Vision

Objective:

To explain in words or diagrams why the focal distances of emmetropic, myopic, and hyperopic eyes will be different and how to compensate for these differences with corrective lenses, at the level of 85% proficiency for each student.

In order to achieve this objective, you will need to be able to:

1. Measure focal distances in models of emmetropic, myopic, and hyperopic eyes.
2. Measure the effects of corrective lens on focal distances in emmetropic, myopic, and hyperopic eyes.
3. To examine the effects of astigmatism, lens removal and pupil size on the vision.

Materials:

Group Supplies:

Eye Model
Light source for the Eye Model
Set of Lenses for the Eye Model
1 Meter Stick
Desk lamp

THE EYE MODEL APPARATUS*

The model eye used in this experiment is a metal container shaped roughly like a horizontal section of the eyeball. A window in one side of the tank is covered with a meniscus lens C which, serves as the cornea. The tank is filled with water, which takes the place of the aqueous and vitreous humors. The interchangeable crystalline lens L is mounted in a septum, which marks the boundary between the humors. In front of the cornea are two additional supports S1 and S2 for corrective lenses. Two supports G1 and G2 are provided for the insertion of additional lenses and a diaphragm. The retina is represented by a circular white area on a removable curved screen R, which may be located at various positions by means of a series of groves in the well of the tank. The blind spot is represented by a back spot painted on the retina.

A diaphragm and the following set of six lenses are mounted individually in metal holders.

1. Spherical convergent (+7.00 d)

2. Spherical convergent (+20.00 d)

3. Spherical convergent (+2.00 d)

4. Spherical divergent (-1.75 d)

5. Cylindrical divergent (-5.50 d)

6. Cylindrical convergent (+1.75 d)

In the case of the cylindrical lenses the axis of the cylinder is indicated on the mount. A backlit light box with a suitable geometric design for demonstrating visual defects completes the equipment.

**Description provided by manufacturer*

Methods and Results:

Vision in the Emmetropic, Myopic and Hyperopic Eye

Parts of the artificial eye:

- **Cornea** is the transparent glass at the front of the artificial eye.
- "**S1**" and "**S2**" positions are in front of the artificial cornea and correspond to the location of corrective lenses (eye glasses or contact lenses).
- "**G1**" position is just behind the artificial cornea and corresponds to the location of the iris.
- "**L**" position is behind "G1" and corresponds to the location of the lens (crystalline lens).
- **Retina** is a curved plate behind the "L" position that can be placed in different slots to simulate eyes of different lengths.

Terminology for different eye lengths:

- **Emmetropic** refers to a normal length eye.
- **Myopic** refers to an elongated eye where the retina is too far from the front of the eye.
- **Hyperopic** refers to a shortened eye where the retina is too close to the front of the eye.

Terminology for different lens shapes:

- **(+) diopter** lens is convex – thinner at edges, thicker in center
- **(–) diopter** lens is concave – thicker at edges, thinner in center.

To begin, fill the eye tank with water just above the flange at the cornea.
We will conduct experiments with many configurations of the eye model, *summarized below and detailed on the following pages*.

1. An emmetropic eye with a +7 diopter eye lens
2. An emmetropic eye with a +20 diopter eye lens
3. A myopic eye with a +7 diopter eye lens
4. A myopic eye with a +20 diopter eye lens
5. A myopic eye with a +7 diopter eye lens; corrected with a -1.75 diopter corrective lens
6. A myopic eye with a +20 diopter eye lens; corrected with a -1.75 diopter corrective lens
7. A hyperopic eye with a +7 diopter eye lens
8. A hyperopic eye with a +20 diopter eye lens
9. A hyperopic eye with a +7 diopter eye lens; corrected with a +2.00 diopter corrective lens
10. A hyperopic eye with a +20 diopter eye lens; corrected with a +2.00 diopter corrective lens
11. An emmetropic eye with varying pupil size
12. An emmetropic eye with astigmatism
13. An emmetropic eye with lens removal

For each configuration (1-10) measure and answer the following:

a) Point the artificial eye toward a well-lit object at least 20 feet away.
Is the image projected on the retina of the artificial eye in focus, Yes or No?

Record your results in Table 1 or Table 2.
Explain why or why not the image is in focus?
Prepare a diagram illustrating the path of light passing from the object through the eye lens system to the point of focus.

b) At your table, point the artificial eye toward the backlit light box and position them 1 meter apart. Move the backlit light box closer to the artificial eye until the image projected on the retina of the artificial eye is in focus. Record this distance.
If the image from the light box is not in focus within 1 meter of the eye, record "**None**"

Record your results in Table 1 or Table 2.
Prepare a diagram illustrating the path of light passing from the object through the eye lens system to the point of focus.

Table 1. Focus distances in eyes without corrective lens:

	Emmetropic (retina in middle slot)	Myopic (retina in posterior slot)	Hyperopic (retina in anterior slot)
+7 diopter eye lens in position L	In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm	In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm	In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm
+20 diopter eye lens in position L	In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm	In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm	In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm

Table 2. Focus distances in eyes with corrective lens:

	Emmetropic (retina in middle slot)	Myopic (retina in posterior slot)	Hyperopic (retina in anterior slot)
+7 diopter eye lens in position L AND designated corrective lens in position S1	Not used	*use –1.75 diopter corrective lens in S_1 position* In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm	*use +2.00 diopter corrective lens in S_1 position* In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm
+20 eye lens in position L AND designated corrective lens in position S1	Not used	*use –1.75 diopter corrective lens in S_1 position* In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm	*use +2.00 diopter corrective lens in S_1 position* In focus at 20 feet or more? _Y__N_ Near Distance in Best Focus _____ cm

In the experiments below you will work at your table and use the backlit light box to determine when the image from the backlit light box is focused on the retina of the artificial eye.

Pupil Size:

Place the retina in the normal (emmetropic) position, the spherical eye lens (+20 diopter) in the (L) position, and adjust the distance from the backlit light box such that the image is clearly focused on the retina. Insert the black diaphragm into slot G1 behind the cornea. What is the effect the diaphragm (which decreases the pupil size) on the brightness and sharpness of the image? Try moving the backlit light box closer and farther away from the eye with and without the diaphragm. In which situation is the depth of focus greater? Record your observations.

Astigmatism:

Place the retina of the eye model in the normal (emmetropic) position. Put the spherical eye lens (+20 diopter) in the crystalline lens position (L) and the cylindrical astigmatic lens (-5.50 diopter) in slot G1 (between the lens and the cornea). The axis of rotation of the cylindrical lens should be vertical. This combination of lenses creates at eye with astigmatism.

Position the backlit light box for best focus of the image.

Describe the appearance of the image when an eye has astigmatism.

Place a cylindrical corrective lens (+1.75 diopter) in slot S1 and rotate this lens until all lines of the object are clearly focused on the retina. Describe the axis of orientation of the corrective lens (+1.75 diopter) with respect to the axis of orientation of the astigmatic lens (-5.50). Note the surface of the astigmatic lens.

Lens Removal:

Sometimes the lens must be removed due to a cataract, for example. Using the eye model with the retina in the emmetropic position, remove the lens from position (L) and place lens (+7 diopter) in the S1 or corrective slot. (Make sure that no other lenses are left in place). At what distance is the image from the backlit light box in focus? What are the visual restrictions in this case?

Discussion

1. Describe the sizes of the images projected onto the retina of the artificial eye. Speculate on ways humans estimate the size of objects in their visual field.
2. Describe the visual performance of the emmetropic, myopic, and hyperopic eye. How close and how far can each type of eye focus an image?
3. What type of corrective lens does a myopic eye need to "see" at a far distance? What type of corrective lens does an hyperopic eye need to "see" close-up?
4. What is meant by accommodation? Describe how accommodation occurs. What muscles are involved? What are the changes in the shape of the lens, and the position of the eyeballs as an object moves closer to the viewer? Explain these changes.
5. What is presbyopia? What is astigmatism?