at near.

When a person with low vision has hyperopia, part of the power of the lens in the magnifying spectacles goes to correcting the refractive error (placing the image on the retina) and the rest is used to magnify.

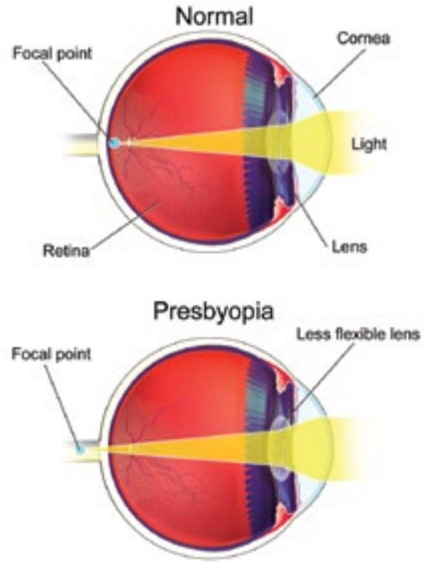
c) Astigmatism

The RE occurs when the light rays entering the eye are bent unequally, causing the horizontal and vertical components of the image to fall in different points on the retina. Astigmatism can present with either myopia or hyperopia.

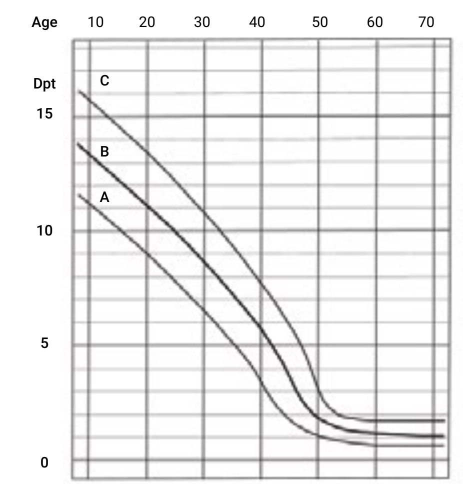
To have the optimal image, people with low vision and high astigmatism need to either have their prescription in the magnifying spectacles or use their distance correction with magnifiers.

d) Presbyopia

When younger, the shape of the lens changes with the position of the object in focus: thin (flattened) when looking at far and thick (rounder) when looking closer (Fig. 5.3). As we age, the lenses loses the ability to become rounder (to accommodate) while looking at close distance and people need to use reading spectacles or bifocals (if they have a refractive error) for near tasks. The amount of correction needed for near is relatively predictable as we get older (Fig. 5.3B). The power needed or addition depends on how close the task is: glasses for the computer viewed at 50 cm need to be weaker than those for reading at 25 cm.



A



B

Figure 5.3 Presbyopia. *A) Graphic representation of presbyopia. The lens stiffens with aging, bringing the focal point behind the retina. B) The amplitude of accommodation decreases with age to reach a plateau at around 50. Illustrations: A) "Presbyopia" by Bruce Blaus licensed under CC BY-SA 4.0. B) "Duane (1922) Fig 4" modified by Hans Strasburger licensed under CC BY-SA 4.0.*

5.2 Correction

The lenses of spectacles that correct refractive errors come in various forms and shapes, summarized in Table 5.1 (see also Fig.5.4).

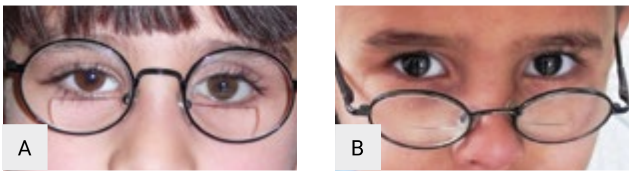


Figure 5.4 Magnifying spectacles. *A) Bifocal spectacles for a child with low vision allowing to correct the refractive error and magnify at near. B) If the child wears his spectacles on the edge of his nose, either the frame needs to be better fitted or the prescription is not helpful to the child. Photos: A) Ameen Harb.*

Table 5.1 Types of lens in spectacles. *The lens found in frames can have different power (plus + or minus -), and even those with similar power they can have different functions.*

Type of lens	Power	Purpose	Near	Far
Spherical (Sph)	+ D	Correct hyperopia	√	√
Spherical (Sph)	- D	Correct myopia	√	√
Cylinder (Cyl)	- or + D	Corrects astigmatism	√	√
Reading (add)	+ D	Correct presbyopia	√	
Prisms	Δ D	Move the image to the side. Can be used to correct squint, convergence problems etc	√	√
Bifocal (multi-focal, varifocal or progressive)	Top: - or + D	Correct myopia, hyperopia and/or astigmatism		√
	Bottom: + D	Correct presbyopia or magnify. Children: segment height at least at the middle of the pupil.	√	

The example of a prescription for a person with hyperopia using bifocal spectacles is given in Table 5.2. The person also has astigmatism on the left eye and a +2.00 addition for near. The prescription includes a based IN prism in the near prescription. In this case it would help the eyes with their convergence (turning in).

Usually, both eyes have similar refractive errors. However, if one eye provides a sharper image than the other, the best image will reach the brain while the image from the other eye will be ignored. If the situation is present in the early years of life the weaker eye might develop amblyopia (lazy eye). Sometimes this will also result in a squint or strabismus (see also Section 3.3).

Table 5.2 Example of a prescription. *OD: right eye, OS: left eye, Sphere (Sph): tells if the person is myopic or hyperopic, Cylinder (Cyl) and Axis: correct astigmatism, Add: corrects presbyopia, Prims: correct binocular problems, base indicates the angle (IN or OUT), PD: Pupillary Distance (PD) is the distance between the eye in mms.*

Type	Eye	Sph	Cyl	Axis	Prism	Base	PD
Distance	OD	+0.50	0	0	-	-	60
	OS	+1.00	-0.5	180	-	-	-
Reading Add	OD	+2.50	-	-	2	IN	-
	OS	+3.00	-0.50	180	2	IN	-

a) Lenses

Optical lenses fall into two categories: Plus (+) lenses, which cause light rays to converge and typically correct hyperopia and presbyopia, and Minus (–) lenses, which diverge light to correct the myopic eyes (Table 5.3 and Fig.5.5).

Plus (+) lenses are the most commonly used lenses in LV because of their magnifying properties. The optical power of lenses is measured in diopters (D). There is a direct relation between the power of a lens and magnification it provides:

$$\text{Magnification (x)} = \frac{\text{Power of the lens (D)}}{4}$$

Example: spectacles lenses with a power of 20 D provide 20/4 = 5x magnification.

Plus (+) lenses make light rays converge to a focal point: this is the focal length of a lens or the distance between the lens and the object where the image is the clearest.

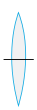
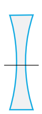
To calculate the focal length of a lens:

$$\text{Focal length (in cm)} = \frac{100}{\text{Power of the lens (D)}}$$

Example: magnifying spectacles with a power of 20 D should be used at 100/20 = 5 cm.

This means that the higher the power of a plus (+) lens, the closer the viewing distance to the picture will be and also the smaller the field of view. In addition, high power lenses produce aberrations, which can be minimized by using aspheric lenses (Fig. 5.6).

Table 5.3 Comparison between Plus (+) and Minus (-) lenses.

Shape	Image	Rays	Thickest part	Purpose
Biconvex 	Magnified +	Converging	Center	• Correct hyperopia • Correct presbyopia • Magnify
Biconcave 	Minified -	Diverging	Periphery	• Correct myopia

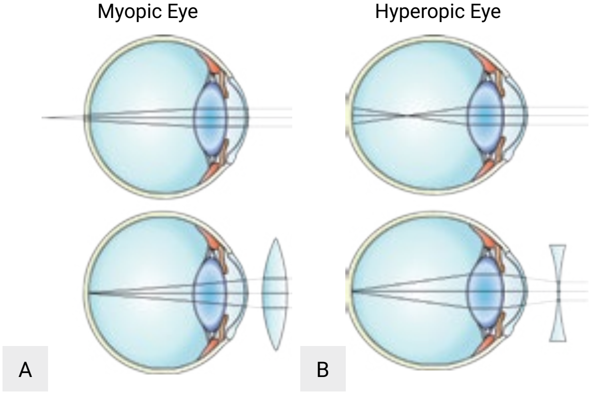


Figure 5.5 Corrections of refractive errors. *A) Biconvex lenses bring the image of the hyperopic eye on the retina. B) Biconcave lenses correct myopia. Illustrations: A) "Hypermetropia color" and B) "Myopia color" by Gumenyuk I.S. licensed under CC BY-SA 3.0.*

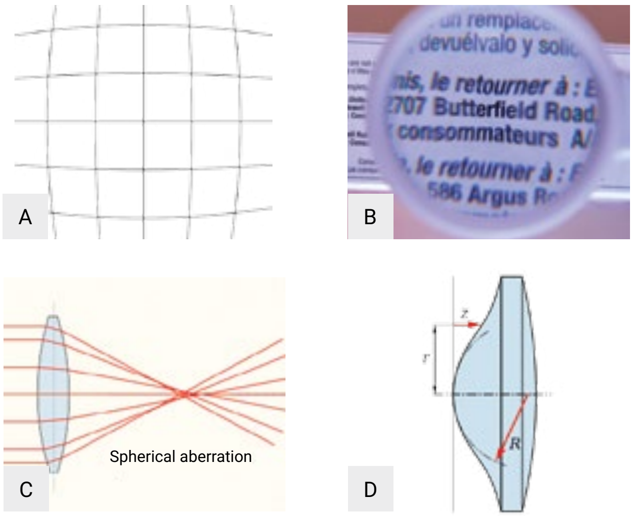


Figure 5.6 Optical aberrations *A) Graphic representation and B) example of how a lens with optical aberrations distorts the image, in particular at the edge. C) The light rays are meeting at different points in space. D) An aspheric biconvex lens, designed to decrease aberrations. Illustrations and photo: A) "Pincushion distortion" by WolfWings licensed in Public Domain B) Ameen Harb. C) "Lens5" by wenDrBob licensed under GFDL.D) "Pfeilhöhe" by I, ArtMechanic licensed under CC BY-SA 3.0.*

b) Contact lenses

The traditional way to correct refractive errors is to use spectacles. The second most common way is with contact lenses, which are more expensive and require more care than spectacles, but have also a number of advantages particularly for those who do not feel comfortable wearing spectacles. Contact lenses come in different materials (Table 5.4). With the advance of laser technology in the last 20 years, an increasing number of people have surgery to permanently remove their RE.

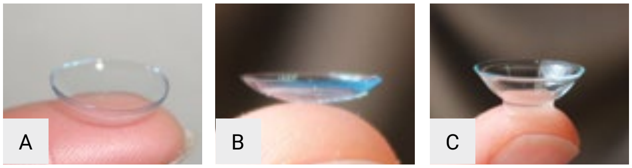


Figure 5.7 Contact lenses. *A) Soft lens. B) Rigid gas permeable lens. C) Scleral gas permeable lens. Photo: A) "Contact lens" licensed under CC BY-SA 3.0.*

Table 5.4 Comparison between types of contact lenses.

Material	Advantages	Disadvantages
Soft (polymer)	• Easy to fit • Quick adaptation • Well tolerated	• Higher infection rates • Disposed of regularly • Not suitable for all prescriptions
Rigid gas permeable	• Wide range of prescriptions • Better image quality • Last 2 years+ • Easy to keep clean	• It takes longer to adapt
Scleral gas permeable	• Can fit scarred and distorted corneas	• Complex fitting • Expensive • Lower wearing times

In people with low vision and a RE, regular spectacles or contact lenses can improve the quality of the image related to the RE. However, once this is done, they remain with subnormal vision.

PART II LOW VISION REHABILITATION

6 ASSESSMENT OF VISUAL FUNCTIONS

The aim of the low vision (LV) assessment is to understand the visual abilities of the persons with LV in order to provide him or her with the appropriate tools, training and advice to use their residual vision to its maximum potential.

6.1 Definitions of low vision

For statistical purposes, the World Health Organization (WHO) for LV Services or Care considers a person with LV as "one with a visual acuity less than 6/18 after best correction or the visual field is less than 10 ° from the point of fixation". In vision rehabilitation, this definition can be extended to "one who has an impairment of visual function for whom full remediation is not possible (...) and which causes restriction in that person's everyday life" (Low Vision Services Consensus Group, 1999).

6.2 The low vision specialist

a) Initial contact

The aim of the first meeting between the person with LV and the rehabilitation team is to identify needs, expectations and realistic goals. Before starting LV work it is important to make sure that the person has received the necessary ophthalmic or medical care. During the interview, a minimum of background information should be recorded (Fig. 6.1). It includes:

- The main problems the person is facing because of the visual impairment
- The diagnosis, ocular medical history, and onset of the VI
- Presence of other disabilities
- Current aids or strategies used to help with the VI e.g. magnifiers, large TV
- Support from family and friends
- The functioning in other areas of daily life may be explored. Does the person have problems at work or school? When shopping or moving around? Is glare a problem?

It is important to approach this conversation in an open and informal way to allow the person with low vision to express his worries and needs.

The person may be embarrassed to talk about the problems faced, or have too low or too high expectations from the rehabilitation process. The initial contact is a good way of gauging and managing these expectations as well as of gaining trust.

Figure 6.1 The initial contact. *The member of the rehabilitation team meets the persons with low vision and the family (here the elder brother). The information collected during the informal interview should be carefully recorded.*

b) During the assessment

The content of the LV assessment varies from person to person. The decision on the functions to assess and the tools to use needs to be based on the information collected during the initial meeting. Because their vision is blurry, assessing the vision of persons with LV can take a lot of time (60 to 90 min) and require the practitioner to use different strategies to obtain information on the status of the vision. The low vision assessment also includes trying various magnifying devices (Fig. 6.2). Table 6.1 lists the Do's and Don'ts of the LV assessment.

Figure 6.2 During the assessment. *A) Explaining the use of each device during the assessment. B) As much as possible, the device should be tried in real situation.*

Table 6.1 Do's and Don'ts of the LV assessment. *Some advices for the low vision specialists.*

Do's
• Ask if the diagnosis is fully understood and if there are questions • Explain what you are going to do • Provide clear instruction • Give the person time to answer (be patient) • Write down answers and behavior • Assure emotional support and encouragement • With children, find strategies to keep their attention
Don'ts
• Stress the person saying "hurry up" or "look harder" • Comment negatively when the person makes a mistake • Continue the assessment when the person is too tired or lost interest

c) After

At the end of the assessment, the implications of the key results should be explained using meaningful examples. It is important to use meaningful examples and clear language, avoiding technical words. The LV specialist can take this step as an opportunity to check that the outcomes of the assessment correspond with the visual behavior of the person with LV. In all cases, the LV specialist should be careful not to make conclusions based on a single assessment, such as whether the child should go to a special or a mainstream school, or if he should use print or Braille as main learning medium.

6.3 Visual acuity

Visual acuity (VA), the ability to distinguish fine details, is the most commonly assessed visual functions. Simply because poor VA has an impact on many aspects of a person's life (Table 6.2 and Fig. 6.3).

Table 6.2 Signs of low visual acuity in daily life. *Examples of the impacts of poor visual acuity on different types of activities.*

Activities	Problems
Communication	Recognizing people, reading facial expressions, making eye contact
Mobility and movement	Finding the way, reading signs, judging distances
Daily life	Finding objects, pouring water into a glass, cooking, finding food on a plate
Near tasks	Reading, sewing, using the mobile phone

Figure 6.3 Example of blurred vision. *A) Normal vision. B) Same image as A) simulating blurred vision. The outlines of the books are visible, but not the details.*

a) Recognition acuity

The most common way to measure VA is using a chart with characters or shapes (optotypes) at a distance of 3 or 6 meters. Recognition VA is usually measured with a line test (Fig. 6.4).

VA is a subjective value expressed as a fraction:

$$\frac{\text{Distance the person assessed needs to see the target}}{\text{Distance a person with normal vision needs to see the same target}}$$

Example: a person with a vision of 6/18 (0.3 sees at 6 m what a person with normal vision sees at 18 m. Normal vision is 18/18 or 1 (Fig. 6.5).

When measuring acuity in a person with LV, it is often necessary to move the chart closer than 3 m (Fig.6.6). In this case, it is convenient to use charts where the size of the optotypes is written as M size (1 M is what a normal person can see at 1 meter, usually around the size of regular print).

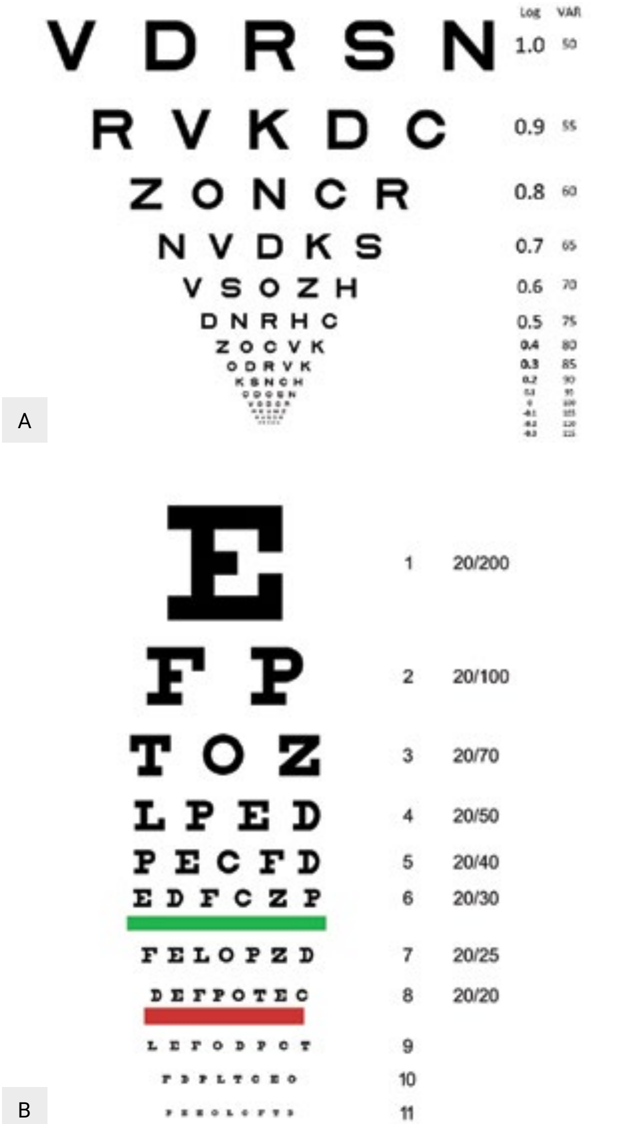


Figure 6.4 **Examples of visual acuity charts.** *A) A logmar chart. The size of the symbols decreases in a logarithmic manner and normal vision is 0.00. B) A typical Snellen chart developed by Dutch ophthalmologist Herman Snellen in 1862, to estimate visual acuity. The E on line one should be 88.7 mm (3.5 inches) tall and when viewed at a distance of 20 ft. Normal vision is 20/20. Illustrations: A) "Logmar chart" by Khex14 licensed under CC0. B) "Snellen chart" by Jeff Dahl licensed under CC BY-SA 3.0.*

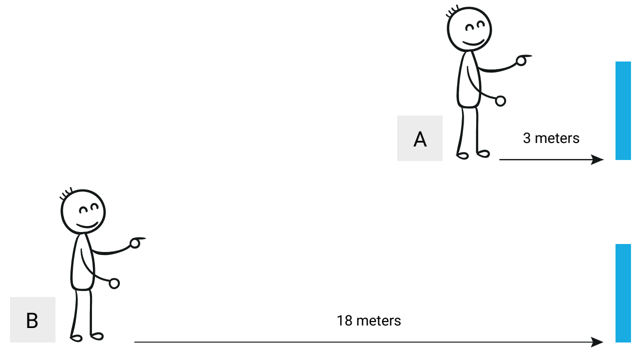


Figure 6.5 **Visual acuity measure and quality of vision.** *When expressed as a fraction, the VA is the relation between A) the distance needed by the person assessed to see a symbol on the chart and b) the distance a person with normal vision can see the same symbol.*

Figure 6.6 **Measuring visual acuity for persons with LV.** *A) The person may need to move the chart very near and to point at the symbols. B) In this case, the child cannot name the shapes so she points at them on the key card.*

The VA is then measured using the equation:

$$\text{VA} = \frac{\textbf{Distance in metres}}{\textbf{M size}}$$

Example: if a person can read 20 M line at 1 m, the VA is 1.0/20 = 0.05 (6/120).

The line tests are a better reflection of the visually busy world we live in. However, if the persons have very poor vision or cannot name the symbol but can match it, it is often useful to point at the symbols (Fig. 6.6). Pointing at a symbol on a line makes fixation easier because there is less information "crowding" the image. It is possible to make the line test easier by covering the lines above or below (Fig. 6.7).

VA can also be measured at near, typically 40 cm. It will differ from distance VA if the person has problems with oculomotor functions or accommodation. If the measurements are made with the same optotypes, comparing the VA at near with the one at distance can help determining if the person has a refractive error. VA results at near better than at far suggest the presence of myopia and in the opposite case, hyperopia or presbyopia.

Measuring near VA is very similar to measuring distance VA. Since the distance is usually in cm, remember to convert it into meters. For example, if a person can read 3 M line at 15 cm, the VA is 0.15/3 = 0.05 (6/120).

Figure 6.7 Hiding the symbols below the target line makes it easier for the viewer. *It can be done by covering the letter A) below or B) above the line to be read.*

Pinhole

A pinhole occluder is an opaque disk with one or more small holes in the center which temporarily removes the effects of the refractive error. Measuring VA with pinhole provides an estimate of the quality of vision once the refractive error is corrected. When VA doesn't improve with the pinhole, it can be concluded that: 1) there is no refractive error or 2) the low VA is caused by another malfunction of the visual system. Person with low vision with central cataract or scotoma may even get worse VA with the pinhole.

Figure 6.8 Pinhole occluders. *The black is a commercial version, the other two are handmade.*

Reading acuity

Reading acuity is a key tool to determine magnification need for reading tasks. While near VA is measured with lines of symbols, reading acuity uses a chart with texts of different sizes. The name of the scale can vary; it is important to be able to relate the chart size to the actual size of text the person needs to read (e.g. a newspaper, school book etc.). The reading acuity is frequently tested at a distance of 25 cm.

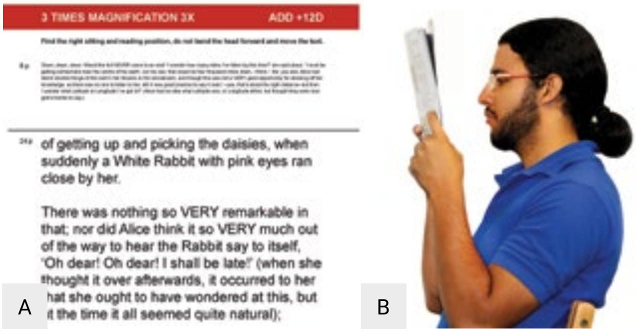


Figure 6.9 Come Closer reading chart. *In this example, if the person can only read the 24 p text (A, bottom) but wants to read the 8 p (A, top), he needs to use 3x magnification (+12D) assuming he has no refractive error or presbyopia .B) The focal distance of +12D magnifying spectacles is 8,5 cm so in a person with no accommodation, the text should be held at this distance.*

b) Resolution acuity

The ability to distinguish black and white stripes from a uniform surface is called resolution acuity or grating acuity. Since bars can be perceived even if a large area of the macula is damaged, resolution acuity alone is a poor indicator of visual function. Nevertheless, it is a useful measurement when VA is too poor to be measured with the traditional charts or if the person cannot match shapes or letters (typically a very young child).

In young children, resolution acuity is usually measured using preferential looking: if a person is presented with two panels, one with black and white stripes (grating) and the other one plain grey, he or she will spend more time looking at the striped than the plain one (Fig. 6.10). The principle of preferential looking is that the eyes will spontaneously move towards objects that are more colorful or complex. This requires careful observation of the eye movements by the examiner. Grating acuity is measured in cycles per degree (cpd), where one cycle is one black strip and one white strip and one degree is one degree of vision.

Table 6.2 Equivalence between visual acuity scales and corresponding visual functioning. *The abilities and range of function are only meant to be guidelines based on the visual acuity and assume that contrast sensitivity and visual field are normal. Adapted from A. Colenbrander.*

Visual acuity scales				Ranges	Estimated reading abilities with print
Decimal	Foot	Meter	LogMAR		
1.60	20/12.5	6/3.8	−0.20	Range of normal vision	Normal visual performance
1.25	20/16	6/4.8	−0.10		
1.00	20/20	6/6.0	0.00		
0.80	20/25	6/7.5	0.10		
0.63	20/32	6/9.5	0.20	Mild vision loss	Can perform most tasks for short periods of time
0.50	20/40	6/12	0.30		
0.40	20/50	6/15	0.40		
0.32	20/63	6/19	0.50		
0.25	20/80	6/24	0.60	Moderate vision loss	Can perform with help (magnifier, large print)
0.20	20/100	6/30	0.70		
0.16	20/125	6/38	0.80		
0.125	20/160	6/48	0.90		
0.10	20/200	6/60	1.00	Severe vision loss	Slower performance needs stronger aids
0.08	20/250	6/75	1.10		
0.063	20/320	6/95	1.20		
0.05	20/400	6/120	1.30		
0.04	20/500	6/150	1.40	Profound vision loss	Minimal performance also uses non optical aids
0.03	20/630	6/190	1.50		
0.025	20/800	6/240	1.60		
0.02	20/1000	6/300	1.70		
0.016	20/1250	6/380	1.80	Near blindness	Relies mostly on non-visual aids
0.0125	20/1600	6/480	1.90		
0.01	20/2000	6/600	2.00		
…	…	…	…		
No light perception				Blindness	

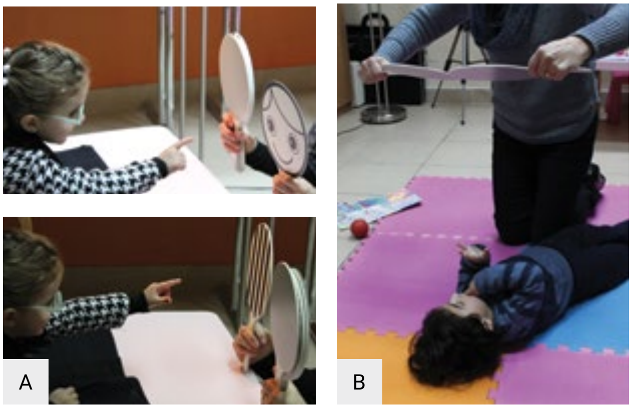


Figure 6.10 Resolution acuity. *A) The child is asked first to point at the face on a large pad, then at the stripes. C) If the child has with poor motor control, the assessment can be done while he is lying on the floor and looking at the eye movements (preferential looking).*

c) Detection acuity

In small children, the quality of the vision can be estimated during informal situations using attractive objects presented at a fixed distance. The goal is to determine the smallest object the child notices on a contrasting background. The targets should be presented silently (no voice or rattle of jewelry) to ensure that the child is responding to the visual stimulation. This information can be useful for the carers and also roughly converted into VA by measuring the diameter of the ball and the viewing distance (Fig. 6.11).

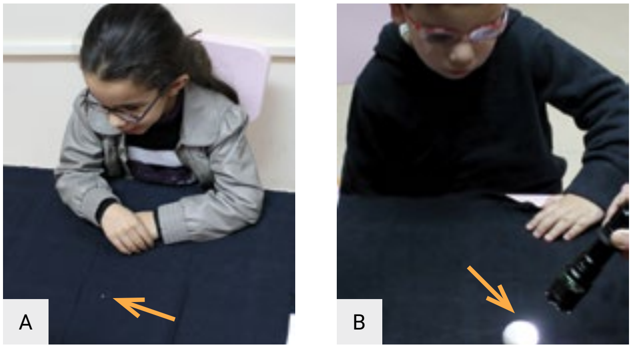


Figure 6.11 Detection using Styrofoam balls. *A) Styrofoam balls of different sizes can be placed on a contrasting background. B) If vision is very poor, the object might need to be illuminated.*

Table 6.3 Tools and techniques to measure visual acuity.

Vision Test	Tool	Notation of results	Prerequisites
No light perception	Pen light	NLP	-
Light perception	Pen light	LP	Head movement towards light
Direction of light	Pen light	Top / down / left / right	Head movement
Movement	Hand	HM (hand motion)	Head movement
Grating	Pads	cpd (cycles per degree)	Attention to stimulus
Detection	Various	Size, color, distance	Attention to stimulus
VA (traditional)	Chart	Fraction	Concept of sameness (matching)
Reading acuity	Text	Various	Ability to read

Table 6.4 Examples of ways to overcome low visual acuity. Simple solutions for general problems are presented.

Problems	Recommendations
Seeing smaller details	• Magnify: move closer, change the size or use magnifier • Increase illumination • Increase contrast • Make fixation easier (point or simplify visual area)
Judging distance	• Train or familiarize with task • Place large visual cues
Decreased visual efficiency	• Train visual skills (localizing, tracing, tracking, scanning) • Allow more time for looking

6.4 Contrast

If we take the smallest line a person can see on the VA chart (black letters on white background) and make it grey instead of black, the person is less likely to be able to read it (Fig. 6.12). This is because our VA is best when the contrast is high. Since the visual environment is rarely black and white but colorful with plenty of shades, the VA values do not have direct functional meaning. In addition to this, some persons with LV have poor contrast sensitivity: their vision falls away more rapidly as levels of contrast decrease. A few of the effects of poor contrast sensitivity on daily life activities are listed in Table 6.5.

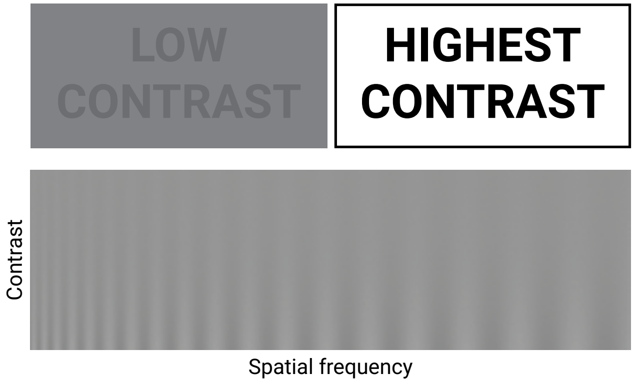


Figure 6.12 Contrast and spatial frequency. *The lines are more visible on the bottom of the graph, where the contrast is higher, than at the top. In addition, they fade away faster on the left side of the graph than on the right side, where the spatial frequency is higher.*

Table 6.5 Signs of poor contrast sensitivity. *Examples of the impacts of poor contrast sensitivity on different types of activities.*

Activities	Problems
Communication	Reading facial expressions
Mobility and movement	Seeing surroundings, judging distances and depth on ground, steps and stairs or low obstacles
Daily living	Finding lost objects
Near tasks	Reading text with poor quality of print

Screening tests for contrast sensitivity provide an estimate on whether the function is normal or not, which is usually sufficient for rehabilitation purposes (Fig. 6.13). A detailed measure of the contrast sensitivity can be obtained with visual acuity charts of different contrasts.

The best way to help people with low vision and poor contrast sensitivity to make a better use of their vision is to increase the contrast between the objects and their surroundings. Examples of ways to overcome poor contrast sensitivity are listed in Table 6.6.

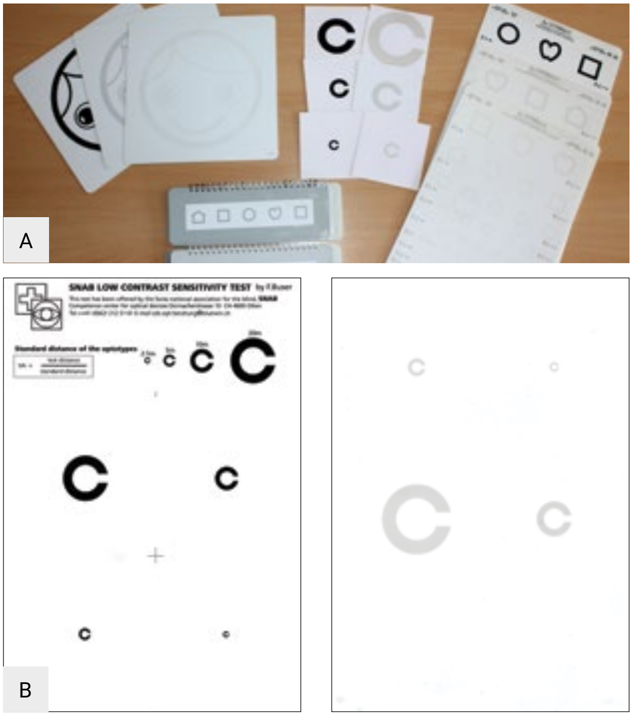


Figure 6.13 The SNAB low contrast sensitivity test. *It is a screening test. The black and white acuity should be measured at threshold. If the person can see the two top Cs (10 and 20 M) at 5 m in black and white (A) and has a normal contrast sensitivity, he should see the two top Cs on the low contrast side of the card (B).*

Table 6.6 **Overcoming poor contrast sensitivity.**

Problems	Recommendations
Seeing small objects	• Put them on a contrasting background • Put objects in good light without glare
Reading	• Insure good quality of prints and copies • Make text and images larger • Follow lines with fingers • Trace over pictures or shapes with a dark pen
Writing	• Use black pens for writing • Use paper with bold lines • Contrast paper with desk surface
Eating	• Contrast the color of the food, plates and table cloth

6.5 Color

People with impaired color vision face a number of obstacles in daily life (Table 6.7). The most common form of color deficiency is inherited and affects the coding of one, two or all three types of cone receptors in the retina (Fig. 6.14). Except in the case of persons suffering from achromatopsia, inherited color deficiency is usually not associated with a significant loss in function.

In low vision, color vision can be used to assess the condition of the center of the retina: loss of function in the macula will result in abnormality in the perception of colors.

Table 6.7 **Signs of problems with color vision**

Activity	Problems
Mobility and movement	Identifying traffic lights
Activities of daily living	Picking clothes Choosing fruits and vegetables
Near tasks	Reading, interpreting pictures

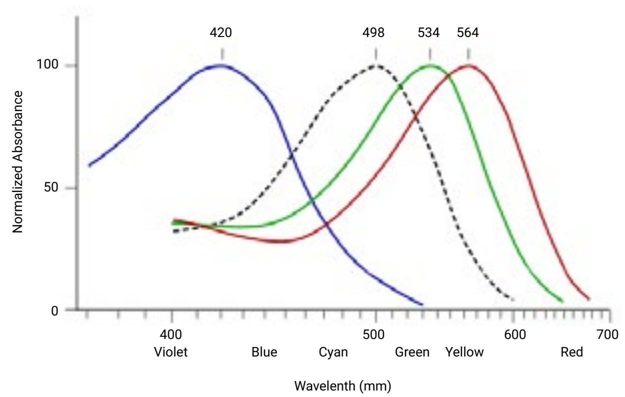


Figure 6.14 **Light and colors.** *There are 3 types of cone photoreceptors in the retina, each one responding best to a specific wave length (420 nm, 534nm or 564 nm). "Cone-response" licensed under CC BY-SA 3.0.*

The Ishihara color test is commonly used and effective to detect inherited red-green color deficiencies in people with full vision (Fig. 6.15). The colored dots used to form numbers can be difficult to detect for a person with low vision, in particular if there is also has poor contrast sensitivity leading to poor test reliability.

In daily life, color deficiencies can be managed relatively easily using environmental cues and simple adaptations (Table 6.8).

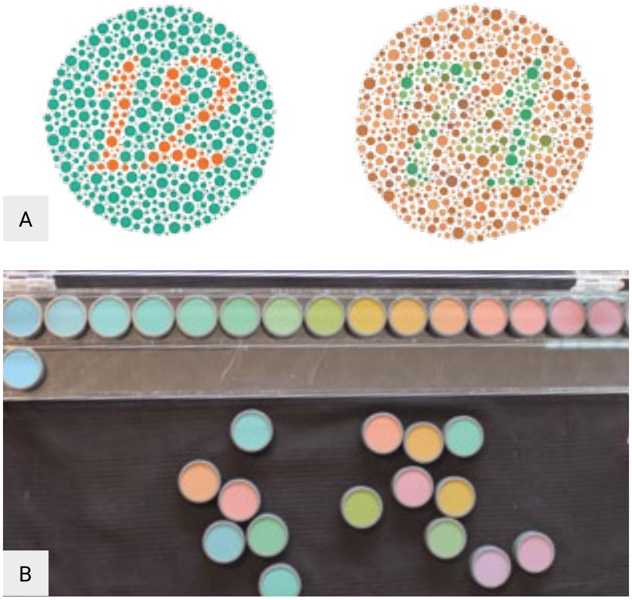


Figure 6.15 **Testing colors vision.** *A) Ishihara test is formed by color plates containing numbers. The image on the left (12) is presented to the subject as an example of the task and a prerequisite before carrying on the test. B) P-15. The task is to order the caps in a color gradient. Illustration: A) "Ishihara Plate No.1" by Nicoguaro licensed under CCO.*

Table 6.8 **Overcoming poor color vision.** *Simple ways to overcome color deficiencies.*

Problems	Recommendations
Naming colors	• Teach the color of common objects and use clues such as color saturation (dark vs. light colors)
Choosing clothes	• Use cloth tags
Reading or looking at images	• Do not use color as the only visual clue in books or class board

6.6 Light Adaptation

Problems with the retina can lead to poor functioning at low levels of light. A sudden decrease in light leads to a change from color vision (all-cone or **phototopic**) to grey vision (all-rod or **scotopic**). Between the two states (only-cones and only-rods), there is **mesopic** vision: low levels of light where colors can be discriminated.

In addition to a change in the types of photoreceptors that are active, adaptation to darkness also includes rapid dilation of the pupil and a change in the retinal sensitivity. During this 20-25 min process, the sensitivity to light increases by 1 000 000 fold. Adaptation from darkness to bright light is a much quicker process and only needs 5-10 min. Functioning at low (mesotopic) light can be estimated using square chips of different colors (Fig. 6.16).

Figure 6.16 **Activity of the photoreceptors after switching off the lights.** *The cones stop working first, then the rods in a much slower time scale. Illustration: "Dark Adaptation" by Dgtdsgn licensed under CC BY-SA 3.0.*

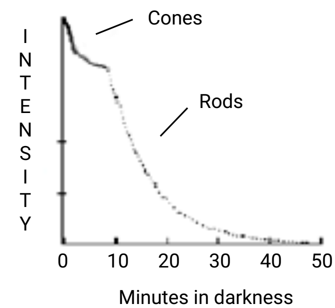


Table 6.9 **Signs of problems adapting to changes in light.** *Examples of the consequences of poor light adaptation on different types of activities.*

Activity	Problems
Mobility and movement	Moving at night in poorly lite areas Going from indoor to outdoor or vice-versa
Daily living	Seeing in the back of cupboards or dark drawers

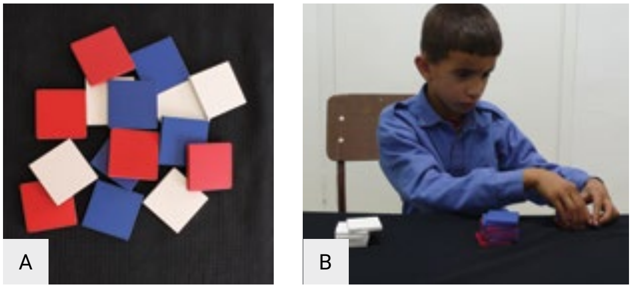


Figure 6.17 **Assessing dark adaptation.** *A) The test consists of blue, red and white squares. The task is to separate them by color in scotopic light. B) The ability to distinguish the red from the blue is a pre-requisite. The boy, who has achromatopsia, can only distinguish the whites.*

Table 6.10 Overcoming slow adaptation to darkness and poor night vision

Problems	Recommendations
Moving from a bright to a dark environment or vice versa	- Take a pause (seconds to minutes) before moving on - Wear sunglasses or filters
Seeing in low light	- Increase the level of light (use torch)

6.7 Visual field

In a person with normally seeing retinas, both eyes provide the brain with a visual field of around 180° on the horizontal plane and 135° on the vertical plane. Because of the retinal organization, we typically use the center of the retina for looking at small things while the peripheral part of the visual field is necessary when we want to move around (Fig. 6.18).

Visual field defects can occur at different levels: retinal, optic nerve or primary visual cortex and take a wide variety of forms. We will divide them into two groups: the peripheral and the central field restrictions. Each visual field defect causes specific problems to the persons affected (Table 6.11).

Because the central part of the retina is where the vision is the best, small defects called scotomas can cause significant vision loss. If the scotoma affects the entire macula, the person will have a poor VA.

On the other hand, a person with small scotomas might have a normal VA (if the symbols on the acuity chart fit in between) but problems reading (Fig. 6.19).

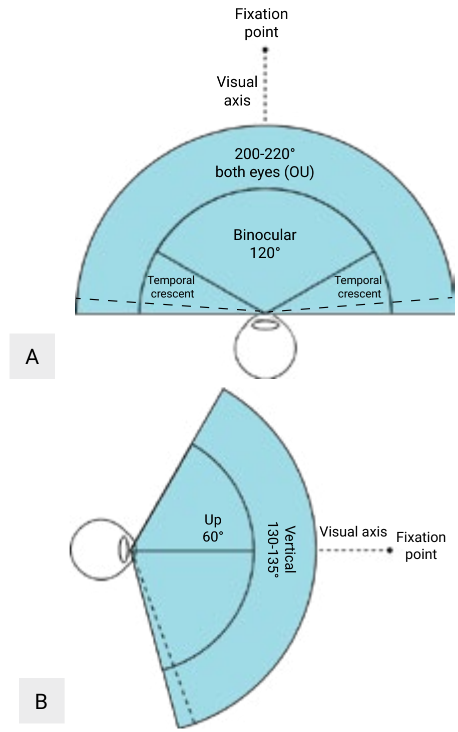


Figure 6.18 **Diagrams illustrating the normal peripheral visual field.** *A) The binocular horizontal visual field. B) The vertical visual field. Illustrations: A) "FOV both eyes" and B) "FOV vertical" by Zyxwv99 licensed under CC BY-SA 4.0.*

Table 6.11 **Signs of visual field restrictions.**

Activity	Problems	
	Central restrictions	Peripheral restrictions
Communication	Making eye contact	Understanding body language Sign language for a deaf person
Mobility and movement	X	Walking (risks of falls) Orientation
Daily living	Recognizing faces Watching TV	Knocks things over Can't find things
Near tasks	Reading	Reading

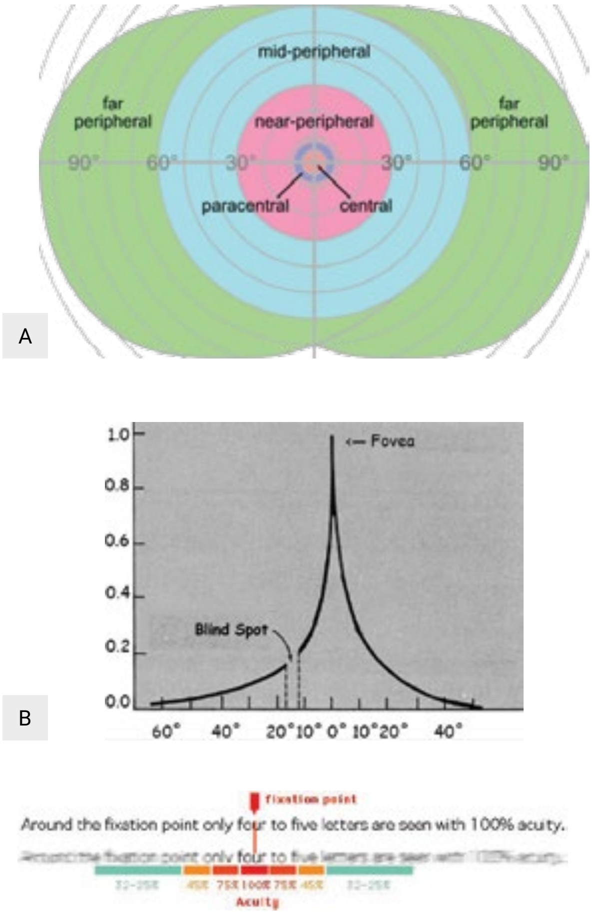


Figure 6.19 **Central visual field.** *A) The peripheral and central visual fields, showed binocularly. The blue circle in the center represents the macula. B) Top: Graph showing that the visual acuity decreases with the distance from the central retina. Bottom: Fluent reading require the central part of the macula to be intact. Illustrations: A) "FOV" by Zyxwv99 licensed under CC BY-SA 3.0. B) Top: "Acuity Human Eye" by Hans-Werner Hunziker licensed with GFDL or CC-BY-SA-3.0. Bottom: "Eye Fixation Reading" by Hans-Werner34 licensed under CC BY-SA 3.0 or GFDL.*

On the other hand, restrictions in the peripheral visual field can severely affect a persons' mobility which is why the WHO definition of LV takes peripheral field loss into account. A person is considered to have LV if the visual field is less than 10º bilaterally, even if the central VA is normal.

When the peripheral loss is significant, it is referred to as **tunnel vision** although the shape of the visual field is actually that of a cone (Fig. 6.21). When the peripheral field damage corresponds to loss of the rods function, the person will also have problems adapting to changes in the level of light (dark to bright areas or vice versa), problems with glare, and in severe cases night blindness (see also Section 6.6).

Figure 6.20 **Simulation of central scotoma.** *A) Normal vision. B) Simulation of the view of a person with a large central scotoma.*

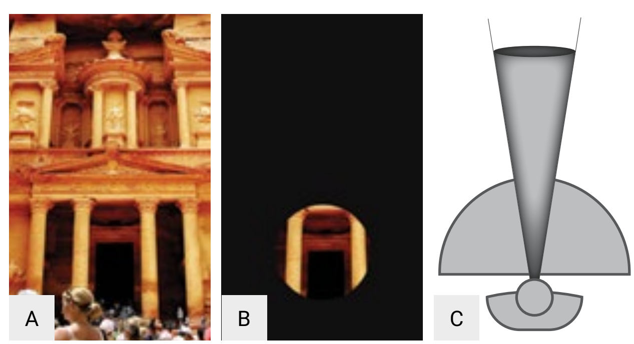


Figure 6.21 **Simulation of peripheral field restriction.** *A) Normal vision. B) Simulation of a limited peripheral field. C) Diagram showing the field of a person with a peripheral field restriction. The size (diameter) of the field depends on the distance between the viewer and the object.*

Perimeters are advanced analytical tools that allow the mapping of the visual field. Field losses can also be measured using screening tools such as the Amsler Grid or the Best Retinal Area (BRA) test for the central visual field (Fig. 6.22 & 6.23) and the confrontational technique for the peripheral field (Fig. 6.24).

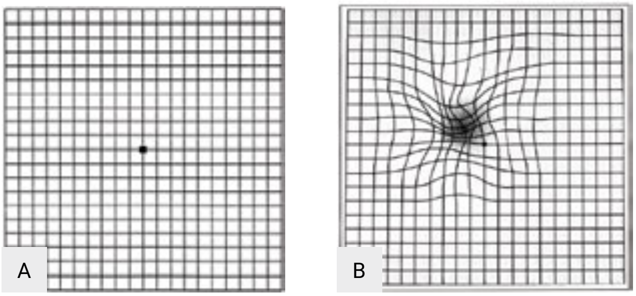


Figure 6.22 Amsler grid. *A) Template. The person should fixate in the center of the grid. B) The grid as seen by a person with central scotoma. The area on the left above the fixation point is distorted. Illustrations: A) "Normal Amsler Grid" and B) "Amsler grid - age-related macular degeneration EC04" by National Eye Institute, National Institutes of Health in Public domain.*

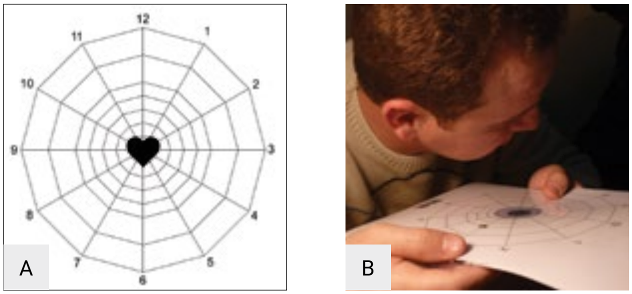


Figure 6.23 Best Retinal Area chart. *A) The test chart includes a fixation target. B) Because of his central scotoma, the best position for the subject to see the central target is with the head tilted.*

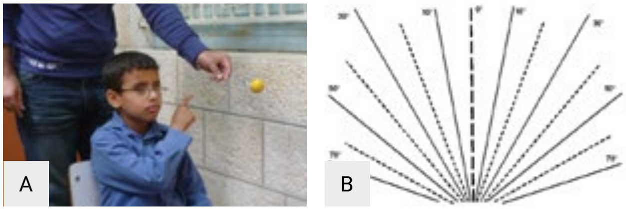


Figure 6.24 Confrontational technique to measure the visual field. *A) The peripheral visual field can be estimated by having the subject fixate a target in front of him and having him detect another object entering his peripheral field. C) The size of the peripheral field obtained with this technique can be more easily approximated if the evaluator has a chart at hand.*

Table 6.12 Overcoming peripheral visual field loss.

Problems	Recommendations
Poor spatial awareness	• Move away from the target to get a wider view • Visual cues and organizational techniques • Multi-sensory approach to gather information • Long cane
Need for increased illumination	• General or task lighting
Sensitivity to glare	• Sunglasses, hats • Positioning away from the light (preferential seating)
Difficulty to adapt to changes in lighting	• Eliminate/reduce extreme changes in illumination • Allow time for eyes to adjust before engaging in activities

Table 6.13 **Overcoming a central visual field loss.**

Problems	Recommendations
Identifying details	• Magnify, move closer to object or bring closer • Increase illumination • Increase contrast • Simplify visual area
Incomplete or “blurred” images	• Train visual skills (eccentric viewing, scanning, tracing, tracking) • Magnify (optical/non-optical)
Color discrimination	• Compare against other contrasting colors • Increase illumination • Memorize
Maintaining eye contact	• Visual skills training (eccentric viewing)
Recognizing people	• Use other sense (voice)

6.8 Higher processing

Problems with higher visual processing are more difficult to recognize and measure than abnormalities in the visual functions discussed previously in this chapter. The contribution of the dorsal and ventral pathways in a given task is often difficult to identify. This is particularly true for children with cerebral visual impairment (CVI), where both pathways tend to be affected (Table 6.14).

Because of the variety and complexity of the functions involved, the assessment of higher visual functions can be done in different ways, using formal or informal tests. Some examples are listed in Table 6.15.

As with blindness, the rehabilitation of persons with problems involving the higher visual centers usually requires compensatory strategies using the others senses.

Table 6.14 **Signs of problem with higher visual processing.**

Activities	Problems		
	Ventral pathway “What?”	Dorsal pathway “Where & How?”	CVI
Communication	Recognizing people’s faces and facial expressions	Seeing lips move while someone is talking	Closes eyes while listening
Mobility and movement	Recognizing places and visual landmarks, spatial memory	Finding places and directions	Lacks visual curiosity
Daily living	Recognizing and naming objects	Grabbing objects	Uses touch to identify objects
Near tasks	Crowding, figure-ground discrimination, visual closure	Copying drawing	Turns head and eyes away before reaching object

Table 6.15 **Assessment of higher visual processing functions.**

Pathway	Examples of tests
Ventral	Matching shapes, angles or length of lines Recognizing faces and facial expressions Visual acuity with crowded symbols
Dorsal	Copying lines and simple shapes Perception of motion

PART II LOW VISION REHABILITATION

7 MAGNIFICATION

Magnifying is simply making things look bigger. It can be done in different ways and not necessarily with optical devices. However, it is important to remember that a blurry image remains unclear even once magnified. In this chapter, we consider four different types of magnification.

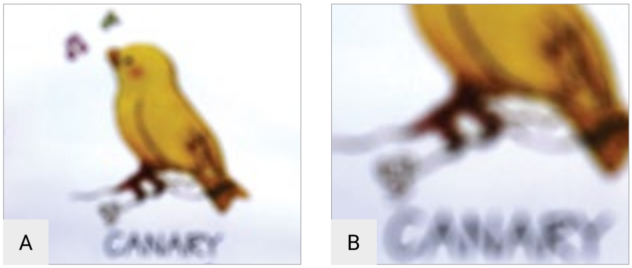


Figure 7.1 Magnification doesn't make a blurred image clear. *A) The image is blurred. B) The same image magnified remains as blurred but the magnified text may become easier to decipher.*

7.1 Relative distance magnification

Decreasing the distance between the object and the eyes makes the object look bigger. This can be done by: 1) moving closer to the object for example sitting closer to the TV or 2) bringing the object closer to the eyes using accommodation or plus (+) lens that will bring the image closer (Fig. 7.2). Relative distance magnification (M_D) is calculated as:

$$M_D = \frac{\textbf{Old distance}}{\textbf{New distance from the object}}$$

Example: a person sitting 3 m from the TV moves to sit 1 m from the TV: the image is magnified $M_D = 3/1 = 3x$

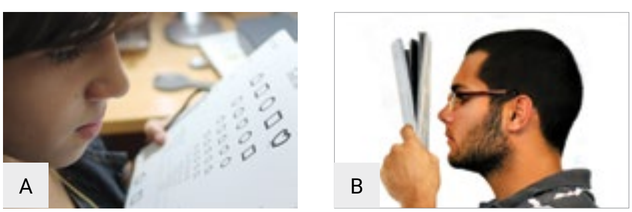


Figure 7.2 Relative distance magnification. *A) Children can easily use their accommodation to see the objects closer. B) When using optical devices, objects need to be moved closer to be at the focal length of the lens.*

7.2 Relative size magnification

This type of magnification involves changing the size of the item to be viewed for example using a larger size of print or a larger clock or watch (Fig. 7.3). Relative size magnification (M_S) is calculated as:

$$M_S = \frac{\textbf{New size of the object}}{\textbf{Old size of the object}}$$

Example: a watch with a 2 cm face is replaced by one with a 5 cm face, the relative size magnification $M_S = 5 / 2 = 2.5$ x.

Figure 7.3 Relative size magnification. *A) The watch to the left has bigger numbers and a better contrast. B) A bigger screen can allow more magnification and to see more words at a time.*

7.3 Real image magnification

This type of magnification includes projecting the image of the object on a screen, such as CCTV, video magnifiers or seeing the object through a clear sphere (bright field magnifier; Fig. 7.4). Real image magnification (M_R) is calculated as:

$$M_R = \frac{\textbf{Height of the new image of the object}}{\textbf{Real height of the object}}$$

Example: the text in a book is 3 mm high. The image seen on the CCTV screen is 30 mm high (3 cm). The magnification $M_R = 30/3 = 10x$.

Figure 7.4 **Real image magnification** *A) The text is read on a TV screen using a mouse CCTV with inverted contrast. B) A child using a dome also called bright field magnifier.*

7.4 Angular magnification

This is when the object is seen through a combination of lenses as in telescopes (Fig. 7). The magnification provided by the device can be calculated using the following equation. At fixed distance:

$$M_{tel} = \frac{\text{Size of the smallest image seen with telescope}}{\text{Size of the image with naked eyes}}$$

Example: when a child is sitting at 1 m from the board, the smallest letters he can read are 20 cm high, while with a telescope, he can read letters 5 cm high. The magnification M_{tel} = 20 cm / 5 cm = 4x.

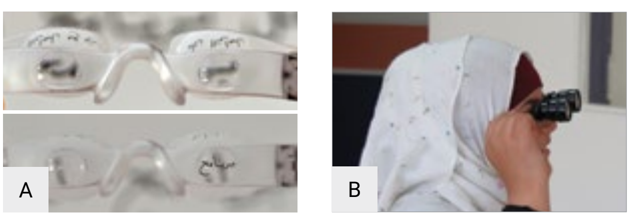


Figure 7.5 **Angular magnification.** *A) MaxTV. The image between the two lenses is inverted. B) Binocular telescope: the ocular (eye piece) is at one end and the objective at the other end of the device.*

7.5 Estimating needs

The amount of magnification a person with LV needs depends on several factors:

- His/her visual functioning (in particular the levels of VA, contrast, visual field)
- The characteristics of the target objects (size and contrast).
- The type of activity (spot or sustained task, on a flat surface or not, always in the same location or not).

It is the responsibility of the LV specialist to make recommendations to persons with LV on the type and size of the magnification they need. Here, we describe two ways to calculate how much magnification is needed.

a. Using the reading chart (for reading at near). The easiest way to calculate the amount of magnification a person needs to read a text is to use a reading chart.

$$\text{Magnification} = \frac{\text{Size of print the person can read}}{\text{Size of print the person wishes to read}}$$

Example: the smallest text a person can read is 16 p and the desired print size is 8 p, the person needs is 16 / 8 = 2x magnification.

Note that when comparing two text sizes, they should be of the same font type since, for example, Arial 9 pts is bigger than Calibri 9 pts (Fig. 7.6). In some cases, it is better to use a ruler and measure the height of the letters.

Figure 7.6 **Comparison of the metrics of the fonts Helvetica Neue, Adobe Garamond and Bickham Script Pro.** *Picture: 'Helvetica Garamond Bickham' by Flamon licensed under CC BY-SA 3.0.*

b. Using the VA value (for near or far tasks). The need for magnification can be estimated using the VA using the following formula:

$$\text{Magnification} = \frac{0.5}{\text{VA of the person with LV}}$$

Example: a person with a VA of 0.1 will need 0.5/0.1 = 5x magnification.

The VA or reading acuity measurements are typically obtained when the person looks for a short period of time (**spot tasks**). To read comfortably for longer periods (**sustained tasks**), the same person will need 2 to 3 x more magnification. This is called the **acuity reserve**. Failing to allow an acuity reserve means the person will find their eyes get tired and they will not be able to continue a task for very long.

Similarly, if a person has poor contrast sensitivity, they will struggle to maintain vision if they are working very close to the level of contrast they can just see. Again to be comfortable people need to be viewing something with significantly higher contrast than their threshold. The levels can be up to 3 times higher than the estimate for spot tasks and 10x for sustained tasks. This is referred to as the **contrast reserve**.

It must be remembered that these calculations are only an estimate to guide the practitioner: the final amount of magnification prescribed should be assessed in the test room before being issued to the user taking into account the task, target, and characteristics of the user (Table 7.2).

Table 7.2 Special considerations when prescribing magnifying spectacle to children and older people.

Child	Elderly
• Accommodation: less magnification (around 50%) may be needed • Happy bringing things closer • Sensitive to peer pressure • More likely to damage devices	• Presbyopia: more power is needed for near tasks • Reluctant to move text closer to the eyes • Physical limitations such as tremor

Examples

Without his distance glasses, the largest font size the man can just read at 25 cm is 24p. To read 8p he needs 24/8 = 3x magnification.

If he wants to do read the newspaper (sustained task) he will need 6x.

If the child can read the 2M line at 8 cm, his VA = 0.08/2 = 0.04. To reach 0.5 he needs 12.5x magnification but since he can accommodate, he might need only half, that is around 6x.

If he wants to study (sustained task), he will need 12x.

7.6 Combining methods

It can be useful to combine two magnifiers, in particular if they are of different types. When this happens, the following principles should be remembered:

- If the magnification methods are **different**, the magnification factors will be **multiplied**. For example using 2X Dome (real image) and coming 3x closer to the text (relative distance) results in $2 \times 3 = 6$X magnification.
- If we magnify more than once using the **same** type of magnification, the magnification factors will at best be **added**. For example, using a laptop screen 2x larger and magnify the print 3X bigger, both using relative size magnification, the total amount of magnification provided is $2+3 = 5$X magnification.

PART II LOW VISION REHABILITATION

8 MAGNIFIERS

Before people agree to use visual aids they need to accept the implications of visual impairment. A person with LV who expects to see things clearly again with a simple pair of new spectacles will be highly disappointed.

8.1 General principles

Spectacles, stand magnifiers, and hand magnifiers are available in a range of different powers to suit different tasks and different people. Optical magnifiers for near tasks are made of plus (+) lenses and the higher the power, the higher the magnification. higher magnification. As a consequence, compared to low power magnifiers, devices with high power of magnification have (see also Section 8.3):

- thicker lenses with smaller diameter
- more aberrations at the periphery
- smallerfield of view
- shorter focal length (Table 8.1)

8.2 Spectacle Magnifiers

Spectacle magnifiers can be divided into 3 groups based in the power of the lens: low power (below +8D); high power (+8 to +16D), and highest power (+18 to +48D). The different types are illustrated in Fig 8.1. Spectacles can be used binocularly up to approximately 3x magnification (+12D). If the power needed is less than 16D and the person has a refractive error, he or she can use bifocals. Although it is more convenient to have bifocal glasses, some people have difficulties adjusting to them especially when moving. In this case, it is better to have two pairs of glasses, one for distance and one for near.

Table 8.1 Example of magnification and focal lengths for plus (+) lenses. *Magnification = Power D/4D; Focal length (cm) = 100/Power.*

Power	Magnification	Focal length
+8.00 D	2x	12 cm
+16.00 D	4x	6 cm
+24.00 D	6x	4 cm
+32.00 D	8x	3 cm

Figure 8.1 Spectacle magnifiers. *A) Binocular spectacles with prisms. B) A child using binocular spectacles (+8D) with base in prisms. C) A teenager looks at the screen of a mobile phone using monocular spectacles (+16D). D) Monocular spectacle with aplantic lens (+32D).*

Tip 1: When selecting the frames, round rims are preferable over rectangular ones: they offer the chance to look through the lenses even if the frame slips down on the nose. Small frames are more suitable for thick (high power and heavy) lenses while large frames provide a bigger field of view. So, they should be as small as possible but as big as necessary.

Tip 2: Adjusting the frames is particularly important if the lenses are heavy. It should be done behind the ear (temple end) and on the nose pad.

Table 8.2 Advantages and disadvantages of magnifying spectacles.

Advantages	Disadvantages
• Wide range of magnification (1x to 12x) • Good field of view • Both hands free • Can be used for long periods • Socially acceptable	• Exact reading distance • High power need short distance and good lighting • Binocularity hard • High power expensive

8.3 Hand magnifiers

Hand magnifiers are magnifying lenses mounted with a handle. They are very common and convenient to use (Fig. 8.2). The viewer controls 1) the distance between the lens and the object and 2) the distance between the lens and the eyes.

Ideally, the lens is held at approximately the focal length of the lens from the object (Focal length (cm) = 100 / Power). As long as the magnifier is held at the same distance from the object, the optical magnification remains the same even with different eye-to-lens distances, but as the distance from the magnifier to the eye increases, the field of view rapidly gets smaller (Fig. 8.3).

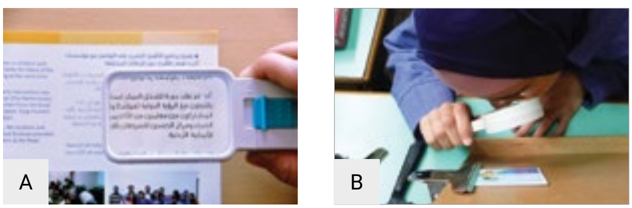


Figure 8.2 Hand magnifiers. *A) The rectangle shape is more appropriate for reading (9D or 2.25x magnification). B) When used very close to the eye, the hand magnifier acts as a monocular lens (4x magnification).It can be particularly useful for people using eccentric viewing.*

> **Tip 1**: The field of view is best when used closer to the eye, as a monocular. This is useful when high power is needed and not available in spectacle form (Fig. 8.2).
>
> **Tip 2**: When carrying out a sustained task, the eye should be no further away than twice the focal length of the lens. For a short (spot) task, the eye should be no more than 4 focal lengths away from the lens (Fig. 8.4).

For example, with a 20D hand magnifier (focal length 1/20 = 5 cm), the eye should be no further than 5 x 2 =10 cm from the lens, and for short visual tasks (spot) no further than 5 x 4 = 20 cm from the lens.

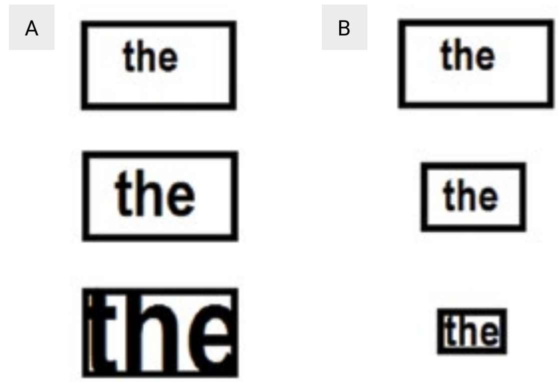


Figure 8.3 What does increasing eye-to-lens distance do? *Example of a hand magnifier used a different eye to lens (the lens stays at the same distance from the text). A) The image seen by the viewer: as the eyes move away from the text (top to down), the word is filling up more of the view. B) In reality, magnification is the same although it is perceived to be greater as words are filling more of the lens. Illustration: Andrew Miller.*

Figure 8.4 A 3x magnifier (+12D) used with two different tasks. *A) For a spot task (reading a label), the hand magnifier is used at 33 cm from the eye. B) When used for long periods of time, such as when reading, the distance between the lens decreases by half. Note that the distance between the text and the lens remains the same (8 cm). See also Table 8.4.*

Table 8.3 **Advantages and disadvantage of hand magnifiers.**

Advantages	Disadvantages
• Eye to target distance can vary • Can be used binocularly • Portable • Socially acceptable • Easily available	• Need one stable hand

Table 8.4 **Lens power, focal length and working distance.**

Lens Power	Focal Length (magnifier to page, cm)	Eye to Magnifier distance	
		Spot task (cm)	Long task (cm)
8D	13	50	25
12D	8	33	17
16D	6	25	13
20D	5	20	10
24D	4	17	8
28D	4	14	7
36D	3	11	6
40D	3	10	5

8.4 Stand magnifiers

Stand magnifiers are useful when magnification is needed for sustained tasks, or if the hands cannot adequately hold the device. These magnifiers have a support to ensure the distance between the object and the lens (focal length) is correct as it is fixed (Fig. 8.5). Because of the support, they often need additional lighting.

Tip 1: To get the best image quality, accommodation or reading glasses may be needed. The amount of reading add will vary with the working position and the device, so simply do a check with flip lenses to find the correct power of add to the nearest 1D.

Tip 2: Use the stand at a comfortable distance when the magnification need is low.

Table 8.5 **Advantages and disadvantage of stand magnifiers.**

Advantages	Disadvantages
• Fixed working distance • Holds the lens at correct angle to text • Possibility of binocular use • Writing under it possible	• Bulky • Needs flat surface • Needs accommodation or reading glasses

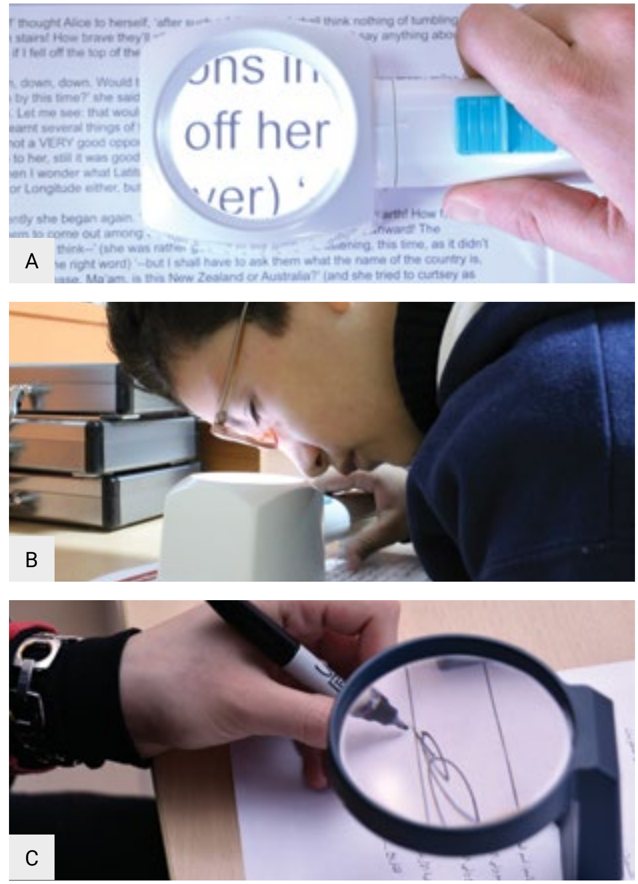


Figure 8.5 **Stand magnifiers.** *A) The illumination is particularly useful for those with central scotoma as it allows wider field of view and increased reading speed (+16D magnifier). B) The user can keep his glasses that correct the refractive error (3x illuminated). C) Some stand magnifiers allow writing underneath (3x magnifier).*

Table 8.6 **Should a magnifier have built in illumination?**

Advantages	Disadvantages
• Reduces small relative scotoma • Increases VA (by increasing contrast)	• Adds weight • Requires access to batteries or power • Might produce glare

8.5 Bright field magnifiers

Also called visolett, dome or flat field magnifiers, they produce between1.5x and 2.2x magnification. They are clear balls (plastic or glass): the larger the proportion of sphere used the higher magnification but the lower the field of view (Fig. 8.6).

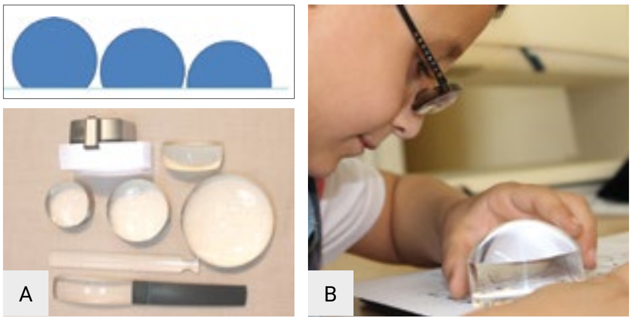


Figure 8.6 Dome magnifiers. *A) Bright filed magnifiers come in a variety of shapes. The larger the proportion of sphere used the higher magnification but the lower the field of view. B) The child can use the dome with his own prescription (correcting the refractive error). Illustration: A) Andrew Miller.*

The diameter of the dome determines the field of view but also the weight of magnifier. If the user can accommodate (child), these devices can be combined with relative distance magnification (move closer) to supply greater magnification effect. For example, the 2x magnification produced by the dome magnifier can be increased by 2.5x as the child has moved from 25 cm to 10 cm and the total magnification reached is 2 x 2.5 = 5x.

Table 8.7 Advantages and disadvantages of bright field magnifiers.

Advantages	Disadvantages
• Simple to use • Brightens objects • Combines well with accommodation • Possibility of binocular use	• Needs flat surface • Low magnification power

8.6 Telescopes

Telescopes can be helpful to most persons with a visual impairment. They are magnifiers composed of at least two lenses mounted in a tube. There are two types: Galilean and Keplerian (Table 8.8). As with the other magnifiers, stronger telescopes have a higher magnification but a smaller field of view than weaker ones. Compared to monocular telescopes, binoculars are simpler to use, easier to hold steady, offer a larger field of view and are cheaper. However binoculars are bulkier and will not focus as close as monocular telescopes (Fig. 8.7).

Mounted telescopes (monocular or binocular) are useful for sustained tasks. In certain parts of the world, bioptic telescopes are used by persons with VA as low as 0.2 for driving cars.

Table 8.8 Comparing two types of telescopes.

Property	Galilean Telescope	Keplerian Telescope
Lenses	+ and –	two +
Magnification	1.2x to 4x	2.75x to 10x
Image quality	Poorer	Better
Weight	Lighter	Heavier
Size	Smaller, shorter	Larger, longer
Price	Less expensive	Expensive

Tip: The closer the telescope is to the eye, the bigger the field of view. Spectacle wearers should use telescopes as close to the eye as possible. Therefore they should either take their spectacles off or fold the rubber eyepiece backwards to allow maximum field of view (Fig. 8.7).

Table 8.9 Advantages and disadvantage of telescopes.

Advantages	Disadvantages
• See objects at intermediate and far distances • Portable	• Need training • Small field of view • Low social acceptability

Figure 8.7 Telescopes. *A) When using binocular telescopes (3x), the focus should be done for each eye. B) The 4x monocular telescope is in contact with the spectacle lens. C) Max details (2x) for work at intermediate distance. D) Bioptic telescope (4x).*

Figure 8.8 CCTV. *A) The device can be used for personal grooming. B) In another model, the camera can project at the black board allowing the student with low vision to read to lesson content from the screen on her desk. C) Mouse magnifier. It looks like a regular computer mouse. The camera is filming the text, which is seen on a TV or computer screen.*

8.7 Electronic magnifiers

a) Closed Circuit Television (CCTV)

This electronic magnifier consists of a camera projecting the image of an object on to a screen. CCTVs provide a wide range of magnification (2x to 70x). In addition, they allow enhancement or adaptation of contrast which is particularly useful for persons with reduced contrast sensitivity. The traditional CCTV is a desk top and bulky device. In recent years, CCTVs have been made more portable and adaptable. For example, students can use a camera to capture the text on a school board and look at the magnified image on a laptop (Fig. 8.8).

The most affordable CCTV are the mouse magnifiers that can be connected to a normal TV or computer screen.

Table 8.10 **Advantages and disadvantages of CCTV.**

Advantages	Disadvantages
• Wide range of magnification • Contrast and colour can be changed • Allows binocular use • Flexible working distance	• Cannot be transported (most) • Great expense • Image and hands at a different place (lag) • Need training • Need power source

b) Portable EVES (Electronic Vision Enhancement Systems)

In recent years, a new generation of video magnifiers has emerged which have a built-in screens that vary from 7 to 18 cm (3”-7”) in size.

In addition a number of mainstream electronic devices commonly available today can be used for magnification: digital cameras (alone or in cell phones) allow the user to zoom on an object, take a picture then magnify it to look at it (Fig. 8.9).

Figure 8.9 Video magnifier. *A) This small video magnifier offers the option to reverse the contrast. B) The camera of a smart phone can also be used as a video magnifier for near and C) as a telescope for distance. Even more magnification can be obtained by magnifying the picture.*

c) Computer magnification

Computers increasingly have a range of accessibility features built in. These can allow screen magnification, change of contrast or size of mouse pointer, or use of text into speech such as magnification Windows 7 (Windows key and +), Voice Over and zoom on iPad (Fig. 8.10). In addition, special programs such as Zoomtext can be bought to produce even more flexibility in changing access to electronic print.

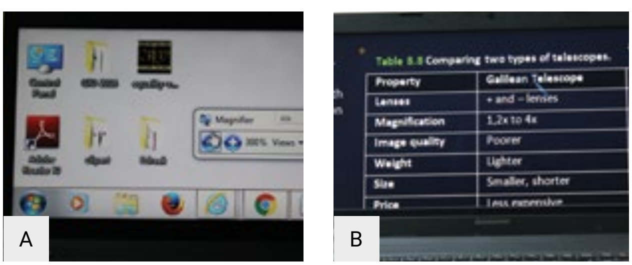


Figure 8.10 Computer magnification. *Nowadays, most operating systems offer accessibility options including A) magnification and B) reversed contrast.*

8.8 Final decision

Choosing the most suitable magnifier involves not only knowing the properties of the devices on offer, but also whether or not they will be suitable for the person and the required task. Generally, visual tasks are divided into categories: near or far and spot or sustained (Table 8.11 and Fig. 8.11). Spot tasks are those that require vision for short period of time such as reading labels or looking at a watch. These tasks can be done with lower magnification (near threshold VA) and with magnifiers that are portable for example hand magnifiers. Sustained tasks like reading a book require higher magnification (2-3x threshold) and magnifiers that are comfortable for example spectacle magnifiers.

How to find the correct magnifier?
(see also Tables 8.12 and 8.13)

1. Consider the results of the functional vision assessment (in particular VA, visual field, contrast and reading acuity).
2. Determine the characteristics of the tasks (distance and duration).
3. Estimate the power of the magnification needed.
4. Offer the person a small object or short text to look at before giving him/her a magnifier with a power slightly weaker than estimated.
5. Record your findings with this device (size of object seen and comfort) then offer a stronger magnifier.
6. Measure and discuss with the person which is the most appropriate device for the task needed.

Table 8.11 **Types of magnifiers and types of tasks.**

Type of Devices	Near Tasks		Far Tasks	
	Spot	Sustained	Spot	Sustained
Spectacles	√	√	-	-
Hand	√	-	-	-
Stand	-	√	-	-
Telescope	-	-	√	√
Electronic	√	√	√	√

Figure 8.11 **Types of tasks.** *A) Spot task are those that requires magnification for seconds, such as reading a label. B) Sustained tasks such as reading the newspaper are done for long periods of time and require more magnification.*

Remember:

1. Less power involves seeing less details but having better working distance and wider field of view.
2. Most children accommodate to get some or all of the magnification needed.

Individual factors:

- Type of visual defect
- Size of visual field
- Stability of the hands
- Ability to be trained
- Need for extra light
- Sensitive to social acceptability

Task requirements:

- Type (spot or sustained)
- Distance (near or far)
- Hands (one, two or none)
- Specific working distance
- Type of surfaces (flat or not)
- Location (single or multiple)

PART II LOW VISION REHABILITATION

9 NON-OPTICAL DEVICES

Besides magnifiers, there is a variety of tools people with low vision can use to improve their visual functioning. These aids typically help dealing with contrast, glare, crowding, or posture. Non-optical aids can be used with or without magnifiers, and in combination with each other.

Some examples are listed in Table 9.1 and illustrated in Fig. 9.1 to 4.

Table 9.1 Examples of non-optical visual solutions.

Problem	Helpful tools	Other options
Contrast sensitivity	• Paper with bold lines • Felt pens • Table lamp	• Change colors of objects or background • Bring more light to the object
Glare	• Special filter lenses, sunglasses, or photochromatic lenses • Cap or visor • Typoscope	• Change position (in space) • Put up curtains
Visual Crowding	• Writing guide • Signature frame	• Clear table top from unnecessary objects
Maintaining posture	• Reading/writing stand or desk	• Place the elbows on the table while holding the book

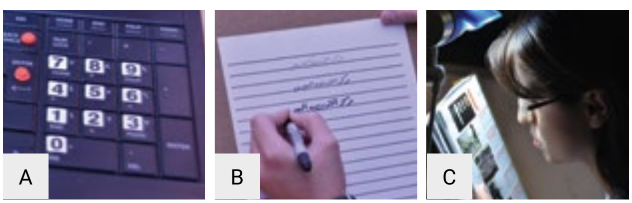


Figure 9.1 Increasing contrast. *Contrast can be improved easily by A) placing stickers with contrasting colors on tools and instruments, B) using felt pen and paper with bold line or C) providing better lighting.*

Light filters are a special category of non-optical aids. They are particularly important for persons who are very sensitive to light and photophobic, but also for those who suffer from glare. Good quality sunglasses should block all the UV light with wave lengths below 400 nm. On the other hand, there are special filters that target the light below a specific wave length. For example, the 450 nm filters block the majority of the light waves below 450 nm while the light above this frequency can go through. So, the higher the wavelength blocked, the darker the glasses (Table 9.2).

Figure 9.2 Decreasing glare. *The amount of glare can be better controlled with A) a typoscope that covers part of the white page to make reading easier, B) a cap or visor that protect from bright light or C) sunglasses that have side shields. Photo: B)"Baseball cap" by TexasRebel in Public Domain.*

Filter lenses offer protection outdoor from the sunlight while lighter ones can also be used indoor. Although people with certain eye disease tend to prefer specific wavelengths, the choice is subjective and requires the person try it in the real situation. If tinted lenses are to be worn outdoors, the person should try them outside.

People with refractive errors need to have the prescription included in the filter, or to wear clip-on filter lenses over their distance glasses. Finally, filter lenses increase the subjective brightness (people feel vision is improved) but may influence colour vision.

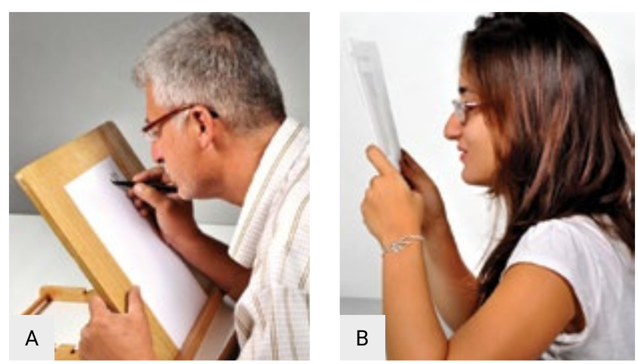


Figure 9.3 Improving posture. *The short distance between the lens and the object can be maintained A) using a stand or B) by putting both elbows on the table.*

Table 9.2 Examples of properties of filter lenses. *CPF: Corning Photochromic Filter.*

Wave length (nm)	Color	Frequently used for	Property
450	Yellow	Optic atrophy, albinism, pseudophakia	Lightly coloured, enhances contrast and helps control glare indoors
510	Orange	Macular degeneration, cataracts, glaucoma, aphakia, optic atrophy	Moderate blue light filtering
CPF 527	Orange-amber	Diabetic retinopathy, photophobia, RP	Darkens to brown in sunlight, gives better visual function and reduced glare

Figure 9.4 Filter lenses. *A) Testing two different wave lengths, 511 and 527 nm. B) A young woman with RP who chose 450 nm for outside. C) A man with RP chose darker polarized filters (P1 550 nm) for outside and the 450 nm for inside. D) Clip-ons (450 nm) added to a distance prescription.*

PART II LOW VISION REHABILITATION

10 VISUAL TRAINING

Persons with low vision and their relatives should know that reading very small things for long periods of time will make the eyes tired but will not damage them. On the contrary, trying to save the children's eyes through minimize using them impedes the development of the visual system and results in poorer visual skills.

10.1 Visual skills

Visual functioning varies widely among persons with low vision: two persons with the same diagnosis and similar assessment results can have very different visual behaviors depending on the devices they use and the training they receive. In addition to their access to rehabilitation services, the age of onset of the impairment is a key factor to explain the variations in visual performances between individuals. Interpreting a blurred image is easier for people who lost vision late in life (they can use their visual memories) than for those born with low vision who have limited visual experiences.

Children with congenital low vision may need to be encouraged to use their vision and also trained to develop basic visual behaviors:

- Attending
- Shifting gaze
- Matching
- Fixating
- Scanning
- Moving hand toward object
- Following a line
- Observing details
- Following a moving object
- Identifying

Figure 10.1 Stimulating basic visual behavior using illuminated objects. *A) The child is enjoying looking at the bright red flower. B) A girl with very poor vision is learning the shapes using a light box.*

Once the basic visual skills are acquired, children with low vision need a good vision stimulation program to develop a greater efficiency in the functional use of their vision. Vision training programs should be interesting and relevant to the children's needs and interests. The training should also take into consideration the following factors:

1. Visual desire (motivation to use vision, curiosity to see).
2. Visual confidence (using visual cues to move, do things).
3. Visual efficiency (developing visual skills such as scanning and tracking).
4. Visual memory (interpreting visual cues based on previous experiences).
5. Special visual strategies (see also Section 10.2).

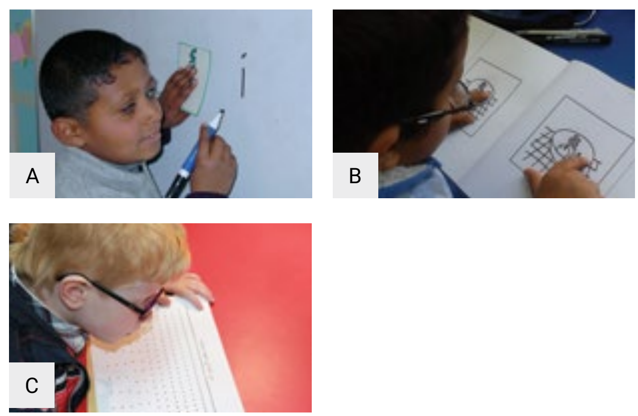


Figure 10.2 Developing visual confidence. *To motivate the children with low vision to use their remaining sight, they should be offered opportunities to do visual tasks that are fun for them such a A) copying, B) matching or C) drawing or connecting dots.*

10.2 Special strategies

a) Null point for nystagmus

The rhythmic movements of the eyes seen in certain persons with low vision are called nystagmus. Movements of large amplitude tends to be related to poor visual acuity and absence of binocularity.

The properties of the oscillations can vary in a given person: the frequency and amplitude of nystagmus tend to increase with monocular occlusion, while the oscillations might decrease if the person's refractive error is corrected or with filter lenses if the person is photophobic. In addition, people with nystagmus often have an optimal visual angle (direction of gaze) where the frequency is lower (**null point**). They can be trained to find the null point and to use it for example while reading with the steady eye technique (moving the text while keeping the eyes in the same position).

b) Eccentric viewing for central scotoma

When the macula is damaged, VA is usually below 0.05 but other parts of the retina can be used with magnification. Persons with a central scotoma can be trained to find the **best retinal area** (BRA) for a given distance. This should be done by systematically testing the peri-macular areas to find where vision is optimal. Once the person has located his BRA he can be trained to use it (Fig. 10.3).

As for persons with nystagmus, people using eccentric viewing should move the text while reading in order to keep the direction of the gaze.

red sad can bad

Figure 10.3 Fixation line for training to use eccentric viewing. *If the person sees better when looking up (above the line), he should be trained to read while fixating a line drawn above the words.*

c) Scanning for tunnel vision

Some eye conditions such as RP or glaucoma are characterized by a loss of the peripheral visual field. The main consequence of peripheral visual field restrictions is problems avoiding obstacles while walking. To move safely, persons with tunnel vision need to develop scanning or sweeping strategies with both the head and the eyes to see what is below eye level or sideways.

Damages to the peripheral retina (and to the rod system) also affect the adaptation to changes in levels of light so people with tunnel vision need to take time when moving from very bright to low levels of light or vice versa. In dim light such as during the night, they may experience night blindness and need to be trained to use a long cane and visual clues.

Reading with a narrow field of view can also be challenging. The number of characters in each fixation field plays a key role in determining the reading speed, and as a consequence, a person with a peripheral field restriction or using a magnifying device will need more time to read a given text than the person with a normal vision who has the same reading abilities. For this reason, people with tunnel vision who also have poor visual acuity will use the lowest possible magnification to make the fixation field wider (allow more words to be seen at once) or a minifier (Fig. 10.4).

Tunnel vision *View with minifier*

Figure 10.4 Minifier. *A) A Person with tunnel vision testing a device (ML RP, 0.5x). B) In the resulting image (bottom), objects are smaller but the visual field is larger than the one allowed by the tunnel vision (top).*

10.3 Use of aids

All visual aids need to be introduced to the user by a professional. This first contact with the device should involve learning:

1. The names of the parts (handle, lens, eye piece, frame).
2. The properties of the device (magnification provided, optimal distance).
3. How to use it (adjust the focus, keep the right eye-object distance).
4. How to keep it (cleaning of the lenses, storing the device, changing batteries).

When training a person with low vision to use a given visual aid, three aspects need to be kept in mind (Fig. 10.5):

1. **Lighting.** Identify a suitable location for the training, insuring adequate light and no glare.
2. **Posture.** Find a comfortable position for the trainee that takes into account the working distance. Using a reading stand or leaning table top can help avoid muscle ache caused by bending on a table.
3. **Content.** Choose interesting and meaningful reading or target material to look at.

The CCTV and the monocular telescopes are the devices that are the least intuitive for the users and may need the most training. High power telescopes offer a small field of view which makes it difficult to the look at the correct target. At first, to make it easier, the trainer should adjust the focus of the monocular on the target (the optical focus varies with the distance, not between viewers if they don't have a refractive error). With time, the user will learn to adjust the focus to the target and also to interpret the images, since only a fraction of the object is visible at once.

Figure 10.5 Training to use visual devices. *A) The trainee should receive something meaningful to do with the magnifier. The father of this young man is a tailor. B) Children books should be available for the young service users. C) A good posture will allow the service user to use the device for longer periods of time. D) Bending over the table may make the use of the magnifier more tedious than it should.*

Figure 10.6 Telescope. *Children using telescope in young ages will need more training than others.*

PART III OTHER AREAS OF INTERVENTION

11 EARLY INTERVENTION

Early intervention refers to the support provided to children with disabilities from birth to 5 or 6 years (pre-school age) and their families. This special care is divided into two types, the support to the families and the promotion of the child's development.

11.1 Supporting families

Having a child with disabilities is an ordeal for most parents. Professionals providing early intervention services help families with two aspects of the situation: the emotional and educational aspects.

a) Emotional issues

Parents can be angry or depressed because of their child with disability, or worried about his future. These feelings can be triggered by stressful events for example the diagnosis, the start of kindergarten (school) or a careless remark from relatives or neighbors. The coping process varies greatly from one family to another depending on the parents' strategies but also on the support provided by the extended family, community, and society. Professionals working with families need to listen to the parents' concerns and answers their questions in a simple and honest way.

b) Parenting

The parents of a child with VI are likely to have uncertainties regarding his upbringing and their own abilities to support it. Professionals can comfort them in their child rearing practices by providing information on the particular developmental needs of their child, modelling good practices, and giving specific advice. Examples in three key developmental domains are given below.

Affection and bonding. Parents need to compensate for missing eye contact by making optimal use of touch and hearing. For example:

- Cuddle him but also make him swing, and carry him around so he can better develop his balance and posture (Fig. 11.1).
- Tell the child where you are, what you are doing, how you feel and what is happening. He will feel more secure.
- Create routines and rituals. It will give the child the feeling of belonging and control.
- Verbalize their feelings and wishes to compensate for the fact that the child with VI cannot read their facial expressions.

Play. For children with VI like for their sighted peers, social interactions in the early years often take the form of play. Examples of suitable games to play with a child with VI include:

- Touch and name the body parts (his, yours), take turns.
- Repeat and imitate sound patterns, songs and nursery rhymes.

Figure 11.1 Physical play is important to develop balance. *A father plays with his daughter with low vision.*

When the child is old enough to play with simple toys (blocks or balls), he needs to be showed.

Tips for Carer:

- Give the child time to react and understand what is happening.
- Encourage the use of touch and hearing.
- Use hand-over-hand or hand-under-hand techniques with verbal descriptions when modeling manual activities (Fig. 11.2).

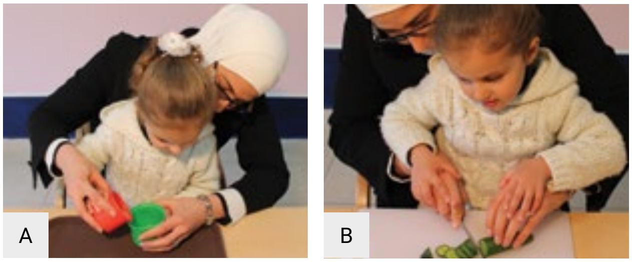
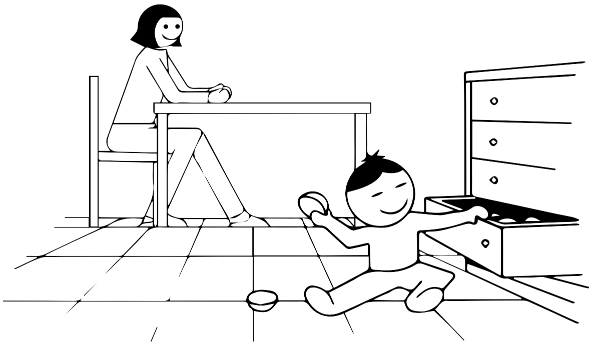


Figure 11.2 Helping just enough. *Hands over hands technique (A) allows the child to receive guidance while gaining direct experiences. For dangerous tasks like cutting (B), the child puts her hands under the ones of the adult (hands under hands technique) to understand the sounds she hears from the kitchen.*

Social behavior. Parents need to promote social interactions and teach social rules to their child with disabilities in a similar way they teach their other children. They should explain the social situations their child cannot observe. They should not to be over-permissive or overprotective, but rather grant increasing freedoms and encourage autonomy while giving consistent rules.



11.2 Promoting development

The goals of the intervention and the strategies used are based on the assessment of the child's skills while taking into considerations the familial and social situations. In most cases, the promotion of the child's development implies first dealing with the developmental challenges.

a) Challenges

In the first years of life, children's desires to move, discover and understand are largely driven by what they see. When a child cannot look at the world around him because his vision is impaired, the learnings other children acquire by observation and imitation can only be partially compensated by touch, hearing, verbal explanations or cognitive reasoning. As a result, children with VI face specific challenges and their developmental milestones are delayed compared to those of sighted children. In order to provide meaningful intervention, it is essential to realize the particularities of children growing with little or no vision. In the sections below, the developmental areas with the greatest differences are presented first.

1. **Orientation** in space is extremely difficult for persons with blindness or low vision. Vision is the dominant sense to be oriented and recognize one's own position in relation to the environment and to other people or objects. Touch is restricted to the near space and sounds can only be processed one by one, combining the information requires more time, training and cognitive abilities than when vision is available.
2. **Manual skills** such as grasping an object, building a tower of blocks, or using a spoon take longer to learn if the child cannot see how others are doing. In typically developing children, the fine-tuned manual coordination is guided and learned via vision so children with impaired vision need lots of experiences to develop fine motor skills.

3. **Gross motor skills** including walking, running, and jumping will be delayed if there is no visual target to motivate the child to do his first steps. In addition, posture and balance are more difficult to acquire without visual support.
4. **Social interactions** are challenging when it is not possible to observe what others are doing, their facial expressions and gestures or to make eye contact.
5. **Special behaviors** can be observed in children with severe VI and blindness.These stereotypical behaviours, which are repetitive movements typically elicited when the child is bored, stressed or undergoing intense emotions such as excitement or happiness (Fig. 11.3).
6. **Concept development** is essential to the building of basic cognitive skills. A child born with poor or no vision has problems developing concrete concepts (objects, distances). Abstract concepts will require more time and special attention if vision is not there.

Fig. 11.3. Eye poking. *A common behaviour among children with congenital blindness which can cause the loss of remaining vision and cosmetic issues (deepening of the eyeb ball in the orbit).*

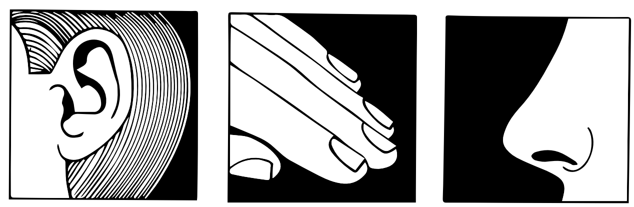
b) Stimulations

The development challenges faced by children with VI can be largely overcome with intervention programs that use strategies and activities appropriate to the child's developmental stage. Here are a few guidelines.

Pre-verbal phase. Before the child starts talking, there are two main avenues to compensate for the vision loss.

Tip 1: Encourage the use of other senses. Children should learn to use hearing, touch and smell along with the remaining vision (if present) in a playful way. The intervention should be fun for the child, structured, use a few simple objects, allow time for the child to understand it and be part of his play repertoire.

Tip 2: Stimulate the use of visual skills. Children born with poor VA often need to be helped to understand the visual information available to them. A visual stimulation program will help them optimize the use of their residual vision. In addition, the children might also need instruction in new viewing techniques like eccentric viewing or scanning (see also Section 10.2).



Children learn by playing so all activities should be embedded in a play situation. Parents usually need help choosing the appropriate play materials. Below is some advice concerning learning material and play space. (Fig. 11.3).

1. Noise-making objects are very important for infants with VI (before 2 years): they help them learn hand-ear or hand-eye coordination (reaching and grasping), moving (trying to catch a ball with a bell) as well as cause – effect relation (pushing a key on a piano to produce a sound).
2. Everyday objects (spoon, comb) or natural material (plants) with different textures that stimulate manual exploration provide the child with concrete experiences. At preschool age, toys or domestic objects can be used to develop cognitive skills such as matching, sorting, arranging things in rows.

3. If the child has residual vision, play materials should have good contrast, bright colors or light, depending on how much detail can be seen.
4. Play area should be delimited. Allocating a corner in a room where the child can find his toys will help him develop spatial concepts.
5. Additional notes:
   - Typical symbolic toys such as dolls and cars can be difficult for blind children. Realistic, everyday objects reflecting their personal experience are better at promoting symbolic play.
   - Soft objects with no clear form can offer interesting tactile stimuli but no clear information on the shapes of objects or their function.

Verbal phase and onwards. From the age of 3 or 4 years, typically developing chidren with VI have acquired enough verbal understanding and cognitive reasoning to understand things they can not see via language and tactil models (if real objects are not available). With these methods and good schooling, the gap in the development between VI and sighted will gradually decrease. On the other hand, problems in orientation and mobility as well as in activities of daily living will persist during the whole life.

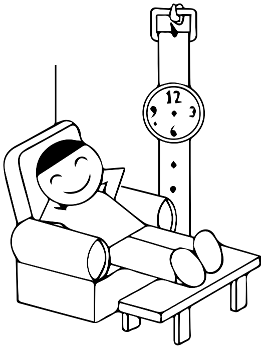
Figure 11.3 Play materials. *A) Objects of daily life with different textures are interesting to touch. B) Mirrors provide a brightness that can be attractive. C) A child with VI and motor disabilities in a 'little room' where visually attractive toys are hanged and reachable. Photo: A) Michael Brambring.*

11.3 Multiple disabilities and visual impairment

The rehabilitation needs of children with multiple disabilities and visual impairment (MDVI) are complex and beyond the scope of this book. Nevertheless, it is worth mentioning that the most common cause of VI in this group is cerebral visual impairment (CVI).

Children with CVI have different needs from those with "traditional" VI not only because they usually have additional disabilities, but also because their problem lies in the processing of the visual information and not in its acquisition. To encourage the children with CVI to develop their visual skills, their parents, carers and professionals should keep in mind the following principles:

1. **Simplicity:** the children with CVI tend to be sensitive to sensory crowding, so toys should be offered one at a time, on a simple background (uncluttered) and a quiet environment.
2. **Familiarity:** the favorite toys and daily use objects (bottle, bowl, cup or spoon) are likely to trigger more interest than novel or strange ones.
3. **Time:** be patient. Children with CVI do not typically look directly at people and objects. When an attractive object is presented, it may take several seconds before the child looks at it and his response might include changes in body position or breathing pattern.



11.4 Services

Early intervention services include educational, psychological and medical support to parents of children with disability. Ideally, children with VI should have access to a multidisciplinary team that includes a physiotherapist, an occupational therapist, a teacher, a psychologist or social worker and a low vision specialist.

In regions where the needs are large and the resources limited, the early intervention services tend to be center-based: a team of professionals sees the children either individually or in group. When the resources are sufficient and the logistics make it possible, the specialists carry out home visits. The services can be offered weekly, monthly or occasionally depending on the availability of the resources and the needs of the family. A list of advantages and disadvantages of each setup is presented in Table 11.1.

Table 11.1 Comparisons between conventional types of early intervention services.

Services	Advantages	Disadvantages
Home visits	• Child in a familiar environment • Professional can better understand needs of family	• Expensive for the service provider • Family may feel isolated
Center based	• More resources available • Child and parents meet others in same situation	• Child in unfamiliar environment • Family need to travel (and leave other children behind)

PART III OTHER AREAS OF INTERVENTION

12 REHABILITATION NEEDS FROM SCHOOL AGE ONWARDS

In most modern societies, schooling is important to ensure people reach their full potential. For children with VI, access to the curriculum requires the use of special tools and teaching strategies typically not available in local schools.

12.1 Schooling

a) Facilities

To students with VI, accessibility to the school curriculum can be a major obstacle to the completion of their studies. Schools for the Blind are found in many parts of the word and include students with blindness as well as low vision. Students with VI can also study among sighted students in their local school (**mainstream**), ideally with occasional visits from specially trained itinerant teachers.

In recent years, the concept of **inclusive education** was developed whereby the entire school (teaching methods, infrastructure) adapts to the particularities of the students instead of the students with special needs adapting to the existing system.

The quality of the educational services the students receive will vary widely depending on the setting and local resources. A few points of comparison between special schools (schools for the Blind) and mainstream schools (local school) are listed in Table 12.1.

Table 12.1 Comparison between the two traditional types of school settings.

School	Advantages	Disadvantages
Special	• More learning materials and technical aids available • Classmates with similar realities	• Students are isolated physically and socially from their home and own community
Mainstream	• Students stay in their community	• Less teaching tools available • Risk of bullying

The life of students with VI can be made easier with a minimum of environmental adaptations (see Chapter 13). However, the human factor is certainly a key to the success of children with VI in school. It includes two aspects, further discussed in the sections below:

- The children with VI: their academic and social abilities; these are part of the expanded core curriculum.
- The teachers: the strategies they use to facilitate learning.

b) Expanded core curriculum

To succeed during their schooling and also in their adult life, children with VI need to develop a special set of skills referred to as the expanded core curriculum which typically includes (but is not limited to) the following topics:

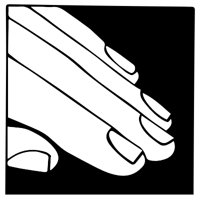
- Braille and communication skills
- Orientation & Mobility or O&M (see also Section 12.2)
- Activities of daily living or ADL (see also Section 12.2)
- Recreation and leisure time skills
- Career education
- Use of assistive technology
- Social interactions
- Visual efficiency for students with low vision (see also Section 10.1)

c) Teaching strategies

Typical classroom teaching relies heavily on visual material supported by verbal instructions. In these conditions, unless special strategies are used, the students with VI will only grasp a fraction of what is being taught. These special teaching techniques are presented in the next section.

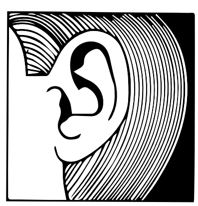
1. Use of other senses

Although touch and hearing may not fully compensate for the vision loss, they can provide the child with precious information about the world.



By moving the fingers over an object (haptics), persons with VI can find out specific properties such as size (if it is small), surface quality, texture, temperature, resilience to pressure, weight, dampness and elasticity. Another advantage of touch is that it functions without light!

However, touch can only be used with objects which are at close range and accessible, that is neither too large (an airplane), too small (an insect), or too fragile (a bubble). Objects that are moving, or substances that are burning or boiling, or have no shape of their own and must be kept in containers cannot be experienced directly by touch. In addition, using haptic perception takes a long time and as a result, studying objects or reading Braille with the finger tips is much slower than with the eyes.



Sounds provide information about the location of objects in space and events. However, the ears like the hands can process only a few sounds at once and putting the information together takes time and training.

To use optimally the information provided by touch or hearing, the students with VI need to have acquired basic skills such as discrimination (to recognize differences in sounds or textures) and identification (to name source of sounds and objects). These skills and others are discussed in Section 12.2.

2. Real experiences (substantiation)

Because they cannot learn by looking at what the others do, children with VI often do not know how to handle and manipulate objects or how they function. To compensate for this lack of experiences, students with VI should learn through hands-on activities, using real objects and not only explanations. For example, if you want to teach a child to open a screw-top jar, provide him with jars of different sizes to open. Another example is illustrated in Fig. 12.1. By allowing the student to practice, he will not only develop the required skill, he will also develop confidence in his own abilities at manipulating objects.

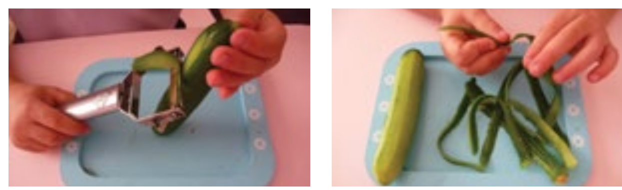


Figure 12.1 Real experiences. *Pealing a cucumber gives the child an opportunity to know its size and parts.*

3. One for each (individualization)

While teachers of sighted children can show an object or a task to everyone at once, teaching students with VI requires much more time and resources. Each student needs time to manipulate the object to find out its properties or to try the task. Thus, the necessary tactile media such as models or Braille books need to be available in sufficient numbers so that each student has access to it.

4. Structure and sequence

Unlike vision, touch allows to explore only a handful of objects simultaneously, making their identification and comparison more difficult. For this reason, planning the right sequence of events is important when teaching students with VI. Here are some basic rules to structure the learning material.

- The **complexity** should be reduced so that the student has an overview of the object or task. For example, when teaching how to put on shoes, it is easier to start with shoes that have Velcro straps than laces. When dealing with large objects (car, plane), models can be used.
- The **number** of elements should increase gradually. For example, if showing how to plug an electrical device to the wall, it is easier if there is only one power cable and one plug.
- The material must be organized in **space**. For example, a set of objects can be put on a tray so that the space is limited and familiar.
- Whenever possible, the learner should have access to simultaneous **perceptions**. For example, objects that need to be compared should be presented at the same time, next to each other.
- The student should have enough **time** to explore the objects.

5. Communication

In school, the spoken words play a key role in passing knowledge. The teacher of students with VI in his class needs to read aloud what he writes on the board and explain what he is doing. In addition, he should express his feeling with words since the student with VI is not aware of the gesture and facial expressions.

In an inclusive setting, the classmates of the students with VI should also be aware of the importance of good verbal descriptions. In fact, for all of those dealing with persons with VI, objects, places or people should be described as precisely as possible.

For example, instead of saying “I am here”, say “I am on your right side” or instead of “It is there”, say “It is on the table in front of you” (see more on this topic in Table 12.2).

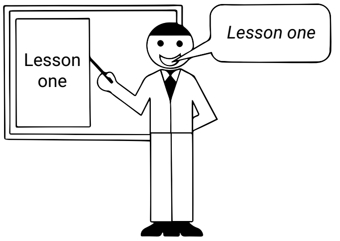


Table 12.2 Guidelines for meaningful descriptions.

Item	Information to give
An object	Material (wood, plastic, glass), use parts (handle, top, bottom), functions (on/off)
A photograph	Front, back ground, main characters and other characters, their actions
A person’s appearance	Height, build (thin, plump, fat), age, face (wrinkled, freckled, tanned, pale), eyes (color), hair, clothes

d) General recommendations for teachers

There are key points teachers in mainstream schools should know if they have a student with VI in their classroom. Here is a short list.

Communication

- Speak to the class upon entering and leaving the room or site.
- Call the student with VI by name if you want his attention and talk to him directly.
- When communicating with a student with VI, always identify yourself and others who are present. Don’t assume that the student will recognize your voice.
- Verbalize what you are doing. The entire class will benefit from enhanced verbal descriptions.
- Avoid moving the teaching tools or furniture in class so that the student with VI can memorize their location.

- If you have problems when teaching a student who is visually impaired, first decide if the problem is related to the disability or not. Consult with the student if you have concerns about accommodations or his/her learning.

Teaching

- Let the student with VI sit in the front of the class so he can hear clearly what is being presented.
- Read out loud as you write on the board and spell out words that may be confused with others sounding the same.
- Allow the student to record lectures or use a note-taker.
- Make sure the student receives all the handouts in advance.
- Do not modify academic standards for students with VI.

Exam accommodations

- Allow more time.
- Offer a quiet and private environment.
- Provide the person with low vision with the size of text he needs.
- When necessary, provide a reader with the appropriate reading and language skills.

e) Role of special teachers

Teachers of students with VI should understand the consequences of the visual disabilities on learning. What can the student see at near and far distances? What devices does he use? Does he have problems seeing at low contrast or distinguishing colors? Is his peripheral field restricted or with scotomas? This information should rely on a good understanding of the eye (Fig. 12.3).

Figure 12.3 Eye model. *A useful tool to understand how vision works and the consequences of an impairment.*

Ideally, students in mainstream schools should receive regular visits of itinerant teachers who teach the students the extra core curriculum and help them determine:

1. The suitable placement (seat) in the classroom, considering the natural and room lights, as well as glare on the working surface.
2. The best learning media (normal print, large print or Braille; Fig. 12.4).
3. Strategies to get hold of the information on the board (verbalization by teacher, optical devices for distance, or collaboration with a classmate.

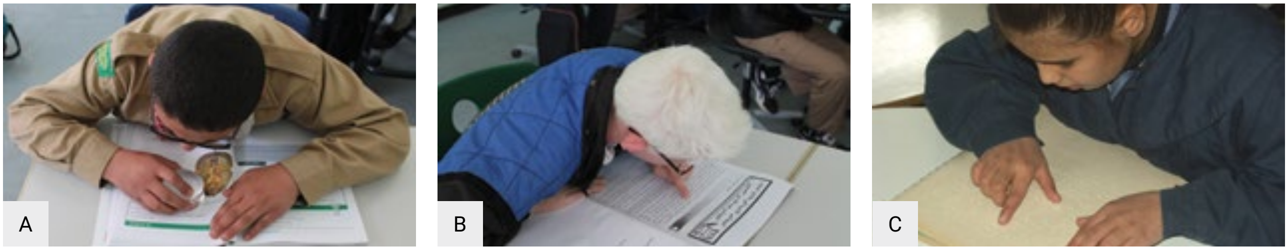


Fig. 12.4 Learning media for students with visual impairment. *A) A student with low vision using his distance correction with a dome magnifier (2x) to read in a regular school book. B) A student with low vision using magnified print. C) A student with blindness reading Braille.*

12.2 Orientation and Mobility

Going from place to place requires being able to walk (locomotion) and knowing where to go (orientation). Orientation and Mobility (O&M) training involves providing the skills and techniques needed to move around safely and efficiently within homes, schools and communities using landmarks and clues.

a) Basic skills

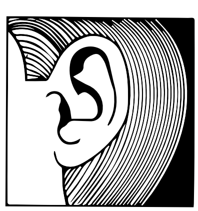
To be willing to move, people with VI need a minimum understanding of the world around them. This is possible through the use of their other senses (sensory awareness) and with a clear understanding of the words used to describe the environment (concepts).

1. Sensory awareness

In order to know where he is, a person with VI must learn to use his other senses (hearing, touch, proprioception and smell) to collect cues such as the sound of a water fountain or the smell of a bakery during working hours and landmarks like special floor patterns or a fire hydrant (Fig. 12.5).

Figure 12.5 Sensory cues and landmarks. *A) Auditory cues include traffic. B) Landmarks include tactile surface. Illustration: B) Detectable Warnings By Ryxhd123 (httpwww.transpo.com) licensed under CC BY 3.0.*

Hearing



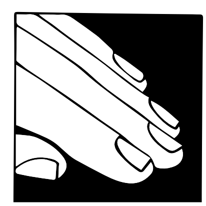
Interpreting basic properties of sounds is essential to persons with VI. They need to learn to localize sounds and use sound clues for orientation, straight line of travel, and safety, for example knowing that if the sound of a car becomes louder, it is coming towards them.

Optimal use of hearing implies the ability to master a certain set of skills. Those are listed and briefly described in Table 12.3.

Table 12.3 Examples for hearing skills.

The skill	Description
Detection	To hear a sound
Identification	To recognize a sound
Discrimination	To distinguish between similar sounds
Localization	To find the position of a sound source
Distance	To estimate the distance of a sound from its source
Shadow	To recognize that a sound is obstructed by an object causing a decrease in the loudness
Gap	To recognize that aa sound through an opening in a surface
Masking	To recognize a sound that is covered by another sound
Alignment	To know the position of the body in relation to moving sound making objects for example parallel to cars (walking on a sidewalk) or perpendicular (crossing the street)
Echodetection	To detect objects by hearing sounds reflecting on them

Touch and proprioception



Combining touch with intentional movements is a very efficient way to explore a surface, to find an object or brings a glass of water to his mouth. Haptic perception involves using touch with proprioception, which is the sense that informs us about the positions of our joints and muscles.

Proprioception usually develops together with vision and children with congenital VI generally need help to learn where their body parts are in space and in relation to the environment. They also need to learn certain movement patterns that are useful when trying to determine the properties of objects. Most of us learned these movements by watching others use them; this is called **incidental learning.** If a person is born with poor or no vision, he will have to be taught. Some examples of purposeful hand movements are listed in Table 12.4.

Table 12.4 Example of purposeful hand movements.

Hand or finger movement	Object property
Stroke over surfaces (lateral motion)	Texture
Apply pressure	Hardness
Put the palm on an object (static contact)	Temperature
Lift an object (unsupported holding)	Weight
Encircle an object (enclosure)	Volume
Follow the contours	Shape
Move parts	Function

Smell

Normally we do not pay much attention to smells unless they are extremely pleasant or offensive, but they can be very useful to know where we are (food in a kitchen, flowers in a garden).

2. Concepts

A concept is set of ideas, symbols or objects typically associated with a word to give it a meaning. Chairs for example, can take many forms: there are dental chairs, lounge chairs, desk chairs, plastic chairs, leather chairs, wooden chairs and so on. A “chair” is different from a “stool” and a “bench”, even though all three concepts belong to the concept of “places to sit down on”.

Teaching concepts requires that the child can find differences and similarities between objects, people or events. The best way to teach a concept is to make it concrete by offering the real object for the person to manipulate. If the object is too large or inaccessible, a 3D model or tactile image can be used. A number of concepts are essential to learning O&M skills and techniques (Table 12.5).

Table 12.5 Examples of concepts in O&M.

Area	Concepts
Body	Body parts, their function and location
	Front, back, left, right, upper and lower body, in front of, behind, above, below, to the right, to the left, midline
Indoor	Walls, ceilings, doors, door frames, windows, shelves, drawers, chairs, table, frames, mirrors, bulletin boards, hallways, room, lights, heaters, air condition, refrigerators , stove, oven , toilets, desks
Outdoor	Sidewalks, streets, yards with grass, cars, traffic lights, trees, park

b) O&M techniques

Persons with severe VI and blindness tend to be reluctant to move by fear of bumping into things or people and getting hurt. Special techniques have been developed to facilitate the mobility and independence in movement of persons with VI. They are listed and described briefly in the section below.

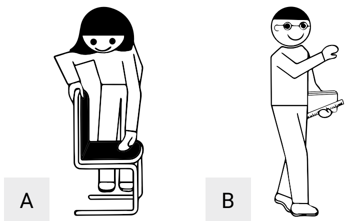
1. Searching

Locating efficiently items dropped requires special strategies.The sweeping motion should be done in a systematic manner, for example from left to right, covering first the space in the near vicinity (near the sound cue) then reaching outwards.

2. Body protection

This technique allows persons with VI to walk safely using one hand to protect their bodies and the other to locate objects (Fig. 12.7). If the person expects head high obstacles like kitchen cupboard doors left open, the protecting hand will be placed at shoulder or head level, palm pointing forward. If the person expect lower obstacles, such as furniture, the hand will be at the level of the waist back of hand pointing forward (lower body protective technique).

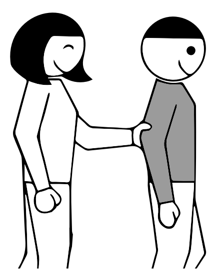
Figure 12.7 Safety. *A) Checking that nothing is on the seat and the orientation of the chair. B) Upper body protection.*



3. Sighted guide

A convenient way for a person with VI to walk with a sighted person is by holding one arm of the sighted guide directly above the elbow and standing one step behind (Fig. 12.8). The sighted guide directs the person with VI around obstacles, stops in front of steps telling the guided person if the steps are going up or down before moving on. They can move efficiently in a variety of settings using special techniques that include making contact, changing sides, reversing directions, opening doors, dealing with stairs, sitting on chairs and in cars.

Figure 12.8 Walking with a sighted guide. *B) walks slightly behind the sighted guide.*



4. Trailing

This technique involves placing the back of the hand or only the finger nails on a wall while walking. It is used to walk along a wall or when looking for cues such as a ramp or a door handle. Trailing can be used together with a white cane, the upper body protective technique, or sighted guide technique.

5. White cane

The white cane is used to detect obstacles on the ground in front of the user. It serves also to identify the person with VI in the eyes of the other pedestrians or drivers.

White canes come in a variety of lengths and tips (Fig. 12.9). The long cane (as high as the armpit of the user) requires more training than the other techniques presented above. It should stay on the ground, rolling from left to right. It helps detect obstacles or changes in the ground level and also provides information on the textures of surfaces such as grass or concrete.

Figure 12.9 White canes *A) Short, identification cane. B) Long cane. Illustrations: A) 'Visually impaired with identification cane' by Zoetnet and B) 'Blind man walking with a long cane' by Jay Galvin, both licensed under CC BY 2.0.*

c) O&M for persons with low vision

Training needs of people with LV vary widely from one to the other. In general, those with a visual acuity of 0.1 and below are likely to face difficulties during outdoor orientation.

Persons with LV might have some advantages over people with blindness while moving around such as being able to identify the direction of traffic, the color of the traffic light, or some visual landmarks. However, they will not be able to rely on their vision as much if the level of light is too low or too high, or if there is poor contrast or too much visual information (visual clutter). The first step when training a person with LV to move independently is to make him understand the effects of his VI on his perception of the environment, for example under different levels of light or contrast, and when obstacles are present in the periphery of his visual field. An overview of the key training areas for persons with LV is presented here.

1. Lighting conditions and glare

Too little or too much light further decreases the ability of persons with low vision to see around. In addition, they can also have problems adapting to abrupt changes in the level of light, for example when going from outdoors to indoors and vice versa or through frequent changes in lighting while walking. Mobility lessons need to be conducted in the lighting conditions which provide the most problems.

2. Changes in depth

Falls can be caused by small changes in the level of the ground that are only noticeable by subtle differences in colors. When a person has poor vision or problems seeing objects at low contrast, such visual cues can be missed or misjudged. He needs to learn to use other information like a railing indicating stairs, and the direction of the slope to determine whether the stairs are going up or down.

3. Restricted fields

Individuals with peripheral restrictions have high risk of bumping into objects when moving. They might be unable to detect obstacles below eye level such as drop-offs, above eye level or at the periphery like branches from trees or half opened doors. To locate targets such as traffic lights or house numbers, people with a limited peripheral field need to learn to scan their surrounding using both head and eye movements in a systematic way to cover the whole area, for example from left to right or top to bottom (see also Section 10.2).

4. Visual efficiency

A person born with LV has typically more problems to interpret visual information than one who had time to collect visual memories and develop concepts before the vision loss. Children with congenital low vision might need to learn the basic concepts as blind do. They will also benefit from a visual stimulation program that includes skills such as tracing and tracking. In addition to the auditory and tactile landmarks, the persons with LV should learn to use visual landmarks for example the outline of a mosque or a building with a particular shape or color.

5. Optical and non-optical devices

When the person with LV uses distance devices such as a monocular telescope or a filter, these devices need to be used during the O&M training (see also Section 8.6).

d) Functional assessment for O&M

Training needs in O&M vary both with the persons and the environment they have to move in. For this reason, the abilities of each person with VI should be assessed before developing a training program. A functional assessment is not a standardized procedure but it is nevertheless systematic. Table 12.6 lists some of the skills and abilities that should be assessed before developing a training plan.

Table 12.6 Functional assessment. *Skills 3, 6, 7 and 9 are specifically for persons with low vision.*

Skill areas	Examples of tasks	Abilities tested/ information collected
1. Straight line of travel	Walk at least 10 m without landmark or trailing and with uneven surface	Posture, speed, confidence, use of visual strategies (scanning or tracing)
2. Obstacle avoidance	Walk on a sidewalk	Posture, speed, confidence, detection of obstacles while moving in quiet area and in heavy pedestrian or car traffic
3. Object identification	Walk on a sidewalk	Posture, speed, confidence, distance from cars parked, traffic lights
4. Step perception	Walk on a path with stairs	Detect changes of depth
5. Street crossings	Stand at an intersection and ask questions about traffic	Judge direction and speed of traffic, know traffic rules
6. Light adaptation	Go from outdoor (bright) to indoor (dim) then back outside	Time needed for light adaptation
7. Walking in low lighting conditions	Walk in an area at low light	Perceiving obstacle below the eye line, ability to visually track, judging height of steps and curbs, finding landmarks, sensitivity to glare
8. Orientation skills	Give instructions to reach a place and come back	Landmarks, visual control, planning a route, concentration on near tasks
9. Color perception	See road signs	Recognizing color coding for traffic signs

12.3 Activities of Daily Living

Visual impairment affects most if not all aspects of a person's activities of daily living (ADL). Nevertheless, people with VI can learn to be independent using special techniques and strategies (Fig. 12.10).

There are dozens of skills in ADL, but not every person with VI needs to master all of them: each one should determine his priorities. Then, each area of ADL can be broken down into a number of skills or abilities. Examples are given in Table 12.7.

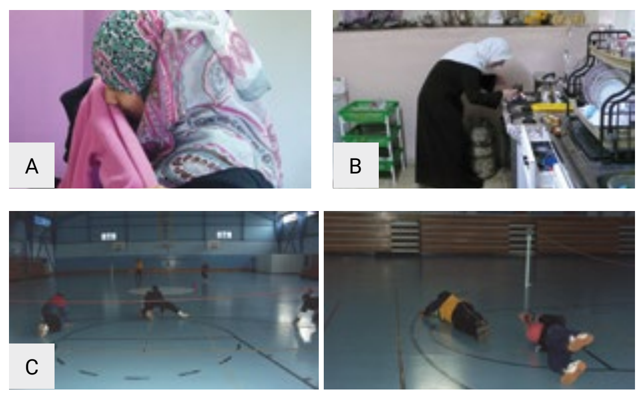


Fig. 12.10 Activities of daily living. *A) A young woman with VI smelling a piece of cloth to know if it is clean. B) A woman with low vision, mother of 3, preparing coffee. C) Men playing goal ball, a special sport developed for persons with VI.*

Table 12.7 Examples of topics taught during ADL training and related skills

Food preparation	Cooking	Eating
- Organizing work place - Measuring fluids and solids - Cutting ingredients - Grocery shopping	- Stove orientation and safety - Dealing with hot fluids and surfaces - Labelling systems for food - Making sandwich	- Eating skills for various dishes - Pouring hot tea or coffee - Pouring soft drink - Cutting meat
Cleaning the house	**Washing clothes**	**Personal grooming**
- Washing dishes - Dusting - Polishing - Recognizing detergents	- Measuring detergent - Using the washing machine - Hanging clothes to dry - Folding	- Combing and styling hair - Showering, shaving, toileting - Washing teeth - Managing the medication
Dressing	**Communication**	**Money**
- Telling front from back - Using a zipper - Buttoning a shirt - Putting on shoes	- Addressing people - Asking for assistance - Self-advocacy	- Distinguish coins and bills - Using ATM machines - Budgeting, credit, interest - Giving change

a) Task analysis

Teaching ADL requires that each task is carefully broken down into small steps in a technique called task analysis (see an example on Table 12.8).

There are two primary strategies for teaching the skills in a task analysis. The strategy used depends on the skill taught and how the person learns.

1. **Total task presentation:** teaching all behavior at once. When using this strategy, the whole sequence of steps is practised every time. Total task presentation is often used for simpler task. The person will initially need a lot of prompting, maybe at each step, then less and less as the person learns the skill.
2. **Forward chaining:** teaching each behavior in sequence. This strategy requires that the first step is taught, practiced and repeated until it is fully learned. Then the second step is taught and reinforced until it is learned. This continues until the last step is learned. Chaining is usually used for more complex tasks like vacuum cleaning a room or cooking a dish.

Table 12.8 Example of a task analysis for the skill "washing hands".

Goal: The student will be able to wash his hands independently	Prerequisites concepts & skills
Entry level: The student is standing in front of the sink	
1. Turn cold water on with right hand	Right / left
2. Put hands under running water for 1 sec	Seconds
3. Pick up soap with right hand	Grasping, soap
4. Rub soap between hands for 3-5 sec	Rubbing
5. Put soap back to dish with right hand	
6. Rub palms together for at least 5 sec	Parts of the hand
7. Rub back of right hand with left hand for at least 2 sec	
8. Rub back of left hand with right hand for at least 2 sec	
9. Rinse hands under water for at least 2 sec	Rinsing
10. Pick up hand towel with left hand	Towel
11. Wipe right hand dry	Wiping, dry, wet
12. Transfer hand towel to right hand	
12. Transfer hand towel to right hand	
13. Wipe left hand dry	
14. Put hand towel back on hook	Hook

b) Guidelines for teaching ADL

Teaching ADL requires careful planning. Here are some important points to keep in mind:

Tips for planning a lesson:

1. Analyse the task (task analysis) by breaking it into small units. Think or modifications to the task to make it easier for the person with VI.
2. Identify the pre-requisite skills and sub-skills.
3. Provide a work area that is free from clutter. The use of non-slip mats may be helpful.
4. Gather necessary equipment.
5. Label the products that cannot be identified by their shape/size. Use contrast when working with clients with low vision.
6. Organize the work space. Assemble ingredients on a tray and keep utensils in a container at the back.

During the lesson

The learner should

- Be motivated to learn the skill
- Be attentive to the task: If the person is not attending to your instructions, he or she will not learn.
- Have the prerequisite skills. Do not assume the person can perform the skill: see it for yourself.

Tips for ADL trainer:

- Provide hints and encouragement.
- Be consistent and precise with your instructions and descriptions.
- Use an orientation system, for example the clock face.
- Clean up as you go along
- Keep a damp cloth nearby for wiping hands.

c) Tools in ADL

Sometime, simple objects can become very useful tools for persons with VI (Fig. 12.11). When available, specials tools can be used.

- Slip resistant mat
- Contrasting chopping board
- Adhesive tactile markers (bump-ons) or large numbers on containers and dials
- Magnification mirror
- Coin holder
- Signature guide
- Divided tray organiser
- Talking watch
- Audible liquid level indicator
- Braille or voice labeller

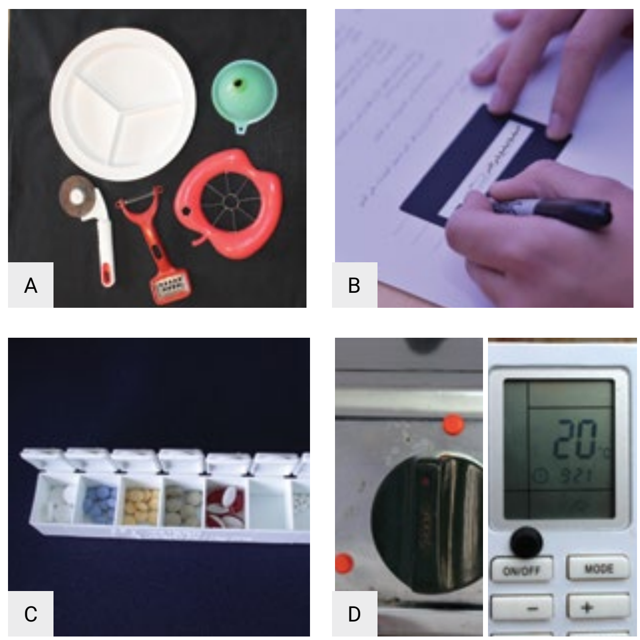


Figure 12.11 Useful tools in ADL. *A) Kitchen tools. B) Signature frame. C) Pill box with divisions for each day. D) Bump-ons and labels are very useful on daily appliances such as remote controls and dials.*

PART III OTHER AREAS OF INTERVENTION

13 ENVIRONMENTAL ADAPTATIONS

Simple changes in the surroundings can have a direct impact on the self-confidence and the quality of life of person with a vision loss by allowing them to move around, orient themselves or doing things more easily.

13.1 General principles

All persons with VI can benefit from applying these three simple principles:

1. **Spaciousness.** Arrange furniture to facilitate movement.
2. **Safety.** Avoid furniture with sharp edges and objects on the ground.
3. **Organization.** Keep objects organized and in a predetermined place so that memory can compensate for poor or no vision (Fig. 13.1). It is important to put inedible or poisonous articles away from food.

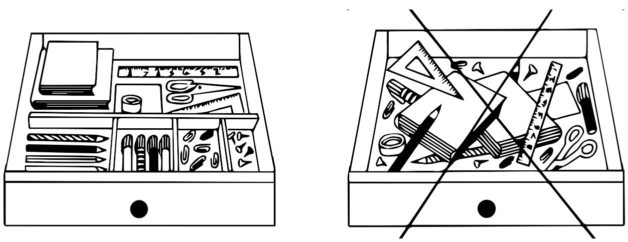


Figure 13.1 Organization. *Organizing the working area makes it easier to find objects and safer if some of them are sharp.*

13.2 Modifications for persons with low vision

Adapting a space for persons with reduced vision can make it more attractive and pleasant to all those using the area. The changes can be divided into four categories.

a) Provide suitable lighting. Most persons with low vision function better with increased levels of light. In open spaces such as halls or corridors, increased diffuse light improves the perspective and makes dangerous areas such as the stairs safer. The light should be uniformly distributed and glare (shiny or reflective surfaces) should be avoided.

Light for near tasks should be concentrated on the work place. The lamps need to be located between the eyes and the object or come from the side opposite to the hand while writing to avoid creating a shadow (Fig. 13.2). Lamps with flexible arms are easier to adjust to the needed position. Supplementary light can also be included with the magnifier.

Figure 13.2 Examples of good and bad lighting. *A) Good lighting should come from behind; when writing the spot lamp should be placed behind, on the side opposite to the hand writing. B) If the light is misplaced, it can create shadows on the page or obscure the text.*

b) Decrease glare. Glare is the harsh light that reaches the eyes and momentarily blurs vision (Fig. 13.3). Some people with low vision are extremely sensitive to glare, in particular those with corneal problems, cataract, RP, albinism or achromatopsia. In order to decrease the glare reaching the eyes, actions can be taken at three levels.

Tips to decrease glare:

1. **The light source.** Natural light entering a room can be controlled with window blinds and if necessary, softened with light shades, while the light within a room should be evenly distributed.
2. **The surface.** Reflection of the light reaching the eyes can be decreased by replacing white with dark surfaces, glossy paper with mat, or using a typoscope.
3. **The eyes of the viewer.** If too much light reaches the eyes, the persons can change position in the rooms towards an area with less light. Outdoor, a hat, cap or visor, sunglasses and special filter glasses are useful. White text on a black background can be produced using a CCTV or a computer.

Figure 13.3 Glare. *The sun reflecting on a shiny surface (pavement).*

c) Increase contrast. The bigger the difference in color between objects, the easier it is to distinguish them from each other so that black letters on white background are easier to see than yellow text on a greyish paper.

Walls of contrasting colors allow the persons with low vision to see the boundaries of the rooms, estimate their size, and move around more easily. Stairs can be modified by adding a stripe of contrasting color at the edge of each step. Doors, handles, electric switches and sockets are easier to find if painted in a different color and luminance than the wall. Various examples are provided in Fig. 13.4.

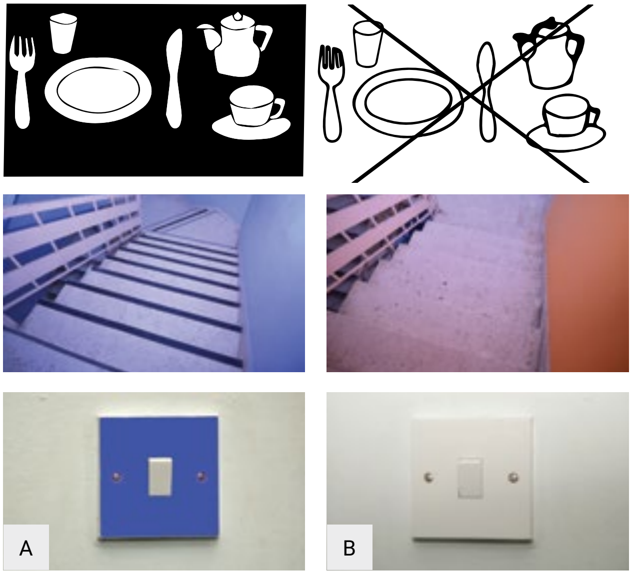


Figure 13.4 Examples of good and poor contrast. *A) Using contrasting colors highlighting the edges of objects or surfaces makes it easier and safer for persons with low vision. B) Examples of poor contrast between the objects and their background."*

d) Avoid visual crowding. Heavily decorated patterns make small objects placed on them difficult to see. For this reason, it is important to choose simple design on carpets, cover for sofas and chairs, table cloths, plates but also computer desktops and background images on mobiles and tablets.

Figure 13.5 Avoiding visual crowding. *A) Selecting a simple background as on the phone makes it easier to see the menu then B) when a busy image is used.*

APPENDICES

APPENDIX 1 INSTRUCTIONS FOR VISION ASSESSMENT

1.1 Visual acuity (VA)

General

- Ideally, the assessment room or testing environment should:
  - Be quiet,
  - Have good light,
  - Have no shiny surface or glare that falls on the testing tools or in the eyes of the subject.
- Threshold acuity (the smallest thing the person can see):
  - Requires that the person can recognize more than 50% of the line recorded.
  - Needs also negative result (something the person cannot see). For example, if the person can read a line with difficulty, the next one, the smallest, should be tried before the line is set as threshold acuity.
  - Remember: it is not always a useful functional measure (it is not comfortable to read for long period at threshold).
- Charts:
  - The abilities of the person being assessed needs to be taken into account when selecting the chart to be used. Charts with E, C, numbers or symbols can be used for people that do not know the alphabet or cannot speak.
  - Before starting the assessment, the examiner should ask the subject to identify the symbols on the first row (by name, use of gesture, or pointing at the symbols on a key card).

Instructions

Far VA

This is the most commonly used measurement of the quality of vision.

Material:
• Distance acuity chart • Measuring tape

Procedures:

1. **Set the distance.** The chart is placed at eye level at a distance of 3 or 4 meters from the subject (depending on the chart). If the top line appears blurred, the chart is moved closer (remember to record the new distance).
2. **Determine the threshold.** Ask the person to name the symbols on the chart, starting from the top line (largest ones). If he can read them all, ask him to read the line below and so on until the symbols are too small for the subject to read (keeping the same distance).

3. **Measure the visual acuity.** The line recorded as threshold acuity is the one where more than 50% of the symbols are read. It can be calculated (in decimals) as the distance (in meter) / Best line read (letter size M).**Measure the visual acuity.** The line recorded as threshold acuity is the one where more than 50% of the symbols are read. It can be calculated (in decimals) as the distance (in meter) / Best line read (letter size M).

Material:

- Near acuity chart
- Measuring tape

Procedures:

Same as for far VA (above).

Reading Acuity

The measure is used to estimate magnification needs for reading tasks. The value recorded depends on the reading chart used. The examiner should be careful that the level of difficulty of the text fits the reading abilities of the person being tested.

Material:

- Reading chart
- Measuring tape
- Reading addition (+4 D) when testing presbyopic patients.

Procedures:

1. **Set the distance.** The person is usually asked to hold the reading chart at 25 cm.
2. **Listen.** Ask the person to start reading the large fonts, then smaller ones until the fluency changes.
3. **Record.** The (threshold) reading acuity is the size of the text at a given distance where the person can read (but is not fluent).

Resolution Acuity

Also called grating acuity, this test is used if the vision is too poor to allow the subject to distinguish the shapes on an acuity chart or if the person doesn't understand how to answer regular eye tests. It can be done as a subjective test (the subject says what he sees) or as a preferential looking situation (the examiner follows the eyes of the subject).

Material:

- Grating pads. They have black and white lines of various widths indicated in cycles per centimeters or cpcm: 0.25, 0.50, 1.0, 2.0, 4.0 & 8.0.
- Grey pad
- Measuring tape

Near VA

It is usually measured after the far VA and should give similar results if the refractive error of the subject is corrected and the charts use the same symbols.

Procedures:

1. **Determine the testing distance.**

   1.1 Measure a distance of 57 cm between the subject and the examiner.

   1.2 Show the coarser grating (0.25 cpcm) next to the grey pad. If the subject:

   - cannot see the lines: decrease the distance by half (29 cm),
   - can see the striped pad: show the finer stripes (8 cpcm). If the subject:
     - can see the stripes, you need to increase the distance (choose a multiple of 57, such as 114)
     - cannot see the stipes: keep the testing distance at 57 cm

2. **Find the resolution acuity.** Keeping the distance, show the grey pad with the test pad (striped) starting with the thicker lines to the thinner ones. The threshold is reached when the subject can see a pad but not the one immediately after.
3. **Register the smallest grating perceived.** At 57 cm, 1 cpcm = 1 cpd. At other distances, you can convert cpcm into cpd at 29 cm the value in cpd decreases by half (1 cpcm = 0,5 cpd) and if you double the distance (114 cm) the value in cpd doubles (1 cpcm = 2 cpd).

Detection Acuity

This is useful for estimating the quality of vision in toddlers. It should be done in a playful way

Material:

- Objects or candies of various sizes and color
- White or black cloth to form a contrasting background
- Measuring tape

Procedures:

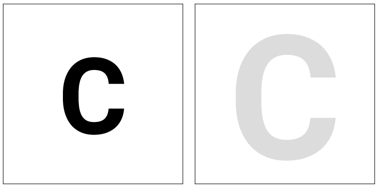
1. **Prepare the space.** The child can be sitting at a table or on the floor. The area in front of him should be plain (without patterns).
2. **Select and place the first target.** It is better to start with a large object not far from the child. The child should be distracted so he cannot follow the hands of the examiner while the object is placed in position.
3. **Ask the child to pick it up what is in front of him.** If he can do it, try a smaller object at the same distance but in a different place (same distance or further).

4. **Record.** The results include the diameter of the smallest object the child can see, its color and the background and the distance at which the child saw it.

1.2 Contrast sensitivity

General

- This information is obtained by comparing the traditional VA (black symbols on white background) with VA with charts made of gray symbols on a white background.
- As for the visual acuity, the testing environment should be quiet, well light room and without glare.



- Charts: be aware that plastic charts tend to become yellow with time and thus unusable.
- The instructions below apply for the SNAB test which is available for free by the Swiss National Association for the Blind. It contains 4 white cards with a black Landolt C ring on one side and a grey ring (contrast of 0.1) 0.2 LOG steps larger than the black one on the other side. The black rings are 4 sizes: 2.5 M, 5 M, 10 M and 20 M.

Material:

- The SNAB low contrast sensitivity test
- Measuring tape

Instructions

Procedures:

1. **Determine the testing distance.** The person doing the assessment stands away from the subject holding the 2.5 M card with the black C at the level of the eyes of the subject (too far for the subject

to see it). The practitioner then walks slowly closer until the subject can see or point the direction of the opening of the black C.

2. **Test the contrast.** Turn the 2.5 M card to the grey side.
   a. If the subject can see the grey side of the 2.5 M card, his contrast sensitivity is normal and the screening test is over.
   b. If the person cannot see the grey side of the 2.5 M card, show the grey side of the next card, the 5 M and ask the direction of the C.
   c. If he cannot see it, try the grey side of the 10 M card. If he still cannot see the C, show the grey side of the 20 M card.
3. **Recording.** This is a screening test and contrast sensitivity is recorded as *normal or near normal* if the person can see the 2.5 M (2.a), *below average* and is likely to cause him problems for some tasks if he sees only the grey side of the 5 M card (2.b), and *very poor* and likely serious problems if he sees only the grey 10 M (2.c).

1.3 Visual field using the confrontational technique

General

- This technique provides a rough estimate of the peripheral visual field.
- It is difficult to use this technique to test persons with central scotomas or nystagmus of high amplitude (no eye contact).
- Since the VA in the peripheral retina is low compared to the center, the size of the object to be detected should be sufficient for the subject to detect it.
- Ideally when testing children, two persons are needed: one to follow the fixation and the other to present the target from behind.

Material:

- Fixation tool
- High contrast ball 4 cm in diameter (the target) on a 25 cm stick or other attractive object
- A4 180° Angle form

Procedures:

1. Position. The subject should be sitting on a chair with sufficient space around it to allow the examiner to stand behind.
2. Fixation. The subject should fixate on an object (of contrasting background) in front of him during the whole test. When the target enters the visual field, the eyes will spontaneously move in this direction.

APPENDIX 2 INSTRUCTIONS FOR USING MAGNIFYING DEVICES

2.1 General

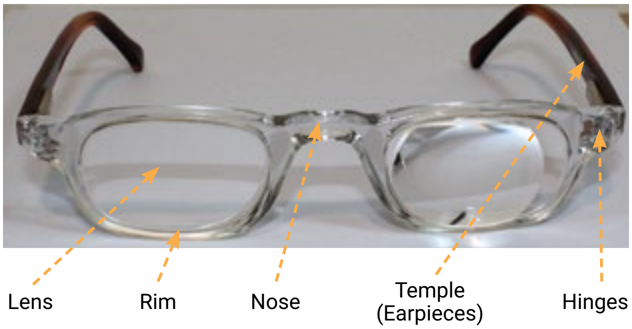
- Upon issuing a low vision device, the professional should do the following:
  1. Explain the benefits and limitations of the device. This can be done using a budgie stick: the person can see the size of print he sees without the device and the size he sees with the device.
  2. Introduce the names of the parts.
  3. Clarify the concept of focus or clear image and explain the focal distance.
  4. Give information on how to:
     a. Hold the device
     b. Keep the lens clean

  c. Store the devices to avoid scratching the lenses (in a pocket or a case)

  5. Stress the importance of:
     a. Using a good body posture while using the device and reading stand for long periods of time
     b. Having good lighting and no glare.
- During the training with the device, the low vision specialist should make sure
  - The training material is relevant and meaningful to the person with low vision.
  - There is plenty of light on the object without glare
  - He or she is aware of the specificities of the optical device (see below)

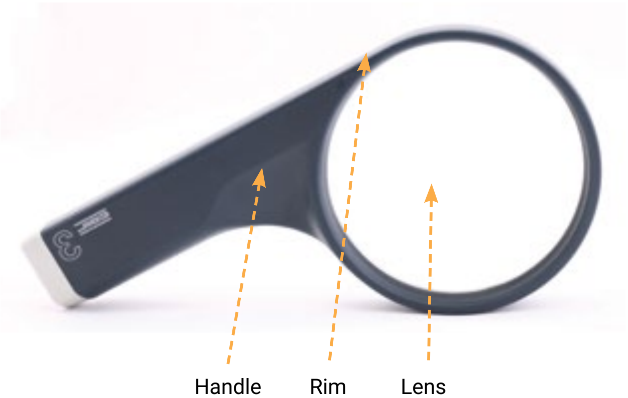
2.2 Spectacles

- **Distance between the lens and the object (focal length).** It depends on the power of the lens: focal length in cm = 100 / power in diopter. The use can find by holding the reading material at arm length, and then moving it slowly nearer until letters are the most clear.
- **If the object or text needs to be held for a long period of time.** The person can put both elbows on the table or use a reading stand.



2.3 Hand magnifier

- **Distance between the lens and the object (focal length).** It can be calculated (in cm) as 100/lens power in diopters.
  - If used for a sustained task (reading the newspaper), the distance between the lens and the object should be within twice their focal length.
  - If the magnifier is used for a spot task (reading a label), it can be used further away (within four times the focal length).
  - Remember that increasing eye to lens distance has no effect on the optical magnification: it is more comfortable for the user but the field of view becomes smaller.

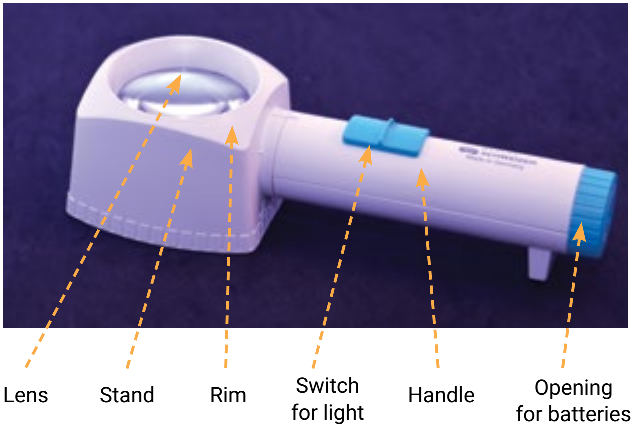


Can also be illuminated, see stand magnifier

- **Distance between the eye and the lens.** If the lens is close to the eye, the user with presbyopia needs to use reading spectacles.

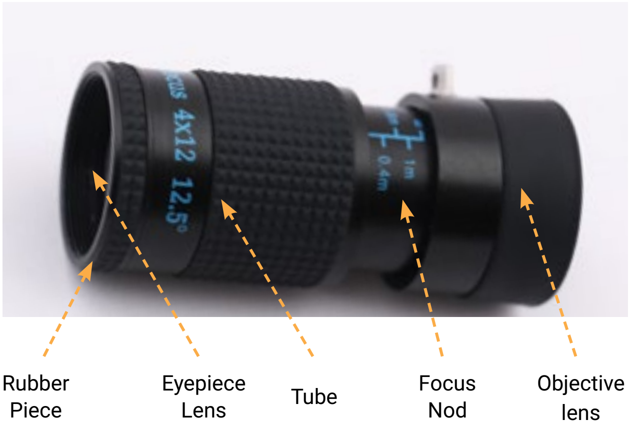
2.4 Stand magnifier

- Choose the most appropriate eye-device distance depending on the target object and the magnification:
  - Increasing the distance will give a smaller field of view but allows binocularity.
  - Decreasing the distance will give bigger field of view but allows only monocular vision. In addition, the user needs to accommodate or in case of presbyopia, to wear reading glasses



Brightfield (Dome)

- Do not use the light directly over it: it will reflect on the surface and create glare.



2.5 Telescope

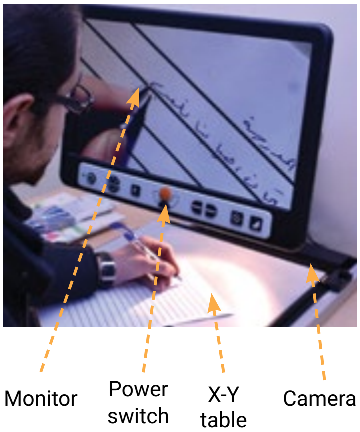
Monocular hand held telescope:

- **Choose the eye.** The user can look at a distant object without the telescope, maintain fixation, then bring the telescope to the best/ dominant eye (for children, it can be useful to start with a cardboard tube). This is the eye to which the user will spontaneously look through.
- **Choose the hand.** It is recommended to hold the eye piece of the telescope by the opposite hand of the dominant eye thereby covering the other eye.
- **Use with glasses.** Spectacle wearers should unfold the rubber in front of the eyepiece for spectacles: doing this doubles the field of view. On the other hand, increasing the distance between the telescope and the eye will decrease the field of view.

All telescopes:

- **Adjust the focus.** The focus of the device is a property of the lens, and to make it easier to the beginner, the examiner can set the focus of the telescope to a given target before handing it over to the person with low vision.
- Training telescopic skills can be done on indoor (items on a wall or board) or outdoor. These skills include:
  - Localizing: knowing where to look
  - Focusing: good manipulation skills giving a clear image for a range of distances.
  - Spotting: combines localizing and focusing skills to see any stationary object at any distance.
  - Tracing: the ability to follow the contours of a stationary line or object.
  - Tracking: following a moving target
  - Scanning: to search the environment for an object not seen.

2.6 CCTV (Closed Circuit Television)



- **Position.** The person with LV should sit on a comfortable chair, with the screen at the level of the eyes.
- **Focus.** This is done when the image is enlarged to its maximum.
- **Magnification.** It is determined by the control switch but also by the position of the viewer: sitting close to the screen allows additional magnification (relative distance). The amount of magnification needed varies with the person and with the task: writing requires less magnification while more magnification is needed for reading and looking at details. Higher magnification gives smaller visual field, so the user should have enough magnification with for the needed field of view.
- **Contrast.** The user can typically choose between real color representation, black on white or white on black.
- **XY-table.** Using the table while reading needs practice. To be fluent, the user should be able to change line without looking at the hands.
- Writing with the CCTV. The user should use low magnification and look to the screen and at the pen.

APPENDIX 3 INSTRUCTIONS FOR OTHER TRAINING

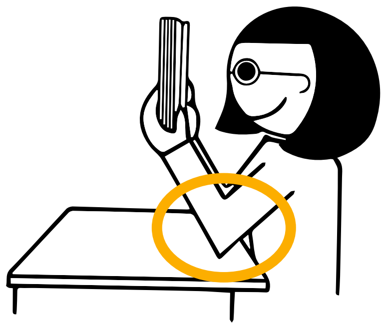
3.1 Reading

General Guidelines

- Provide good illumination and no glare
- Ensure comfortable posture using reading stand or a leaning table top.

Low Visual Acuity

The steady-eye technique should be used for short reading distances. This strategy involves moving the text instead of the eyes. The following instructions are for the reader:



1. Set the required eye-book distance based on the focal length of the spectacles or the power of accommodation.
2. Rest the elbows on the table or against the sides of the body.
3. Move the book as you read, keeping the fixation of the eyes at the same point in space and the reading distance unchanged.
4. When reaching the end of the line you can either:
   a. Look back to the beginning of the same line then go down to next one.
   b. Put a finger at the beginning of the line you are reading, so when moving to the next line you just need to move the finger one line down.

Central scotoma

People using eccentric viewing need:

- Magnification to compensate for the lower resolution of the retina in the best retinal area (BRA).
- Tools such as the BRA chart.
- Training to use the BRA efficiently:
  1. Choose a fixation area (typically above or below the line) that allows the text to fall on the BRA.
  2. Hold the eye still and move the text when reading (see above the Steady eye technique).

Nystagmus

- Find the optimal visual angle where nystagmus frequency is the lowest.

- Avoid monocular occlusion which tend to increase the amplitude of the nystagmus
- The reader should avoid moving the eyes when reading.

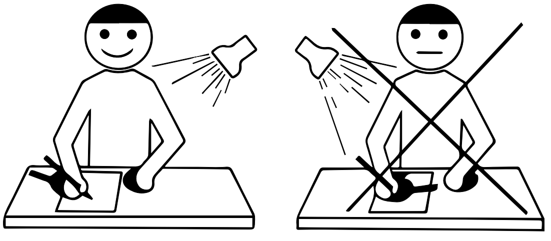
Small central visual field (tunnel vision)

- It is recommended to offer the lowest possible magnification to make fixation field wider.
- The reader should:
  - Scan the entire page before starting to read to orient himself on the content to be read.
  - Use normal reading but with shorter fixations than those used by normal readers.
  - When reaching the end of the line the reader can either):
    a. Follow the line just read to the start then look down to next one.
    b. Put a finger at the beginning of the line being read and move the finger down when the eyes reach the end of the line.

3.2 Writing

General Guidelines

- Consider lower magnification devices to allow for more distance between the paper and the eyes
- A number of simple tools can be used by person with low vision for writing such as:
  - Felt-tip pens
  - Bolded line paper
  - Typoscope and signature frame
  - Reading stand to bring the paper closer rather than bending over the paper
  - Lighting had to come over the shoulder of the non-writing hand to avoid shadow from the writing hand on the page.

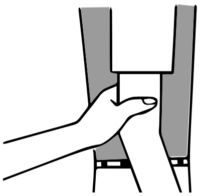


Special tips:

- The writer can place the index finger of the non-writing hand at the end of last written letter and place the pen tip next to the finger to start writing the next word.
- The quality of the hand writing can improve with simple exercises such as:
  1. Tracing with a pen tip along given path like dotted lines shapes and letters.
  2. Tracing in mazes and circling word in search puzzles.
  3. Copying letters and small words.

3.3 Sighted guide technique

Starting position



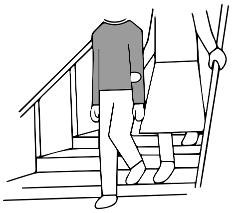
1. Contact: the guide touches the blind person's hand with the back of his hand.
2. Grasp: the blind person grasps the guide's arm above the elbow with the fingers on the inside of the arm (near the guide's body) and the thumb on the outside. The grasp must be firm to be maintained while walking, yet not so tight as to cause discomfort.
3. Stance: the guide will stand with his arm relaxed at his side or bent at the elbow. Meanwhile the blind person stands one half step behind the guide with his arm bent.

Narrow passage

1. The guide will move his arm diagonally across his back and continue facing forward.
2. The blind person will straighten out his arm and move directly behind the guide thus following effectively in single file.

Stairs

The guide will:



1. Stop just before the stairs and tell the blind person if the stairs go up or down.
2. Step onto the first step ahead of the blind person.
3. Stop at the end of the stairs and tell the blind person that you are at the end.

The blind person will:

1. Bring your toes to the edge of the stairs.
2. Use the handrail if possible
3. Start a full step after the guide.

REFERENCES AND USEFUL RESOURCES

This textbook is intended to support practical knowledge so the scientific references are limited to a minimum.

Books and research articles

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- Lovie–Kitchin, J. (2011) Reading with low vision: the impact of research on clinical management. Clinical and Experimental Optometry 94: 121–132.
- Resnikoff, S., Pascolini, D., Etya'aale, D., Kocur, I., Pararajasegaram, R., Pokharel, G.P. & Mariotti, S. P. (2004) Global data on visual impairment in the year 2002. Bulletin of the World Health Organization 82: 844-51.
- Stevens, G.A., White, R.A., Flaxman, S.R., Price, H., Jonas, J.B., Keeffe, J., Leasher, J., Naidoo, K., Pesudovs, K., Resnikoff, S., Taylor, H. & Bourne, R. R. (2013) Global prevalence of vision impairment and blindness: magnitude and temporal trends, 1990-2010. Ophthalmology 120: 2377-84.

Documents free to download (as of August 2016)

- Come Closer (Reading chart) in Arabic, English, French, Russian and Swahili done by the GJU: www.visionme.org.
- Community Eye Health Special Edition on Low Vision Care, including a Standard List: www.cehjournal.org/wp-content/uploads/download/ceh49.pdf.
- Csocsán, E. & Sjöstedt, S. (2008) Learning and Visual Impairment: 200 Years of Experience and Challenges of Today (READER): www.isar-international.com/_files/didaktikpool_9_20090710102624.pdf.
- Inde K. (2007) See bad feel good: http://www.arkiv.certec.lth.se/doc/seebadfeelgood/seebadfeelgood.pdf.
- National Eye Institute Visual Functioning Questionnaire - 25 (VFQ-25): https://nei.nih.gov/sites/default/files/nei.../vfq_sa.pdf .
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- Ryan, B. & Margrain, T. (2005) A course in low vision practice (need to login): www.opticianonline.net/a-course-in-low-vision-practice-series-overview.

Useful links

- www.chetana.org.in
- www.isar-international.com
- www.lowvisiononline.unimelb.edu.au
- www.perkinselearning.org
- www.visionme.org

GLOSSARY

The term (wiki) refers to definitions found in en.wikipedia.org.

Aberration A distortion in an optical system. If a magnifier has aberration, only few letters in the center of the lens will be in focus, while the rest of the text is blurred and distorted. It is caused by the failure of rays to converge at one focus.

Acquired It is said of a disease which is not caused by heredity but to the environment such as infections or traumas.

Activities of Daily Living (ADL) The actions a person does on a day-to-day basis. These activities vary with age and gender and typically include: eating, bathing, dressing, grooming, taking medications, shopping, using the telephone, leisure time activities and managing money.

Acuity reserve The fact of increasing the amount of magnification estimated to take into account the duration of the task. When the person with low vision will use the devices for long periods of time such as reading the newspaper or studying (sustained tasks), the magnification is doubled (2:1) to take into account the eye fatigue.

Agnosia The inability to recognize objects, persons, sounds, shapes, or smells while the sense involved and the memory are functioning (wiki). Visual agnosia occurs when the ventral visual pathways are damaged.

Amblyopia Also called lazy eye, amblyopia is the decreased vision in an eye that otherwise appears normal (wiki). It occurs when there is a significant difference in acuity between the eyes: the image of the best eye is processed by the brain while the image of the weak eye remains blurred.

Ataxia Neurologic sign affecting voluntary muscle movements (wiki). Visual ataxia occurs when the dorsal visual pathways are damaged.

Bifocal A lens with two different optical powers, for example the top part to correct the refractive error and the lower part to magnify.

Binocular Binocular vision is when both eyes are used together. Binocular spectacles or telescopes are devices that provide one lens for each eye.

Bioptics Bioptic telescope are head-mounted eyeglasses that provide distance magnification and allow persons with low vision to drive cars (in places that allow it).

Blind In this book, we use the term blind for people who have not useful vision instead of criteria based on visual acuity.

Blind spot An area of the retina where the optic fibers get together to form the nerve. It has no photoreceptor and is therefore not sensitive to light.

Census Procedure carried on by a government to acquire and record information about each citizen of a territory.

Concept An abstract idea or a mental symbol associated with a word that represents a group of things, people, places or thoughts. The concept 'table', for example, include dinner table, work table, coffee table, etc.

Conceptual analysis A technique of analysing a concept by defining it through its characteristics and breaking it down into prerequisite concepts. For example, the characteristics of the concept 'table' is object, in the category of furniture, and pre-requisites concepts are the various types of table such as dinner table, work table, coffee table.

Congenital A birth defect or a condition existing at or before birth regardless of the cause (wiki).

Constant contact technique Using the cane in a side-to-side motion while maintaining a constant contact between the cane tip and the walking surface.

Diagonal technique Holding the cane diagonally across the body as protection for obstacles in front the body and to gather information on the ground.

Eccentric viewing The use of the retinal area outside the macula for viewing in the case of central vision loss. This causes the persons to look 'side ways' and makes eye contact difficult.

Emmetropia When the eye is looking far away (the lens is relaxed) and the image is formed directly on the retina (no refractive error).

Filter lenses Colored lenses that blocks certain part of the light spectrum to decrease the bright light reaching the eye and improve vision.

Generalization Applying the similarities or abstracted properties to a new object.

Glare Difficulty seeing in the presence of bright light (directed or reflected). The blinding effects of very bright light reflecting on shiny surfaces.

Haptic perception When perception is achieved through active exploration of surfaces and objects by a moving subject (the hand) as opposed to passive contact (wiki).

Hereditary It is said of an eye disease that is transmitted by the genes of the parents.

Hyperopia Commonly known as farsighted or longsighted, it is a defect of vision caused by the light which does not directly focus on the retina but behind it (for example when the eyeball is too short or the lens cannot become round enough) causing difficulty to focus on near objects (wiki).

Landmarks Permanent features in the environment which can be used by a person to determine his or her position in space.

Low vision A person with low vision is one who has an impairment of visual function for whom full remediation is not possible by conventional spectacles, contact lenses or medical intervention and which causes restriction in that person's everyday life". Low Vision Services Consensus Group (1999 www.lowvision.org.uk

Mobility Walking or moving from place to place.

Monocular When only one eye is used (monocular vision) or when a device supports only one eye.

Myopia Also near-sightedness and short-sightedness, it is a condition of the eye where the light that comes in does not directly focus on the retina but in front of it, causing the image that one sees when looking at a distant object to be out of focus, but in focus when looking at a close object (wiki).

Null point A position of the gaze in which the eyes of someone with nystagmus are the most stable.

Nystagmus Involuntary eye movement, acquired in infancy or later in life that usually results in reduced vision.

Orientation Knowing a given position in space in relation to other objects or places.

Photoreceptors A specialized type of neuron found in the retina that is capable of converting light into signals that can stimulate biological processes (wiki).

Photophobia Discomfort or pain to the eyes due to light exposure (wiki).

Preferential looking A technique to assess vision in non-verbal persons. It uses the assumption that the eyes will be attracted towards the most attractive stimulus (when visible). It is measured by observing the eye movements.

Presbyopia A condition associated with aging in which the eye exhibits a progressively diminished ability to focus on near objects (wiki).

Refractive error When the light entering the eye does not focus on the retina. If no correcting lenses are provided, it can cause reduced visual acuity.

Scanning Systematic use of head and eye movements to search the environment for specific objects.

Scotoma A partial alteration in the field of vision causing a loss of visual acuity.

Screening Procedures to identify people with certain symptoms of a disease or condition among a given group.

Sensory awareness In the case of people with visual impairment: gaining information about the world through the other senses which are hearing, smell, touch and proprioception (www.tsbvi.edu/seehear/fall98/waytogo.htm).

Sighted guide Technique used when a sighted person walks with a person with visual impairment.

Spectrum The portion of the electromagnetic spectrum that is visible to the human eye. A typical human eye will respond to wavelengths from about 390 to 700 nm.

Spot task An activity that is carried out only briefly, for example reading the label on a container.

Squint See strabismus.

Strabismus A condition that prevents a person from directing both eyes simultaneously towards the same fixation point. The eyes are not properly align with each other and binocular vision is compromised (wiki).

Survey A method for randomly collecting quantitative information in a population (wiki).

Sustained task An activity that is carried out for long periods of time, for example reading a book or studying.

Syndrome A set of medical signs and symptoms that are correlated with each other and, often, with a specific disease (wiki).

Task analysis Detailed actions needed to carry out a task, broken down into steps and listed in the correct sequence.

Touch technique Using the cane in a rhythmic side-to-side motion (lifting the cane from the ground).

Tracing Following a stationary line with your eyes like shorelines , curbs, the top of hedges.

Tracking Following visually a moving target.

Threshold acuity The smallest details a person can see for a short period of time.

Tunnel vision Loss of peripheral vision with retention of central vision, resulting in a constricted circular tunnel-like field of vision (wiki).

Vision rehabilitation Process of restoring functional ability and improving quality of life and independence in an individual who has lost visual function (wiki).

Visual acuity Clarity of vision or the ability to see details. It is a subjective measure.

Visual impairment Visual impairment, also known as vision impairment or vision loss, is a decreased ability to see to a degree that causes problems not fixable by usual means, such as glasses (wiki). People use different definitions of visual impairment. In this manual, we use the term visual impairment for both low vision and blind. In some places, it is used for low vision only.

Visual prosthesis Device designed to restore part of a failing visual system. The most famous ones the retinal prosthesis.

Visual stimulation The action of using vision to make it more efficient using for example scanning techniques, or to help vision develop in young children by presenting them attractive visual targets to look at.

INDEX

MANUAL IN VISION REHABILITATION

This book takes a multidisciplinary approach to vision rehabilitation, with an emphasis on services to persons with low vision. The content is meant to be supplemented by lectures and practical activities.

PART 1 Fundamentals of Vision Rehabilitation: Eye structure and functions, eye diseases, signs, symptoms and other senses

PART 3: Other areas of intervention: Early intervention, school, orientation and mobility, daily living skills and environmental adaptations

PART 2 Low Vision Rehabilitation: Refractive errors, visual functions, magnification, visual devices, visual skills and training

APPENDICES: Instructions for vision assessment, using magnifying devices, special visual techniques and practical activities

This publication is one of the outcomes of the Tempus IV project entitled ***Curriculum and Skill Development in Vision Rehabilitation*** which includes 10 Universities and non-governmental organizations from Europe and the Middle East committed to improve services to persons with visual impairment.

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