ASSOCIATED PHORIAS WITH & WITHOUT CENTRAL FUSION LOCKS

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ABSTRACT

Several instruments are routinely used in the measurement of the associated phoria. Depending on the instrument used, the target may or may not have a central fusion lock. Clinically it is important to know what impact the central fusion lock has on the associated phoria if one is using that measurement to evaluate the stability of the binocular system or to develope a treatment regime, particularly in the prescription of lateral prism.

In this study, measurements of associated phorias taken with two instruments possessing central fusion locks, the Bernell Box with fixation fisparity slide and the Borish Nearpoint Card, are compared with measurements of associated phorias taken with an instrument having no central fusion lock, the Fixation Disparometer. Results of this study indicate that measurements made with the two central fusion lock targets (the Borish Card and Bernell Box) are not significantly different but measurements made with the Fixation Disparometer are significantly different from those found with the Borish Card. Measurements made with the Fixation Disparometer and Bernell Box did not correlate.

INTRODUCTION

Most patients with dissociated phorias+ have a fixation disparity under binocular viewing conditions.[1] A fixation disparity can be thought of as a misalignment of the visual axes existing in the presence of single binocular vision.[FIG. 1] The misalignment is very small and, according to Morgan, rarely exceeds ten minutes of arc in normal binocular vision.[2] It may be due to an aiming error of one eye, if there is an ocular dominance, or both eyes, if no ocular dominance if present (mixed dominance).[3,FIG. 2] The amount of prism nessecary to eliminate this fixation disparity is called the associated phoria measurement. It is measured more often clinically than the angular amount of the fixation disparity itself and, as such, is used more frequently to evaluate the stability of the binocular system.

There are differing views as to why fixation disparities, or associated phorias, exist. Bishop[1] believes that the misalignment of visual axes is an adaptation to a binocular vs monocular set of visual directions. Others, including Ogle,[4,5] regard fixation disparity as the result of an oculomotor imbalance leading to a small error in convergence: Even when fusional vergence, operating to prevent diplopia, overcomes the dissociated heterophoria there still may remain a slight difference in vergence for the object viewed. Schor[6], following an idea from Ogle, explains fixation disparity as a small convergence error that is purposeful: The misalignment acts as the

+ i.e. heterophoria as measured under monocular viewing conditions

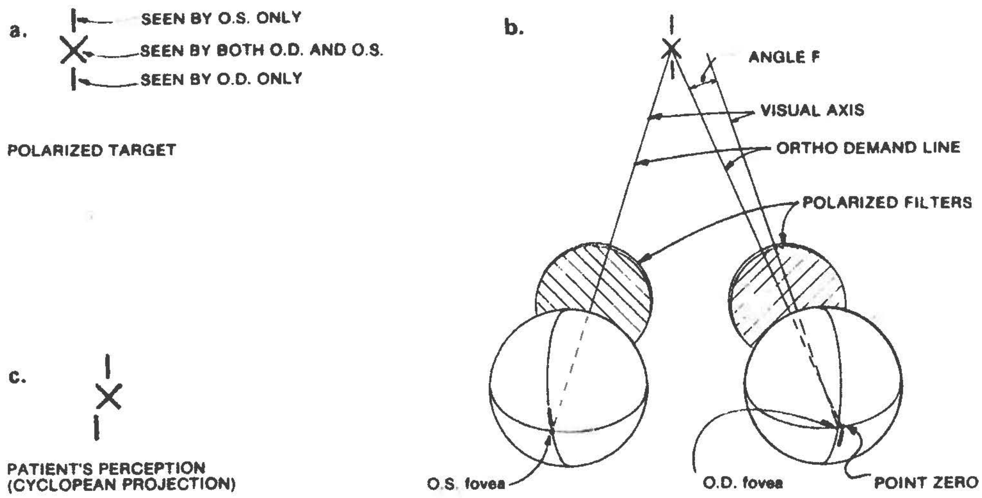


FIGURE 2-51 — Illustrations of fixation disparity. (a) Target viewed by patient. Polarization allows top line to be seen only by the left eye and the bottom line only by the right eye. The centrally fixated X is non-polarized and seen by both eyes; (b) Theoretical posterior view of the eyes illustrating angle F in the case of an exo fixation disparity; (c) Patient's perception in case of exo fixation disparity. The X and bottom line fall on point zero of the right eye, but the X is fused because of Panum's area. Vernier acuity is very sensitive and allows slippage to be noticeable.

FIG 1. Illustration of fixation disparity. (reprinted from reference #2, p 130)

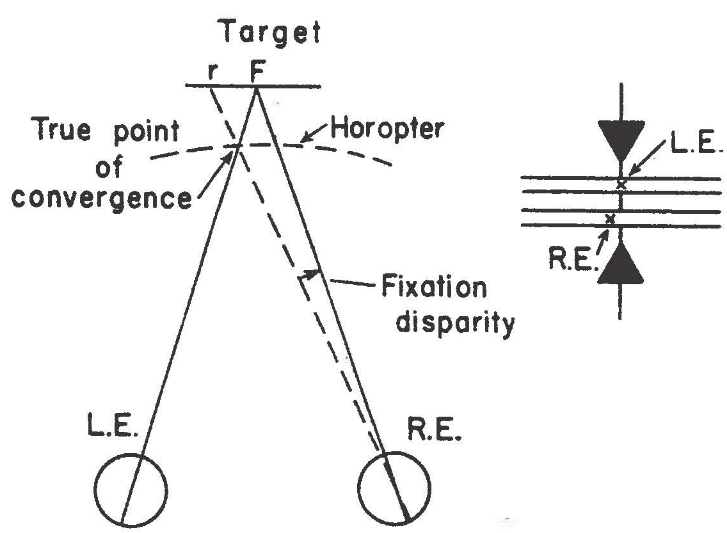


Fig. 5–2. The manner in which an observer whose left eye was highly dominant and who also was esophoric adjusted the two point light sources so that each appeared aligned with the central vertical line of the target seen binocularly. (From Ogle, K. N.: *Researches in Binocular Vision,* New York, Hafner Publishing Company, 1964. By permission of the publisher, Hafner Publishing Company.)

FIG 2. Ocular dominance in fixation disparity. (reprinted from reference #3) stimulus to maintain convergence and therefore preserve binocularity.

Sensory fusion is present in the presence of fixation disparity because normally the two retinas are associated cortically by means of corresponding areas rather than by discrete points[1]. For each point on one retina there is a small area of points on the fellow retina within which biocular stimulation will result in sensory fusion. As long as retinal disparity is less than the dimension of this fusional area, called Panum's Fusional Area, single binocular vision is present.

The size of Panum's Fusional Areas increases with retinal eccentricity.[1,7] Research measurements of the size of Panum's Areas range from 6 to 15 minutes of arc centrally (well within the location of the foveola) and from 15 to 70 minutes of arc at six degrees eccentricity.[FIG. 3, TABLE 1] Absolute disparities within the foveola (i.e. one degree of the center of the macula) result in central fusion and fine stereopsis. Peripheral fusion and qualitative stereopsis (Up to 70 seconds of arc can be acheived.) is present for disparities out as far as seven degrees from the center of the foveola.[1, FIG. 4]

Since Panum's Areas are larger in the periphery, it is thought by some invertigators that the fixation disparity should increase as details to stimulate fusion become more peripheral. Perhaps the rationale here is that more error in vergence would be possible, still letting the person see singly and binocularly, if Panum's Fusional Area is larger. Several experiments have been performed to confirm or disprove the theory that fixation disparity is larger as fusional target detail becomes

Macular Area

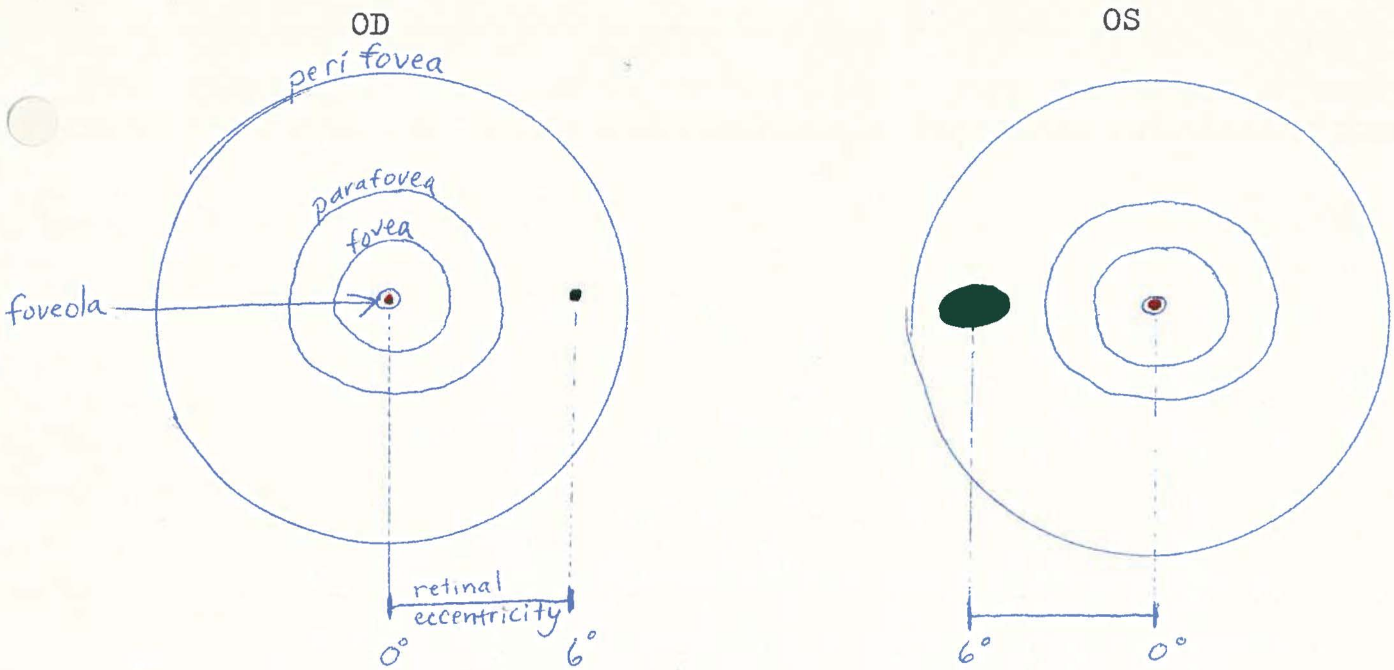


FIG 3. Schematic diagram demonstrating normal retinal correspondance and relative sizes of Panum's Areas centrally vs peripherally.(Note that areas are ellipses as vertical extents have been found to be smaller than horizontal.[1])

Macula OD

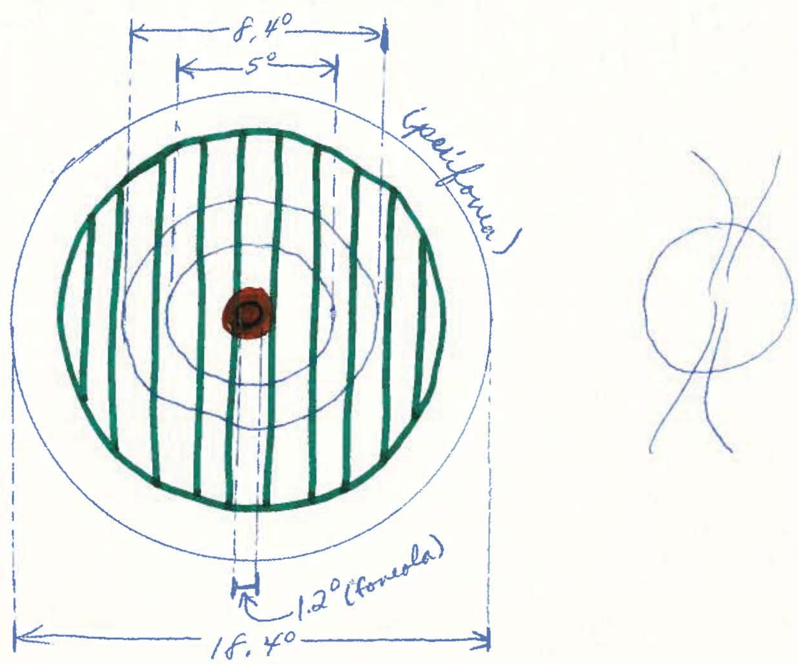


FIG 4. Central vs peripheral fusion areas: central fusion mechanism operates within red area(2° diameter) while peripheral fusion mechanism operates within green lined area (14° diameter).(measurements courtesy of reference #1)

more peripheral. In each case forced vergence fixation disparity curves[++] were generated and compared for different targets. Results are conflicting. A preliminary study by Ogle[7] using letters as detail for fusion[FIG. 5a] supported the theory that fixation disparity is larger as target contour becomes more peripheral.[FIG6a] However, in later studies by Ogle[7] and Shepard[8] where only square frames were used to stimulate fusion,[FIG 5b] fixation disparity was unaffected by the peripheral angle of contour.[FIG 6b,c] The aforementioned studies only compared targets having fusional contour in the periphery; none of the targets had central fusion detail. In a different approach, Carter[9] designed a study to compare fixation disparity with vs without foveal fusion contours. By allowing binocular view of one vernier target line and monocular view of the other,[FIG 5c] he attempted to measure uniocular components of fixation disparity separately. These he added together and called the fixation disparity found with both central and peripheral fusion locks. Carter then measured the fixation disparity in the conventional manner (one eye seeing one vernier line, the other eye seeing the other line) using the same target; this resulting in the fixation disparity with only peripheral contours. When he compared the two forced vergence curves derived in this manner, he found that there were differences.[FIG 6c] With foveal fusion present fixation disparity rarely exceeded six minutes of arc, even with high forced convergence and divergence. With only peripheral fusion, fixation disparity readings of ten to twenty minutes of arc were common. In an extensive study of

++ For a review on actual measurements of fixation disparities, associated phorias, and generation of forced vergence curves see reference #3, p 30-34, 39-47.

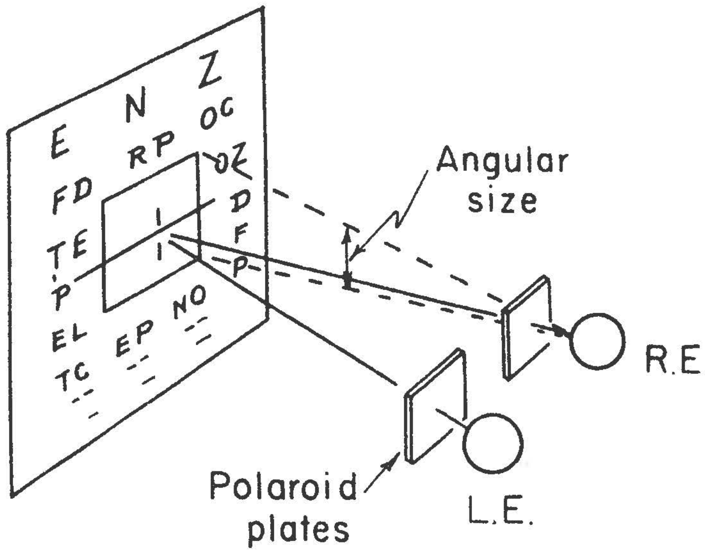


Fig. 3–12. The influence on fixation disparity of restricting fusion to peripherally visible details was studied by increasing the size of the central area within which there were no details to stimulate fusion.

FIG 5a. Fixation disparity target used in Ogle's original studies. (reprinted from reference #7)

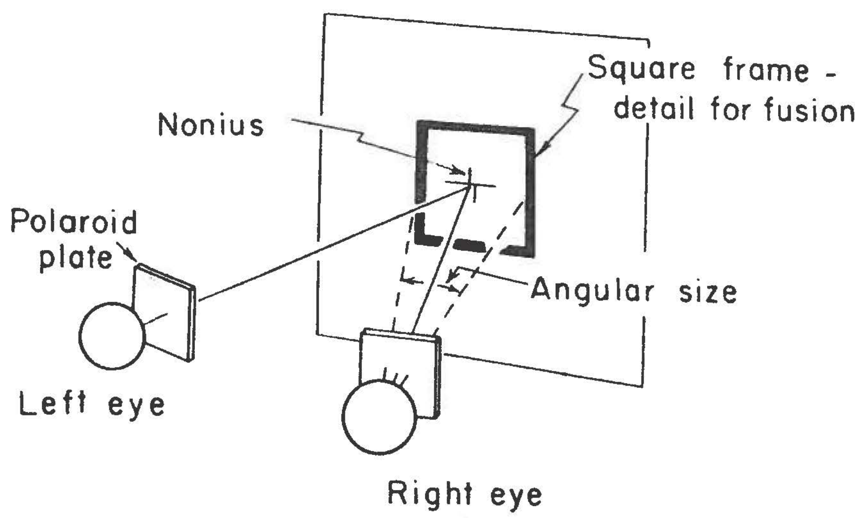


Fig. 3–15. Illustration of the simple pattern for contours which would stimulate fusion at a particular peripheral part of the visual field.

FIG 5b. Fixation disparity target used in Shepard's and Ogle's later studies. (reprinted from reference #7)

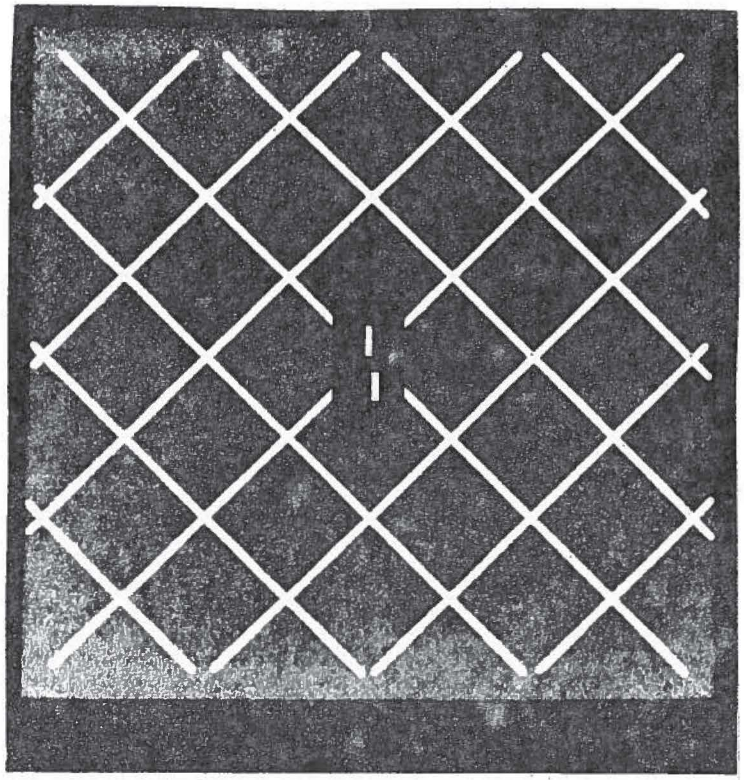


Fig. 2. The crisscross fusion pattern and vernier test lines used to measure fixation disparity.

FIG 5c. Fixation disparity target used by Carter. (reprinted from reference #9)

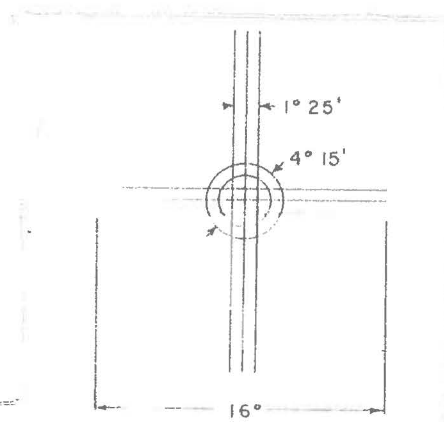


Fig. 2. The fixation target. When located 51.4 cm. from the eyes, as for these experiments, its dimensions in visual angle were as shown.

FIG 5d. Fixation disparity target used by Hebbard. (reprinted from reference #11)

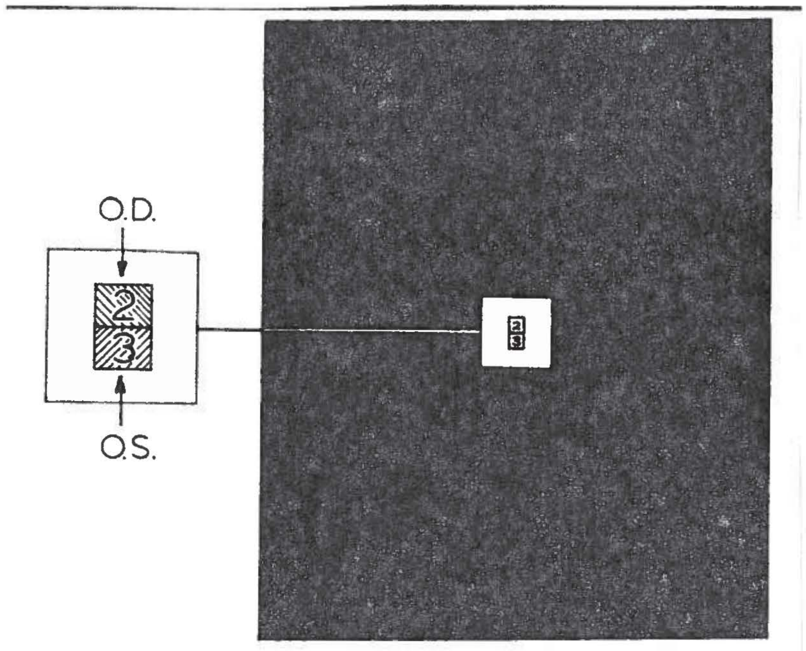
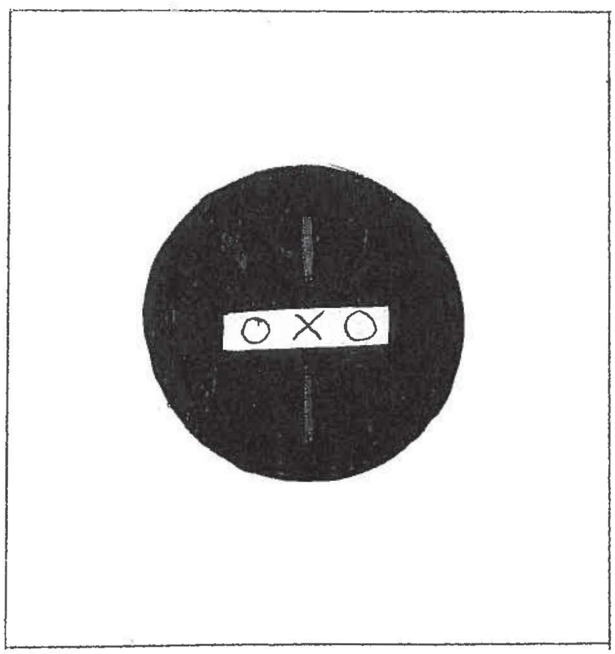


Figure 1: The Goodlaw Card

FIG 5e. Goodlaw Test. (reprinted from reference #10)



The upper line is polarized for the right eye; the lower line for the left.

FIG 5f. Mallett Test. (as described by Borish's <u>Clinical Refraction</u>, 3 ed.,1975, p 838)

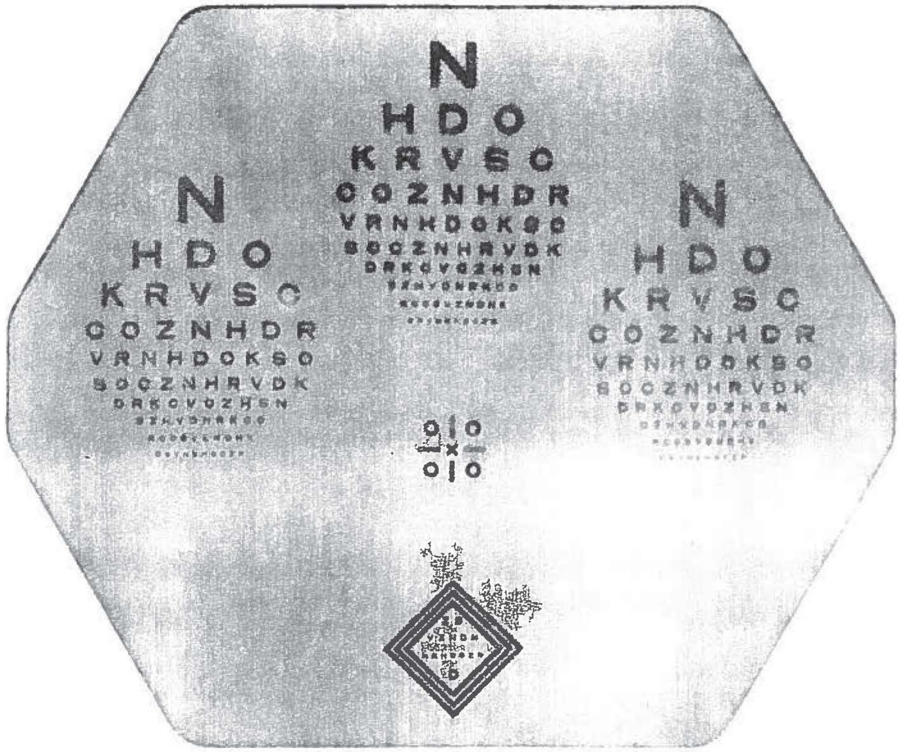


FIG 5g. Borish Nearpoint Card.

FIG 5h. Bernell Box with fixation disparity slide. (right)

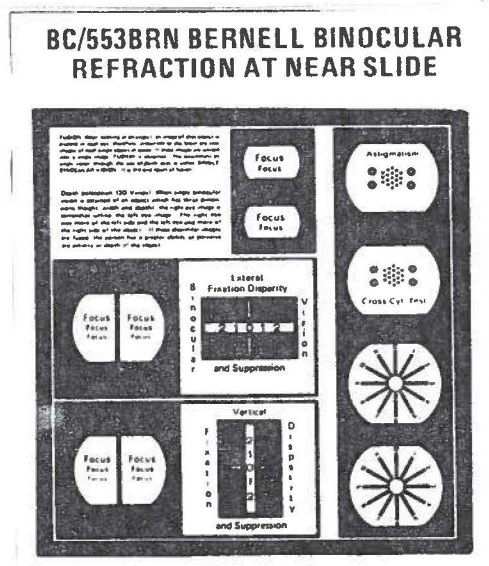


FIG 5i. Fixation Disparometer target. (below)

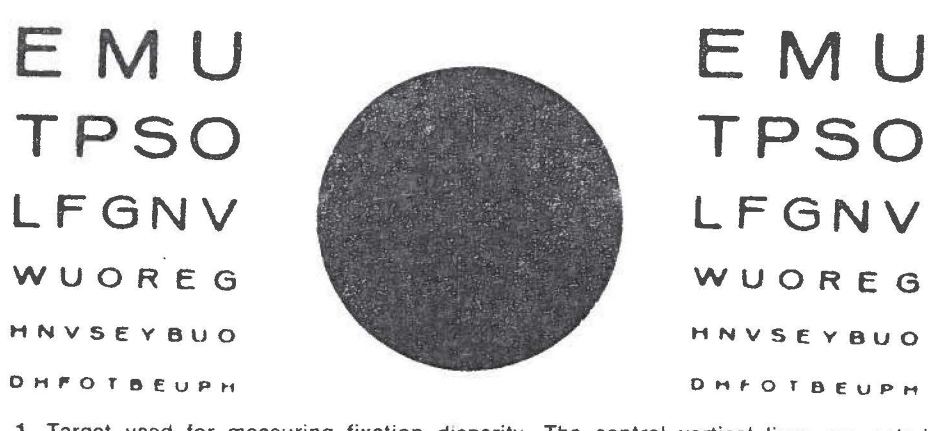


FIG. 1. Target used for measuring fixation disparity. The central vertical lines are polarized so hat each is seen by 1 eye under binocular viewing conditions.

1960,[10] Hebbard used a self-designed fixation disparity target [FIG 5d] to generate forced vergence curves. One of the many parameters that he compared was foveal vs nonfoveal fusion. He found nonfoveal curves were steeper in slope than foveal curves.[FIG 6e] This seems to support Ogle's initial research.[7]

Although the previous studies were not concerned specifically with associated phorias, they all indirectly measured associated phorias in generating the forced vergence curves. In none of the studies was a significant difference in associated phorias found with different target contour angles, including targets with foveal fusion detail: Even if the forced vergence curves changed with peripheral target detail, they still had approximately the same X-axis intercept --------the associated phoria.

A more recent study was designed by Griffen, Shultz, and Vansuch[11] to measure associated phorias with clinically used fixation disparity targets. They compared associated phorias found with a peripheral fusion lock target in the Goodlaw Test, [FIG 5e] and a central fusion lock target in the Mallet Test.[FIG 5f] Measurements were not significantly different,[FIG 6f] once again supporting the view that the associated phoria is independant of target contour angle.

Several fixation disparity targets are routinely used with patients besides those already mentioned. The present study will investigate associated phorias found with three of those targets. Two targets having central fusion locks[FIG 5g,h] and one target having a more peripheral fusion clues[FIG 5i] will be compared in an attempt to demonstrate reliability of use clinically.

FIG 6a.

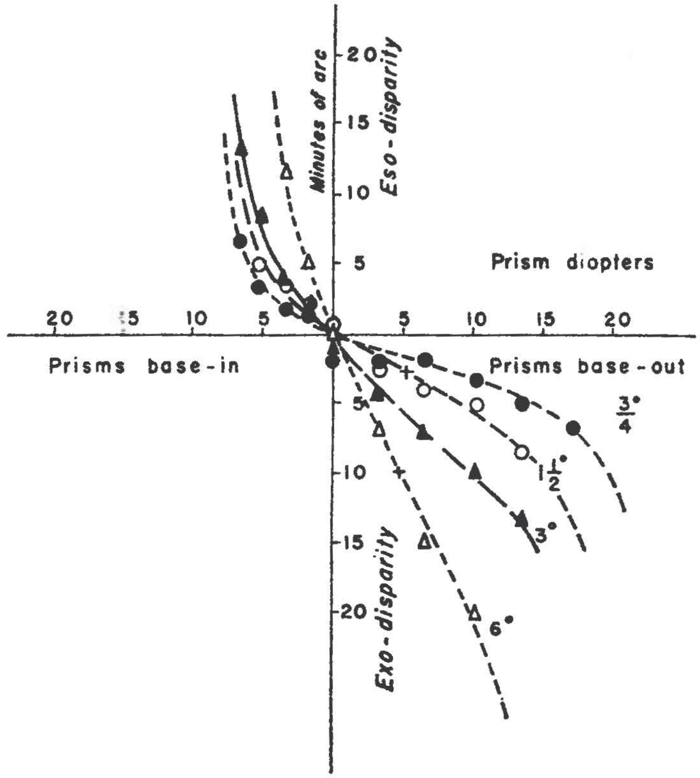


Fig. 3–13. Influence of the size of the field of print on fixation disparity. (Modified from Ogle, K. N., Mussey, F., and Prangen, A. de H.: Fixation disparity and the fusional processes in binocular single vision, Am. J. Ophth., *32*:1069–1087, 1949. By permission of the publisher, Ophthalmic Publishing Company.)

FIG 6b.

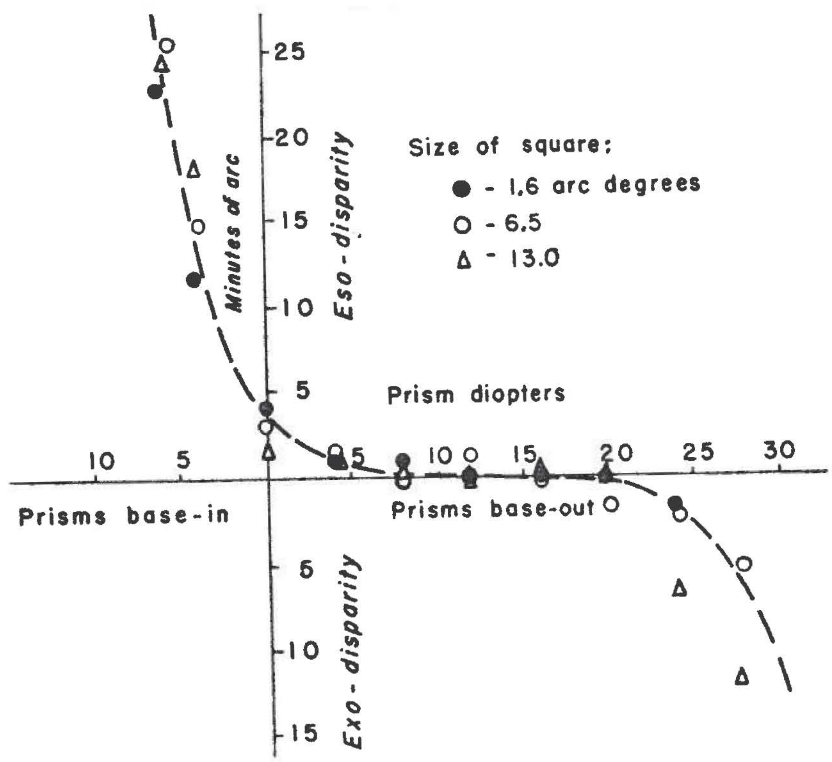


Fig. 3–17. Fixation disparity data obtained when the fusion details are square frames restricted to peripheral angles of different sizes.

(reprinted from reference #7)

FIG 6c. (reprinted from reference #7)

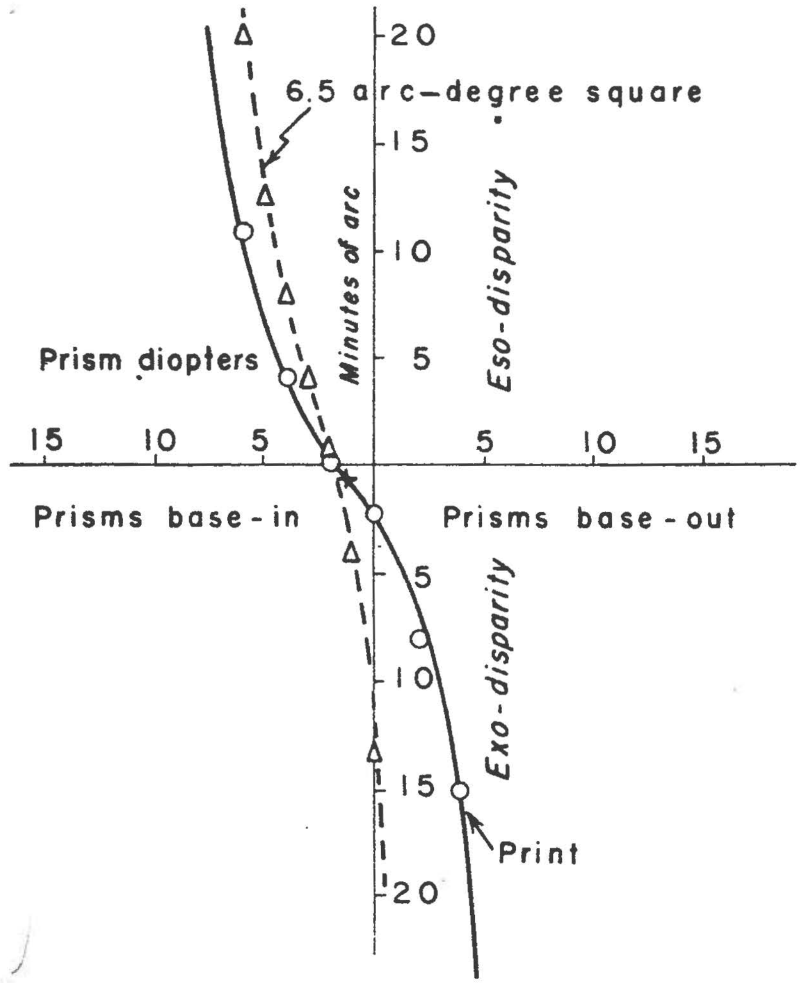


Fig. 3–18. Comparison of data obtained with a target with much deta for fusion and a square frame as illustrated in Figure 3–15.

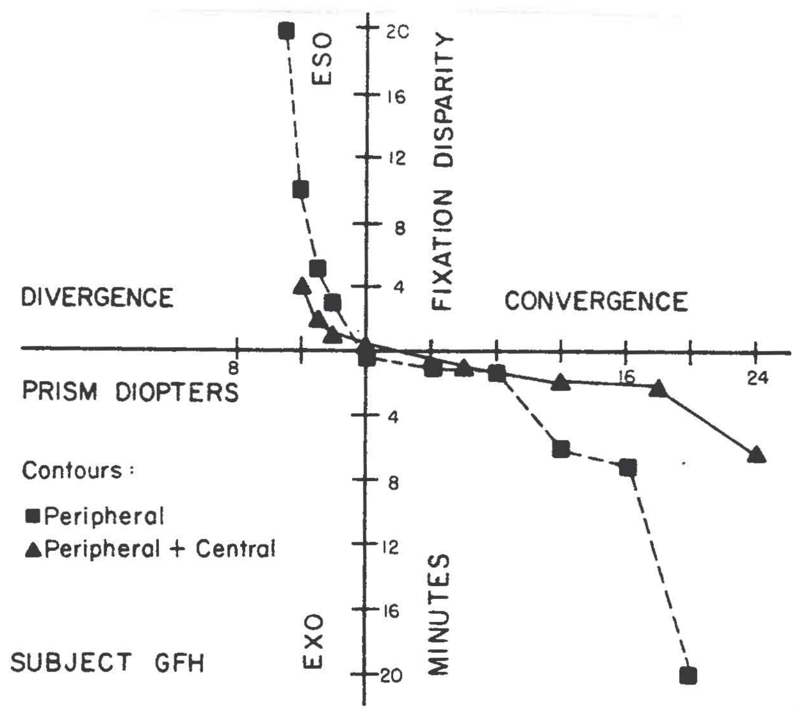


FIG. 6. Adding central fusion contours to a fixation disparity target already having peripheral fusion contours results in a flatter curve.

FIG 6d. (reprinted from reference #5)

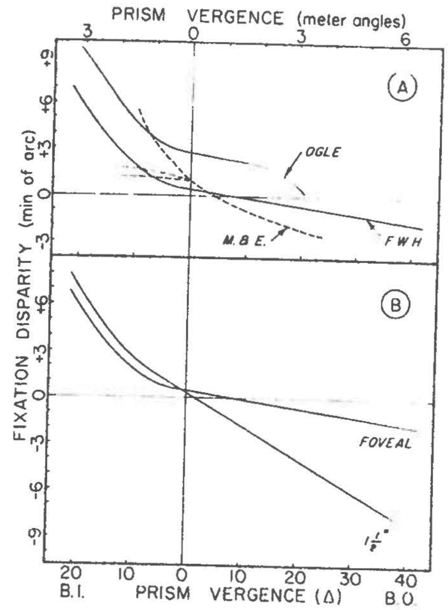


Fig. 5. A. The foveal fixation disparity curve as a function of prism vergence with zero lens add obtained in this study, as compared to curves obtained by Ogle, and Mitchell and Ellerbrock. See text. B. Fixation disparity as a function of prism vergence, obtained with zero lens add and bifoveal fusion, as compared with the fixation disparity obtained for the same subject and lens add when no detail existed in the central 1.5 degree-diameter area of the fusion target.

FIG 6e. (reprinted from reference #11)

TABLE 4

COMPARISON OF CLINICAL RESULTS SHOWING AGREEMENT BETWEEN TWO DIFFERENT TESTS FOR FIXATION DISPARITY.

D = Direction of Associated Heterophoria (eso or exo)
M = Magnitude (prism diopters) of Associated Heterophoria
*N = 16

Relative	Number	%
Number that agree exactly in D & M on both tests	1	6.66%
Number that agree in D & M with tolerance of 0.5 prism diopter	4	26.66%
Number that agree in D & M with tolerance of 1.0 prism diopter	11	73.33%
Number that agree in D & M with tolerance of 1.5 prism diopters	15	93.75%
Number that *disagree* in Direction of Deviation found with each test	1	6.66%

*Total number of sample found with associated heterophoria using both tests is 16 (i.e., 100% for this table).

FIG 6f. (reprinted from reference #10)

PROCEDURE

The three targets used in this study are the Bernell Box with fixation disparity slide, Borish Nearpoint Card, and Fixation Disparometer.[FIG 5f,g,h] At the 40 cm testing distance the nearest angular distance to fusion detail for each is, respectively: 0°, 1.32°, $.20^\circ$... all less than the central 2 degrees. However, the Disparometer lacks a "central fusion lock".[++++]

Eighteen subjects, ranging in age from 21 to 35, were selected for this study on the basis of their availability for measurements. All had clear single binocular vision through their prescriptions at near, with no central suppression. Each subject was seen on three different days.[+++] At each session lateral associated phoria measurements at 40 cm were taken with the three fixation disparity targets, although the order of instrumentation was varied in the following manner:

	Target 1	Target 2	Target 3
session 1	Borish Card	Fix. Disparom.	Bernell Box
session 2	Fix. Disparom.	Bernell Box	Borish Card
session 3	Bernell Box	Borish Card	Fix. Disparom.

The total length of testing at each session never exceeded five minutes, the average time needed for each target being 30 seconds for the Bernell Box and the Fixation Disparometer, and 45 seconds for the Borish Card.

During measurements a bracketing method was used. If the vernier target lines initally appeared misaligned, prism was added until the subject reported perfect alignment. From

+++ 3 subjects could not return for final readings so the data already collected on them was used for the averages, ranges.

++++ Central fusion lock implies binocular fixation clues are more centrally located than vernier target lines.

that point prism was adjusted in a BI direction until first noticeable misalignment of target lines, then reduced until they appeared perfectly realigned. This was repeated on the BO side of the associated phoria. Even when the subject's initial reponse indicated orthophoria, BI then BO prism was added and reduced ; utilizing the same bracketing method. The result for each subject during each session with each target was a range of prism for which the target lines appeared perfectly aligned. The width of this range is a reflection of the precision of measurement and varied with the subject.

During testing the neutralizing prism was placed before the deviating eye in the case of marked dominance, or in front of the left eye if the subject could not judge which, if any, line was off-center (mixed dominance). A flashing technique was utilized in all cases except with four subjects who could judge alignment best if they were not flashed. Otherwise, the eye receiving neutralizing prism was continuously flashed and the prism power changed only while the eye was momentarily covered.

After all the data was collected, each subject's associated phoria and range of measurement was averaged for each of the three targets. The average associated phorias and ranges were first evaluated by inspection, then the associated phorias statistically analyzed by a "t-test" and Pearsonian Correlation of Coefficiant series.

RESULTS

By inspection of the average associated phorias, TABLE 1 differences among targets may not be evident but with statistical analysis, utilizing a "t-test", differences appear. TABLE 2,3 The Borish Card and Fixation Disparometer associated phorias are correlated (r=.679629)* but significantly different (t=2.26769) where t>2.11 means significant). This indicates that associated phoria measurements made with one were significantly different from the other. The Fixation Disparometer and Bernell Box associated phorias are not considered correlated (r=.390896)** implying that these two targets do not even measure the same parameter. Associated phorias found with the Borish Card and Bernell Box, the two targets having central fusion locks, are correlated (r=.705522)* and <u>not</u> significantly different(t=1.64281) indicating that measurements found with these targets are the same within experimental error.

By inspection of the average range of measurements TABLE 2 it can be seen that ranges varied from subject to subject but were about the same from target to target with any one subject. The exception is that ranges tended to be just slightly lower with the Fixation Disparometer with a single subject. Regardless of the minutely higher precision found with the Disparometer, precision seemed to be a factor more inherent in the subject than in the target.

* The Pearsonian Correlation Coefficient is significant at greater than the 99% significance level.

**This correlation coefficient was not statistically significant.

TABLE 1. "Average associated phoria/Average range" (+ = exo deviation, - = eso deviation)

Subject	Borish Card	Fix. Disparometer	Bernell Box
1	$.33/1.\bar{6}$	$1.5/1.0$	$.83/1.\bar{6}$
2	$0/2.\bar{6}$	$2.3/2.0$	$1.6/1.3$
3	$1.\bar{6}/2.0$	$.6/.6$	$3.0/2.0$
4	$1.0/0$	$0/0$	$.58\bar{3}/1.1\bar{6}$
5	$2.0/1.\bar{3}$	$-1.\bar{6}/0$	$-.3/3.\bar{3}$
6	$-2.1\bar{6}/0$	$-5.0/0$	$-2.0/0$
7	$4.\bar{6}/6.\bar{3}$	$2.5/4.\bar{3}$	$-.6/8.\bar{3}$
8	$-2.3/1.\bar{3}$	$-5.1\bar{6}/1.\bar{6}$	$-1.0/1.\bar{6}$
9	$.1\bar{6}/1.0$	$-5.\bar{3}/1.0$	$.\bar{6}/.\bar{3}$
10	$-.\bar{6}/.\bar{6}$	$.83/0$	$0/1.\bar{3}$
11	$3.83/1.\bar{6}$	$0/.\bar{3}$	$3.8\bar{3}/.\bar{3}$
12	$-2.1\bar{6}/2.\bar{3}$	$.5/.\bar{3}$	$-2.\bar{6}/2.0$
13	$2.5/.3$	$2.1\bar{6}/0$	$1.5/0$
14	$6.\bar{6}/2.0$	$7.1\bar{6}/1.0$	$3.5/.3$
15	$1.\bar{3}/.\bar{6}$	$.\bar{3}/.\bar{6}$	$.8\bar{3}/.\bar{3}$
16	$2.\bar{6}/2.0$	$-.3/.\bar{6}$	$.1\bar{6}/0$
17	$1.0/0$	$0/0$	$.5/1.0$
18	$0/0$	$1.0/0$	$-4.0/0$

TABLE 2. Results of t-test. (17 degrees of freedom)

Targets Compared	t	p
Borish Card & Fix. Disparometer	2.26769	< .01
Fix. Disparometer & Bernell Box	.31539	> .25
Borish Card & Bernell Box	1.64201	< .06

TABLE 3. Results of Pearsonian Correlation of Coefficiant.

Targets Compared	r	p
Borish Card & Fix. Disparometer	.679629	< .01
Fix. Disparometer & Bernell Box	.390896	=.21
Borish Card & Bernell Box	.705522	< .01

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