Field Perception

Prepared by:
Todd Gillihan
Krysta Thomsen

Prepared for:
Dr. James Miller, O.D.

March 14, 2003

Abstract:

Many explanations have been given as to the portrayal of visual space through eyes other than your own. We have a mechanical sense of the optics and of the field, with pictures, discussions, and materials to relate the personal perception of vision from one individual to another. These physical explanations coupled with diagrammatic association have long been our reference to patients, community lectures, informative lessons, and classroom discussion. Communication about various refractive states, disease conditions, visual disturbances, and other perceptual vision phenomenon depends primarily on your interpretation of the data present related to visual space, your interpretation to the professional presentation, or painting a 'minds-eye' picture to a description given by a patient presenting with the condition. We suggest an objective situation to facilitate and influence the understanding of ones perception of the world around them under conditions observed by those individuals who encompass various circumstances. We propose an end point of 33 frames and lenses along with informative instructions and travel cases, each designed individually specific to stimulate these different states. We can provide a more personal universal understanding of how people visualize the world with myopia, hyperopia, exotropia, antimetropia,, diabetic retinopathy, macular degeneration, cataracts, field loss with glaucoma, vertical imbalance, and many other situations that impact the perception of our visual space.

Your vision is an important sense that you rely upon more than you probably think. Most of us knew or currently know someone who wears glasses. Some people wear glasses to see distant objects clear, some wear them to keep their eyes looking straight ahead, and your grandparents may wear special reading glasses to help them see up close. Have you ever wondered what the world looks like for those people? Not only considering these people, but try to imagine how the world looks through the eyes of someone with an eye disease such as glaucoma, cataracts, diabetes, color blindness, or other eye problems. Our intent is to help others get a basic understanding and general visualization of why all people do not see the same way, and how we are able to help some of these people.

There are many different reasons why we may not be able to see well. Sometimes we are just born that way, or possibly our eye muscles do not work properly. Other changes occur as we get older when parts of the eye do not work as well as they used to. Many diseases that your optometrist can detect can cause changes in the eye that affect our vision and make images appear blurry, distorted, or make us lose sight

completely. In order to better understand these various eye disorders we will break them into five groups; 1. Refractive errors or situations that make distance or near blurry, 2. Phorias, or conditions that cause an eye to turn in, out, up, or down, 3. Presbyopia, or those that affect the vision of older people, 4. Diseases which affect the health of the eye, and the path to the brain., and 5. color vision problems.

Later, you will have the opportunity to try on thirty-threedifferent pairs of eyeglasses which were made to simulate these different vision anomalies. It is our intent that this project will be used in educational facilities, community education, demonstration in the exam room for the patient and family, for upcoming optometry students, and any other situation that renders awareness or further understanding. Awareness and education about the importance and manifestations of sight will promote detection and management from your regular scheduled visits to the optometrist.

REFRACTIVE ERRORS

The medical term given when light enters the eye and is focused on the retina without the help of eyeglasses or anything else is called *emmetropia*. Emmetropes don't need to wear eyeglasses or contact lenses to see things in the distance clearly. *Myopia* (spectacle 1 & 3) or nearsightedness occurs when light is focused on a point in front of the retina, which is the projector screen of the eye. This occurs in one of two instances when we are young. Either the eye itself is too long, or the front surface of the eye called the cornea is too steep. Just as a projected image that is not properly focused on a projector screen is blurry, so is the image in the eye. Using minus power concave lenses in glasses can move the image further back onto the retina where it becomes clear.

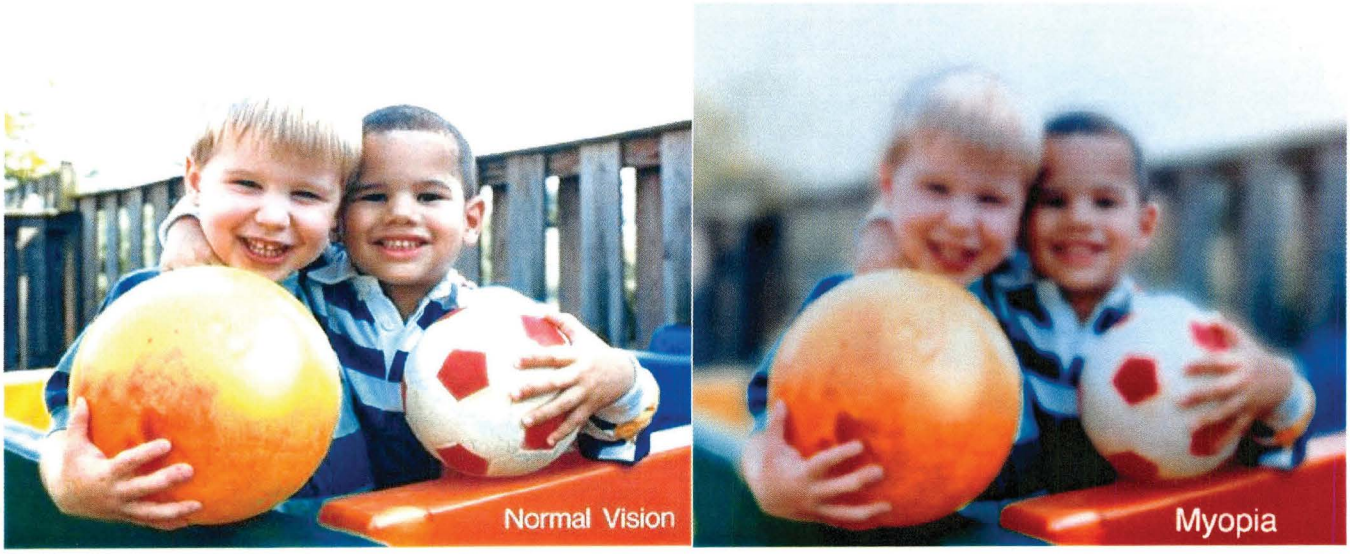

Figure 1. *a)* Children at play as viewed with emmetropic vision and *b)* the same children as seen through the eyes of a myopic person. [6]

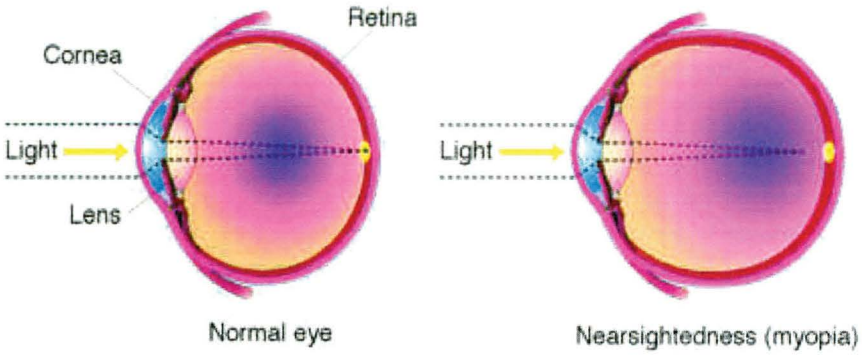

Figure 2. Light focused on the retina of an emmetropic eye compared to light focused on the retina to a point in the myopic eye[4]

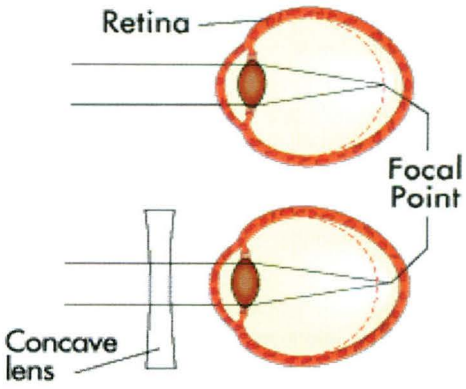

Figure 3. A concave lens can put the light in focus on the nearsighted eye[5]

Hyperopia (spectacle 2 & 4) or farsightedness results when light entering the eye is focused on a point behind the retina. This can occur depending on whether the eye is either too short, or the cornea too flat. The image again is blurred because it is not focused directly on the retina. Using plus power convex lenses can correct this condition. Plus lenses move the picture forward onto the retina to make it clear.

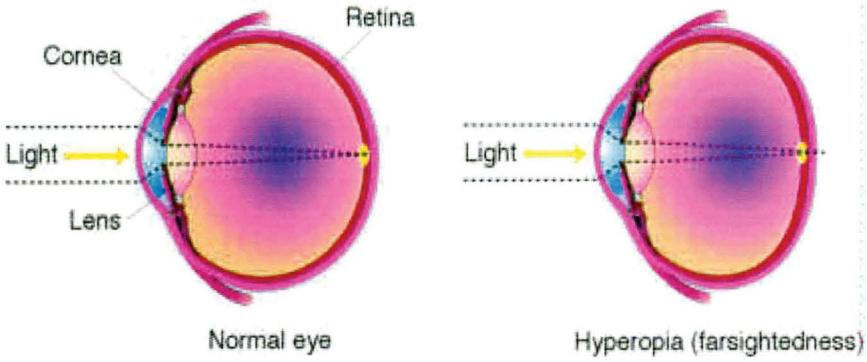

Figure 4. Light focused on the retina of an emmetropic eye compared to light focused in front of the retina in a hyperopic eye. [4]

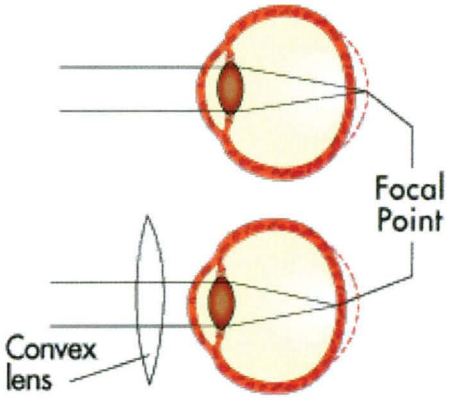

Figure 5. A convex lens can focus the light on the retina of a farsighted eye[5]

Astigmatism (spectacle 5,6,7) describes the blurred image that occurs from the front clear part of the eye, the cornea, not being round. The eye in this case is shaped more like a football than a baseball with one direction of the ball being flatter and the other being steeper. In this situation an image is projected toward the back of the eye and not all of it is focused in the same spot. Cylindrical lenses help make the defocused image focused on the retina.

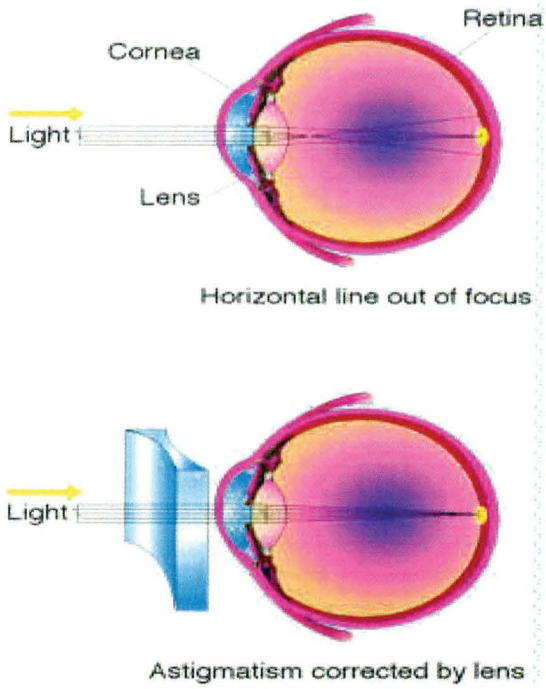

Figure 6. Light focused as blur circles in the astigmatic eye compared light focused in the same eye corrected with a cylindrical lens[4]

Antimetropia (spectacle 8) is a condition in which the image is focused in a different place in each eye. The magnifying power of the right eye is different than the power of the left eye. This results from one eye being more nearsighted, and the opposite eye being more farsighted.

Phorias

Exotropia (spectacle 9) is the outward deviation of an eye. Not everyone's eyes are aligned perfectly straight. Small amounts of exotropia may be difficult for someone to see when looking at you, but in great enough amounts it can cause eyestrain and double vision. Special procedures and techniques used in vision therapy can help train people to realign their eyes or make better use of the vision they currently have. Typically, those who are born with this are able to suppress or hide the image from one eye to achieve single vision. Often those who acquire this later in life, from an accident for example, are unable to suppress one eye and see double images called diplopia.

Esotropia, (spectacle 10) or an inward deviation of one eye can also cause visual disturbances similar to exotropia. Plus power lenses can sometimes be used to relax the eyes and make distance viewing more comfortable. Special lenses called prism can also be used in some cases to move the image the patients sees to a more comfortable position. Prisms are used in spectacles to help esotropes and exotropes see one thing and not two. In large deviations, surgeons sometimes attempt to straighten the eye by performing surgery on one or more of the muscles. Although this may help, not all patients achieve success with surgery.

Hyper or *hypo phorias* (spectacle 11) are less common, but more likely to cause vision problems in smaller amounts. These occur when the eye turns either upward or downward. Even minimal amounts of eye turn up or down can cause reading difficulties and diplopia. This can be corrected with prism in your spectacles which move the image up or down to line it up with the eye that is turned.

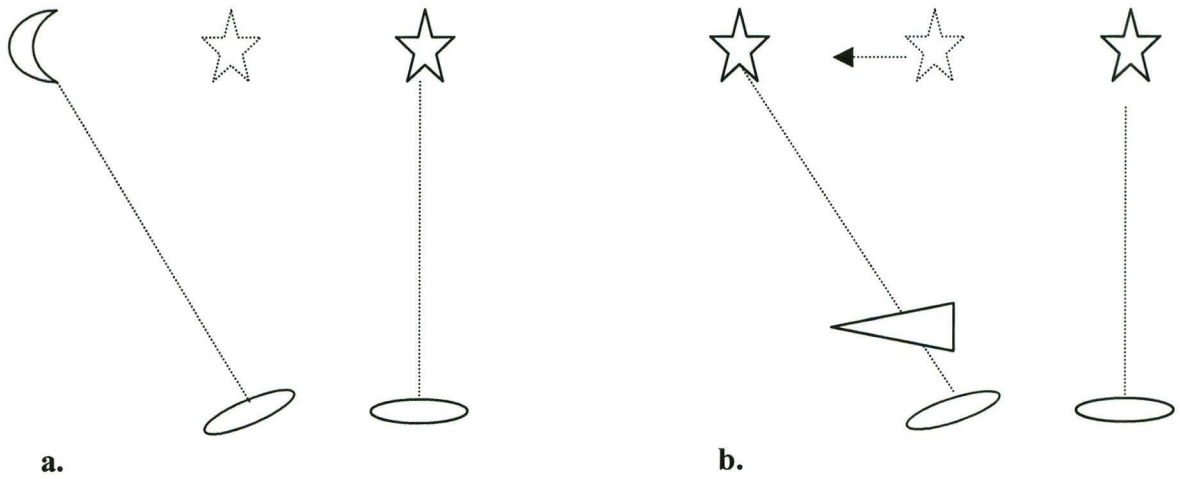

Figure 7. *Exotropia* with a) one eye seeing a star and the other a moon, and b) corrected with prism, the star is seen by both eyes eliminating double vision

PRESBYOPIA

The change in the eyes that cause blurring of your near vision as you get older is called presbyopia. Over time, the lens inside the eye loses its elasticity and the muscles in your eye can no longer change the shape of the lens and you loose your near focusing flexibility. This normal aging process typically becomes noticeable around age 40. These people can be helped with reading glasses or a type of lens called a bifocal. A bifocal lens allows for the viewing of distant objects through one portion of the lens, and near objects by looking through another portion.

Flat top bifocals (spectacle 12) are easily recognized. A majority of the lens is used to see at distance while a segment with near power or more magnifying power is used for reading in the bottom of the lens. This segment is shaped like an upper case D, with the flat portion facing upward. The person simply looks down through this part when they want to see something up close.

Trifocal lenses (spectacle 13) are identical to the bifocal with one exception; there is a middle zone for viewing objects at an intermediate distance, which is about from an arms length away to the far edge of a typical desk. This area is placed between the distance and near areas of the lens. People who have a need to see further than arms length often request this lens. It is useful for those who want to read labels off shelves at the grocery store, play cards, play pool, or sit back from their computer.

Round segment bifocals (spectacle 14) perform similarly and are an alternative to the flat top bifocal. They have the same distance viewing with a near portion built in. Some people find the round segment more visually pleasing than the D-shaped flat top bifocal. It is thought that the round shape has a less visible line than the flat top.

Double D bifocals (spectacle 15) are available for those who have occupations or hobbies that require them to be able to see clearly at near above and below their line of sight. These bifocals have distance viewing in the center with a D shaped near segment at the top and the bottom of the lens. Auto mechanics or electricians who work with near objects above and below their head throughout the day commonly use this design.

Progressive add lenses (spectacle 16) are quickly becoming the most popular bifocal lens. It is often desired by the younger generation of bifocal wearers who do not want others to know they are wearing a bifocal. Aside from having no visible line, there is a very functional advantage to the progressive bifocal lens. This lens allows for a smooth transition from distance vision, through your intermediate zones, and down to near vision. Therefore, the wearer is capable of having clear vision at all viewing distances. One downside is an area of distortion at the outer edges of the lens caused by the design of the lens.

Executive bifocals (spectacle 17) are an uncommon but sometimes practical use for spectacle lenses. The executive has a near portion that extends all the way across the bottom portion of the lens. This can be useful for people requiring good peripheral vision at both distance and near. It does not possess the same interruption of vision that a smaller segment may cause when looking to the side, or the distortions that are common of a progressive bifocal. This panoramic view can benefit those with jobs requiring them to look at several computers, instrument clusters, multitasking desk workers, or even quilters who need to see the whole pattern all at one time.

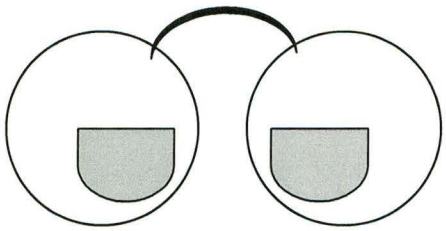

Figure 8. Flat top bifocals

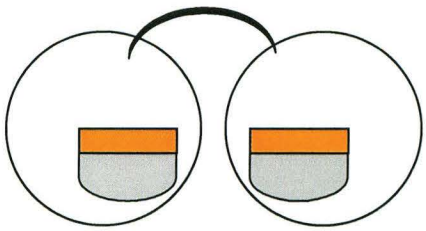

Figure 9. Trifocals

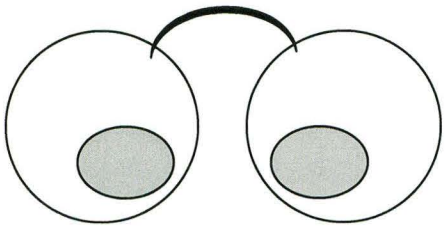

Figure 10. Round segment bifocals

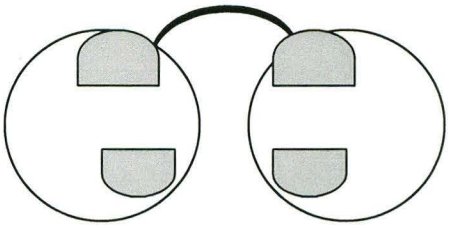

Figure 11. Double D segments

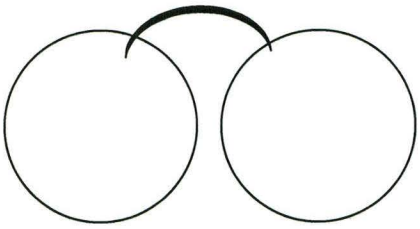

Figure 12. Progressive lenses

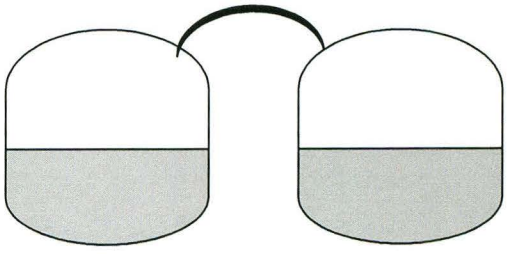

Figure 13. Executive bifocal

EYE DISEASES THAT CAUSE VISION LOSS

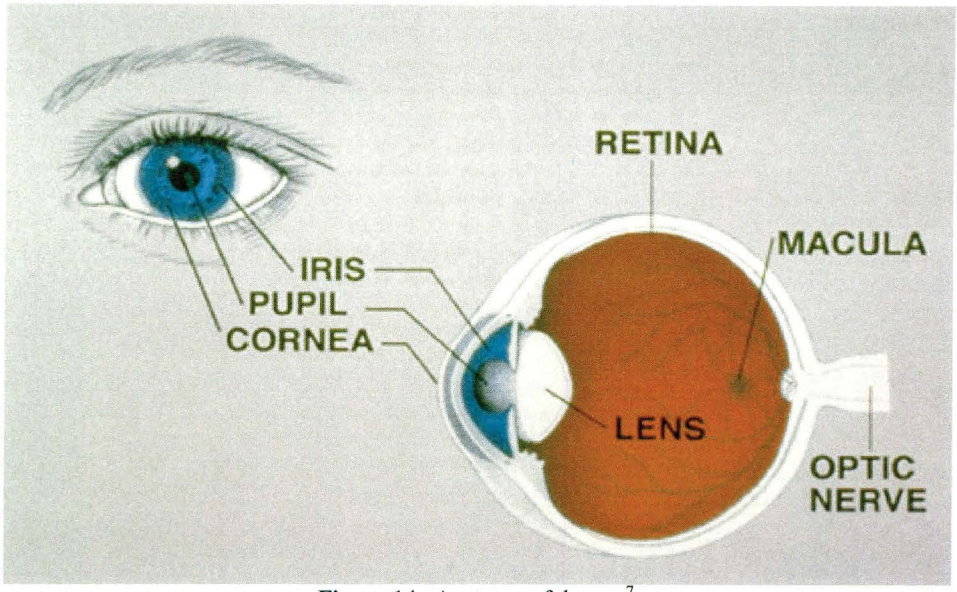

Figure 14. Anatomy of the eye[7]

Nuclear sclerotic cataracts (spectacle 18) are the most common type of cataract seen with age. Cataracts are inevitable to everyone. Its not some disease process, everyone at some point in their life will develop these normal age related changes if they get old enough. Over time, the clear lens inside the eye begins to yellow and eventually turns brownish yellow. This can be imagined as a windshield becoming dirtier over time, it becomes harder to see out if you don't wash it.

Glaucoma (spectacle 19) is an increase in the pressure inside the eye, which if untreated can lead to optic nerve damage. This results in progressive, permanent vision loss starting with unnoticeable blind spots in your periphery, progressing to tunnel vision and then to blindness. This or any other eye conditions we are discussing are not infective, they are not contagious; most are a result of hereditary, lifestyle, or the natural aging of the human body. Glaucoma is not something you feel; actually people who have this usually do not realize they do until it's detected at an eye examination by their optometrist. The eye produces a fluid in one part and drains it out in another. With glaucoma your eye is either producing too much fluid or not draining it fast enough. The glaucoma damage and side vision loss that results is not something that can be fixed, only managed. The damage can be slowed down but the vision loss cannot be brought back. Without management, vision loss will continue to move centrally. Treatment includes the use of special eye drops or surgery, but vision cannot be spared or regained by simply wearing eyeglasses. Between two to three million people in the United States have glaucoma.[4] It is the leading cause of preventable blindness in the United States and the most frequent cause of blindness in African-Americans, who are at about three times higher risk of glaucoma than the rest of the population. The risk of glaucoma increases dramatically with age, but it can strike any age group, even newborn infants.[6]

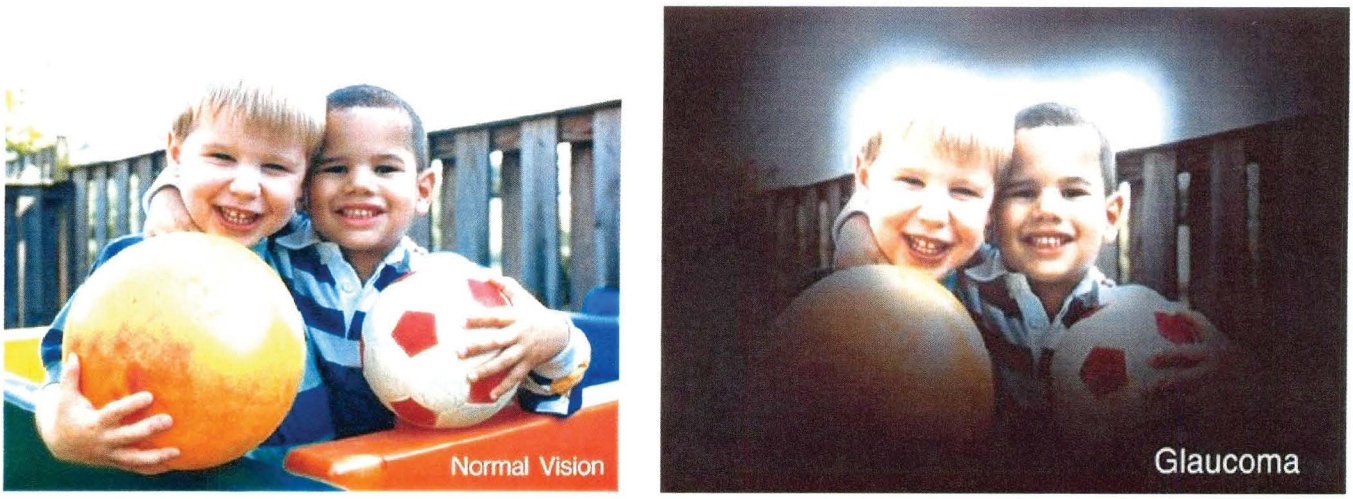

Figure 15. The view through healthy eyes compared to the same view through the eyes of someone with glaucoma. [6]

Age related macular degeneration, ARMD, (spectacle 20) is the progressive deterioration of a critical region of the retina called the macula. The macula is a small, 3-5 mm area in the retina that is responsible for central vision. This disorder leads to irreversible loss of central vision, although peripheral vision is retained. In the early stages vision may be gray, hazy, or distorted. This results in a change of shape, *metamorphopsia*, (spectacle 21) of objects as in straight lines being bent or a hallway looking like a wavy stream shaped like an hourglass.[8] This tissue destruction process occurs in some aging people and cannot be corrected with eyeglasses. Treatment is limited to certain cases, however, studies indicate that certain vitamins and minerals meeting specific criteria may help prevent or slow the progression of the disease.[6] Macular degeneration is the most common cause of legal blindness in people over 60, and accounts for approximately 11.7% of blindness in the United States. This disease affects about 28%, or one in every four persons of the population over age 74. Approximately 10 million Americans have some vision loss that is due to ARMD.[4]

Figure 16. The view through healthy eyes compared to the same view through the eyes of someone with macular degeneration. [6]

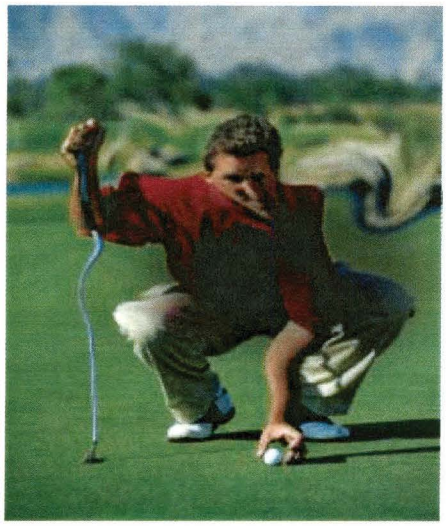

Figure 17. Metamorphopsia from Macular degeneration[7]

Retinitis pigmentosa, RP, (spectacle 22) is a genetic disease that slowly leads to blindness in the form of progressive tunnel vision. The majority of peripheral vision becomes lost and the person has the sensation of looking through a straw. There is no treatment at this time, although special low vision lenses can try to increase the patient's field of view. The retina lines the inside surface of the back of the eye and is made up of several layers. One layer contains two types of photoreceptor cells referred to as the rods and cones. The cones are responsible for sharp, central vision and color vision and are primarily located in a small area of the retina called the fovea. The area surrounding the fovea contains the rods, which are necessary for peripheral vision and night vision. The number of rods increases as you go away from the center of vision. The rod and cone photoreceptors convert light into electrical impulses and send the message to the brain through the optic nerve. In RP, the photoreceptors (primarily the rods) begin to deteriorate and lose their ability to function. Since the rods are primarily affected, it becomes harder to see in dim light resulting in decreased night vision. As the condition worsens, peripheral vision disappears, which results in tunnel vision. The ability to see color is eventually lost. In the late stages of the disease, there is only a small area of central vision remaining. Ultimately, this too is lost.

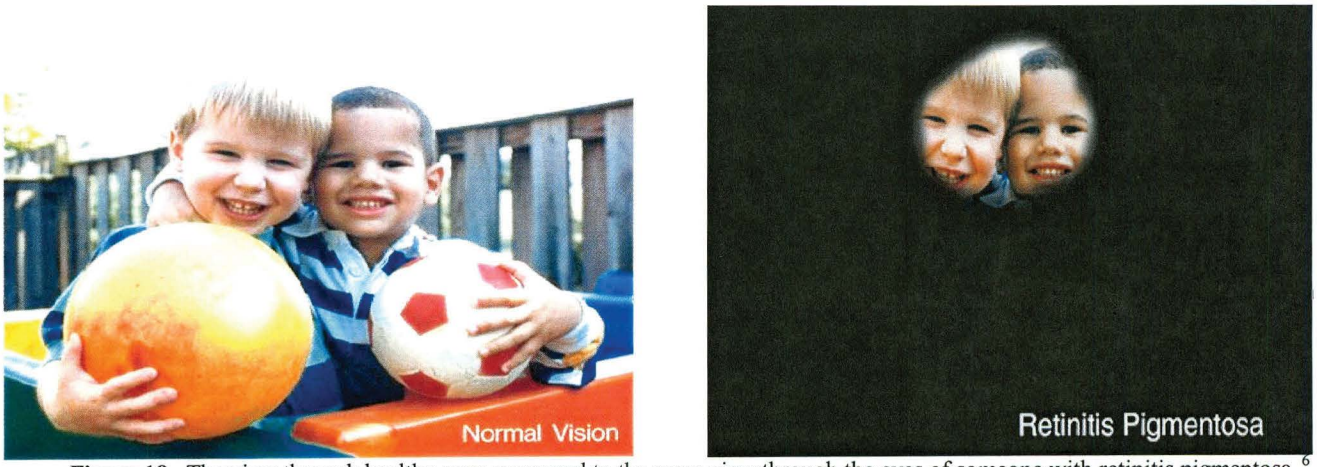

Figure 18. The view through healthy eyes compared to the same view through the eyes of someone with retinitis pigmentosa.[6]

Diabetic retinopathy (spectacle 23) is a disease of the blood vessels in the eyes of patients with diabetes. Either the blood vessels swell and leak fluid or new blood vessels begin to grow in the retina where they shouldn't be. As one of the leading causes of blindness in the United States, nearly half of all diabetics will have some form of this eye problem. The longer you've been diagnosed and more unstable your blood sugar control is, the more likely you are to develop diabetic retinopathy. People with this may experience blurring of their vision or loss of patches of their vision as the blood vessels leak and the retina swells. Lasers can be used to seal up leaky vessels so vision doesn't get worse, but vision often does not come back. Most diabetics will not have any changes in their vision, but the optometrist can detect damage and help prevent possible vision loss if they do.

Figure 19. The view through healthy eyes compared to the same view through the eyes of someone with diabetic retinopathy.[7]

The vitreous is a substance in the back of the eye that has the look and feel of jello. This substance is connected to the retina in a handful of spots. As you get older and this turns from a jello consistency to a watery substance, it breaks apart from the retina. Sometimes the areas that break apart from the retina do not completely liquefy and part of the vitreous 'floats' around in your eye. This normal aging process is called a *posterior vitreous detachment*. Some people see this floating around in their vision like a fly buzzing around their head or a cobweb in front of them. It moves when your eyes move. Sometimes this substance does not completely break apart and can pull and tug at the retina. The retina cannot sense pain, actually the retina senses light. When you put your hand on a hot pan you pull away because you sense heat. Your eyes only sense light and when you see a flash (spectacle 24) of light, this might be a clue that something is wrong inside the eye.

Corneal edema, (spectacle 25) or swelling of the front clear part of the eye, can occur for a number of reasons. As fluid fills the cornea, it loses its clarity and becomes more opaque resulting in blurred vision. Some forms of glaucoma can cause this. Any trauma that results in corneal damage can cause problems for the rest of your life and result in frequent experiences of corneal edema and pain that we call recurrent corneal erosions.

A common complaint from eyeglass wearers is that people looking at them see many light reflections off the front of their spectacles. This problem can be minimized with *antireflective coatings* (spectacle 26) on your spectacles. This coating reduces the reflection on your glasses as people look at you and also reduce the glare as you look out of them. The glare does not go away, only becomes less of a nuisance.

VISUAL PATHWAY FROM THE EYES THROUGH THE BRAIN

Loss of vision in specific areas of your surroundings occur as a result of tumors, blood vessel problems, and any form of trauma or injury which may lead to either nerve or blood vessel leakage or blockage. These problems correspond to specific areas of the brain where the injuries are, and result in specific pattern-like loss of vision that follow right side, left side, upper half, lower half, or a combination of these together giving the vision loss. Most of the vision loss may not be noticeable. By that I mean you're not looking straight ahead and you see that everything on your right side is black. You just don't see things there much like when a car is driving by you and disappears behind you. You can't see blackness; there is just nothing there for your brain to interpret. This is called visual neglect; your brain is neglecting to see what is in front of your eyes.

Hemianopsia (spectacle 27) means that exactly half (hemi-) of the vision is defective. We say it's on the right or left side depending on where the loss is. If we say bitemporal we mean you lost vision in (bi-) two eyes, and the loss was on the outside near your temples (-temporal). When the loss occurs as a *bitemporal hemianopsia*, (spectacle 28) it can indicate that a tumor may be present in part of the brain called the pituitary gland and is pressing on the nerve fibers that travel to the optic nerve head in the back of the eye. We may say there is a *binasal hemianopsia* (spectacle 29) if the vision loss is (bi-) in both eyes, (-nasal) near the nose, and (hemi-) half of your visual field is lost. If vision loss occurs binasally, a patient should be checked for an internal carotid aneurysm, which is an enlargement in a portion of a large blood vessel that puts pressure on the nerve fibers. *Quadrantopsia* (spectacle 30) is a pie shaped loss that affects one quarter (quadrant-) of the vision.

COLOR BLINDNESS

Color blindness is an abnormal condition characterized by the inability to clearly distinguish different colors of the spectrum. Basically, colorblind people have a hard time telling the difference between certain colors. The difficulties can be mild to severe. Color blindness is a misleading term since people with this condition usually can still see colors. Color deficiency is a more accurate description since they tend to see colors in a limited range. 4.5% of the population has a color deficiency and most are inherited but some are brought on by injury or disease.[10] Normal color vision requires the use of specialized cells called cones, which are located in the retina of the eye. There are three types of cones, termed red, blue, and green, which enable people to see a wide spectrum of colors. An abnormality, or deficiency, of any of the types of cones will result in abnormal color vision.

Protanomaly (spectacle 31) occurs when there is a problem with red cone cells. Because of this problem the person either cannot see red at all, has difficulty telling the difference between red and green, or sees only a limited range of red colors. This is a much more complex topic that is being simplified here to make it understandable, but not all colorblind people see the same thing; they are all unique and experience the world different from one another and from people who are not colorblind. With reduced or no red cones, more or the other colors are seen. Looking through the green tinted lenses, most reds will look black or darker.

Deuteranomaly (spectacle 32) occurs when there is a problem with green cones. The same thing as above occurs but the person sees more red and no green or a limited range or green. Looking through the red tinted lenses you can see that most green things look dark or hard to tell their green. Unfortunately with the lenses we have in our set, the color of the lens is not a good example to show how color vision problems appear, but they will give some basic understanding.

Tritanomaly (spectacle 33) is the least common, and is many times associated with disease or damage to the eyes. This color deficiency indicates a lack of blue cones. Therefore, it is difficult to see most shades of blue because there are more middle and long wavelength colors getting through. When looking through the yellow tinted lenses, you will see that blue colors look washed out.

CONCLUSION

A variety of common ocular anomalies have been described to be a teaching tool and an introduction into various conditions of the eyeball. Presentation of the material has been laid out for easy understanding for translation to various age appropriate cognitive capabilities. As optometrists we are constantly giving patients and others education on different refractive states and disease processes. There is great difficulty in knowing whether this information is interpreted as the optometrist knows it in their mind. Appreciating our communication about various refractive states, disease conditions, visual disturbances, and other perceptual visual phenomenon depends primarily on subjective understanding of the data presented and in turn painting a 'minds-eye' picture of what it is you think is being stated.

The world around us is viewed and judged very differently from person to person depending on many things including the health, genetics, and anatomical structuring of the eyeball and related components. The figures in the paper, along with the manipulated spectacles to look through will give others a "see it for yourself" visualization to understand that there is a difference in how people afflicted with various conditions interpret their visual surroundings. Stressed during presentation of the material should be that of a regular scheduled eye exam with your optometrist to ensure proper detection and management of these and the hundreds of other conditions that affect the eye.

The style of presentation will vary depending on the people being presented to. Possibilities could include a quick, brief introduction into each condition followed by letting them try on the spectacles and glance through the material. You could hold small groups and go into detail reading right from this paper while one spectacle is passed around to get more in-depth information. You could separate the spectacles into the 5 categories and spend time on each category for a more individual introduction. Either way, keep in mind that there are 33 conditions being simulated with the idea of opening someone's eyes to how people see the world and not a mere memorization about detailed facts of ocular anomalies.

Bibliography

1. Brooks, J.C, Owens, D.A.. 2001. Effects of luminance, blur, and tunnel vision of postural stability, Journal of Vision, 1(3) 304a

2. Brown, A.M. & Lindsey, D.T. 2001. The color blue: A psychophysical explanation for a linguistic phenomenon [Abstract]. *Journal of Vision*, 1(3), 59a, **http://journalofvision.org/1/3/59**, DOI 10.1167/1.3.59.

3. Doi, T.L., KA., Gunther, P.J., 2001. Prism adaptation effects of absolute distance judgement. Journal of Vision, 1(3). 5a

4. **http://www.ehendrick.org/healthy/index.htm** . Health Information Library. 2002

5. **http://www.howstuffworks.com/eye8.htm** . How Vision Works. Dr. Carl Bianco, M.D., January 2003

6. **http://www.nei.nih.gov/photo/sims/sims.htm** . June 2001

7. **http://www.stlukeseye.com/** . St. Luke's Cataract and Laser Institute. 2003

8. **http://www.visualexpert.com/** . Perception depends on attention. Vusual expert. 2001.

9. Rosenblum, L.P., Perceptions of the impact of visual impairments on the lives of adolescents, Journal of visual impairments, 7.2001, 94(7) p 434-445

10. Shovlin, Joseph , Color-Deficient Patients See Red? Review of optometry. Vol. No: 139:04 Issue: 4/15/02

11. Walker, Visual perception and mental imagery. Pantone. Scientific American, march 86. v254(3), pp 112-118

12. American Optometric Association. **http://www.aoa.org/** .2003

13. Future Optometrists. **http://www.futureoptometrist.com/** Laura K. Windsor, O.D. 2/2003

spectacle number	Simulated Condition	Right Lens	Left Lens
1	low myopia, or correction for low hyperopia	+2.00 sphere	+2.00 shpere
2	low hyperopia, or correction for low myopia	-2.00	-2.00
3	high myopia, or correction for high hyperopia	+6.00	+6.00
4	high hyperopia, or correction for high myopia	-6.00	-6.00
5	astigmatism correction	plano -1.75 X 180	plano
6	astigmatism correction	plano -1.75 X 090	plano
7	astigmatism correction	plano -1.75 X 135	plano
8	antimetropia	+2.00 sphere	-2.00 sphere
9	right exotropia	8^ base out prism	plano
10	right esotropia	8^ base in prism	plano
11	right hypertropia	4^ base down prism	plano
12	flat top bifocal	plano distance, +2.00 ADD	plano distance, +2.00 ADD
13	trifocal	plano distance, +2.00 ADD	plano distance, +2.00 ADD
14	round segment	plano distance, +2.00 ADD	plano distance, +2.00 ADD
15	double D segment	plano distance, +2.00 ADD	plano distance, +2.00 ADD
16	progressive addition lens	plano distance, +2.00 ADD	plano distance, +2.00 ADD
17	executive bifocal	plano distance, +2.00 ADD	plano distance, +2.00 ADD
18	nuclear sclerotic cataracts	brownish yellow	brownish yellow
19	glaucoma	center clear, haze	center clear, haze
20	age related macular degeneration	center black	center black
21	metamorphopsia	smucked clear coat	smucked clear coat
22	retinitis pigmentosa	center clear	center clear
23	diabetic retinopathy	blotchy	blotchy
24	flashes	nail ploish glops	nail polish glops
25	corneal edema	tacky finger prints	tacky finger prints
26	polycarbonate lens with an antireflective coating	antireflective coating	plano, no coatings
27	left hemianopsia (brain lesion)	left side black	left side black
28	bitemporal hemianopsia (pituitary tumor)	temporally black	temporally black
29	binasal hemianopsia (internal carotin aneurysm)	medial black	medial black
30	right inferior homonymous hemianopsia	left upper quadrant black	left upper quadrant black
31	protan color deficiency	green lens	green lens
32	deutan color deficiency	red lens	red lens
33	tritan color deficiency	yellow lens	yellow lens