THE EFFECT OF SMALL AMOUNTS OF ARTIFICIALLY INDUCED ANISOMETROPIA ON THE FORCED VERGENCE FIXATION DISPARITY CURVE

by

David Farah

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ABSTRACT

This experiment examined the effect that the introduction of small amounts of anisometropia had on the forced vergence fixation disparity curves of four subjects. Its purpose was to investigate whether the forced vergence fixation disparity curve could be a clinically useful technique in questions concerning small amounts of anisometropia. The results of this experiment show the response of the forced vergence fixation disparity curve to small amounts of anisometropia to vary with the subject as well as the portion of the curve. In some cases, as little as 0.50 D had a noticable effect while in other cases, 1.00 D of anisometropia appeared to have no effect. Finally, applications of this approach are considered.

INTRODUCTION

A search of optometric and physiological optics literature failed to reveal any previous experimentation on the relationship between small amounts of artificially induced anisometropia and the forced vergence fixation disparity curve directly. Certain papers, however, do contain information which may be applicable to this topic.

Carter[1] suggests that a measured fixation disparity may vary in as little as fifteen minutes if the subject is given time to adapt through the prism being used. This would indicate that more rapidly responding subjects may tend to show greater changes in the forced vergence fixation disparity curve.

Flom and Goodwin[2] examined the difference in response to fogging lenses between the two eyes. The implication here was that, with a refraction done at distance, creating artificial anisometropia of small amounts at near could actually be equalizing the two eyes of some people. The prediction would then be made that for a portion of the population, small amounts of anisometropia may cause changes in the fixation disparity curve opposite to what somewhat larger amounts of anisometropia would cause.

Peters[3] stated that as little as .12D of anisometropia can effect the binocular system of certain individuals as measured by stereosensitivity. He found that .75D to 1.00D of anisometropia would almost certainly have an effect.

Rutstein[4] like Carter suggests that an adaptation process may be present in the visual system by which an inherent fixation disparity tends to maintain itself.

Finally, an interesting conclusion was reached by Saladin and

METHODS

The subjects for this experiment were four prepresbyopic males who had no symptomatic binocular problems or strabismus. They also lacked any uncorrected anisometropia of 0.25 D or more.

Each subject sat for four separate sessions over a period of four weeks. The first session began with a careful subjective refraction which included a critical balancing using at least three balancing procedures. After this was done, and at each of the three subsequent sessions, four forced vergence fixation disparity curves were measured using a disparometer at 40 cm. One curve was taken with only the subjective refraction placed in the phoropter (level 0), while the other three curves were taken with +0.25 D, +0.50 D and +1.00 D spheres placed before the right eye in addition to the subjective refraction (level 1, 2 and 3 respectively.) The order in which the curves were done, was selected from a list of possible orders produced from a random drawing made before the start of the data collection.

Each curve consisted of the fixation disparity measured with seven amounts of prism placed in front of the phoropter: 6 BI, 3 BI, 0, 3 BO, 6 BO, 12 BO and 20 BO. Between the measuring of the curves, the subject was given a ten minute rest period where he was allowed to look around the room normally out from behind the phoropter.

During the taking of the data, the subject was instructed to read the lowest line of letters he could next to the two vertical lines. When the line of letters was clear, he was to glance at

Carr[5]. They found that the forced vergence fixation disparity curve may undergo changes with changing test conditions in the case of symptomatic subjects, whereas such changes were not manifest with asymptomatic subjects.

the two vertical lines and make a judgement as to whether the upper line was to the right or to the left of the lower line. He was told to use only his first impression and not to stare at the lines. This was to be done three times or until the subject got a consistant impression, before he reported 'right' or 'left' to the examiner. Every point on each curve was determined by bracketing three or more such responses from the subject.

At the final session, Nott retinoscopy was performed at 40 cm, while the subject read aloud from a printed page. The material was approximately the same size as the lowest line of letters on the disparometer.

RESULTS AND DISCUSSION

The data that was collected during this experiment is presented in four tables. In addition, the individual points from the four sessions were averaged and graphed for easier inspection.

In order to look at the effect that the introduction of small amounts of anisometropia had on the fixation disparity curves, it is necessary to examine the limit on the accuracy of the data. In a clinical setting, it is often as important how the subject responds as it is what the subject responds. Such is the case in this experiment. There was a great deal of variability between subjects with respect to the amount of time needed to make a response, the number of responses needed to bracket and thus determine a point on the curve and the repeatability of the points.

The disparometer can change the separation of the two vertical lines in steps of two minutes of arc. In many instances, changing the separation two minutes of arc produced a definite reversal of the response from 'right' to 'left' or 'left' to 'right' and at these times, the fixation disparity was recorded as the amount between the steps. Taking this into consideration, as well as the degree of repeatability obtained during the experiment, I feel that the limit on the percision of fixation disparity points measured with a disparometer is about plus or minus one minute of arc.

It is with this in mind that I determined the criterion that two curves were the same or different; If the points at the same vergence level on two of the average curves were separated by up to one minute of arc, I considered them to be the same. If the points were separated by three minutes of arc, I considered them to be different. Between one and three minutes of arc, I looked to see if there were distinguishable trends between two or more consecutive points to judge if there were a difference between them. These standards would be modified in cases where the subject's responses showed a tendency for greater variability than plus or minus one minute of arc.

This method of analysis is valid in my opinion because my concern here is whether this technique is clinically applicable. To me, that means that generally, only one or two curves would be taken at the subjective refraction and at the level of anisometropia in question. If it takes ten curves and statistical analysis to determine that there is a difference then I certainly would not be willing to incorporate this technique into my arsenal of diagnostic tests in a general optometric practice. Further, statistical analysis on information gained from a small number of trials, which requires the examiner to set a level of certainty, is no more accurate than if the examiner gets a feeling for the quality of the subject's responses and uses this to determine the allowed variability between two points before they are considered different. I am keenly aware that this opinion is not universally shared, particularly by those who were trained mainly in mathematics and have little experience in the variety of things which affect a human's response on a subjective test. I will discuss the results of each subject's responses separately.

Subject #1 gave responses moderately rapidly and with a moderate amount of repeatability. Only at the extreme end of the graph, at 6 BI, did two points vary more than one minute of arc but at those points there was no discernable trend. If any trend exists among these curves, it would seem that between 3 BI and 6 BO, the level 0 and level 1 curves appear to be about 0.5 to 1.0 minutes of arc more eso that the level 3 curve. However, this trend is not distinct enough to be certain.

Subject #2 gave responses moderately rapidly but with the least amount of repeatability of any of the four subjects. Indeed, bracketing to determine the final data point took more trails because the subject's responses changed frequently even at the same separation of the lines. In addition, he sometimes found it difficult to fuse 6 BI and 3 BI. The points from these occasions are marked (D) for double on the table and were not included in the averaged graphs. There was also a wide variability at the 20 BO end of the graph leading me to discount both extremes.

There does seem to be a trend for the center range of vergences in which increasing the amount of plus sphere before the right eye causes the fixation disparity curve to shift to a less eso position. This trend would be more evident if the data from 4/4/'83 was removed as it contains many extreme points which distort the averages leaving the possibility that something extraneous may have influenced that session's data. At any rate, that the trend is most evident with no extra prism in place, the natural state of functioning, probably indicates a definite change in the amount of fixation disparity with induced anisometropia.

Subject #3 gave moderately repeatable responses but gave them slower than any of the other three subjects, much slower in fact. There is a clearly distinguishable trend in which the level 0 and level 1 curves are less eso than the level 3 curve. Except for the extreme BO end, the difference between level 0 and level 1, and level 3 start at about one minute of arc for 6 BI and slowly grow to about two minutes of arc at 12 BO. This difference, while manifest with 1.00 D of anisometropia, is not discernible with only 0.50 D of anisometropia.

Subject #4 responded rapidly and gave very repeatable responses except at the 20 BO end of the level 3 curve where there was a lot of variability. Again there is a clearly discernible trend in which the curves tend to become less eso with increasing amounts of plus before the right eye and the differences get larger with increasing amounts of BO prism. In this case, there also appears to be an effect from +0.50 D as well as +1.00 D as in the other cases.

The results of Nott retinoscopy showed that subjects #1 and #2 responded to the plus lenses before the right eye by relaxing accomadation the same amount and using the right eye's clear image to read. Subject #3 gave a variable accomadative response, at least part of the time, overaccomadating to use the left eye to read. Subject #4 appears to have responded to the plus lenses by relaxing accomadation half the amount to maintain equal blur between the eyes. While the result was consistant during the Nott retinoscopy, subject #4 also reported that one of the vertical lines on the disparometer was fatter than the other during the measuring of the level 3 curve which leads me to suspect just the opposite of the Nott retinoscopy. The difference might be due to the fact that that the subject read the material aloud during the Nott retinoscopy providing more feedback on the text's clarity than he received by looking at a single line of letters during the measuring of the fixation disparity curves. His rapid responses tend to support this also.

There are three times during an optometric exam when an optometrist may want to know if a small amount of anisometropia is having an effect of the binocular system. First of all, a patient may present with a small amount of physiological anisometropia. Secondly, an improper optical correction may induce a small amount of anisometropia. This is particularly common with contact lenses as balancing may be less accurate than with spectacle lenses. Finally, anisometropia can be purposefully created as with the monofit technique for presbyopic contact lens wearers.

In the first two cases, it may be desireable to determine if vague symptoms can be attributed to binocular changes caused by the anisometropia. In the last case, the examiner may want to know the degree of binocular changes that would occur with a certain amount of anisometropia.

CONCLUSION

The effect of small amounts of anisometropia on the forced vergence fixation disparity curve varies with the individual to the extent that 0.50 D can have an effect in some cases while 1.00 D does not in others. A portion of the curve or the whole curve may show a change. Plus lenses before the right eye can cause the curve to become more or less eso.

It would appear that the forced vergence fixation disparity curve shows promise as a sensitive indicator of binocular changes in cases where there is a question as to whether or not a small amount of anisometropia is effecting the binocular system. A correlation between Nott retinoscopy and the response of the forced vergence fixation disparity curves was not evident.

Name #2
Age 24

Habitual Rx
OD -5.50 ɔ -.25 x 030
OS -6.75 DS
BVA (subjective)
OD -5.50 ɔ -.25 x 030
OS -6.75 DS
Date of exam and order of presentation
3/9/'83 0231
3/10/'83 2301
3/27/'83 0132
4/4/'83 0123

	OD	OS
0	+.25	+.25
1	no log	+.50
2	no log	+.50
3	no log	+.75

	6 BI	3 BI	0 BI	3 BO	6 BO	12 BO	20 BO
0	12s	11s	9s	5s	4s	3s	4s
0	18s (D)	12s (D)	10s	8s	7s	4s	1s
0	(D)	9s	11s	9s	6s	4s	1x
0	8s	6s	6s	5s	3s	Ø	2x
1	9s	10s	7s	6s	5s	4s	3s
1	17s (D)	11s	10s	6s	6s	2s	Ø
1	14s	10s	7s	6s	4s	2s	2s
1	12s	10s	9s	6s	6s	4s	2s
2	11s	9s	8s	5s	5s	5s	3s
2	7s	8s	7s	5s	4s	4s	4s
2	(D)	13s	10s	8s	7s	4s	1s
2	13s	12s	10s	6s	6s	1s	Ø
3	10s	9s	6s	7s	5s	4s	6s
3	12s	9s	6s	5s	5s	5s	5s
3	10s	8s	7s	7s	4s	Ø	1x
3	20s	12s	10s	8s	4s	4s	1x

Name #3

Age 22

Habitual Rx

OD -3.25 DS

OS -3.25 ⊃ -.25 x180

BVA (subjective)

OD -3.25 DS

OS -3.25 ⊃ -.25 x175

Date of exam and order of presentation

3/6/83 3021

3/8/83 1320

3/13/83 0321

4/6/83 0213

	OD	OS
0	no lag	no lag
1	no lag	+.25
2	-.25	+.25
3	+.25	+.75

	6 BI	3 BI	0 BI	3 BO	6 BO	12 BO	20 BO
0	5s	3s	2s	1s	2s	Ø	1s
0	3s	1s	1s	1s	1x	1x	2x
0	4s	1s	1s	1s	1x	1x	1x
0	4s	1s	1s	1s	1s	1x	1x
1	4s	2s	2s	1s	1s	1s	2x
1	3s	3s	Ø	1x	1x	3x	4x
1	4s	3s	2s	1s	1s	Ø	Ø
1	4s	3s	3s	1s	1s	1x	1s
2	3s	3s	1s	1s	Ø	1s	2x
2	3s	1s	1s	Ø	Ø	1x	3x
2	3s	2s	2s	1s	Ø	1x	1s
2	2s	1s	1s	1s	1s	1s	1s
3	7s	4s	3s	3s	2s	1s	2x
3	3s	3s	1s	1s	1s	1s	1s
3	4s	3s	1s	1s	1x	Ø	1x
3	5s	4s	3s	3s	2s	1s	2x

Name #4
Age 24

	OD	OS
0	no log	no log
1	-.25	no log
2	no log	+.75
3	-.50	+.50

Habitual Rx
none

BVA (subjective)
OD -.25 ⊃ -.25 x085
OS -.25 ⊃ -.25 x100

Date of exam and order of presentation

3/4/85 2310

3/6/85 2130

3/12/85 0312

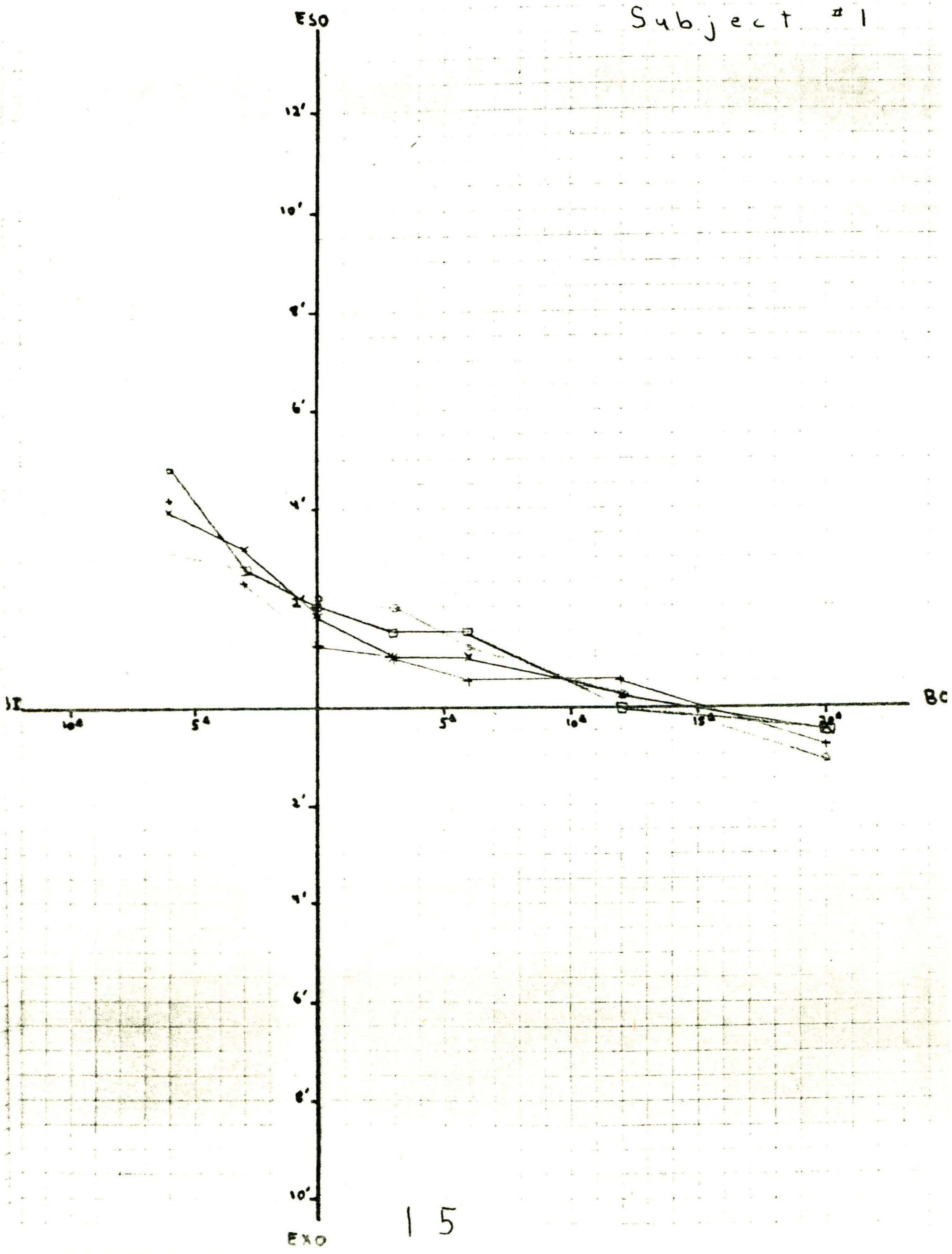
4/5/85 1023

	6 BI	3 BI	0 BI	3 BO	6 BO	12 BO	20 BO
0	2s	1s	1s	Ø	Ø	1x	3x
0	2s	1s	Ø	1x	1x	2x	3x
0	2s	1s	1x	2x	1x	3x	4x
0	2s	1s	Ø	2x	Ø	3x	4x
1	2s	Ø	Ø	1x	1x	2x	5x
1	1s	Ø	1x	2x	1x	3x	6x
1	1s	Ø	1x	1x	1x	2x	4x
1	2s	1s	Ø	1x	1x	4x	6x
2	1s	2s	Ø	1x	2x	2x	4x
2	1s	Ø	1x	1x	3x	2x	3x
2	1s	1s	1x	1x	2x	3x	4x
2	2s	1s	1x	1x	3x	3x	3x
3	1s	1s	2x	3x	4x	5x	14x
3	1s	1s	Ø	Ø	3x	5x	10x
3	Ø	Ø	1x	2x	3x	4x	8x
3	Ø	1s	1x	2x	3x	5x	6x

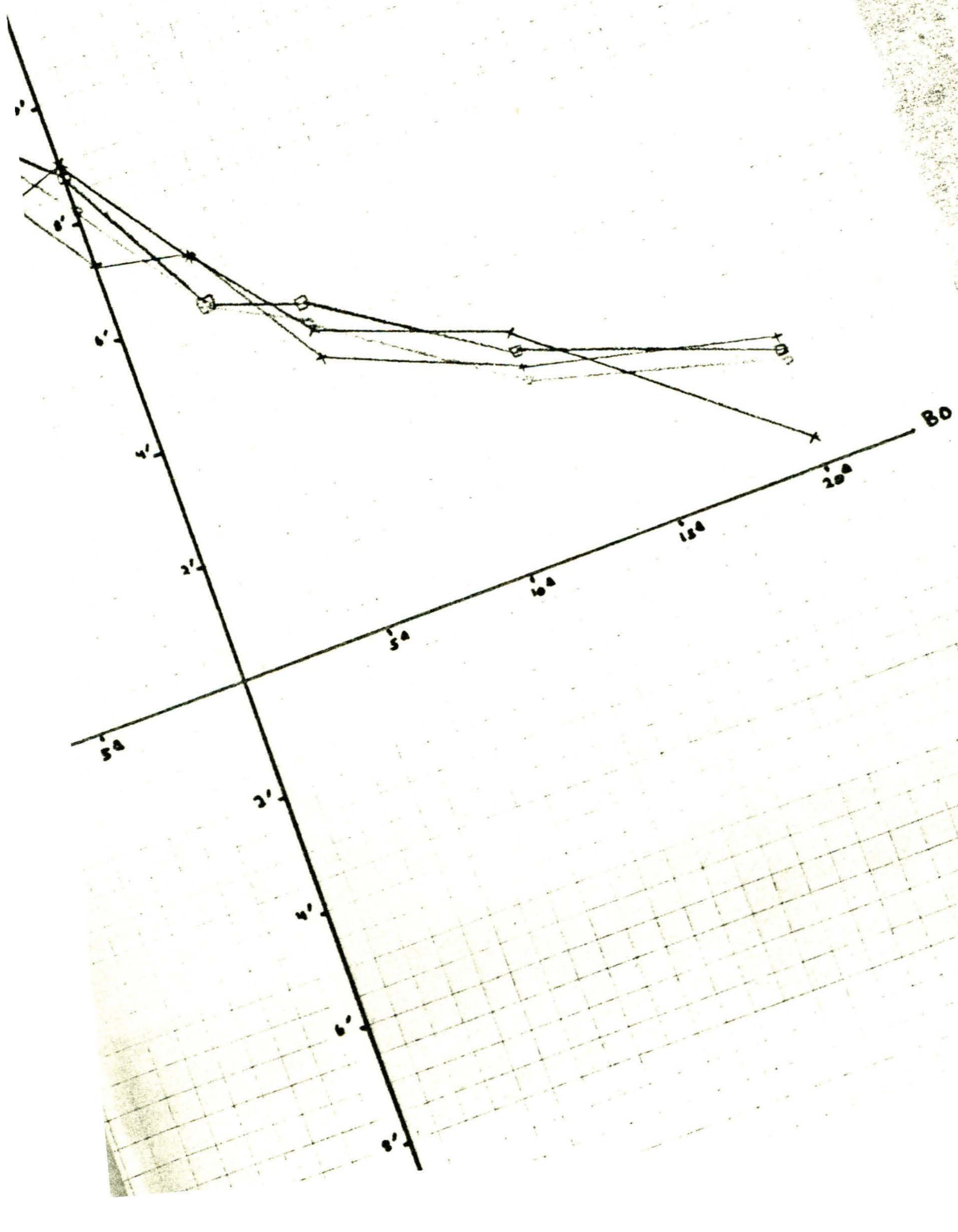
KEY

X	————	0.00 D	level 0
[illegible]	————	+0.25 D	level 1
□	————	+0.50 D	level 2
+	————	+1.00 D	level 3

Subject #1



Subj-



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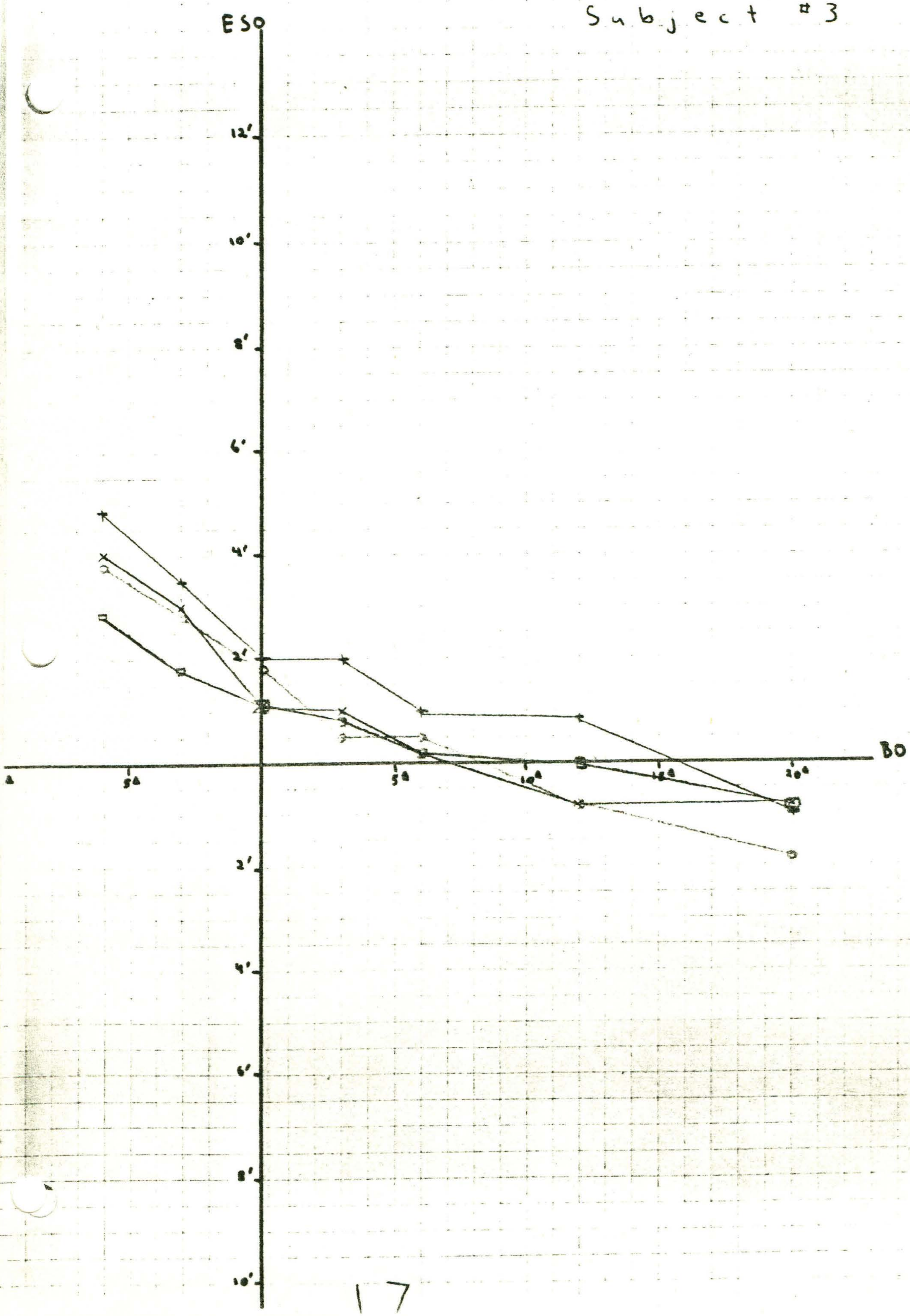
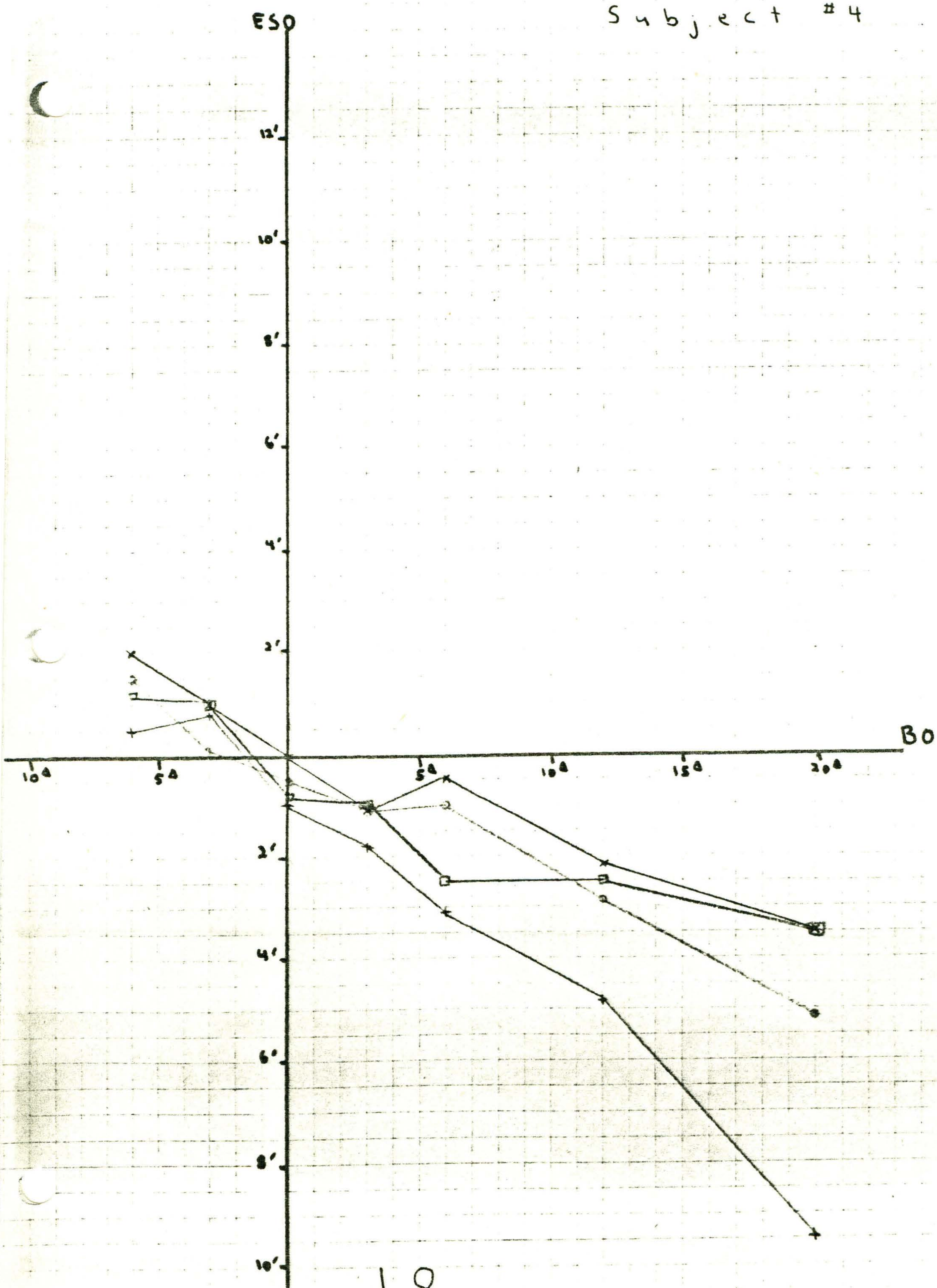


Subject #4



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Name #1
Age 25

Habitual Rx
OD -5.00 ⊃ -.50 x 055
OS -5.50 ⊃ -.25 x 180

BVA (subjective)
OD -5.00 ⊃ -.50 x 060
OS -5.50 DS

Date of exam and order of presentation
3/9/83 1230
3/10/83 3102
3/12/83 0231
3/27/83 2013

	OD	OS
0	+.75	+.75
1	+.25	+.50
2	+.25	+.50
3	no log	+.75

	6 BI	3 BI	0 BI	3 BO	6 BO	12 BO	20 BO
0	4s	3s	1s	1s	1s	1s	1x
0	5s	5s	4s	3s	3s	1s	1s
0	4s	3s	2s	1s	1s	Ø	1x
0	3s	2s	Ø	Ø	Ø	1x	1x
1	2s	1s	1s	1x	Ø	2x	4x
1	4s	3s	2s	2s	1s	1s	Ø
1	4s	4s	4s	3s	3s	2s	1s
1	3s	3s	2s	2s	1s	Ø	2x
2	4s	2s	1s	Ø	Ø	1x	2x
2	6s	4s	4s	3s	3s	1s	1s
2	5s	4s	2s	2s	2s	Ø	1x
2	4s	1s	1s	1s	1s	Ø	Ø
3	3s	2s	1s	1s	Ø	1s	2x
3	4s	2s	1s	1s	Ø	Ø	1x
3	5s	4s	2s	1s	2s	1s	1s
3	5s	2s	1s	1s	Ø	Ø	1x