FIXATION DISPARITY TYPES

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FORCED VERGENCE/FIXATION DISPARITY CURVES

One way to evaluate the efficiency of a patient's disparity vergence system is to see how fixation disparity changes when different amounts of BI or BO prism are introduced before the eyes. Ogle investigated different subjects and classified them into four response types (Figure 22.1, below), which are plotted as forced vergence/disparity curves.

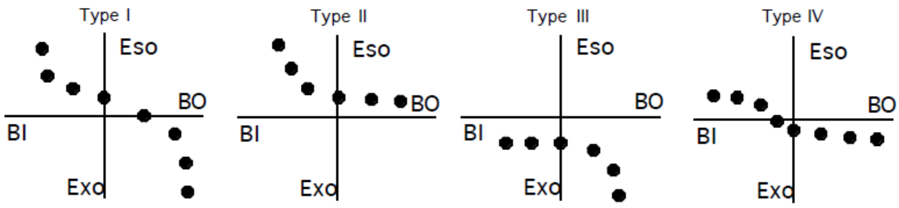

Figure 22.1 *Ogle's four fixation disparity types, plotted as forced vergence/fixation disparity curves. Also see Fig. 21-27 in Borish, Fig. 3-10 in Steinman, or Figure 5 in Goss.*

This is the standard way to display the response of the disparity vergence system to the vergence stimulus. The amount of BI and BO prism, which stimulates different amounts of disparity vergence, is plotted on the x-axis. The disparity vergence response, that is, how closely the visual axes keep up with the stimulus, is plotted on the y-axis. This procedure is specifically designed to evaluate the fine disparity vergence system. To better understand what these graphs show, consider a theoretical patient with:

- Zero fixation disparity,
- His/her ability to converge is limited to 10 Δ BO, and
- His/her ability to diverge is limited to 10 Δ BI.

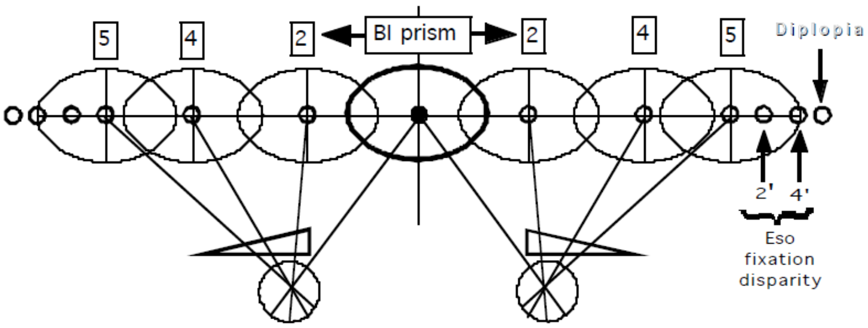

Figure 22.2 *Forced divergence with BI prism before both eyes.*

As illustrated in Figure 22.2, at first, with no prism before either eye, the eyes perfectly fixates the center black dot. There is no fixation disparity. Panum's areas (greatly magnified) for OD and OS are shown by the ovals and they are first superimposed. BI prism is gradually increased, and the fixation point appears to move outward before each eye. The eyes maintain perfect bifoveal fixation, and move outward, following the target (2, 4, 5 Δ OD, OS). After diverging at total of 10 Δ BI OU, the eyes reach their limit and refuse to go further. Panum's areas remain in their current positions. More BI prism is added, and since the eyes no longer follow the target, the image begins to slide off the center of Panum's area, causing a slight eso fixation disparity (2').

Q Can you understand why fixation disparity is sometimes called, "retinal slip?"
A It is as if the visual axes slip off the fixation target.

Additional prism moves the image toward the periphery of Panum's area, increasing the eso fixation disparity to 4'. Beyond this, the image falls outside Panum's area, and the patient experiences diplopia. These results are recorded in the left half of Table 22.1.

Table 22.1 Data from responses shown in Figure 22.2 and 22.3.

	Base In							Base Out					
Prism	13	12	11	10	8	4	0	4	8	10	11	12	13
FD	Dipl	4eso	2eso	0	0	0	0	0	0	0	2exo	4exo	Dipl

Figure 22.3 illustrates the response for the same theoretical patient when BO prism is added. At first, with no prism before either eye, both eyes are perfectly fixating the center black dot.

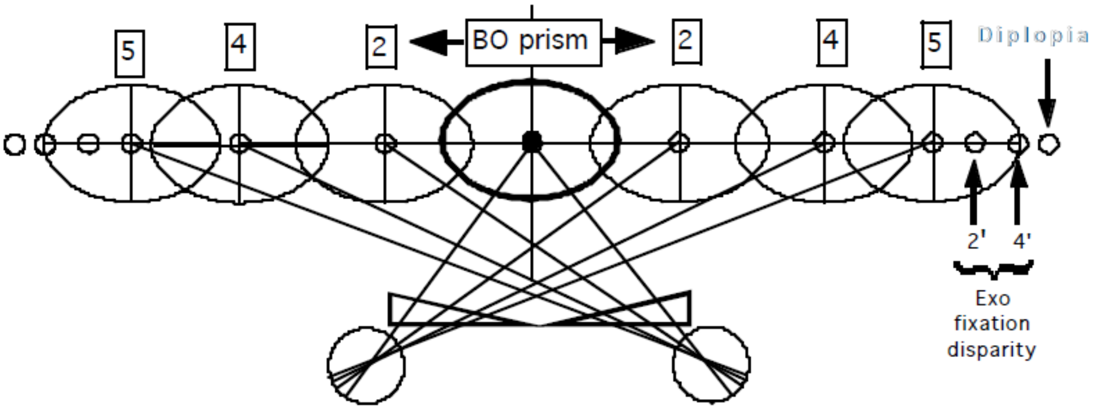

Figure 22.3 *Forced convergence with BO prism before both eyes.*

BO prism is gradually increased, and the fixation point appears to move inward before each eye (left for OD; right for OS). The eyes maintain perfect bifoveal fixation, and converge inward, following the target (2, 4, 5 Δ OD, OS). After converging of 10 Δ BO OU, the eyes have reached their limit and stop. Panum's areas remain in these positions. More BO prism is added, and since the eyes no longer follow the target, the image begins to slide off the center of Panum's area, causing a slight exo fixation disparity (2').

Additional prism moves the image toward the periphery of Panum's area, increasing the exo fixation disparity to 4'. Beyond this, the image falls outside Panum's area and the patient experiences diplopia. The results of adding BO prism are recorded in the right side of Table 22.1 and the data are plotted in Figure 22.4.

The curve of Figure 22.4 looks like the Type I plot, except that the horizontal section is perfectly flat and lies on the x-axis. It is perfectly flat because, between 10 Δ BI and 10 Δ BO, the fixation disparity does not change (it remained zero). The y-intercept indicates the fixation disparity when no prism is before the eyes; in this case it is zero. The steep up- and down-turn portions indicate the sudden increase in fixation disparity as the image begins to slip across Panum's area.

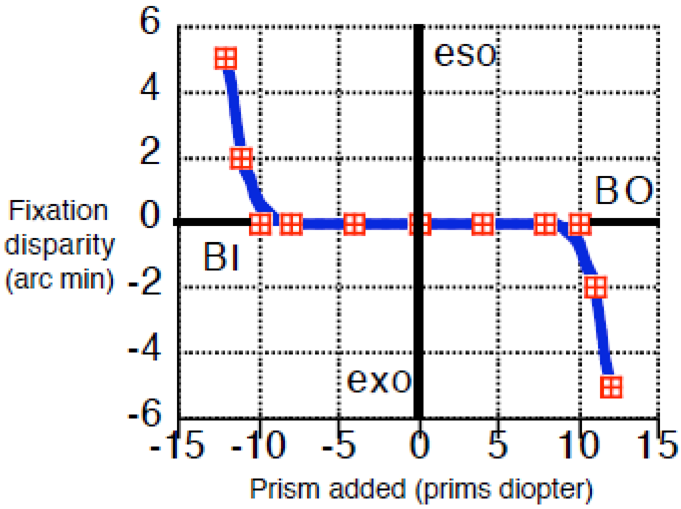

Figure 22.4 *Plot of Table 22.1 data*

If an eso fixation disparity was present, the curve would have been shifted upward. An exo fixation disparity would shift the graph downward. A greater slope across the middle section would show that fixation disparity is slowly changing with the addition of prism. When prisms stimulate vergence eye movements, the eyes tend to lag behind the prism, causing a gradual change in the amount of fixation disparity. This is reflected in the slope. The flatter the slope, the better the eyes are able to maintain their starting level of fixation disparity.

In a **Type-I** exo fixation disparity, the graph would be similar to that in Figure 22.4 except the curve would be shifted downward (exo fixation disparity) and probably be slightly more sloped. Figure 22.5 shows how the fixation disparity would gradually change with the addition of BI prism.

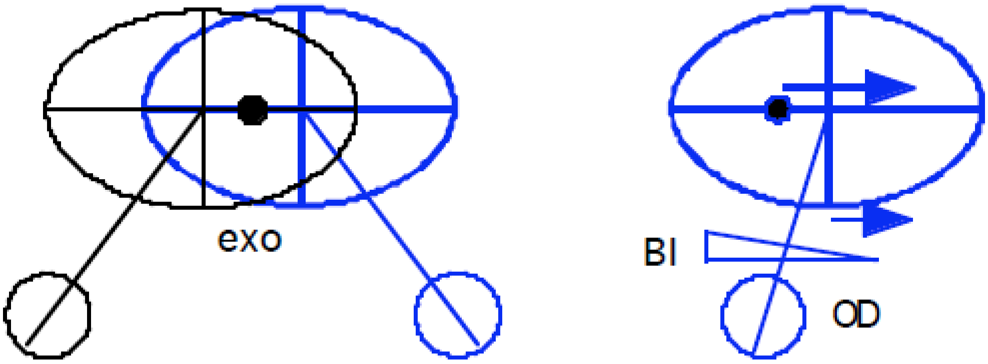

Figure 22.5*. In an exo fixation disparity, the addition of BI prism causes the exo to decrease, and then become eso.*

Starting with no prism before the eyes, the gradual introduction of BI prism shifts the optical image outward. For the right eye, the fixation point is to the left of the visual axis at the beginning, but prism shifts it to the right. The eye also moves to the right, but more slowly that the prism, so the fixation object begins to “catch up” with the visual axes. Therefore the exo fixation disparity gradually decreases. See the lower curve in Figure 22.7. When enough prism is added, the object “catches up” with the visual axis and the fixation disparity becomes zero. The amount of prism that causes the fixation disparity to decrease to zero is the associated phoria. As more BI prism is added, the object appears to move to the right of the visual axis, and an eso fixation disparity gradually increases. In an exo fixation disparity, BO prism would cause the exo deviation to steadily increase, because the eye lags behind the deviation, as shown in Figure 22.6.

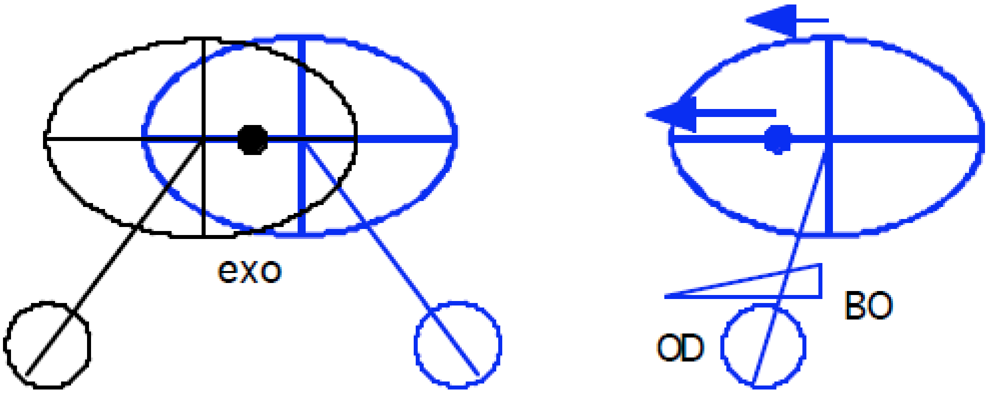

Figure 22.6 *In an exo fixation disparity, the addition of BO prism causes the exo to increase.*

Note how the cases illustrated in Figures 22.5 and 22.6 would account for the shape of the lower forced vergence plot shown in Figure 22.7.

In an eso fixation disparity, BI prism causes the eso deviation to steadily increase, while BO prism causes the eso deviation to decrease, go to zero, then become more exo.

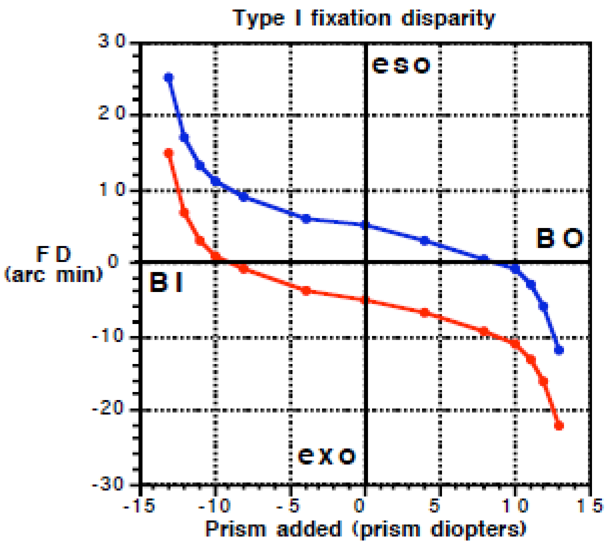

Figure 22.7 *Type I eso and exo examples.*

In a **Type II** curve, the patient has an eso fixation disparity that stays nearly constant as BI or BO prism is added, across most of the function. After a certain amount of BI (forced divergence) is added, however, the eso fixation disparity rapidly increases. At that point, the eye essentially stops following the prism. This makes sense because, if the person is esophoric, he/she can converge easily, but has difficulty diverging.

In the **Type III** response, the patient has a relatively constant exo fixation disparity across most of the range. When a moderate amount of BO prism (forced convergence) is added, however, the exo fixation disparity rapidly increases. This means that the eye has stopped following the prism. If the person is exophoric, he/she can diverge easily, but his/her range of convergence is more limited.

In the **Type IV** fixation disparity example shown in Figure 22.1 above or **Steinmann Fig. 3-10**, the patient has a small exo fixation disparity. As BO prism is increased, the exo fixation disparity increases slightly, and then remains constant. The eye continues to follow the prism closely. As BI prism is increases (middle of the graph), the fixation disparity quickly converts from exo to eso. This means the eyes are not following the prism very closely, until a certain amount of eso fixation disparity develops. Then it holds steady as more BI prism is added.

When analyzing the fixation disparity curves, special attention is given to the following features:

- Fixation disparity, or the y-intercept
- Associated phoria, or the x-intercept
- Curve type
- Slope of the curve at the y-intercept
- Inflection point, or center of symmetry of the curve

INTERPRETATION OF FIXATION DISPARITY CURVE TYPES

Theoretically, an ideal response would be a symmetric Type I curve that crosses near the origin. This would show a low fixation disparity, low associated phoria, and a system that is able to follow BI and BO prism equally well. This is not necessarily a requirement for normal, comfortable binocular vision, but departures from the ideal can be used to evaluate a possible binocular problem.

Fixation Disparity
A large fixation disparity can indicate that the binocular system is under stress, either due to excessive demands (intense near work), or inherent weakness in the system. Normal fixation disparities should be between **6 arc minutes exo or 4 arc minutes eso**.

Associated Phoria
The prism needed to correct a fixation disparity is called the **associated phoria**, since it is measured while the patient is binocularly fusing. The **dissociated phoria** is the heterophoria that we normally measure by the von Graffe technique or during the cover test since the eyes are dissociated; that is, when binocular fusion is interrupted.

Some references, including Steinman (p. 61), say that associated and dissociated phorias are usually of the same direction, but others say that they are rarely the same (Borish). Some doctors prescribe correcting-prism based on the associated phoria finding. This is more useful in prescribing vertical than horizontal phorias. The correct prescription of vertical prism is more critical than horizontal prism because the eye’s vertical fusion ability is much weaker than for horizontal fusion.

Slope of the Curve
The steepness of the slope was discussed above. Some clinicians think that a slope greater than **1 arc min/ prism diopter** may be associated with visual discomfort. A flatter slope indicates prism adaptation and Steinman points out that “vergence adaptation is a ‘good’ sign of a healthy binocular system. Patients who are poor adapters may run into difficulties.” (p. 64) Patients with binocular stress can benefit from vision therapy (VT), and one way to monitor progress is to see if the slope of the fixation disparity curve decreases with VT (Steinman, p. 66).

Many patients will show some adaptation to prism, so when measuring the forced vergence fixation disparity function, you should not let the patient wear one prism power for too long. Also alternate BI and BO prism as you make the measurement (Steinman p. 63). According to Saladin (Borish Chapter 21):

“A prism stimulus time of 1 min or more in a normal subject practically guarantees a flat curve. Because of this time dependence, diagnostic criteria have been developed using standardized stimulus presentation time of 15 sec.”

Curve Type
The Type I curve is most common and is considered a normal response. The other types may indicate some degree of binocular dysfunction. Type II curves are usually found in patients with esophoria, while Type III curves are associated with exophores (Steinman, p. 66).

With vision therapy Type III curves sometimes change into Type I curves, but Type II responses are more resistant to change. Type IV response patterns are not well understood, but they are associated with binocular dysfunction, such as aniseikonia. With vision therapy, these can also be converted to a Type I response.

VERTICAL FIXATION DISPARITY

Vertical deviations are less common than horizontal deviations and are usually of smaller magnitude. In some respects the vertical vergence mechanism is simpler than the horizontal, because accommodation does not provide direct input and vergence adaptation is slower. These factors make it easier to measure vertical fixation disparities.

Even though they are small, vertical deviations may cause more problems since the eyes have greater difficulty fusing vertical disparities. In addition, the presence of a vertical deviation can contribute to horizontal deviations. As with horizontal fixation disparities, vertical fixation disparities can be plotted as a function of forced vertical vergence, using BU and BD prism. An example is shown in Figure 22.8. As before, the y-intercept indicates the vertical fixation disparity, and the x-intercept shows the vertical associated phoria. Since vertical vergence adaptation does not usually come into play, the curves are usually steeper than those on the horizontal plot.

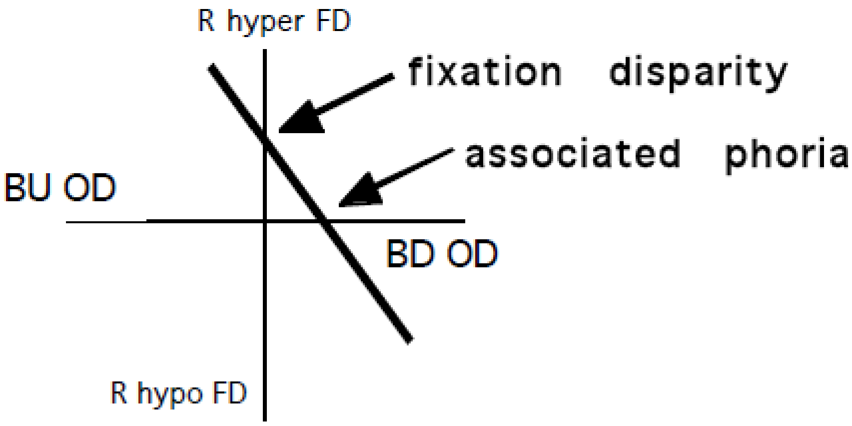

Figure 22.8 *Vertical fixation disparities can be plotted as a function of forced vertical vergence, using BU and BD prism.*

Clinical example:
A 17-year old male patient visited an eye clinic for a general eye exam. He had no glasses and mentioned consistent eyestrain when reading. He also said that he sometimes loses his place when reading and often uses his finger to follow the lines. His distant vision was fine, and he had no other complaints. A 2 BU vertical phoria was recorded in a previous exam, but the eye (OD or OS) was not recorded and prism was not prescribed.

Table 22.2 Example of clinical findings in a vertical phoria case.

	Von Graffe	BU OS Duction	BD OS Duction	Assoc Phoria	Fix Disparity
Far	1 BU	4/2	2/0	0.5 BU OS	See Figure
Near	0.5 BU OS	2/0	3/1	--	--

To verify the vertical phoria, we measured the fixation disparity. A near test, such as the Wesson card or Disparometer, was not available, but we found a vectograph projector slide, which contained a fixation disparity test similar to that shown in Figure 22.9. The left figure shows which part of the target was seen by which eye when polarizers were worn. The middle figures shows what a patient would see if he had no fixation disparity. The right figure shows what this patient actually saw.

Q From what you know about visual direction, did the vertical fixation disparity agree with the direction of the associated phoria?

In this case, prism was prescribed according to the associated phoria finding.

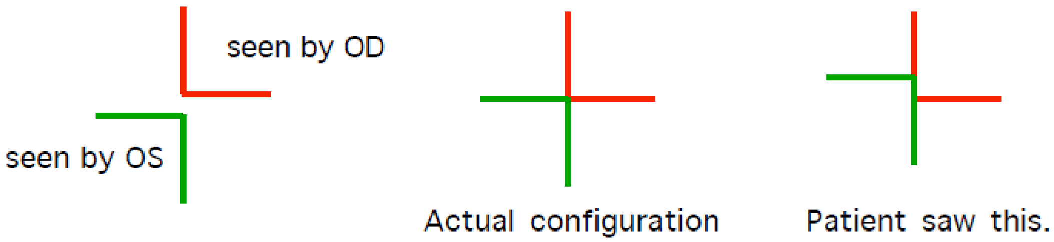

Figure 22.9 *Example results for a far vectograph fixation disparity chart.*

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