THE CLINICAL SIGNIFICANCE REGARDING THE ORDER OF PRISM PRESENTATION ON FIXATION DISPARITY CURVES

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ABSTRACT

The effect of prism presentation order was evaluated to determine its effect on fixation disparity curves. Three fixation disparity curves were taken on fourteen subjects with each curve varying the order of prism presentation. As was found in past studies involving heterophorias, subjects prism adaptation increased if base-out prism was presented first. Minimal prism adaptation occurred with presentation of base-in prism initially.

INTRODUCTION

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Clinicians have routinely tested vergence ranges by presenting base-in prism before base-out. This minimizes the effects of prism adaptation and controls accomodation. However, the order of prism presentation relative to changes in fixation disparity curves (f.d. curves) has never been evaluated. This investigation tested the clinical significance of horizontal prism presentation order on forced vergence fixation disparity curves.

Fixation disparity is the failure of the foveal lines of sight to intersect exactly at the fixation object. This misalignment is small enough to fall within Panum's fusional area and single binocular vision is still present. Heterophoria measurements are usually larger than the fixation disparity and often in the opposite direction; i.e., exophoria with an eso fixation disparity.

The angle of fixation disparity will change if prism is introduced before the eyes. A fixation disparity curve is a graph of the fixation disparity as a function of the interposed prism. This essentially monitors the fixation disparity during vergence testing.

Ogle classified fixation disparity curves into four types according to the increase (or lack of it) in the amount of fixation disparity that occurs with the introduction of base-in or base-out prism. Type I responds to divergent and convergent stimuli about equally[1]. This curve with a flat slope and low y-intercept is the ideal. Type I f.d. curves with a steep slope and/or high y-intercept offer the most success with visual training. F. d. curves are classified as type II when errors in convergence are smaller than errors of divergence[1]. Forced vergence F. D. curves classified as Type III have convergence errors greater than divergence errors. Both Type II and III are very resistant to visual training procedures, Prism prescription is the recommended treatment although adaptation may occur[2]. The prism perscribed should allow the patient to operate on the flat portion of the curve. Type IV f. d. curves indicate a very unstable oculomotor system.

Prism adaptation begins after fusional vergence has been stimulated 10 - 15 seconds and is complete after 1 - 15 minutes[3]. Therefore, in testing vergence ranges during routine visual examinations prism adaptation is likely to occur. Schor reported 60% of the population adapts more to convergence than divergence and suggested measuring divergence before convergence to minimize prism adaptation[1]. This corresponds to the fact that convergence responses to base-out prism have longer latencies but higher velocities (127 msec. and 2.5 deg^2/sec) than divergence (119 msec and 1.25 deg^2/sec)[4].

Recent work with fast and slow fusional vergence systems and prism adaptation has suggested separate mechanisms control the tonic levels of fusional convergence and divergence over long periods of time. This hypothesis is supported by the amplitudes of slow fusional vergence as being unequal in response to convergence and divergence stimuli with adaptation occurring more rapidly in response to base-out prism[4].

Past studies point towards base-out prism adaptation occurring more rapidly and in larger amounts than base-in prism adaptation. There are a few isolated reports of the opposite happening[5], however, which should not be discounted. The purpose of this study will determine if the sequence of prism presentation significantly alters forced vergence f. d. curves.

METHODS

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All subjects had normal binocular vision and wore their habitual corrections placed in a phoropter. F.d. curves were taken using a Disparometer at 40 cm and Risley prisms were used to present the prism. Illumination was provided by an overhead reading lamp. Base-out prism was presented at the individuals positive relative convergence limit (blur) as the subject viewed the fixation letters on the side of the disparometer making certain the letters were clear and single. An associated phoria was recorded and the prism immediately reduced to 8 p.d. while the subject again fixated the small letters on either side of the vernier lines. Another associated phoria was measured, the prism then removed and the measurement repeated. In this way a fixation disparity curve was developed with further readings taken at 8 p.d. base-in and finally the negative relative divergence limit.

A second fixation disparity curve was formed by first recording the fixation disparity through zero prism, 8 p.d. base-in, and at the negative relative divergence limit of the subject. The base-out tail of the f. d. curve was obtained by measurements taken through 8 p.d. base out and at the positive relative fusional limit. This curve represents the customary procedure used in clinical testing.

The final forced vergence f. d. curve was recorded through the subjects negative relative divergence limit, 8 p.d. base-in, zero prism, 8 p.d. base-out and the positive relative fusional limit.

RESULTS

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The resulting three prism induced f.d. curves were plotted on one graph for each of the fourteen subjects and compared. All the curves which first presented base-out prism at the subjects positive fusional limit showed the greatest adaptation to the prism with the resulting associated phoria manifesting more exo at the extreme base-out end. The amount of exo induced varied between subjects with the averaged exo being 4 p.d. (as determined from comparing it to the customary prism presentation of zero to base-in to base-out f. d. curve). Three subjects exhibited 10 p.d., 7 p.d., and 6 p.d. (respectively) more exo with the prism presented in this manner. The remaining eleven subjects had between 1 and 4 p.d. more exo disparity.

The forced vergence f.d. curve presenting the prism at the subject's divergence limit of clear vision varied greatly between subjects. At the base-in end of the curve, subjects exhibited minor adaptation to the base-in prism in the form of greater eso (3 p.d. average). Three subjects showed no change from the customary f. d. curve and the remaining three subjects showed slightly more exo. This latter phenomenon of "negative" prism adaptation was a probable artifact of testing. The rest of the graph paralleled the customary curve closely.

At the y- intercept (zero prism), the difference between the three curves was never more than 2 p.d. in 12 of the 14 subjects. In one subject there was 5 p.d. difference between the f. d. curve presented in the customary manner and the curve beginning at the subject's positive fusional limit. Another subject exhibited a 4 p.d. difference between the f.d. curves presenting the prism at the positive and negative fusional limits.

DISCUSSION

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Past studies have shown prism adaptation occurring faster for base-out prism tham base-in but have based their work on heterophorias and not fixation disparities[5]. This point becomes especially important when considering the fast and slow vergence system is a closed loop system in which phorias do not play a part. Disparity drives the fast vergence system which in turn drives slow fusional vergence. Therefore, the question of prism presentation order in forced vergence fixation disparity curves becomes increasingly important.

This study found base-out prism adaptation to be faster and greater when compared to base-in prism on f.d. curves. Schor's work [1,4], which found a higher velocity for convergence (base-out stimulus) and increased base-out adaptation upholds these findings. Further, this evidence also provides support for the hypothesis that separate control centers exist for slow fusional divergence and convergence. For such a dual system to exist, velocities would be different for each slow fusional movement (divergence and convergence).

It should be noted, however, that all subjects involved in this study produced Type I curves. Steep slopes of some f. d. curves did not apparently indicate any more or less prism adaptation during testing procedures. Problems with fatigue (particularly divergence) at the extreme ends of the curves were encountered with three subjects. The fatigue was experienced in each subject during the collection of the third f. d. curve data (negative fusional limit to positive fusional limit).

An unforseen difficulty arose attempting to test untrained observers. Either their previous visual tasks were not demanding enough to discriminate fine misalignments of the targets or their intelligence limited their understanding of the instructions.

SUMMARY

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In conclusion, the best order of prism presentation is still the customary procedure which tests fixation disparity first without prism then proceeds to base-in prism and finally to base-out. Prism adaptation will occur if starting with either base directions fusional limit and thus slightly alter the resulting f. d. curve. A falsely steep or flat curve could be generated.

REFERENCES

[1] Schor, C.M. The influence of rapid prism adaptation upon fixation disparity. Vision Res 1980; 19: 757-765

[2] Carter, D. B. Effects of prolonged wearing of prism. Am J Optom Arch Am Acad Optom 1962; 40: 263-273.

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[4] Schor, C. M. Fixation disparity: A steady state error of disparity induced vergence. Am J Optom Physiol Opt 1980; 57: 618-631.

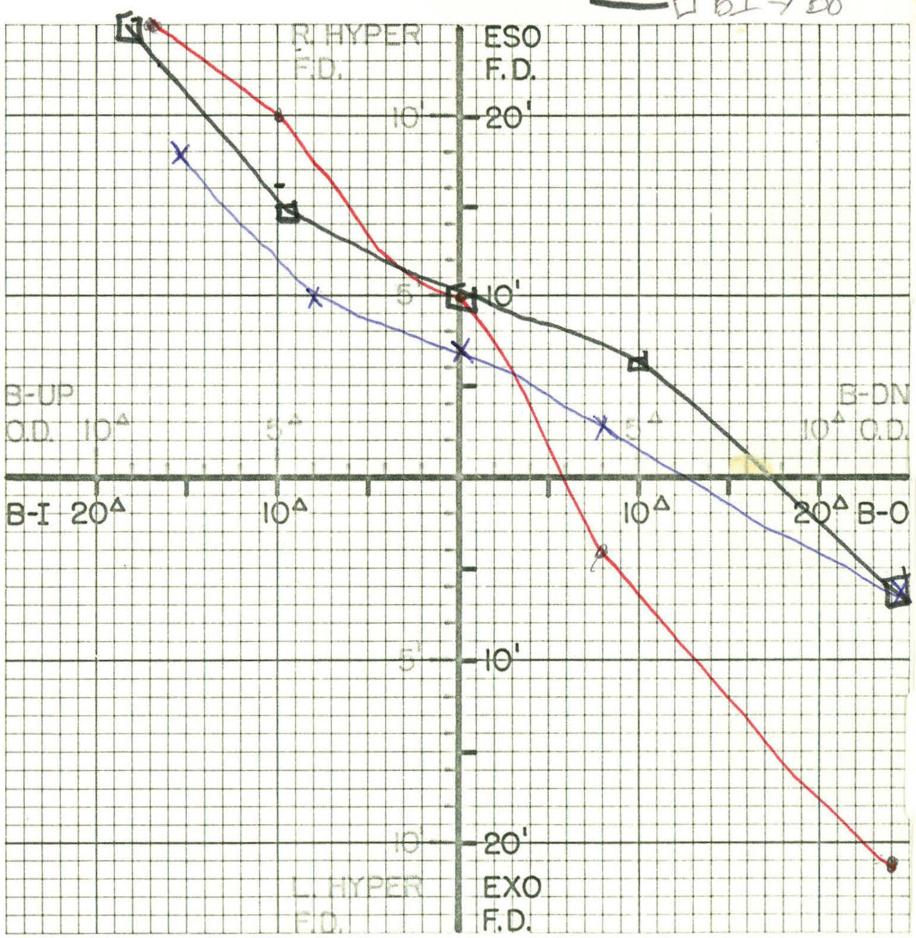
[5] Mitchell, A. M. , Ellerbrock, V. J. Fixation disparity and the maintenance of fusion in the horizontal meridian. Am J Optom 1955; 32: 520-534.

FIXATION DISPARITY CURVE

NAME T. P.
DATE 2/83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS:

• BO → BI
X Ø → BI → BO
☐ BI → BO

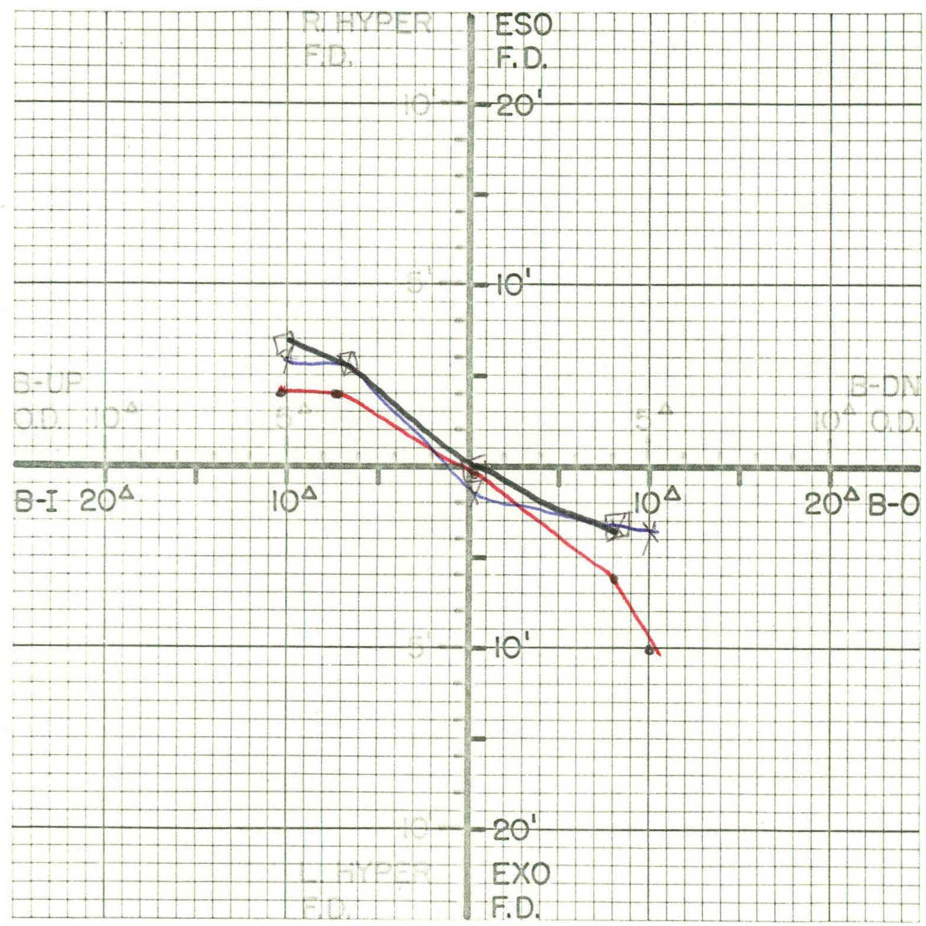


FIXATION DISPARITY CURVE

NAME A. H
DATE 4/83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS:

• BO → BI
X Ø → BI → BO
☐ BI → BO



FIXATION DISPARITY CURVE

NAME M.F
DATE 3-83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS:
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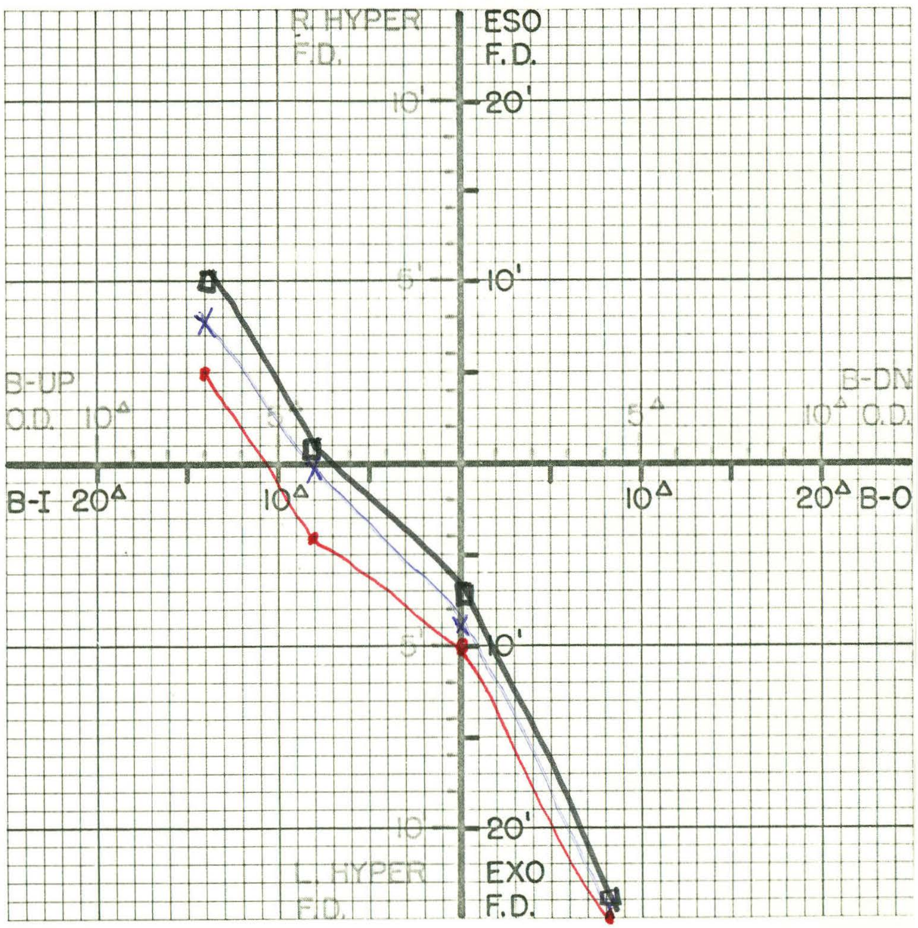
x Ø → BI → BO
☐ BI → BO



FIXATION DISPARITY CURVE

NAME M.B
DATE 4/83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS:
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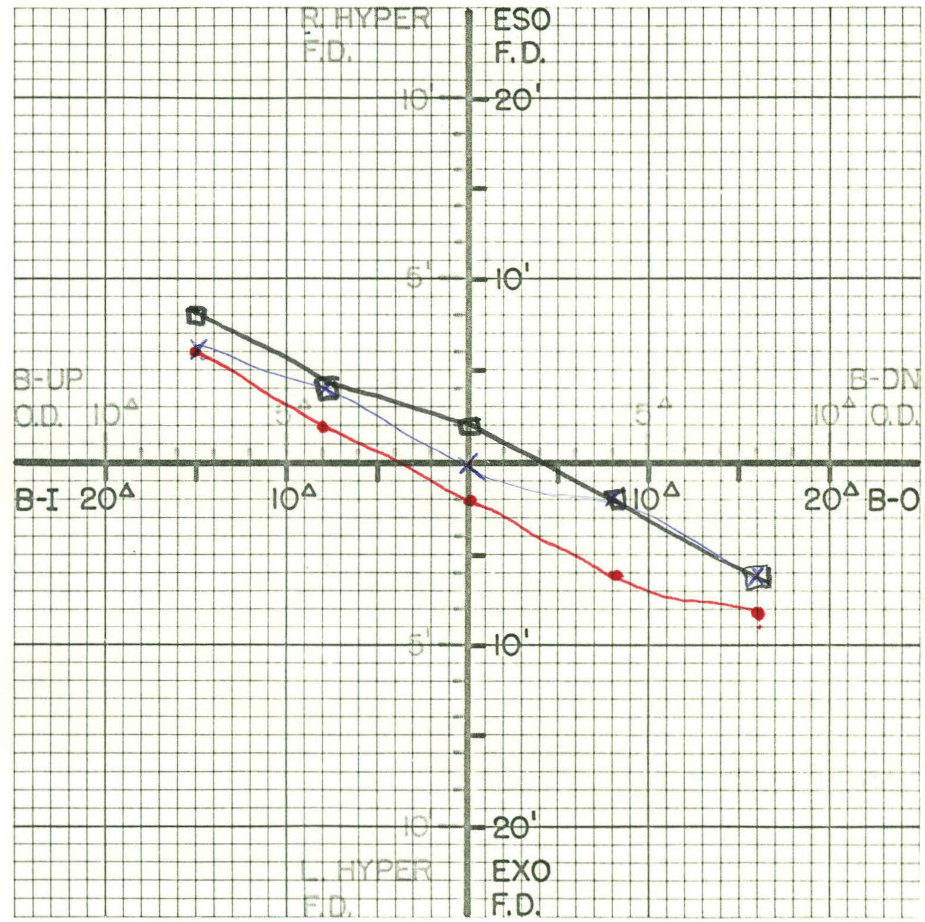
x Ø → BI → BO
☐ BI → BO

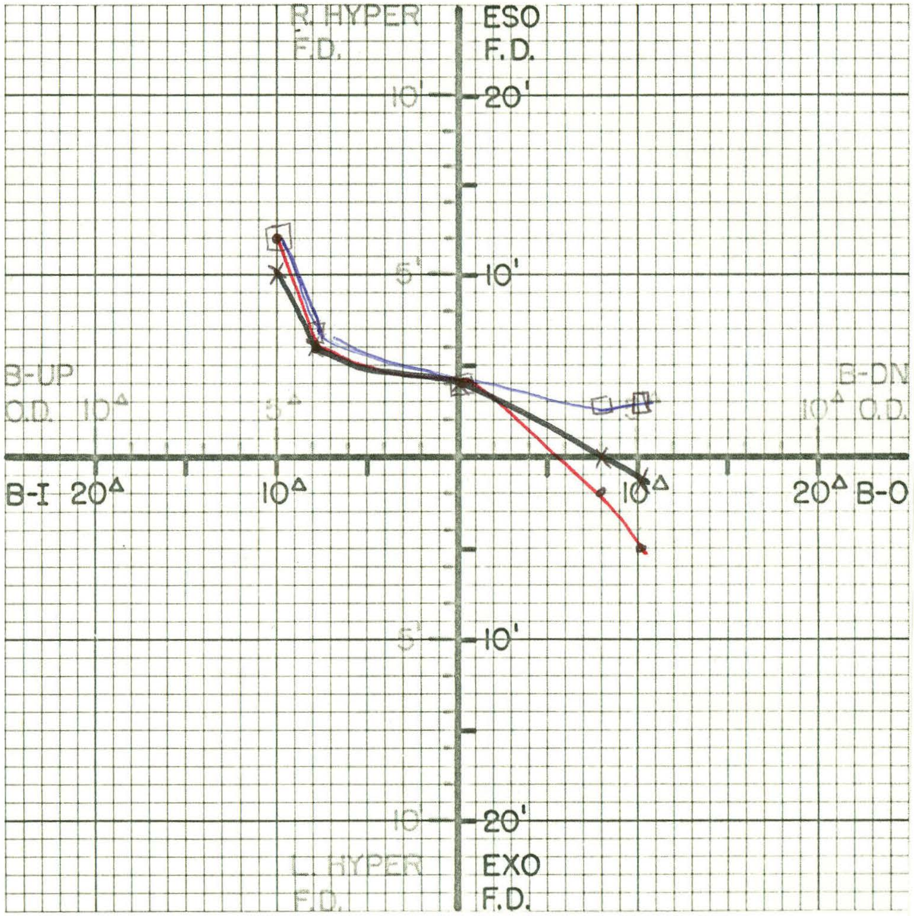


FIXATION DISPARITY CURVE

NAME S. L.
DATE 4/83
DISTANCE
☐ LATERAL ☐ VERTICAL

COMMENTS :

— • BO → BI
— x Ø → BI → BO
— ☐ BI → BO

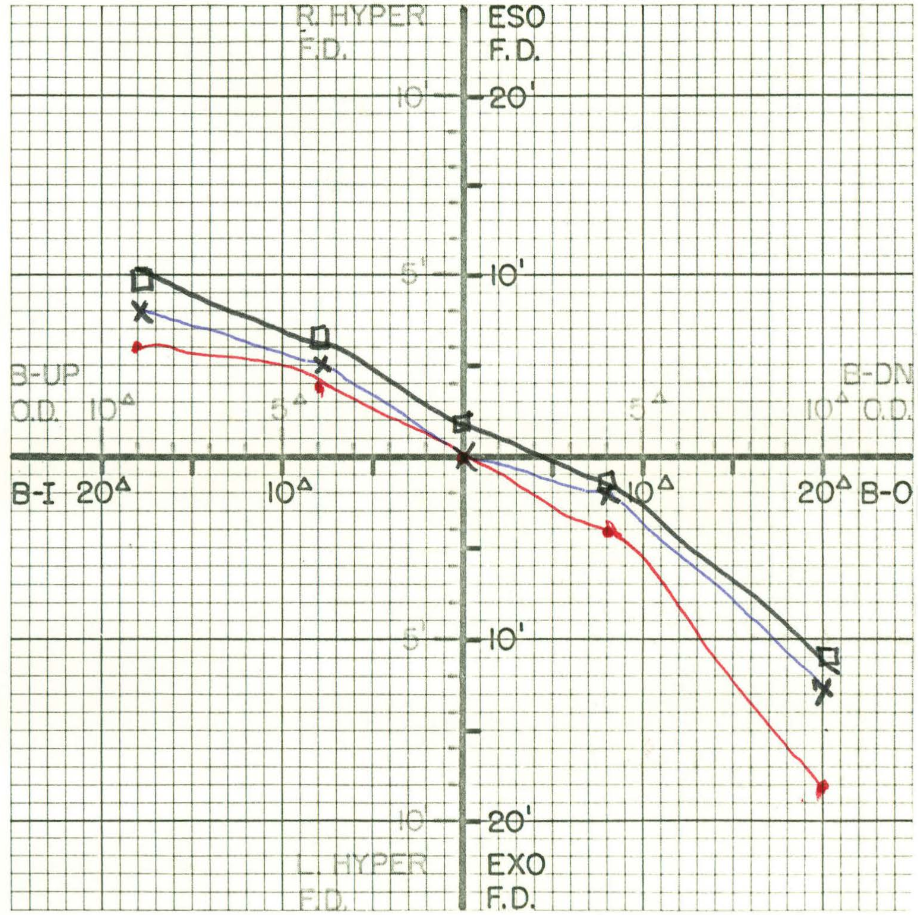


FIXATION DISPARITY CURVE

NAME Y. T.
DATE 3/83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS :

— • BO → BI
x Ø → BI → BO
— ☐ BI → BO

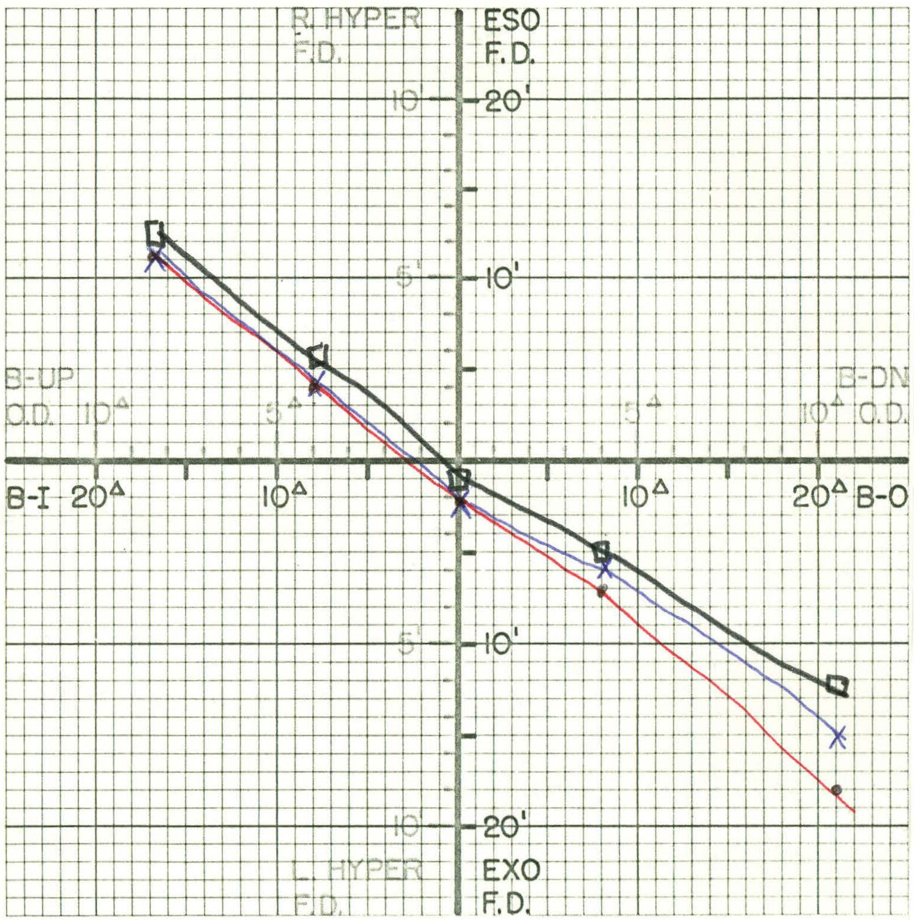


FIXATION DISPARITY CURVE

NAME A.V.
DATE 3/83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS :

- red line: · BO → BI
- blue line: x ∅ → BI → BO
- black line: ☐ BI → BO

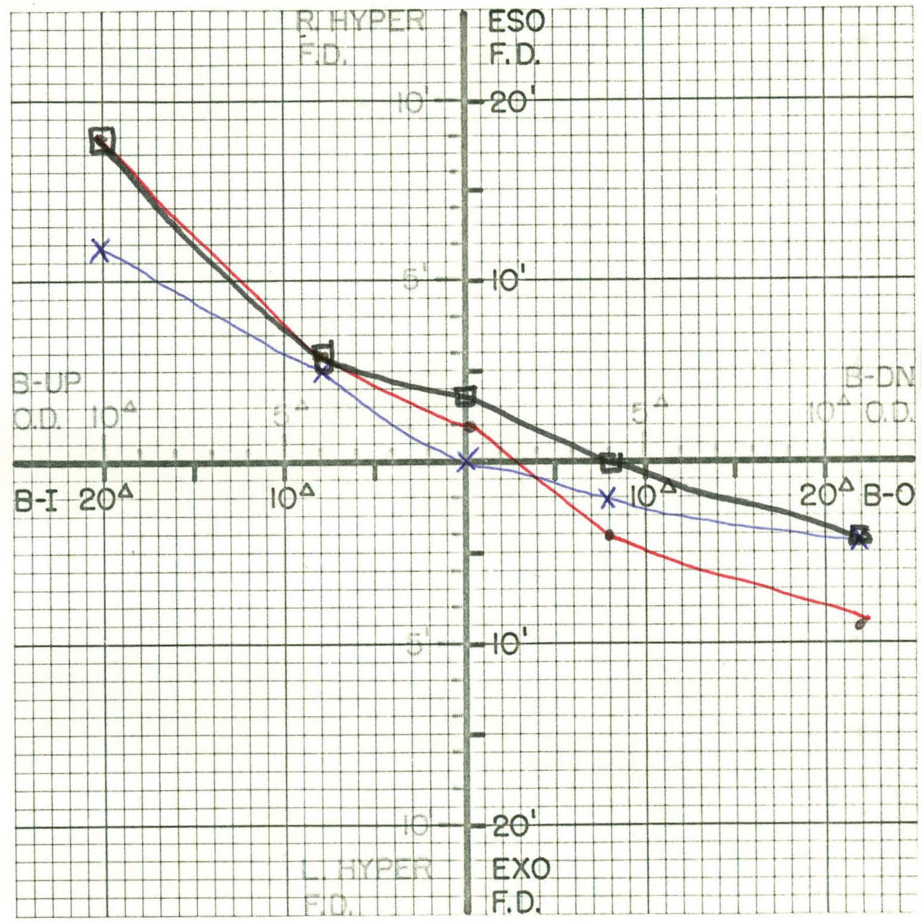


FIXATION DISPARITY CURVE

NAME S.R.S.
DATE 2/83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS :

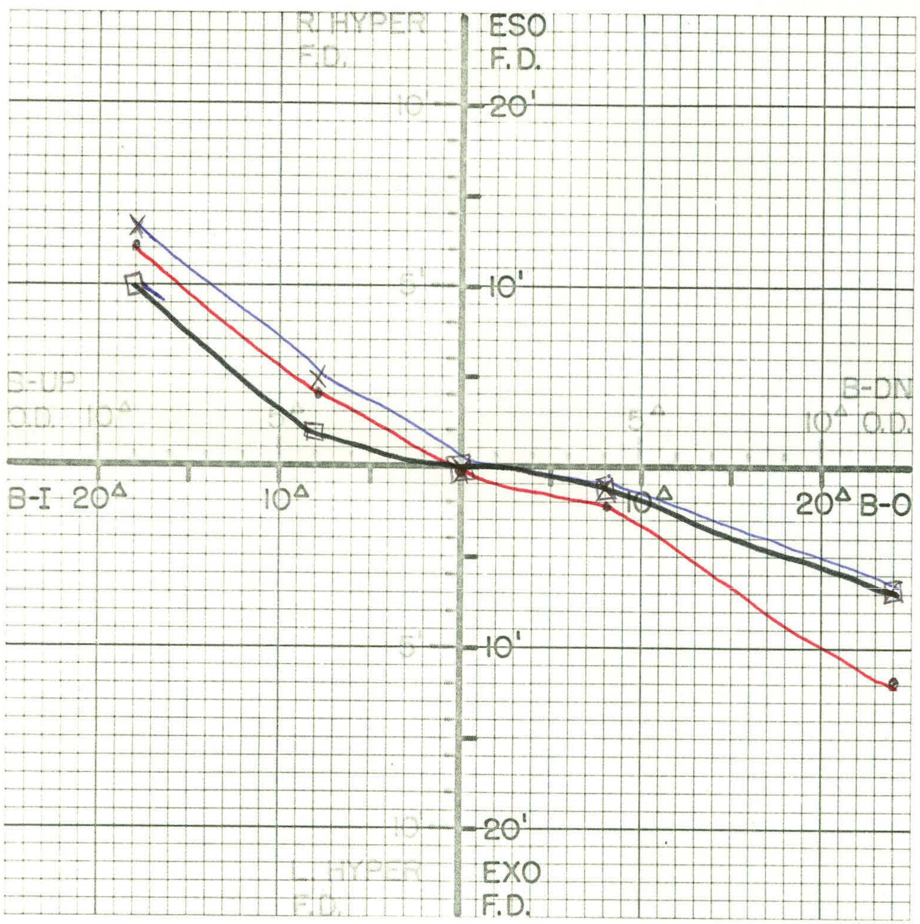
- red line: · BO → BI
- x ∅ BI BO
- black line: ☐ BI → BO



FIXATION DISPARITY CURVE

NAME K. T.
DATE 10/82
DISTANCE
☒ LATERAL ☐ VERTICAL

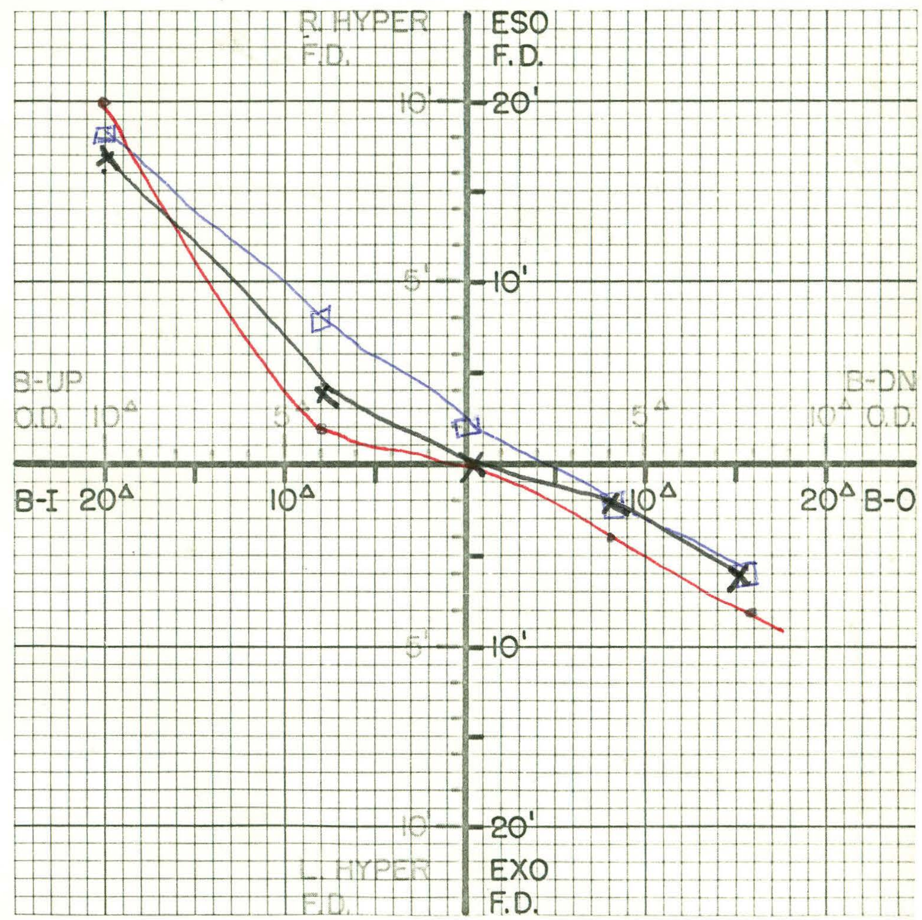
COMMENTS :
— ∘ BO → BI
x Ø → BI → BO
▬ □ BI → BO



FIXATION DISPARITY CURVE

NAME Ca E.
DATE 4/83
DISTANCE
☒ LATERAL ☐ VERTICAL

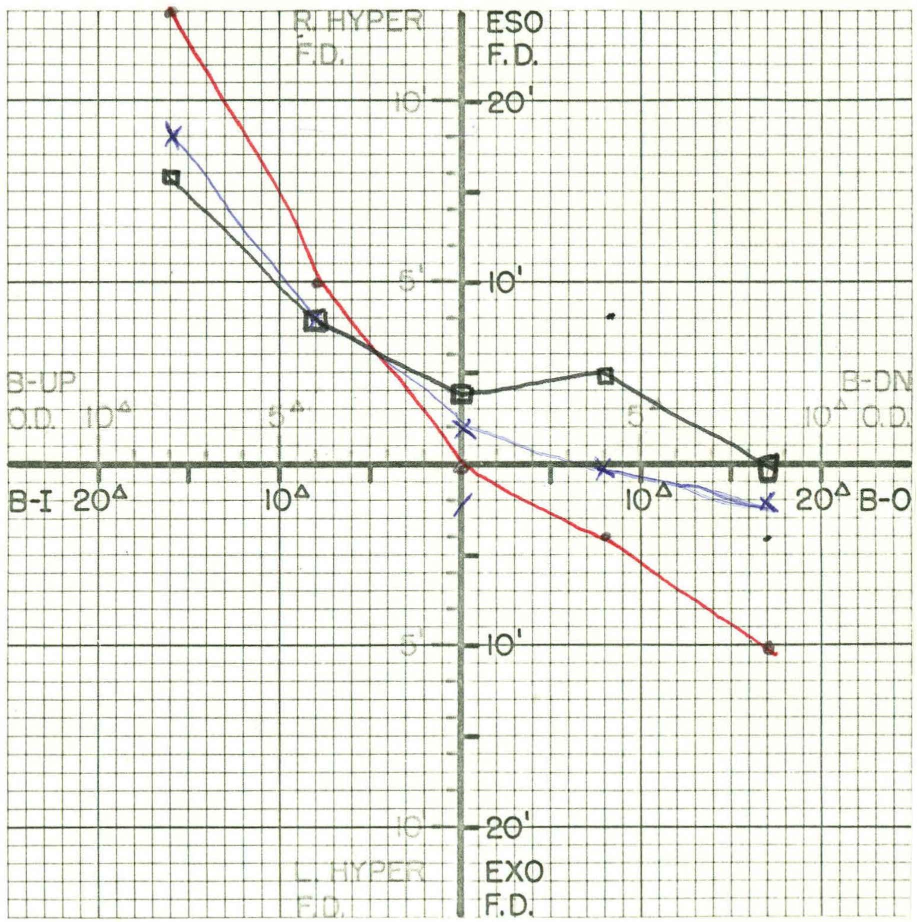
COMMENTS :
— ∘ BO → BI
x Ø → BI → BO
□ BI → BO



FIXATION DISPARITY CURVE

NAME J.F
DATE 4/83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS : • BO → BI
X O → BI → BO
☐ BI → BO



FIXATION DISPARITY CURVE

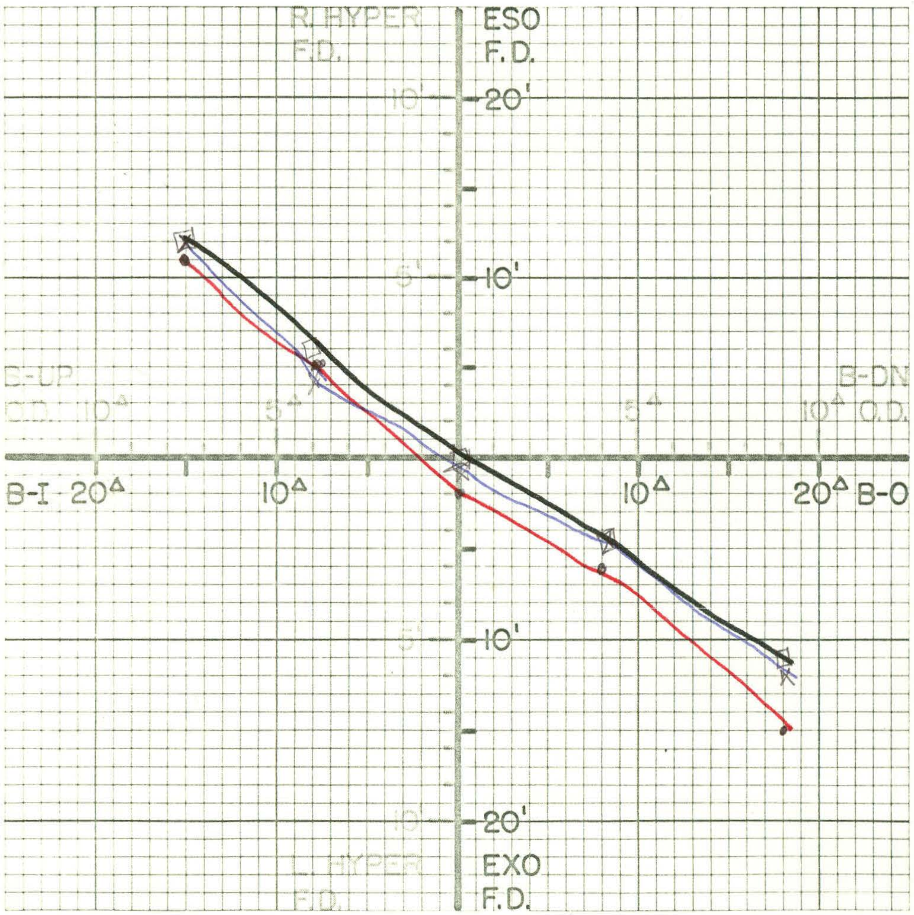
NAME D.F
DATE 10/82
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS : • BO → BI
x Ø → BI → BO
☐ BI → BO

FIXATION DISPARITY CURVE

NAME DB
DATE 3-83
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS :
• BO → BI
× Ø → BI → BO
☐ BI → BO



FIXATION DISPARITY CURVE

NAME L.K.
DATE 10/82
DISTANCE
☒ LATERAL ☐ VERTICAL

COMMENTS :
• BO → BI
× Ø → BI → BO
☐ BI → BO