1960

Norms for fixation disparity through plus and minus spheres as a function of time

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Abstract

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Degree Type

Thesis

Degree Name

Master of Science in Vision Science

Committee Chair

Harold M. Haynes

Subject Categories

Optometry

NORMS FOR FIXATION DISPARITY THROUGH PLUS AND MINUS SPHERES AS A FUNCTION OF TIME

by

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SUBMITTED IN PARTIAL FULFILLMENT OF

THE REQUIREMENTS FOR THE DEGREE

DOCTOR OF OPTOMETRY

of

PACIFIC UNIVERSITY

1960

ACKNOWLEDGEMENTS

The authors wish to express their appreciation for the willing assistance rendered by the many persons who served as subjects in this study. They are particularly grateful to Dr. Harold M. Haynes, whose help and guidance enabled the work to be carried to completion.

TABLE OF CONTENTS

	Page
THE PROBLEM AND ITS SCOPE	1
The Problem	1
Delimitations	1
Definitions	1
Previous Experiments	2
METHODS OF INVESTIGATION	3
Equipment	3
Procedure	4
RESULTS	6
Population Characteristics	6
Plano stimulus	6
Minus stimulus	6
Plano after minus	6
Plus stimulus	6
Plano after plus	7
Individual Patterns	7
Those changing equally with plus and minus	7
Those changing with plus, but not with minus	7
Those changing with minus, but not with plus	8
Those changing little with either plus or minus	8
Those not showing an after effect of plus or minus or both	8
Need For Further Investigation	9
SUMMARY AND CONCLUSIONS	10
BIBLIOGRAPHY	19

LIST OF TABLES AND GRAPHS

Table **Page**

I. Frequencies..... 11

II. Means and Standard Deviations for Each Stimulus and Time..... 12

Graph

1. Means for Each Stimulus and Time..... 13

2. Subject Who Changes Equally With Plus and Minus..... 14

3. Subject Who Changes With Plus, but Not With Minus.... 15

4. Subject Who Changes With Minus, but Not With Plus.... 16

5. Subject Who Shows no Plus After Effect..... 17

6. The Number of Subjects Showing No Disparity Change Through Plane After Plus, Minus, or Both..... 18

THE PROBLEM AND ITS SCOPE

THE PROBLEM

The main purpose of the investigation was to determine how a random sample of the prepresbyopic population responds, in terms of fixation disparity, to different dioptric vergences as a function of time.

DELIMITATIONS

The study was limited to the establishment of population norms using a polaroid fixation disparity slide designed by Dr. Harold M. Haynes. All subjects were between 15 and 35 years of age and had a minimum of 20/25 acuity at the thirteen inch testing distance. All testing was done with the subject's distance prescription in place. The sample included 75 men and 27 women, all of whom were college students.

DEFINITIONS

"Fixation disparity" is the subjective measurement of the amount of off pointing of the eyes under binocular conditions.

"Exo fixation disparity" refers to an underconvergence with respect to the plane of regard.

"Eso fixation disparity" refers to an overconvergence with respect to the plane of regard.

PREVIOUS EXPERIMENTS

Ogle[1] reports the results of two subjects who were tested with plus and minus spheres. He summarizes by stating:

"In general it appears that the fixation disparity vergence curves are displaced laterally as though the lenses merely added a constant equivalent prism vergence change. The magnitude of the equivalence is about .6 MA to 1 diopter lens power (3.5 to 4 p.d./D) though this may vary somewhat between individuals."

1. Kenneth N. Ogle, Binocular Vision, p. 83.

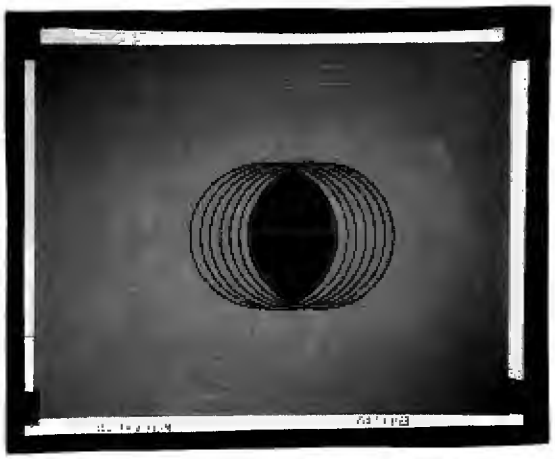
METHODS OF INVESTIGATION

EQUIPMENT

1. Van Orden flipper with back illumination.
2. One pair minus 1.50 D. spheres.
3. One pair plus 1.50 D. spheres.
4. Polaroid spectacles.
5. Reduced Snellen Card (16').
6. Fixation light and millimeter rule.
7. Watch with sweep second hand.
8. Polaroid fixation disparity slide.

The test slide was constructed so that with the polaroid spectacles in place the arrow was seen with the left eye only, the numbered scale with the right eye only, and the peripheral rings with both eyes. The separation between each numbered dot was 2.7 mm, which is an angular subtend of 28'30" or .52 prism diopters. Number 4 on the slide was the position of zero fixation disparity.

PICTURE OF THE SLIDE



PROCEDURE

Each subject's interpupillary distance was measured using the corneal light reflex method. The pupillary distance of the instrument was set to coincide with the subject's interpupillary distance to minimize induced prismatic effects. The shaft of the instrument was set at thirteen inches.

The subject was shown a series of diagrams illustrating what he might see during the test. The diagrams used were: (1) a slide showing the arrow over a number; (2) one showing only the numbers (arrow suppressed); (3) one showing only the arrow (numbers suppressed); (4) one showing the slide doubled. The student was instructed to report if any of these situations occurred.

It was explained that each time the examiner said "now" the subject was to report over what number the arrow pointed. It was also emphasized that the subject should interpolate to the nearest quarter if the arrow fell between two numbers.

The polaroid spectacles were put in place and the subject was instructed to fixate the 20/20 line of the reduced Snellen, which was placed over the polaroid slide. The examiner then explained that he would say "now" upon removal of the card and every five seconds thereafter. The subject was cautioned to hold his head stationary in the instrument throughout the test.

The sequence of testing was as follows:

STIMULUS	IMMEDIATE	5"	10"	15"	20"	25"	30".
plano							
-1.50							
plano							
+1.50							
plano							

Five seconds after the 30 second plano reading the minus spheres were flipped before the patient's eyes, the examiner said "now" and the testing continued as before. At the end of the 30 second minus phase the minus lenses were flipped up and the plano sequence repeated. At the end of the sequence, the reduced Snellen was placed before the polaroid slide and the minus spheres replaced by the plus spheres. The card was removed, the plus spheres flipped into place, and the procedure was continued for 30 seconds through plus. At the end of the plus phase the spheres were flipped up and the final plano sequence taken.

RESULTS

POPULATION CHARACTERISTICS

The means and standard deviations for each stimulus and time are listed on table II on page . The means are shown on graph 1. page .

I. PLANO STIMULUS

An exo fixation disparity was noted immediately upon uncovering the slide. This increased slightly up to ten seconds and finally stabilized between fifteen and twenty seconds.

II. MINUS STIMULUS

The disparity was shifted immediately into eso and was fairly stable as a function of time.

III. PLANO AFTER MINUS

The disparity was again displaced into exo. This was at first higher than through the first plano, but finally stabilized exo to the plane of regard, although less than originally. This might indicate an induced effect due to the previous minus, although this is of questionable statistical significance since the magnitude of the difference was very small.

IV. PLUS STIMULUS

Plus spheres moved the disparity high into exo with an increasing drift noted up to ten seconds. After twenty seconds the disparity decreased to a level

just slightly higher than the immediate response.

V. PLANO AFTER PLUS

The previous exo disparity was here markedly reduced and remained so as a function of time. The amount of disparity was considerably less than through the first plano and showed no tendancy to return to the original level. This indicates an even greater induced effect due to the previous stimulus, although in the same direction as with minus.

INDIVIDUAL PATTERNS

No attempt was made to evaluate these patterns statistically. They were obtained by examining the raw data and by roughly sorting the individual cases into arbitrary groups.

I. THOSE CHANGING EQUALLY WITH PLUS AND MINUS

Approximately 20% of the subjects fell into this grouping. In general, this pattern is characterized by a stable posture around zero fixation disparity through all plano phases and equal, opposite disparities through plus and minus. An example is shown in graph 2.

II. THOSE CHANGING WITH PLUS, BUT NOT WITH MINUS

This pattern included roughly 16% of the subjects. As a rule they showed zero fixations disparity through plano and minus, but a marked exo disparity through plus. This was usually quite stable through time. Graph 3 shows an example of this pattern.

III. THOSE CHANGING WITH MINUS, BUT NOT WITH PLUS

This pattern was much like pattern II except that no change in disparity was noted through plus. Approximately 27% were included in this group. An example is shown on Graph 4.

IV. THOSE CHANGING LITTLE WITH EITHER PLUS OR MINUS

Only 10% of the subjects responded in this manner. These subjects might include those who are extremely facile in adapting to various dioptric vergences, those with low phoriasphere relationships at near, or those who are rigid in their convergence postures.

V. THOSE NOT SHOWING AN AFTER EFFECT OF PLUS, MINUS, OR BOTH

The mean responses through plano after plus show a definite reduction in exo disparity when compared with those through the first plano sequence. This after effect was also noted in the mean responses through plano after minus, although to a much lesser degree. Upon examining the raw data, however, it was observed that 42 of the subjects showed no after effect for either plus or minus. This might indicate that the remaining 60 subjects skewed the distribution in that direction, and that a larger sampling is necessary to draw any valid conclusions regarding this shift.

Twelve of the subjects were not affected by minus alone and 16 were not affected by plus alone.

Graph 5 shows an example of no plus after effect while graph 6 shows the number in each no-effect category.

NEED FOR FURTHER INVESTIGATION

The purpose of this study was limited to establishing population norms. It must be considered, therefore, to be the first step in a series of investigations in this area of fixation disparity.

Subsequent studies might include the following:

1. A statistical evaluation of individual patterns.
2. Correlation of patterns with optometric case types.
3. Comparison of fixation disparity/sphere ratios with phoria/sphere relationships.

SUMMARY AND CONCLUSIONS

1. The population in general exhibits an exo fixation disparity which is relatively stable in amount as a function of time.

2. Minus sphere moves the fixation disparity to a posture slightly eso to the plane of regard. This posture is stable in amount as a function of time.

3. Minus sphere affects the posture through plano afterwards by decreasing slightly the exo fixation disparity.

4. Plus sphere moves the fixation disparity high in the exo direction. This is not so stable in amount through time as with minus sphere.

5. Plus before plano causes the mean disparity to be markedly reduced in exo with respect to the disparity through plane before any lenses have been in place.

6. The mean after effect of plus is greater in amount than that of minus.

TABLE I

FREQUENCIES

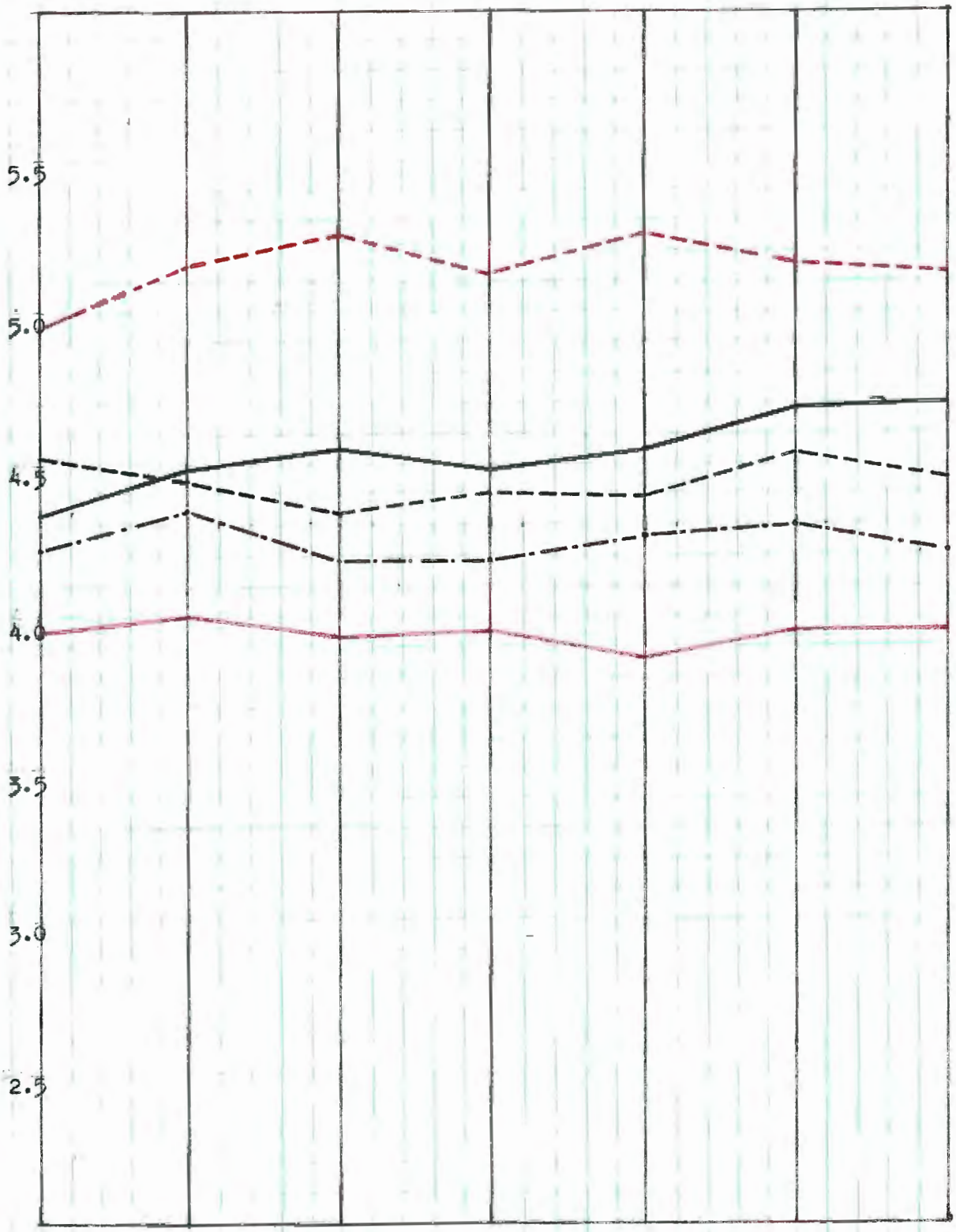
BOX	0.5-0.99	1.0-1.49	1.5-1.99	2.0-2.49	2.5-2.99	3.0-3.49	3.5-3.99	4.0-4.49	4.5-4.99	5.0-5.49	5.5-5.99	6.0-6.49	6.5-6.99	7.0-7.49	7.5-7.99	S	D
1.	0	0	0	0	0	3	0	67	13	6	0	3	0	3	2	3	2
2.	0	0	0	1	0	1	4	62	8	10	1	4	0	7	3	0	1
3.	0	0	0	1	0	0	2	59	11	8	0	2	2	9	2	3	3
4.	0	0	0	1	0	1	7	53	10	9	2	2	0	9	2	1	4
5.	0	0	0	1	0	1	5	52	9	8	3	4	1	5	4	4	5
6.	0	0	0	0	1	0	5	50	14	8	1	4	0	3	4	3	9
7.	0	0	0	1	0	2	5	54	10	8	0	1	3	12	2	1	3
8.	2	0	0	5	0	7	14	45	5	8	1	2	0	1	2	1	9
9.	0	1	0	0	2	1	28	47	4	4	2	3	0	2	0	2	6
10.	0	1	0	4	1	4	22	52	3	2	2	1	0	3	1	1	5
11.	2	0	1	1	1	6	20	52	4	4	1	0	1	2	2	1	4
12.	2	1	0	0	3	3	20	51	1	4	2	1	0	2	0	2	10
13.	3	0	0	2	1	4	19	53	4	5	2	1	0	2	1	1	4
14.	2	0	1	1	1	4	27	43	5	3	0	3	1	2	2	1	6
15.	1	0	0	0	0	2	4	51	6	18	3	6	1	5	1	1	3
16.	0	0	0	1	1	0	4	60	10	12	2	1	1	5	3	0	2
17.	0	0	0	2	0	0	3	63	6	13	1	2	1	2	2	2	5
18.	0	0	0	1	1	0	6	60	11	7	2	4	0	4	3	1	2
19.	0	0	0	0	1	0	6	63	8	8	1	3	1	7	0	2	2
20.	0	0	0	0	1	0	6	60	10	7	3	4	1	4	5	0	1
21.	0	0	0	1	0	1	4	61	7	8	2	4	4	2	3	5	0
22.	1	0	0	0	0	0	1	37	11	16	8	7	0	7	7	1	6
23.	1	0	0	0	0	0	2	39	10	13	2	3	2	10	15	5	0
24.	0	0	0	1	0	0	2	32	14	10	3	7	1	12	13	2	5
25.	0	0	0	1	0	0	1	37	12	8	3	2	5	6	14	8	5
26.	0	0	0	1	0	0	1	36	8	9	3	5	1	13	13	5	7
27.	0	0	0	1	0	0	1	39	10	6	4	6	0	11	14	2	8
28.	0	0	0	1	0	0	2	35	10	13	2	6	1	8	13	4	7
29.	1	0	0	0	0	1	11	59	9	8	0	5	0	3	0	5	0
30.	0	0	0	0	0	3	8	66	6	3	1	4	0	3	5	3	0
31.	0	0	0	0	0	2	12	70	2	4	0	4	0	0	4	3	1
32.	0	0	0	1	0	4	10	60	8	3	0	5	1	2	1	6	1
33.	0	0	0	0	0	1	9	69	4	5	0	3	1	2	3	1	4
34.	1	0	0	0	0	1	8	67	5	3	2	5	0	4	2	3	1
35.	0	0	0	1	0	2	6	67	7	5	3	2	0	1	2	4	2

To find what numbers 1 through 35 pertain to refer to page 12. The uppermost horizontal row of intervals represents the numerical scale on the polaroid slide and the frequencies for each are shown in the columns below. Included are the frequencies for suppression, S, and doubling, D.

TABLE II

MEANS AND STANDARD DEVIATIONS
FOR EACH STIMULUS AND TIME

STIMULUS	IMMEDIATE	5"	10"	15"	20"	25"	30"
PLANO	1. M 4.32 S.D. 1.66	2. M 4.49 S.D. 2.10	3. M 4.56 S.D. 2.18	4. M 4.49 S.D. 2.13	5. M 4.55 S.D. 2.19	6. M 4.59 S.D. 1.98	7. M 4.60 S.D. 2.34
-1.50	8. M 3.95 S.D. 2.14	9. M 4.00 S.D. 1.61	10. M 3.93 S.D. 1.57	11. M 3.95 S.D. 2.03	12. M 3.87 S.D. 1.68	13. M 3.96 S.D. 2.20	14. M 3.96 S.D. 2.18
PLANO	15. M 4.52 S.D. 1.91	16. M 4.45 S.D. 1.98	17. M 4.33 S.D. 1.73	18. M 4.40 S.D. 1.96	19. M 4.39 S.D. 1.82	20. M 4.53 S.D. 2.10	21. M 4.45 S.D. 1.99
+1.50	22. M 4.94 S.D. 2.52	23. M 5.15 S.D. 3.00	24. M 5.26 S.D. 2.72	25. M 5.12 S.D 2.82	26. M 5.25 S.D. 3.02	27. M 5.17 S.D. 2.82	28. M 5.12 S.D. 2.75
PLANO	29. M 4.22 S.D. 1.44	30. M 4.35 S.D. 2.04	31. M 4.19 S.D. 1.70	32. M 4.19 S.D. 1.79	33. M 4.27 S.D. 1.77	34. M 4.30 S.D. 1.98	35. M 4.21 S.D. 1.56



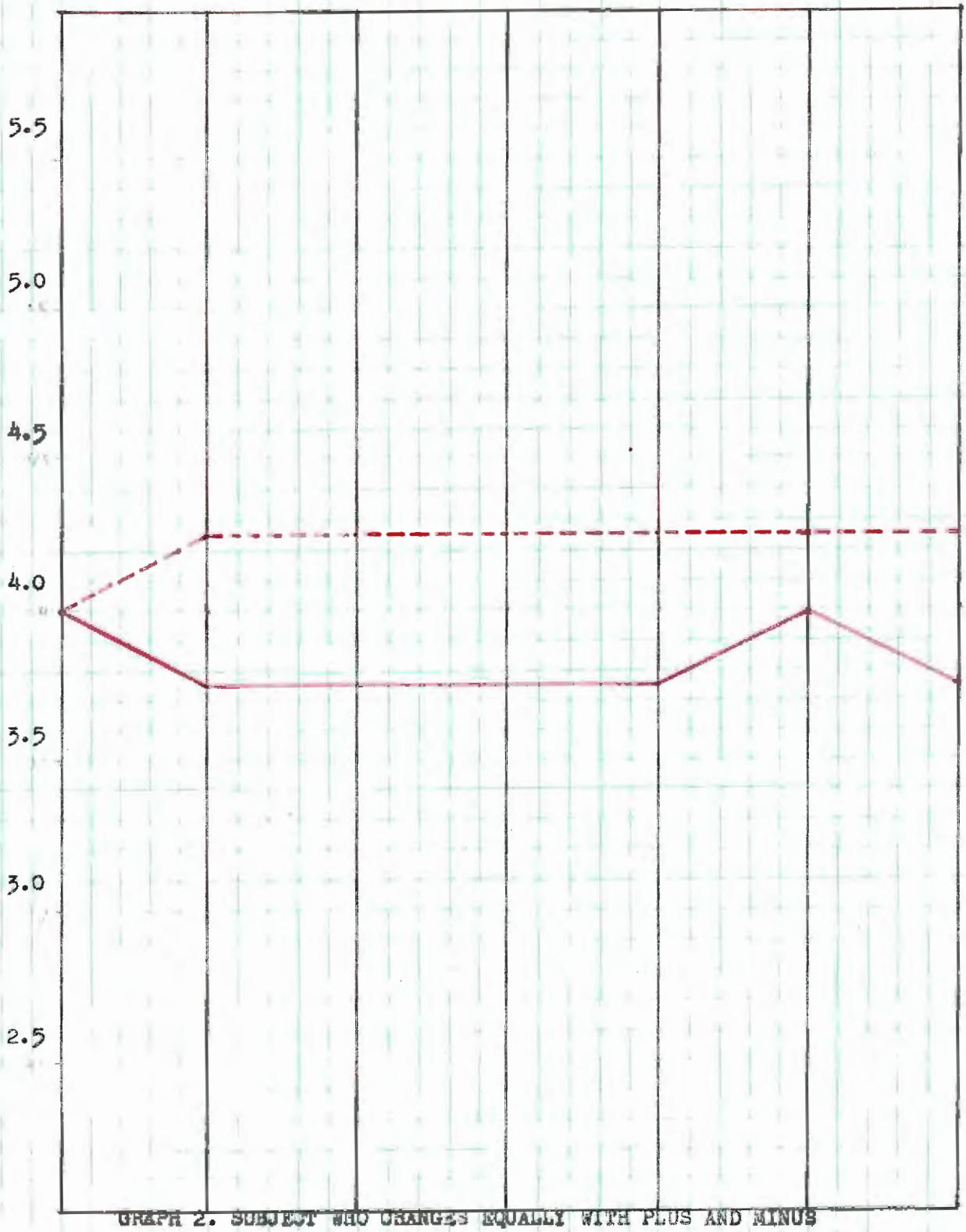
GRAPH 1. MEANS FOR EACH STIMULUS AND TIME

first plano ——— plus - - - -

minus ——— plano after plus —·—·—

plano after minus — — — —

4 on the ordinate is zero fixation disparity

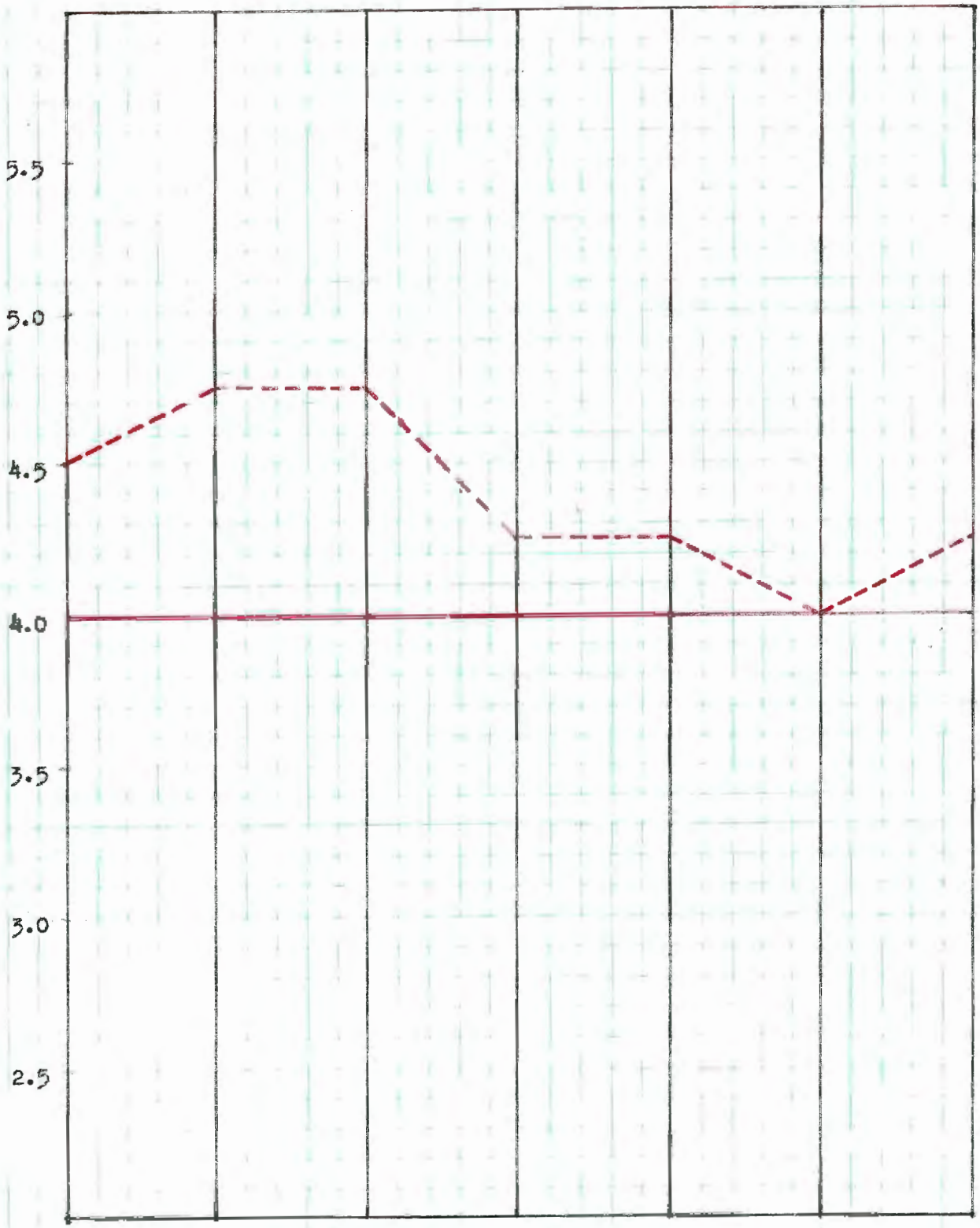


GRAPH 2. SUBJECT WHO CHANGES EQUALLY WITH PLUS AND MINUS

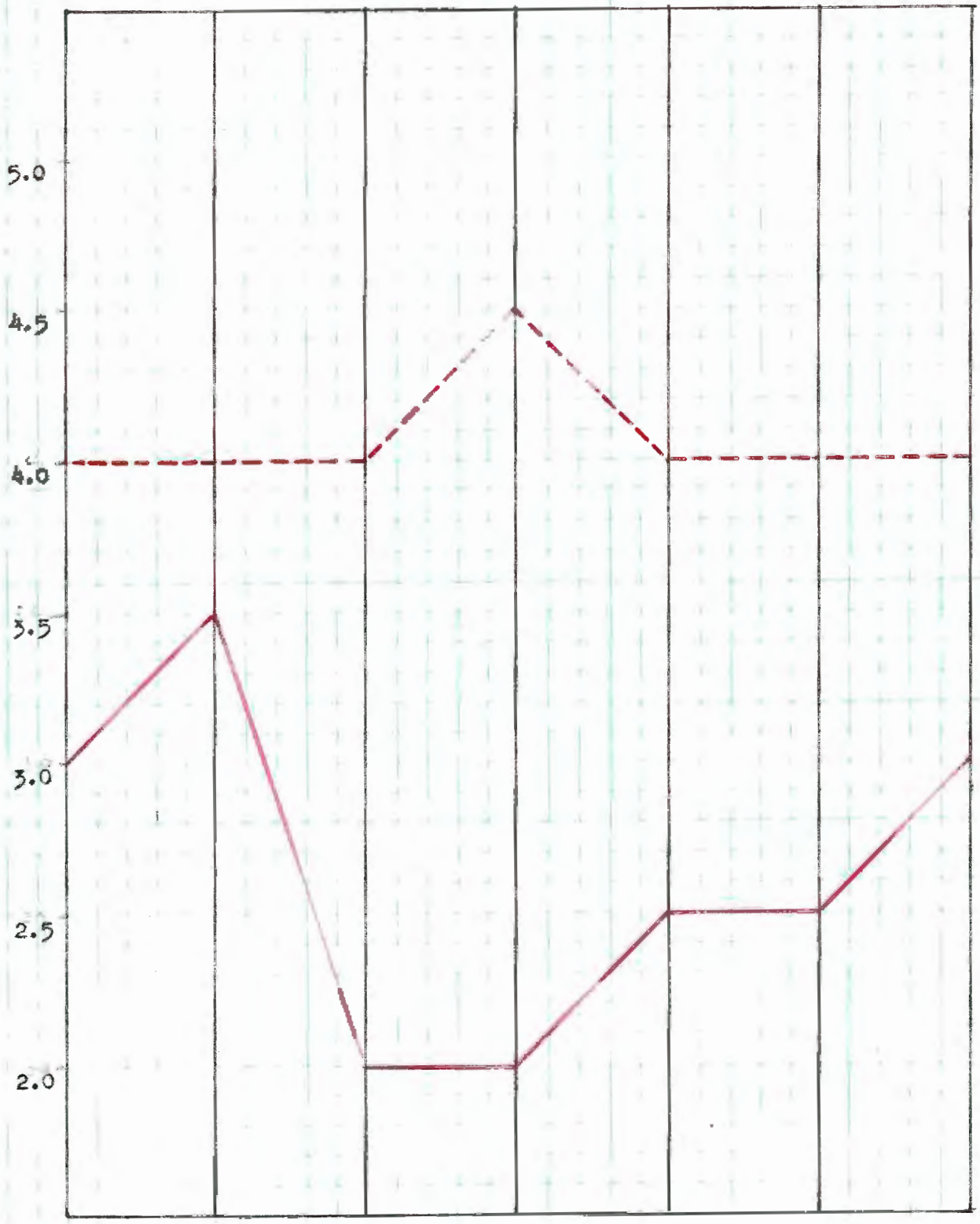
minus ——

plus – – – –

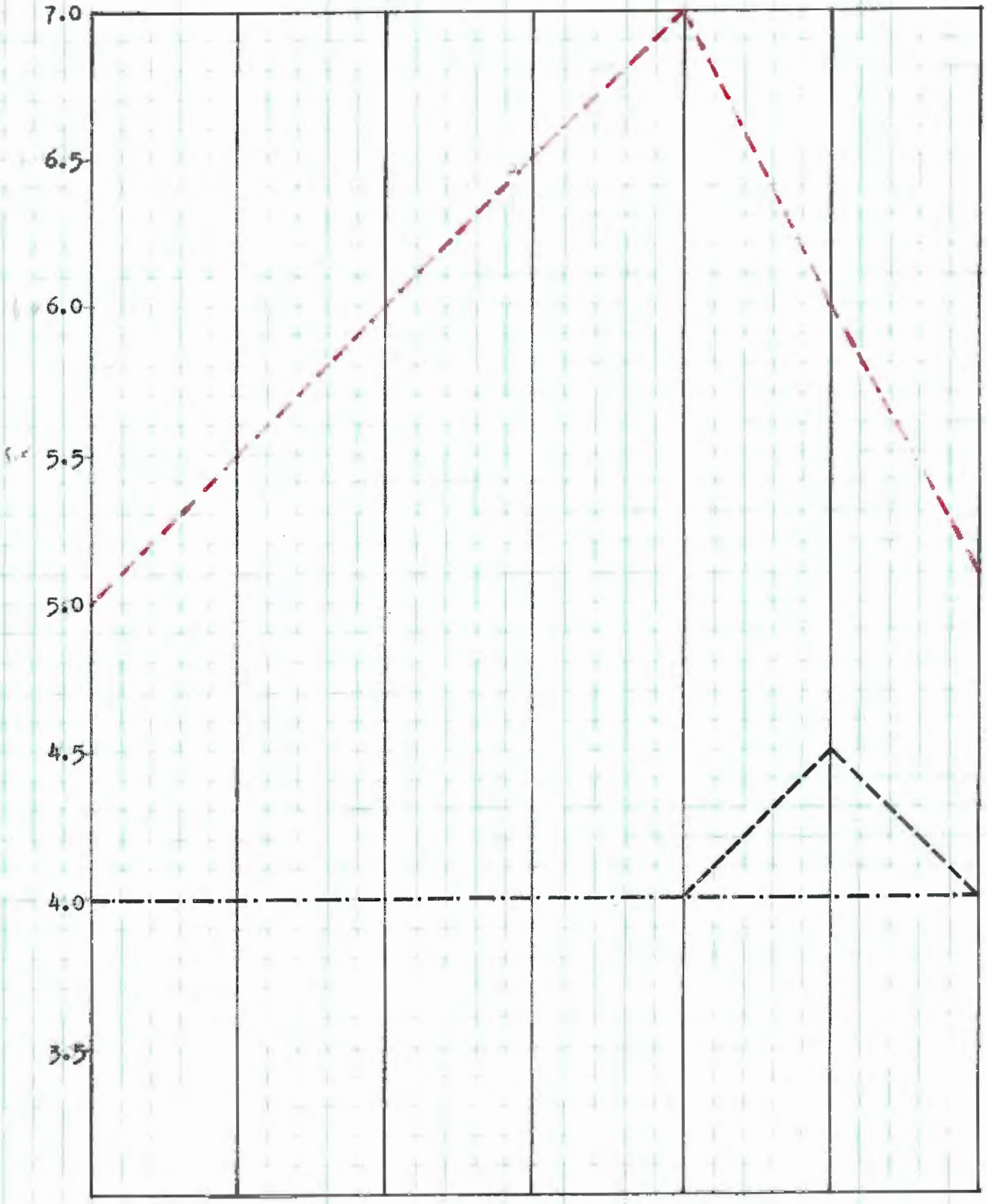
4 on the ordinate is zero fixation disparity



GRAPH 3. SUBJECT WHO CHANGES WITH PLUS BUT NOT WITH MINUS
minus ——————
plus - - - -
4 on the ordinate is zero fixation disparity



GRAPH 4. SUBJECT WHO CHANGES WITH MINUS BUT NOT WITH PLUS
minus ——
plus - - - -
4 on the ordinate is zero fixation disparity



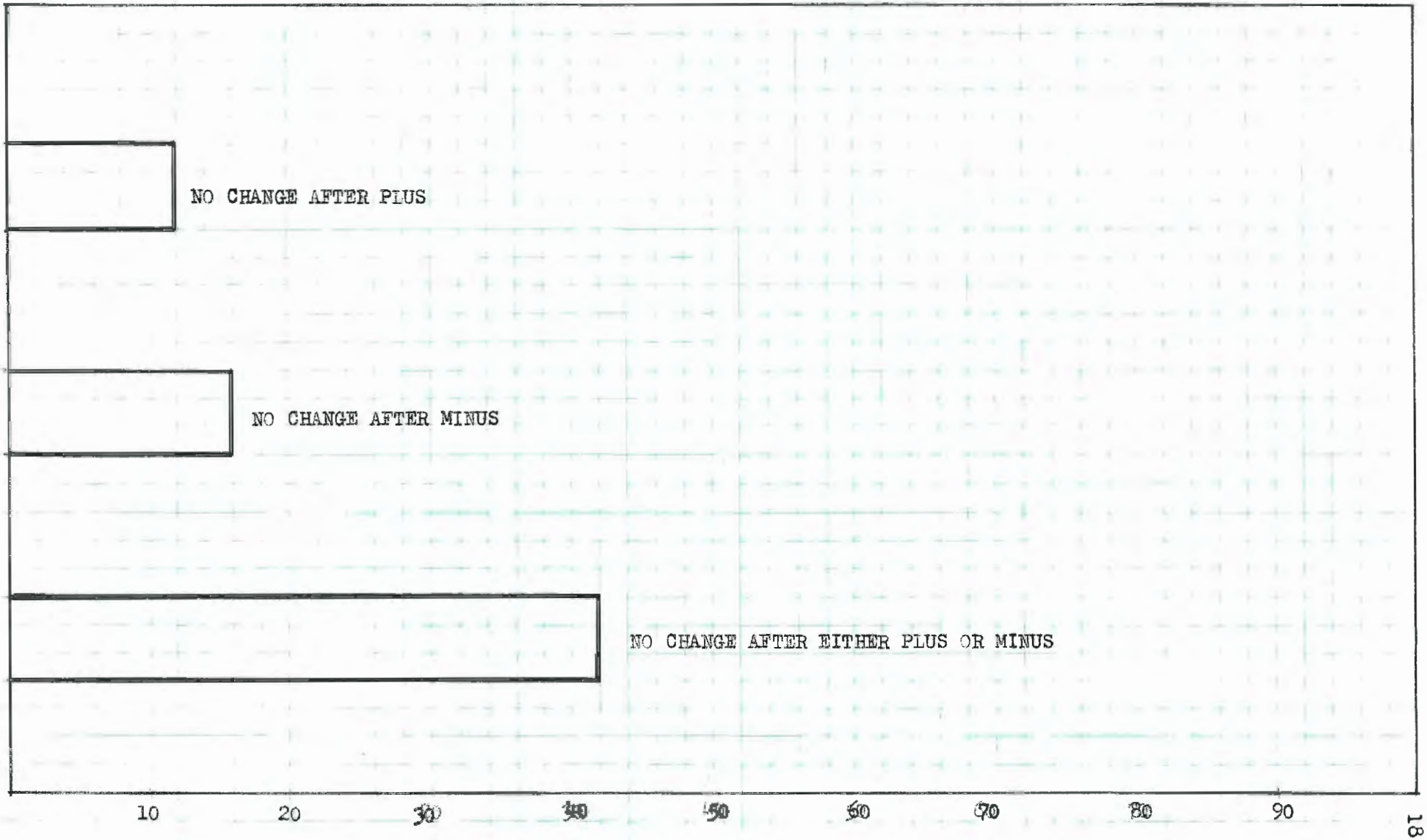
GRAPH 5. SUBJECT WHO SHOWS NO PLUS AFTER EFFECT

plus — — — —

plano after plus —·—·—·—

plano after minus — — — —

4 on the ordinate is zero fixation disparity



GRAPH 6. THE NUMBER OF SUBJECTS SHOWING NO DISPARITY CHANGE THROUGH PLANO AFTER PLUS, MINUS, OR BOTH

N 102

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