Vision Science III - Ocular Motility and Binocular Vision

Lecture 8 - Measuring Fixation Disparity

(Steinman, Chapter 3, p. 59-61)

REVIEW

Q. What is a fixation disparity?

Q. How is a fixation disparity different from a heterophoria or heterotropia?

Q. Why are fixation disparities important in clinical optometry?

Q. What is the relationship between disparity vergence and fixation disparity?

Q. What are some basic elements that you must include in designing any fixation disparity test?

TESTING FOR FIXATION DISPARITY

Lecture 7 presented the basic design features for a fixation disparity test. Since fixation disparity exists only during binocular fusion, you must have some part of the target that is *seen and fused binocularly*.

Q. Why is a von Graffe heterophoria test not a test for fixation disparity?

A. There is no binocular fuison, but the eyes are dissociated by prism.

During binocular fusion the two visual axes may be deviated slightly from perfect fixation, so we must also have some way to identify the location of the OD and OS visual axes. A fixation disparity test must therefore have the following:

- A binocularly-seen fusion lock
- A portion seen only by OD
- A portion seen only by OS

To standardize test conditions and simplify interpretation, most fixation disparity tests are designed so that the

- fusion lock has an angular width of 1.5°, and the
- upper line is seen by OD.

Figure 1 represents the basic layout of the **Wesson card**, one popular fixation disparity test.

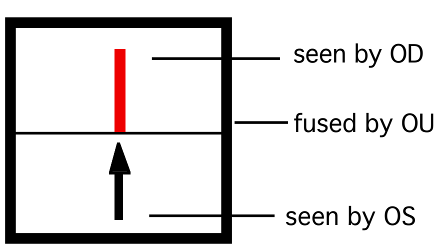


Figure 1. Wesson card design

Once you've satisfied these requirements, you must be able to ascertain three things:

- Does the person have a fixation disparity?
- If so, is it an eso or exo disparity?

- How large is the fixation disparity?

Assume that a person with *no fixation disparity* wears polarizing glasses and views the Wesson card shown in Figure 1.

Q. What should he see?

Q. How will it be different if the patient has a fixation disparity?

Is it eso or exo?
In a fixation disparity, the lines will appear deviated to either side. The direction that the lines appear to be deviated indicates whether the patient has an eso or exo fixation disparity. With the above design (Wesson card approach), a person with an exo fixation disparity will see the upper line (seen by OD) to the left and the lower line (seen by OS) to the right. This is illustrated in Figure 2.

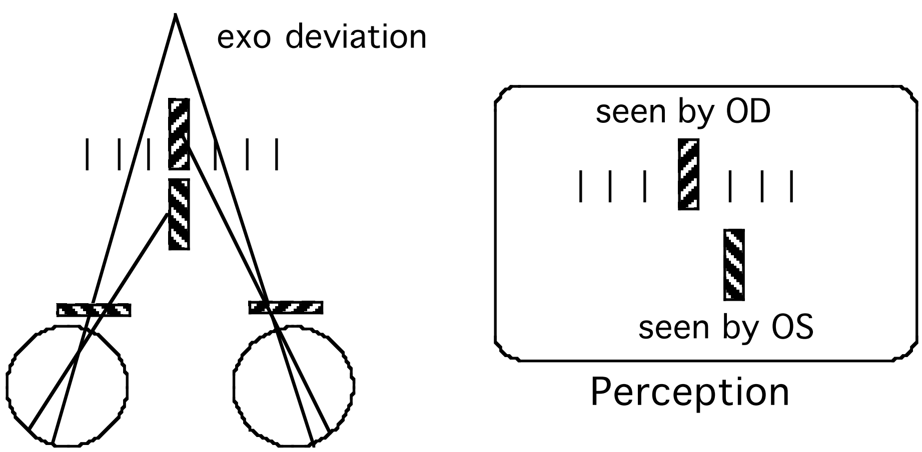


Figure 2. Perception of polarized targets in an exo fixation disparity.

To understand why the person sees this with a exo fixation disparity, keep in mind that the ...
- lines on the Wesson card are *actually centered*, but
- they *appear deviated* due to the fixation disparity.

The polarized lines mark the intended fixation point but each eye's visual axis misses it.

Q. In an exo fixation disparity, where is the fixation point (marked by the upper line) relative to the OD visual axis?

Q. Where then, should the upper line (seen by OD) appear to be, relative to OD's oculocentric straight-ahead direction?

Q. In an exo fixation disparity, where is the fixation point (marked by the lower line) relative to the OS visual axis?

Q. Where then, should the lower line (seen by OS) appear to be?

A person with an eso fixation disparity will have the opposite perception—the upper line (seen by OD) will appear to be to the right and the lower line (seen by OS) will appear to be to the left. You should be able to explain why a patient sees the lines in this orientation. For your own study, draw a figure similar to Figure 2, but for an eso fixation disparity.

You need to know, not only the direction, but also the magnitude of the fixation disparity. Some tests, such as the Wesson card, indicate this by a graduated scale that measures the separation between the lines. The Wesson card has color coded lines to indicate certain amounts of fixation disparity for two standard test distances.

The Sheedy Disparometer
This is another instrument designed to measure fixation disparity, but it uses a different approach, which requires a different interpretation. The **Sheedy Disparometer** has a set of targets with lines offset by predetermined amounts in either the eso or exo direction. The person selects the target that appears aligned. It is labeled with the amount and direction of the fixation disparity. Figure 3 shows the principle of the Sheedy Disparometer. In effect, the separation of the polarized lines is adjusted until they coincide with the visual axes in the fixation plane. In that position, they will appear to be aligned binocularly. In this instrument, the polarized lines are *moved into the position of the visual axes*. In contrast, the Wesson card uses lines that are actually centered, and they *mark the intended fixation point*.

Thus, the Sheedy Disparometer uses the opposite approach to measuring fixation disparity compared to the Wesson card. To understand why the person seen this with a exo fixation disparity, keep in mind that
- the lines are *actually deviated*, but
- they *appear centered*, due to the fixation disparity.

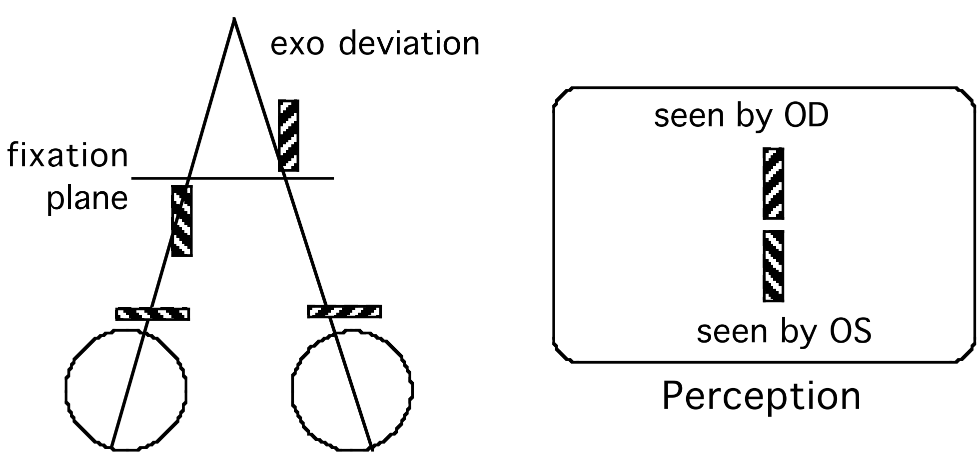


Figure 3. Principle of the Sheedy Disparometer.

SUMMARY

In the case of the Sheedy Disparometer, the patient moves the polarized lines until they appear aligned. That is, they must move the upper line (seen only by OD) until it falls on the OD visual axis; the lower line (seen only by OS) is moved until it falls on the OS visual axis. *The polarized lines tag or mark the location of the visual axes (not the fixation point)*.

In an exo fixation disparity, the visual axes are outside the fixation point, so the line for OD will be to the right and the line seen by OS will be to the left.

In an eso fixation disparity, the visual axes cross in front of the fixation point. Therefore the line seen by OD will be to the left side, and the line seen by OS will by to the right.

Note that for the Disparometer, if there is a fixation disparity, the lines are actually displaced, but they appear to be aligned in the center (to the patient). Diagnosis is based on what the *doctors sees* (the actual displacement of the lines). This is opposite to the Wesson card, which bases the diagnosis on what the *patient sees*. Diagnosis using the Disparometer is summarized in Table 1.

Table 2 summarizes the *perceived position* of the lines when a patient is tested using the Wesson card. The principle is opposite to the Disparometer. The Wesson card shows the relative *perceived oculocentric visual direction of the fixation point (not the visual axes)*, for each eye.

In a Wesson Card, an exo fixation disparity, the OD visual axis passes to the right of the fixation point, so relative to the OD visual axis, the fixation point appears to the left. The OS visual axis passes to the left of the fixation point and the lower line (fixation point seen by OS only) is to the right of OS visual axis.

In a Wesson Card, an eso fixation disparity, the OD visual axis passes to the left of the fixation point, so relative to the OD visual axis, the fixation point (top line for OD) will appear to the right. The OS visual axis passes to the right of fixation, so the fixation point (bottom line for OS) will appear to the left.

In the Wesson card, if there is a fixation disparity, the lines are actually aligned in the center, but they appear to be misaligned to the patient (to the patient). Diagnosis is based on what the patient sees (the apparent displacement of the lines). This is opposite to the Disparometer.

Table 1. The Sheedy Disparometer marks the location of the visual axes of each eye.

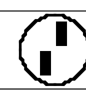
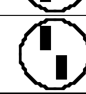
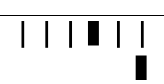
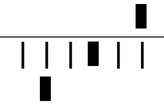
Disparometer™	Actual position		Doctor sees
FD type	Upper (OD)	Lower (OS)	
exo	right	left	
eso	left	right	

Table 2. The Wesson card shows the perceived location of the fixation point relative to each visual axis.

Wesson card	Apparent position		Patient sees
FD type	Upper (OD)	Lower (OS)	
exo	left	right	
eso	right	left	

DISPARITY VERGENCE RESPONSE AS A FUNCTION OF FORCED VERGENCE
Ogle studied the disparity vergence system by measuring how fixation disparity changes as different amounts of base-in (BI) or base-out prism (BO) are placed before the eyes. He divided the response of different subjects into one of four types, which are shown in **Steinman Fig. 3-10**, **Borish Fig. 20-27, and Goss Fig. 9.5.**

To understand these curves, let us consider the response of one eye (i.e., OD), which is perfectly fixating a near point. What will happen when BI prism is gradual increased before that eye, assuming there is no fixation disparity?

BI prism before OD makes the fixation point appear to move out (right). This creates a small amount of disparity vergence, and the eyes attempt to follow the fixation point as it moves out. OD tries to keep the image on the fovea (Figure 5). The same thing happens with OS.

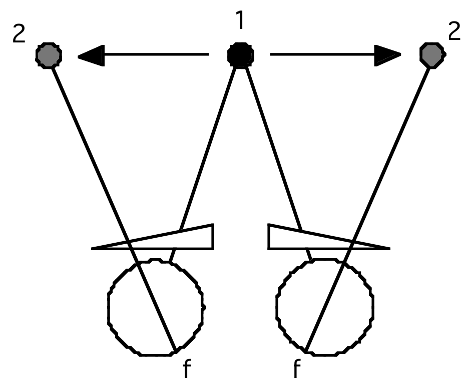


Figure 5. Both eye initially fixate Point 1. BI prism makes it appear to move outward, and this stimulates disparity vergence, which moves the eyes outward.

You could visualize the same action by showing the monocular perception for each eye. Assuming the person had cross hairs imprinted on his OD fovea (this could be done using a strobe to create an after-image), and this were projected out into object space, the oculocentric perception for OD (of the situation in Figure 5) could be illustrated as shown in Figure 6.

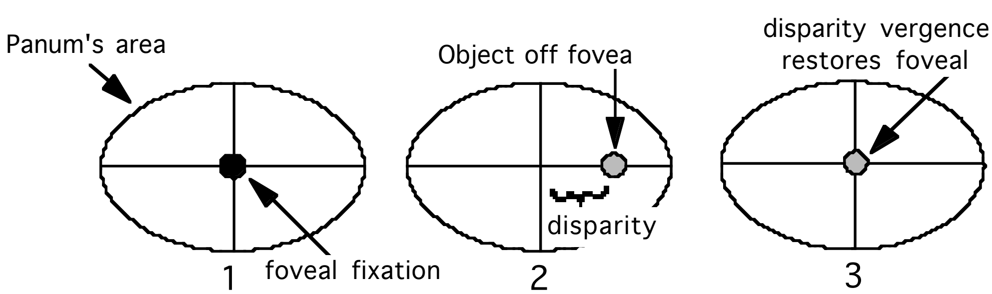


Figure 6. Oculocentric *visual space* view for OD. 1) Foveal fixation prior to introducing BI prism. 2) BI prism moves the image to the right (for OD). This creates a small disparity, within Panum's area, which stimulates disparity vergence (divergence), which then restores foveal fixation (3).

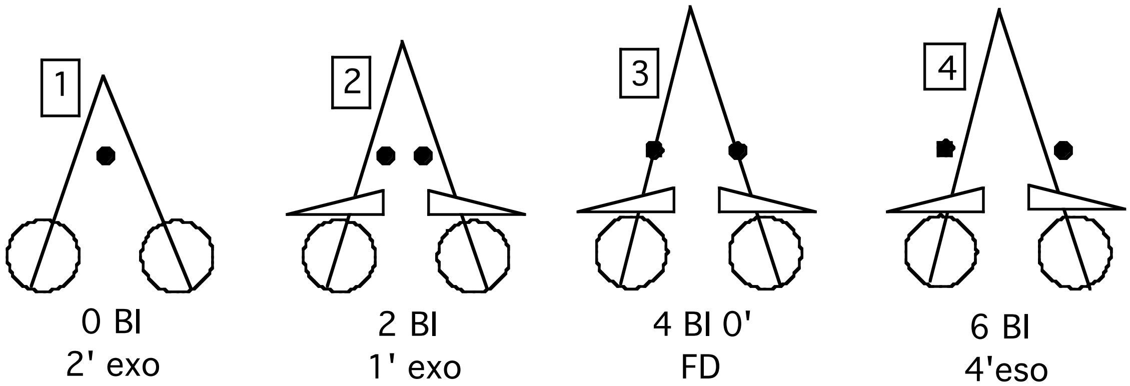


Figure 7. As BI prism is increased, the amount of exo fixation disparity decreases (steps 1-2), until it reaches zero (step 3). The amount of prism needed to bring fixation disparity to zero is the **associated phoria**. More BI results in an eso fixation disparity (step 4).

Now consider the case of an exo fixation disparity and a typical response as BI prism is introduced. This is illustrated in Figure 7. Considering the image seen by OD only, as BI prism causes it to shift rightward and it approaches the visual axis. Notice that the eyes are beginning to diverge, but only slighlty. The exo fixation disparity will therefore decrease. Eventually, with additional BI prism, the exo fixation disparity will decrease to zero. More BI prism will shift the images farther to the right, beyond the fixation axis, so the person will have an eso fixation disparity that gradually increases with increasing BI prism. A similar process affects OS.

This can also be illustrated using the oculocentric visual space diagram, as shown in Figure 8. This shows the situation for OD only; in theory a similar process would be occurring with OS.

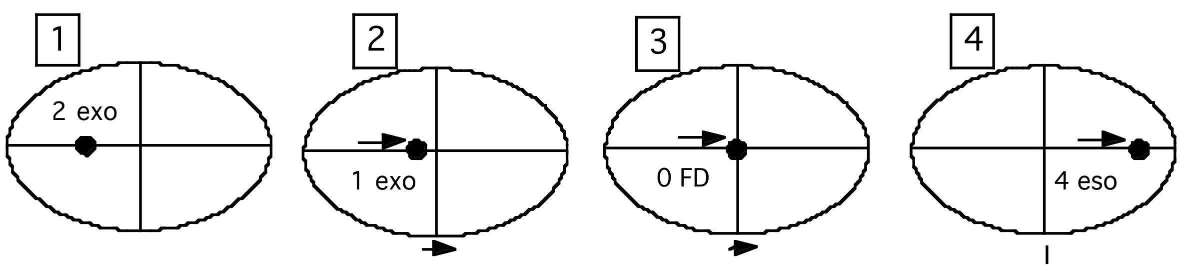


Figure 8. OD oculocentric object space visual diagram.

In the example shown in Figure 8, the person starts with an exo fixation disparity (1), and BI prism is added. The prism moves the object to the right, toward the fovea; but the fovea also moves right, though not as much (2). Eventually enough prism is added that the object catches up with the visual axis (3). As more BI prism is added, the object moves beyond the visual axis and the eye fails to keep up, causing an increasing eso fixation disparity.

The values shown on Figures 7 and 9 are summarized below in Table 3.

Table 3. Table showing results of the test illustrated in Figrues 7 and 8.

BI added	0	2	4	6
FD	2 exo	1 exo	zero	4 eso

The same process could repeated for the same patient using BO prism. Hypothetical results are shown in Table 4. Can you explain why we would get the results shown in Table 4?

Table 4. Table showing results when BO prism is added.

B0 added	0	2	4	6
FD	2 exo	3 exo	6 exo	8 exo

The complete response can be plotted on a graph such as that shown in Figure 9, below. This shows an example of a Type I fixation disparity response to forced vergence.

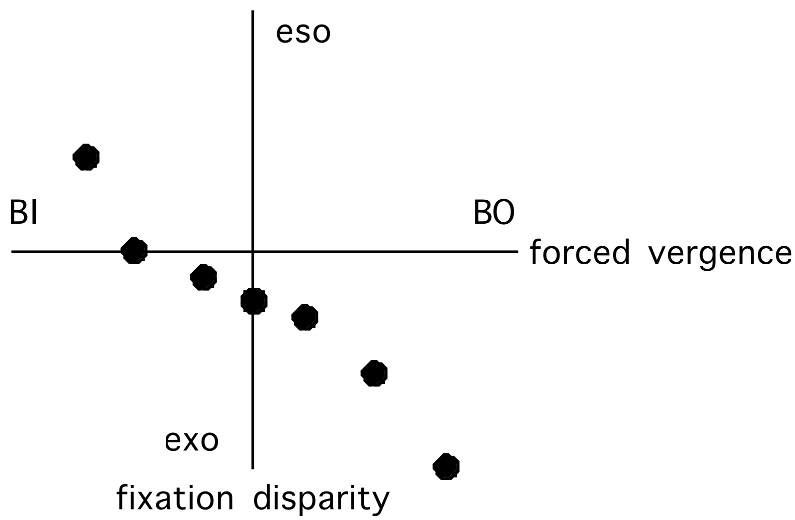


Figure 9. Disparity vergence stimulus-response curve for a Type I response.