Vision Science III - Binocular Vision Module

Lecture 11 – Ocular Dominance

(Steinman Chapter 2, p. 24—27; Chapter 3, p. 56-57)

OVERVIEW OF OCULAR DOMINANCE

One of the important major topics that fall within the study of binocular vision is ocular dominance. Ocular dominance is clinically important in vision therapy and sports vision, but perhaps the most significant application of the principles of ocular dominance is fitting of monovision contact lenses.

Ocular dominance is a potentially confusing area because there are different definitions for dominance and different, sometimes unrelated methods to determine ocular dominance. The Dictionary of Visual Science (p. 210) defines ocular dominance in this way:

> *The superiority of one eye over the other in some perceptual or motor task. The term is usually applied to those superiorities in function which are not based on a difference in visual acuity between the two eyes, or on a dysfunction of the neuromuscular apparatus of one of the eyes.*

One reference book (Reading RW. Binocular Vision - Foundations and Applications, Butterworths, Boston, 1983, p. 284) lists several descriptions of the dominant eye, including the following list.

1. The eye whose image is seen more frequently in binocular rivalry. (sensory dominance)
2. The eye that has the “more substantial-seeming image” in physiological diplopia. (sensory dominance)
3. The eye whose image is less readily ignored, as in monocular microscopy (sensory dominance)
4. The eye with which one sights. (directional dominance)
5. The eye with which one notices less jump in an alternate cover test. (directional dominance)
6. The eye that centrally fixates in the presence of a fixation disparity. (oculomotor dominance)

The various types of ocular dominance tasks may be divided into three broad sub-categories, each of which suggests a different way to measure the dominance.

1) Sensory dominance,
2) Oculomotor dominance and
3) Directional dominance.

Sensory dominance may occur when there is a difference in the two retinal images that might lead to rivalry or some binocular interaction. For example, there may be differences in image clarity, brightness or color. Based on these differences, the visual system might find it easier to suppress one eye than the other, or to favor one eye over the other. This category corresponds with the first three bulleted items quoted from Reading above.

Oculomotor dominance usually refers to the eye that does a better job of fixating on an object of regard under binocular conditions. For example, if in a case of fixation disparity, most of the deviation were in one eye, the other eye would be considered the dominant eye (last bullet above).

Directional dominance is the most familiar since most of the clinical procedures test for this category of dominance. This corresponds to the 4th and 5th bullets listed above. Directional dominance is sometimes referred to as sighting dominance.

A directional dominance or sighting test can be done in various ways. You could, for example, have the patient form a hole with his hands and binocularly center an object in that hole. When he alternately occludes either eye, only the dominant eye will still see the same object.

A variant of this test is to have the subject center your (the doctors) right eye in the hole. You will then be looking through the hole at his directionally dominant eye.

RELATIONSHIP BETWEEN THE DIFFERENT KINDS OF OCULAR DOMINANCE

Among the three categories of ocular dominance mentioned above, directional dominance is the one that is usually measured clinically, but other test have been developed to determine sensory dominance. One sensory dominance test will be described below. Oculomotor dominance is rarely measured in clinical practice.

There is no reason to assume that, for any individual, the same eye will be dominant for all three categories above; it is possible that a person may be right eye sensory dominant, but then left eye directional dominant. This, in fact, was the topic of a student research project in 2001 by Nancy Buset and Sonja Toelkess. They tested a number of subjects for both sensory and directional dominance and found that they were not always the same in many of the subjects.

In addition, it is possible that a person's dominance could change depending on the fixation distance (far vs. near, etc.), or for different visual tasks. The degree of dominance can also vary. Some people may be strongly dominant in one eye; some people have a nearly equal preference for either eye, and some people may freely alternate dominance between the two eyes.

OCULAR DOMINANCE AND MONOVISION

The following are important considerations in monovision contact lens fitting:

- Sensory versus directional dominance
- Dominance at far versus near
- Is the person strongly dominant, or is the preference nearly equal between the two eyes?

Why is ocular dominance an important consideration in monovision contact lens fitting? It can...

1) Help you decide which eye you should correct for near or far.
2) It can help you predict how successful a person may be with monovision.

Traditionally, doctors perform a directional dominance test at far only, and then correct the dominant eye for far and the non-dominate eye for near. But since we are concerned about how a person may adapt to a clear retinal image in one eye and a blurred image in the other eye, sensory dominance, rather than directional dominance is most relevant. In addition, it would be better to test dominance at both far and near.

Therefore, when testing a monovision patient, rather than testing for the sighting eye, it is better to know how blur in either eye affects binocular vision. Previously we noted that monocular blur degrades binocular contrast sensitivity, and the effect increases with increasing blur. Similarly, we expect that monocular blur can degrade binocular visual acuity. In both of these tests, the effect can vary depending on ocular dominance.

> *Apparently, the non-dominant eye has better tolerance for blur. (Quote from article on ocular dominance by Ooi that appeared in Optometry in 2000.)*

This principle leads to the following technique to test for sensory dominance.

Consider the case of a person who requires a +1.50 add. Let him fixate the far visual acuity chart binocularly and introduce a +1.50 lens over the right, then left eye. See if the patient notices any difference in the clarity of the letters, viewed binocularly, when either the right or left eye is blurred. If, for example, the binocular visual acuity is better when the left eye is blurred, then OS is the non-dominant eye. Blurring the dominant eye (OD) is more disagreeable. That is, they prefer to leave the right eye unblurred at far. This would suggest that you should put the near correction on the left eye.

In this kind of case, you should also test the patient at near. When viewing the near chart binocularly, see if the visual acuity is better when a -1.50 lens is placed over the right or left eye. If the patient has better vision when the lens is placed over the right eye, he has left eye sensory dominance at near. That is, he prefers to fixate with his left eye at near. In such a case the person should be corrected with the distance correction over the right eye and the near correction over the left eye. This is illustrated in Figure 1 below.

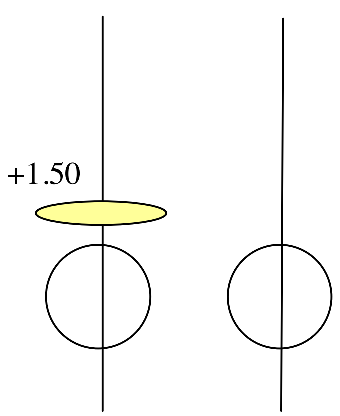
What if the person the person has a strong preference for right eye dominance at both far and near? This patient may have difficulty adapting to monovision.

Other patients may have relatively weak dominance or no clear preference for either the right or left eye at far or at near. These patients will have a better prognosis for success with monovision than the person with strong dominance for the same eye at both far and near.

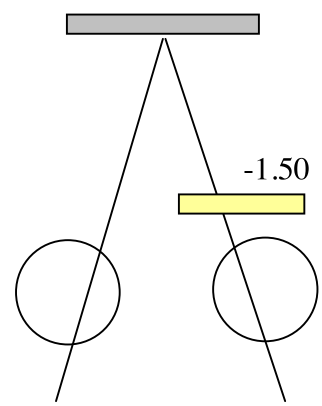
STEREOACUITY AND MONOCULAR BLUR
Stereoacuity is also degraded by monocular blur. It is interesting to note that monocular blur has a greater effect on stereoacuity than if the same amount of blur were presented to both eyes. This is probably related to foveal suppression of the monocularly blurred image.

The clinical application of this is that, in order to give a patient maximum binocular visual acuity, contrast sensitivity and stereopsis, it is best to fully correct both eyes, thereby providing each retina with a high quality image, which will be fused by the visual system.

If you fully correct a patient with a long standing monocular blur, it may take some time for the visual system to improve to maximum binocular vision as it adapt to the to the new correction.



Far binocular VA less affected with +1.50 over OS.



Near binocular VA less affected with -1.50 over OD.

Figure 1. This illustrates the ideal sensory dominance situation when fitting a person with monovision contact lenses. In this case, you would fit the right eye for far and the left eye for near. The eye that notices the blur less is the non-dominant eye. Binocular vision is more strongly affected when the dominant eye is blurred.

CORRELATIVE DOMINANCE
In some cases it may be of interest to compare hand dominance with ocular dominance. This is referred to as correlative dominance.

Crossed dominance is a condition when the hand and eye have opposite dominance; for example, a person who is right eye dominant but left handed. This could be an important consideration in certain tasks, such as shooting a rifle or throwing a ball, but there's no general consensus as to whether crossed dominance is good or bad.

UTROCULAR DISCRIMINATION

In normal binocular viewing the visual system receives input from each eye and combines it into a single percept. Once sensory fusion has occurred, is it possible for a person to tell what visual information originated from which eye? The ability to tell which eye the information came from, under binocular conditions, is called **utrocular discrimination**. Quoting from Steinman (p. 56):

> *Helmholtz argued that it [monocular information] could not be [lost during binocular fusion], since the information from each eye alone is what gives rise to binocular disparity and vergence responses. If the visual system totally merged the information together without keeping track of the eye of origin of the information, we would be unable to tell crossed from uncrossed disparities and make appropriate vergence responses to each.*

Carefully designed experiments have proven that utrocular discrimination does not exist. That is, a person cannot tell which eye has been stimulated, when viewing under binocular conditions.

BINOCULAR REFRACTION

Some doctors advocate measuring the patient's refraction under binocular viewing conditions. This is certainly closer to natural viewing conditions. Vectograph slides are sometimes used to measure the refraction of one eye while both are viewing and fusing the chart. Another technique uses a septum to block part of the chart from being seen by either eye, while other parts of the chart are seen binocularly.

Humphriss recommended a binocular refraction technique that uses what he called a "physiological septum." He blurred one eye with +0.75 over the estimated distance refraction, while refining the refraction of the other eye. The chart is binocularly fused, but best visual acuity can only be seen by the unblurred eye.

Because all elements of the binocular fusional system are in play, it is less likely that you will accidentally "over-minus" the patients using this technique. Excessive minus would stimulate accommodative convergence. In order to maintain fusion, the visual system would have to activate a compensating amount of fusional divergence (disparity vergence). Negative vergence accommodation would tend to inhibit the initial over-accommodation. Binocular refraction helps to stabilize accommodation for the appropriate distance more effectively than is possible with monocular refraction.