Vision Science III: Ocular Motility & Binocular Vision

Lab 1 - Visual Direction

Binocular vision is such a natural part of our daily lives that we fail to appreciate some of the complex issues involved in creating a single sense of direction from two eyes. Early vision scientists designed simple experiments that allowed them to discover some of the basic principles of visual direction. We will repeat some of these experiments in today's lab. Work in pairs, but take turns so each person can be the subject of each experiment. Turn in one sheet per pair, with the results for both subjects, as well as answers to the discussion questions.

1. LOCATING YOUR EGOCENTER

When computing our sense of binocular visual direction, the brain receives **oculocentric direction** and **ocular orientation** data from each eye. It then computes a unified sense of direction, such that the location of objects are perceived as if viewed from a virtual **cyclopean eye** located at the **egocenter**. Most scientist say that the egocenter located is approximately midway between the two eyes, but some suggest that it is centered in the dominant eye, the center of rotation of the head, or elsewhere. It is also possible that the egocenter may vary from person to person.

- Tape together several pieces of paper to make one long piece, which you tape to the upper surface of the cardboard. Let a few inches of the paper extend beyond the end that will against the subject's face.
- Cut the paper and fold it under the board, so you will be able to move it against the subject's face, with the eyes over the edge of the upper surface.
- Stabilize the board against the subject's face, just below eye-level, and mark the location of the corneal apices on the paper.
- Draw a line between the two corneal apex marks, and mark its center. This point will be the origin of an x-y coordinate system measured in mm, as shown in Fig. 1.

Insert a pin at anywhere near the far edge of the paper. While the subject views the pin binocularly, help him insert another pin at a nearer location such that the two pins appear to be pointing directly towards the subject. The subject may wish to verify alignment by shifting fixation between the near and far pins. The fixated pin should appear single, but the other will be double. Center the doubled images on the single one. The position of the two pins defines a line that, in theory, points directly to the egocenter. Draw this line.

Repeat for several angles of gaze. Remove the paper and extend the straight lines to their intersection. The lines should all converge on the ego center. Estimate the (x, y) coordinates of the egocenter, in mm, based on the coordinate system shown in Fig. 1. Note that points behind the origin will have a negative y coordinate.

Enter your information in Table 1 and in the Excel spreadsheet.

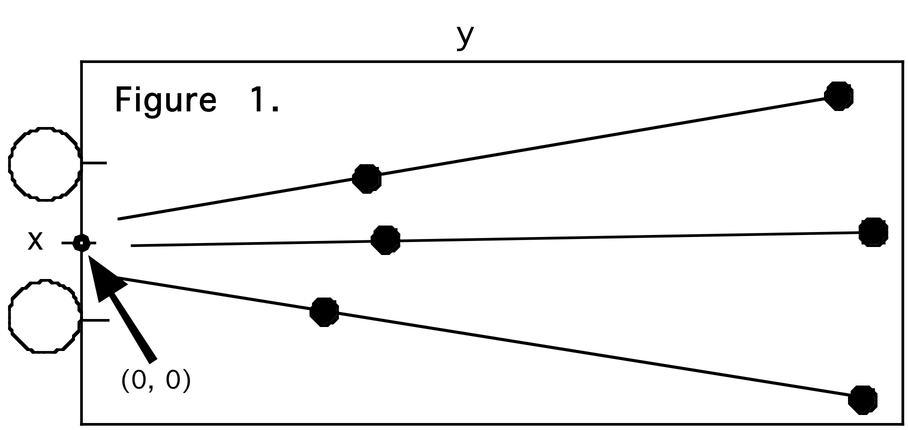

Figure 1.

Table 1.

Subject	Dom eye	PD	Egocenter x	Egocenter y

2. OCULAR ORIENTATION AND PERCEIVED BINOCULAR DIRECTION

We learned that binocular visual direction is computed from the 1) oculocentric direction and 2) the orientation of each eye. If we ensure that both eyes are foveally fixating, the local sign from both eyes will be straight ahead. We may then use prisms to alter the orientation of the eyes and see if binocular visual direction changes as expected.

One way to study the relationship between perceived and real space is to have a subject observe a target and let him indicate its apparent location. For example, you could have the person point with their hands to the apparent position of a near object, while their hands are under a table. This limits their position estimate to the perceived visual direction. Visual and tactile feedback, as the hand approaches the target, are not allowed, since the hand is out of view.

- Tape a piece of paper to the bottom side of the board, centered on a point about 100 cm in front of the egocenter. Mark a point near the center of the paper.
- Put a wire, or pin all the way through the board at that point, to locate the corresponding point on the top of the board.
- Insert a pushpin into the top of the board at this point. It will be the fixation point.
- Stabilize the cardboard against the subject's face as you did before.
- Let the subject binocularly observe the pushpin's location while he or she uses another pin to mark its perceived location on the bottom side of the board. Repeat five times and estimate the mean perceived location of the pin relative to its actual location.
- Using the trial frame or loose prism, place about 15 prism diopters of yoked prism (base left) before both eyes.
- While fixating the pushpin through the prism, have the subject indicate its perceived location under the board as before.
- Record the perceived angular direction of the upper pushpin, relative to the origin (between the corneal apices) and y-axis, in prism diopters. For example, if the pin appeared to be straight ahead, its direction would be zero. If it was slightly to the left, its direction would be a negative value, in prism diopers.

Subject	Direction of pin without prism	Direction of pin with prism	Relative shirt (with minus without)	Ratio of shift:prism value

3. Hering's laws of visual direction

Hering (1879) formulated his laws of visual direction, which include the concept of a cyclopean eye and retinal correspondence between the two eyes.

A. Laws of oculocentric visual direction

- All objects that lie on a particular visual line in object space form images on the same retinal point and therefore have the same visual direction (points A, B, C in Lecture 3, Figure 1).
- Each visual line and its retinal point have a unique oculocentric visual direction associated with it.
- Images that fall on different retinal locations are perceived to have different directions.

B. Laws of egocentric (cyclopean) visual direction

- The positions of all objects in space are judged as if seen by the cyclopean eye.

- An object on the primary visual line of either eye will appear to be on the primary visual line of the cyclopean eye.
- If a peripheral object and its visual line make some angle with the primary visual line in one eye, it will appear to make the same angle with a corresponding visual line relative to the cyclopean eye primary visual line.

C. Laws of identical visual directions or binocular visual direction

- Every visual line in the visual field of one eye has a corresponding visual line in the other eye, and the corresponding visual lines have identical perceived visual directions.
- The visual direction of fused images that fall on slightly disparate retinal points, is the average of the two visual directions.

Experiment 3a.

- Study Fig. 2, and, based on the laws of visual direction, predict what the person should see when binocularly fixating on a point at the end of the line. Based on Hering's laws of visual direction, predict what the person with normal binocular vision should see. Draw a picture of what you predict here.

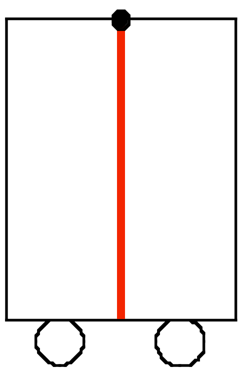

Figure 2. Predicted Observed

- Using the material provided, set up the experiment and carefully observe the perceived locations of the line. Draw a picture of what you see.

Experiments 3b.

- Make the simple stimulus shown in Fig. 3, below and repeat the same analysis.

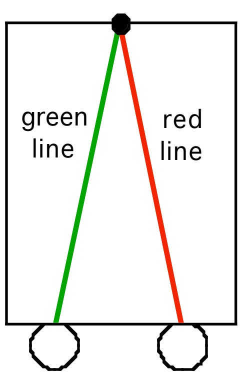

Figure 3. Predicted Observed

Explain why you saw what you did.