5-1967

An investigation of the changes in binocular accommodative rock performance as a function of spherical lenses

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Abstract
This study has been conducted to determine the change in cycles per minute as a function of dioptric change in lens power on the plus and minus binocular accommodative rock.

Degree Type
Thesis

Degree Name
Master of Science in Vision Science

Committee Chair

Subject Categories
Optometry

AN INVESTIGATION OF THE CHANGES IN BINOCULAR ACCOMMODATIVE ROCK PERFORMANCE AS A FUNCTION OF SPHERICAL LENSES

A THESIS

PRESENTED TO THE FACULTY

OF

PACIFIC UNIVERSITY

BY

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IN PARTIAL FULFILLMENT

OF THE REQUIREMENTS FOR THE DEGREE

DOCTOR OF OPTOMETRY

MAY 1967

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INTRODUCTION

Binocular relative accommodative rock is a procedure employed to determine the relative reaction time of the accommodation system. It is used for both testing and training purposes. A normative study[1] of this procedure has been conducted using plus two and minus two diopter lenses. The results of this study are particularily valuable with respect to the testing aspect of the procedure. In training, however, it is often desirable to utilize lenses greater or lesser in power than two diopters. This paper gives an indication of the effect of dioptric change in lens power on the cycles per minute so that a gauge of performance can be employed.

STATEMENT OF THE PROBLEM

This study has been conducted to determine the change in cycles per minute as a function of dioptric change in lens power on the plus and minus binocular accommodative rock.

EQUIPMENT

The equipment consisted of the following:

1. Keystone Van Orden Flipper
2. V.O. #16 reduced Snellen chart
3. One pair each of the following lenses:
   - -5.00
   - -4.00
   - -3.00
   - -2.00
   - -1.00
   - +0.50
   - +1.00
   - +1.50
   - +2.00
   - +2.50
4. Stop watch
5. Armrest

All of the subjects faced the same wall in the same windowless room. The wall is covered with rough plaster and is light yellow in color. The luminaires were held constant by maintaining the rheostat at its maximal setting. The level of illumination was further maintained by closing the room door during each session.

EXPERIMENTAL PROCEDURE

The study was conducted with eight subjects selected from a group of volunteers. The criteria for selection were as follows:

1. Those who had had prior visual training were excluded.
2. -5.00D and +2.50D lenses represented the two extremes of our procedure. If the subject could not clear and single the bottom line of the reduced Snellen chart through the -5.00 and +2.50 lenses, with his habitual distance Rx in place, he was excluded from the study.

Seven of the subjects were male, and one was female. The age range was from 19 to 27 years.

PROCEDURE

1. The shaft of the Van Orden Flipper was set at 16 inches.

2. Each subject's near P.D. was measured, and the instrument was set accordingly.

3. With his habitual distance prescription in place, the subject was instructed to read the 20/20 line of the reduced Snellen target. He was then required to single and clear the same line through both -5.00 and +2.50 diopter lenses.

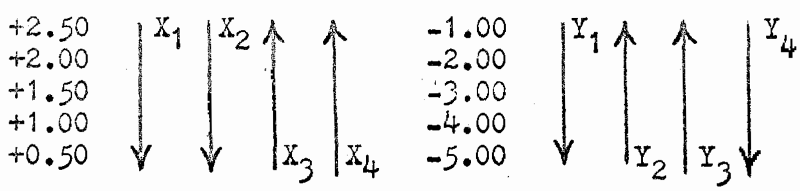
4. The subject was then instructed in the testing procedure (see instructions), and a demonstration was performed.

5. In order to control the variable of the practice effect, the following procedures were employed:

   a. Each subject was trained with +2.00 diopter lenses until the cycles per minute gain was no greater than one. The subject was then trained with -2.00 diopter lenses until a similar platequ was reached. In each case the rock was maintained for one minute.

   b. The order of lens presentation was varied for each subject so that a balanced sequence for the group was used. For example, the first column of arrows on the left indicates that the subject began the series with the +2.50 lenses and the lens powers were reduced in ½D. steps until the plus series was completed. Then he was started on the lowest minus power lens and the minus was increased in 1.00D. steps until the -5.00 lens was reached. This was the end of the testing sequence for that subject.

      The first column as just described uses X_1 as the beginning point of the testing. If Y_1 is taken as the beginning point of the testing the subject starts with low minus, works up through the minus, and then starts at the upper end of the plus range, as indicated by the X, and works down through the plus range, ending the testing sequence with the +0.50 diopter lens. The other columns are interpeted in the same manner.



PROCEDURE (continued)

6. One cycle consisted of flipping the lenses from plano (no lenses in place) to X lens power and back to plano.

7. The time and cycles were recorded by the examiners. The rock was maintained for one minute and the cycles were recorded after 30 and 60 seconds.

INSTRUCTIONS [2]

1. How many charts do you see? (If one, proceed.)
2. Can you read all the letters in the bottom row? (If yes, proceed.)
3. Read the letters aloud to me.
4. Now the examiner changes lenses before the eyes.
5. How many charts or sets of letters do you see?
6. (If one chart is reported, ask)"Did you see two charts before you saw one?"
7. Can you read all the letters in the bottom line?
8. The purpose of this test is to determine how many times a minute you can flip lenses up and down while you keep the bottom line clear and single.
9. As soon after each flip as you can see one chart and all the letters on the bottom line, flip the lenses again.
10. Try to flip the lenses as rapidly as possible but, remember, do not flip the lenses until after you see one chart and all of the letters on the bottom line.
11. Continue to flip the lenses until I tell you to stop.
12. Always start with the lenses up.

RESULTS

A total of eight subjects were trained with +2.00 lenses until a plateau of no more than one cycle per minute gain was obtained. This procedure was then repeated with the -2.00 lenses. Training sessions ranged from two one minute sessions to eight one minute sessions before the stipulated plateau was reached.

The performance of the eight subjects was approximately twice as fast as the norms found in a previous study.[2] This we attribute to the training program given before testing and the fact that we had a highly select group in that all of our subjects could clear and single the target through -5.00 and +2.50 diopter lenses. The fact that we were working with a select group seems to be more relevant to the high performance than the training because several of the subjects required few training sessions to reach a plateau.

A large variance in individual performance is seen at the extreme ranges. With -5.00 lenses the cycles varied from zero to $32\frac{1}{2}$ cycles. With the +2.50 lenses the cycles varied from $6\frac{1}{2}$ to $45\frac{1}{2}$. It should be noted that the cycles change with the +0.50 and -1.00 lenses appeared to be limited by the instrumentation.

Three subjects showed an increase in cycles per minute as a function of dioptric change in lens power. One had a two cycle increase from a -3.00 to -4.00 diopters while the mean change was a 6.4 cycle decrease, one had a 4 cycle increase from +1.50 to +2.00 while the mean change was a 7.6 cycle decrease, and one had a $1\frac{1}{2}$ cycle increase from -3.00 to -4.00 while the mean change was 6.4 cycles decrease.

One subject was unable to complete a single cycle with the -5.00 lenses, although in the pre-testing he was able to clear the -5.00 phase without difficulty. We have no explanation for this failure to sustain the accommodative rock beyond the pre-testing period. This value was dropped from the table.

Each subject's individual pattern conformed to the general pattern indicating that the change in cycles per minute as a function of lens power is a regular function. The slopes for the plus and minus lens powers are different, however.

Table 1 shows the cycles change per 60 seconds between first and last training sessions.

Table 2 shows the cycles change per 60 seconds between first training and last testing session.

Table 3 shows the cycles per 30 seconds of the actual testing sequences.

Table 4 shows the cycles per 60 seconds of the actual

RESULTS (continued)

testing sequences.

Table 5: Mean percentage change in cycles per minute.

Table 6: Mean and median changes in cycles per 60 seconds as a function of lens power.

Graph 1: Mean cycles per minute and standard deviations as a function of lens power; minus phases.

Graph 2: Mean cycles per minute and standard deviations as a function of lens power; plus phases.

Graph 3: Plot of individual subject's cycles per 60 seconds as a function of lens power with respect to mean cycles per 60 seconds; minus phases.

Graph 4: Plot of individual subject's cycles per 60 seconds as a function of lens power with respect to mean cycles per 60 seconds; plus phases.

Graph 5: Mean cycles per 30 and 60 seconds as a function of lens power.

Graphs 6-13: Cycles per 30 and 60 seconds as a function of lens power; subjects 1-8.

All data is recorded in cycles per minute, or cycles per thirty seconds as indicated.

SUMMARY

Eight subjects meeting the required standards were selected from a group of volunteers. Each was first trained and then his performance was evaluated on the binocular accommodative rock as described. A graphical and statistical analysis of the results is presented.

Plus phase

Subject	Number of 1 min. training sessions	+2.00 1st 60 sec.	+2.00 last 60 sec.	Net gain
1	2	29	30	+1
2	2	37	37	0
3	2	43	43	0
4	2	$15\frac{1}{2}$	13	$-2\frac{1}{2}$
5	2	$31\frac{1}{2}$	29	$-2\frac{1}{2}$
6	2	24	22	-2
7	7	$35\frac{1}{2}$	60	$+24\frac{1}{2}$
8	8	30	60	+30

Minus phase

Subject	Number of 1 min. training sessions	-2.00 1st 60 sec.	-2.00 last 60 sec.	Net gain
1	2	$31\frac{1}{2}$	28	$-3\frac{1}{2}$
2	3	47	$52\frac{1}{2}$	$+5\frac{1}{2}$
3	2	60	60	0
4	2	25	23	-2
5	4	34	$38\frac{1}{2}$	$+4\frac{1}{2}$
6	2	25	25	0
7	4	21	$17\frac{1}{2}$	$-4\frac{1}{2}$
8	4	29	50	+21

Table 1: Cycles change per 60 seconds between first and last training sessions.

Plus phase

Subject	+2.00 1st 60 seconds training sessions	+2.00 last 60 seconds testing session	Net gain cycles per one minute
1	29	33	+4
2	37	39	+2
3	43	38	-5
4	15½	16	+½
5	31½	35	+3½
6	24	32½	+8½
7	35½	55	+19½
8	30	65	+35

Minus phase

Subject	-2.00 1st 60 seconds training session	-2.00 last 60 seconds testing session	Net gain cycles per one minute
1	31½	35½	+4
2	47	66	+19
3	60	61	+1
4	25	33	+8
5	34	45	+11
6	25	37	+12
7	21	33	+12
8	29	75	+46

Table 2: Cycles change per 60 seconds between first training and last testing session.

SUBJECT	LENS POWER									
	-5.00	-4.00	-3.00	-2.00	-1.00	+0.50	+1.00	+1.50	+2.00	+2.50
1	5½	8	13½	18	31	29½	22½	20	16½	9
2	11	15½	21	33	42	55	42	23	18	8
3	17	18	20	30	43	73	33	22	15	11
4	4	10	9	17½	26	27	17	14½	8	3
5	12½	19	17	22	29½	44½	32½	25	16½	13½
6	3	8½	12½	18½	24½	19	20	14	15½	13
7	-	9½	9½	16	23½	35	34	26	26	14½
8	15	23	27	35	49	50	42	35	30	22
Mean	8.6	13.9	16.2	23.8	33.6	41.6	30.4	22.4	18.2	11.7

Table 3: Cycles per 30 seconds

SUBJECT	LENS POWER									
	-5.00	-4.00	-3.00	-2.00	-1.00	+0.50	+1.00	+1.50	+2.00	+2.50
1	8½	14	30½	35½	71	66	45	41½	33	20½
2	22½	31½	43	66	95	118	86	52	39	24½
3	32½	38½	49	61	90	168	66	46	38	23½
4	6½	16½	18½	33	51½	56	35	28	16	6½
5	18	37	35	45	61	90	67	52½	35	26
6	7½	13½	23½	37	51	38½	40½	28½	32½	26
7	-	23	21½	33	52½	71	70	55	55	35½
8	25	54	58	75	91	95	85	71	65	45½
Mean	15.2	28.5	34.9	46.9	70.4	87.8	61.8	46.8	39.2	26.0
Median	8.0	27.7	32.8	41.0	66.0	80.5	66.5	49.0	36.5	24.3
S.D.	10.6	7.9	14.1	16.7	18.7	15.1	19.6	14.3	8.9	11.3

Table 4: Cycles per 60 seconds

Minus Phases

-1.00 to -2.00:	33.5% Decrease
-2.00 to -3.00:	25.6% Decrease
-3.00 to -4.00:	17.3% Decrease
-4.00 to -5.00:	47.0% Decrease

Plus Phases

+0.50 to +1.00:	29.6% Decrease
+1.00 to +1.50:	24.3% Decrease
+1.50 to +2.00:	16.2% Decrease
+2.00 to +2.50:	33.7% Decrease

Table 5: Mean percentage change in cycles per minute.

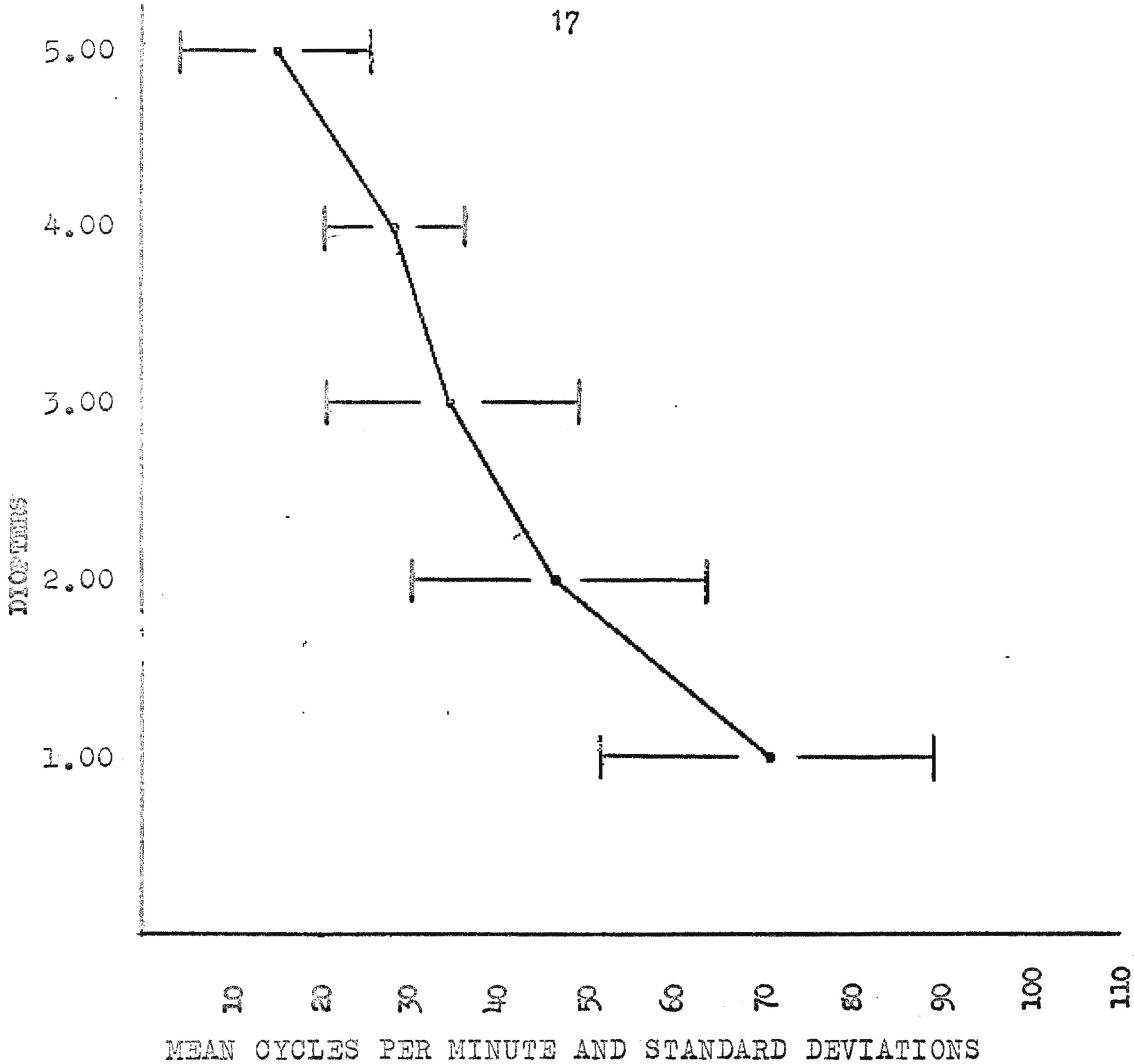
MINUS PHASES

Change In Lens Power	Mean Change In Cycles	Median
-1.00 to -2.00	22.2	19.0
-2.00 to -3.00	12.1	11.8
-3.00 to -4.00	6.4	7.0
-4.00 to -5.00	13.4	9.5

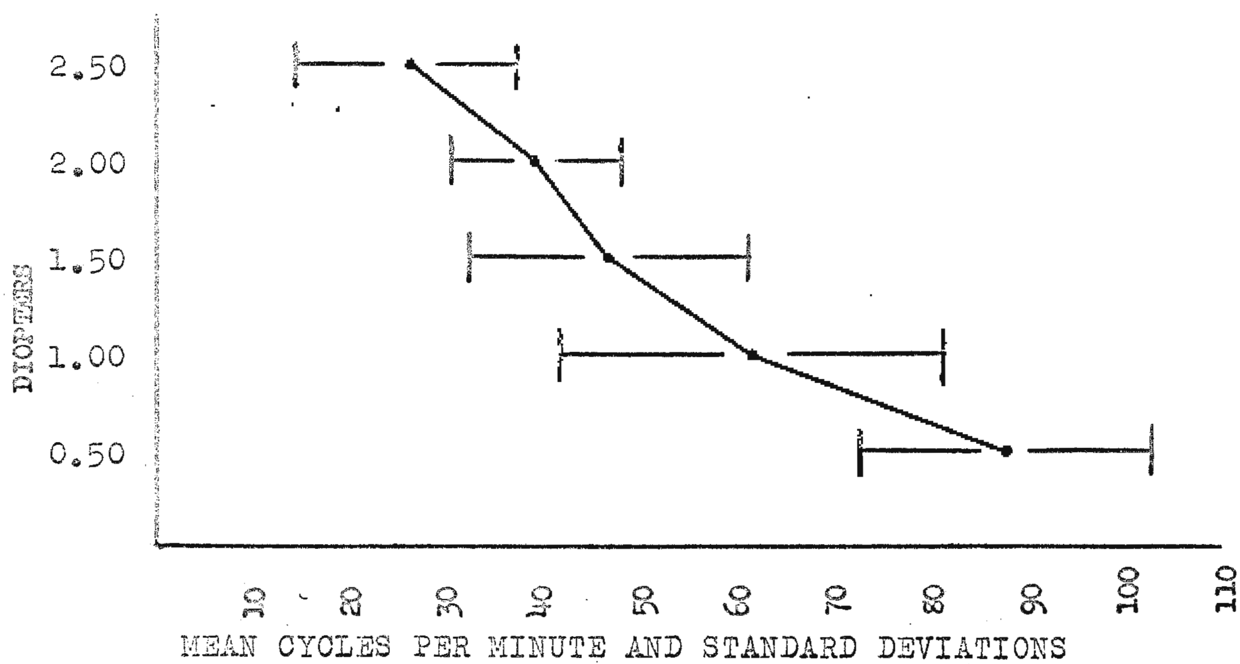
PLUS PHASES

Change In Lens Power	Mean Change In Cycles	Median
+0.50 to +1.00	26.0	21.0
+1.00 to +1.50	15.0	14.3
+1.50 to +2.00	7.6	8.3
+2.00 to +2.50	13.2	13.5

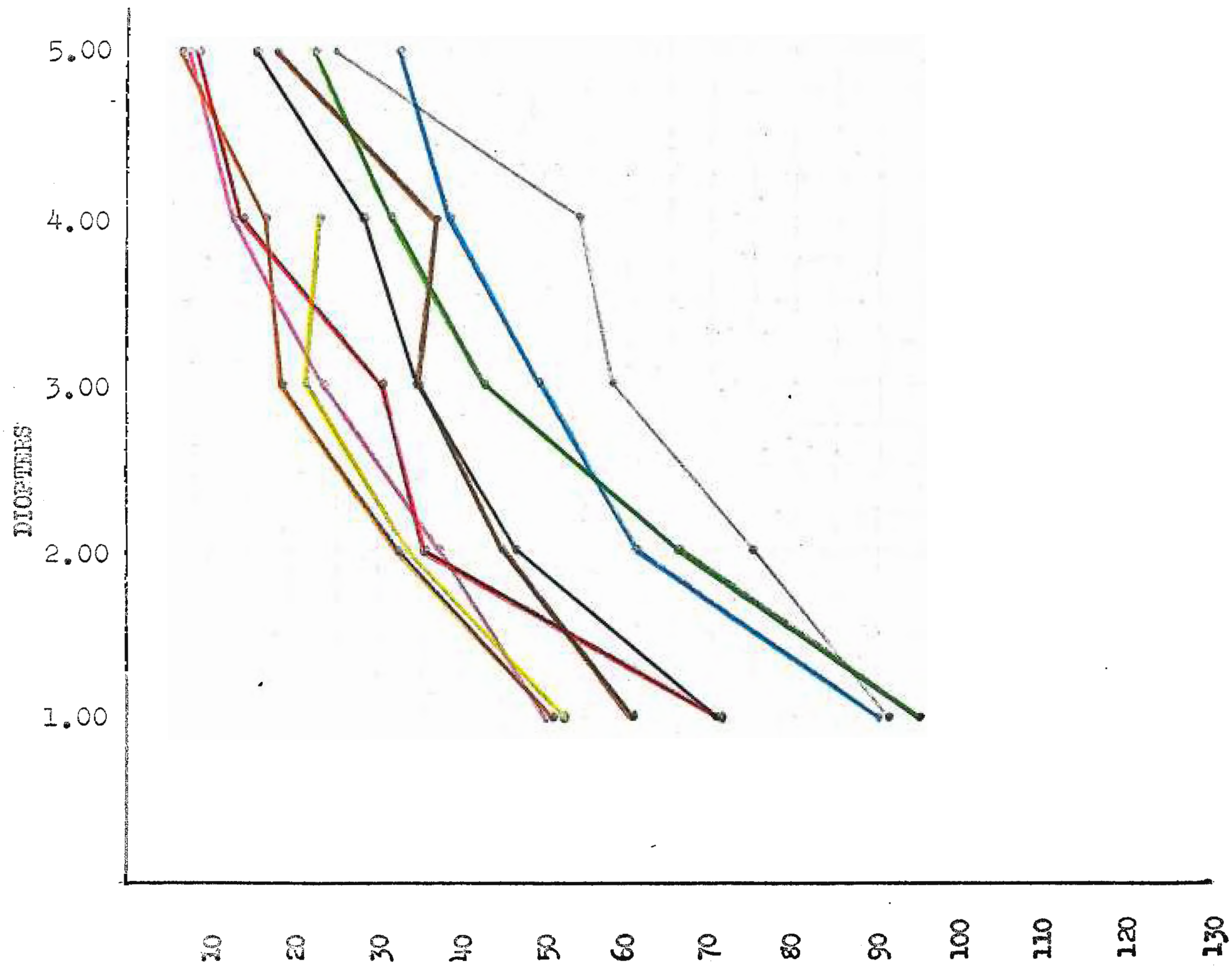
Table 6: Mean and median changes in cycles per 60 seconds as a function of lens power.



Graph 1: Mean cycles per minute and standard deviations as a function of lens power; minus phases

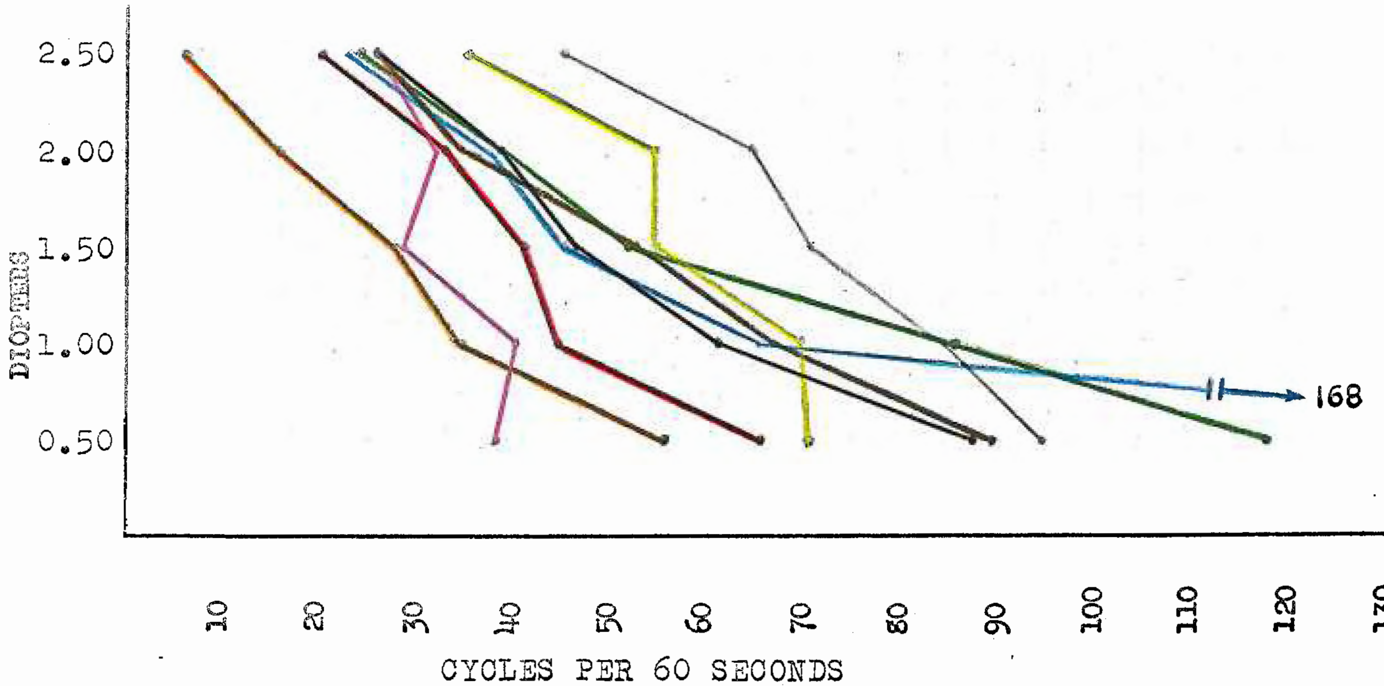


Graph 2: Mean cycles per minute and standard deviations as a function of lens power; plus phases



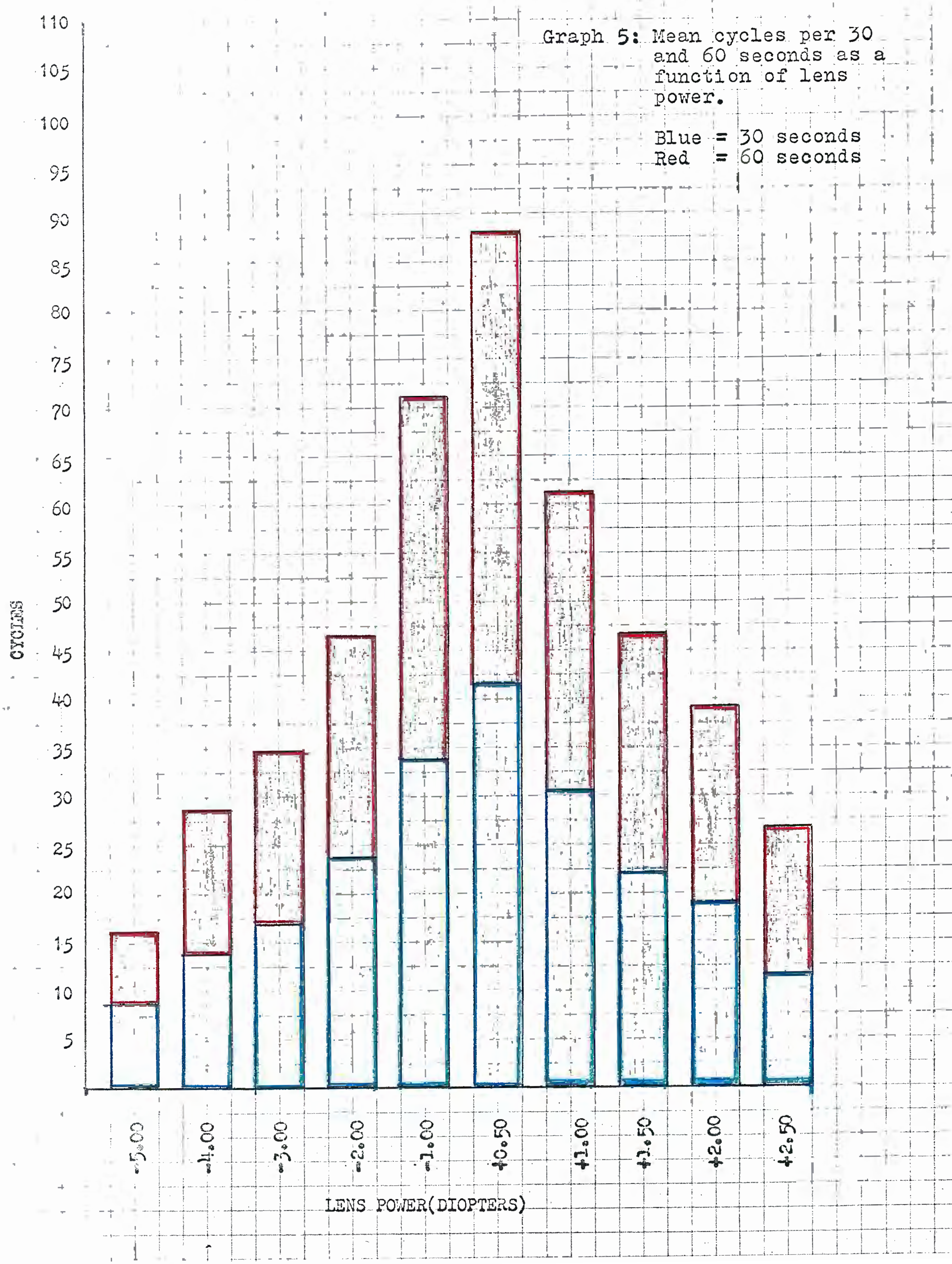
Black - Mean
Red - Subject 1
Green - Subject 2
Blue - Subject 3
Orange - Subject 4
Brown - Subject 5
Pink - Subject 6
Yellow - Subject 7
Gray - Subject 8

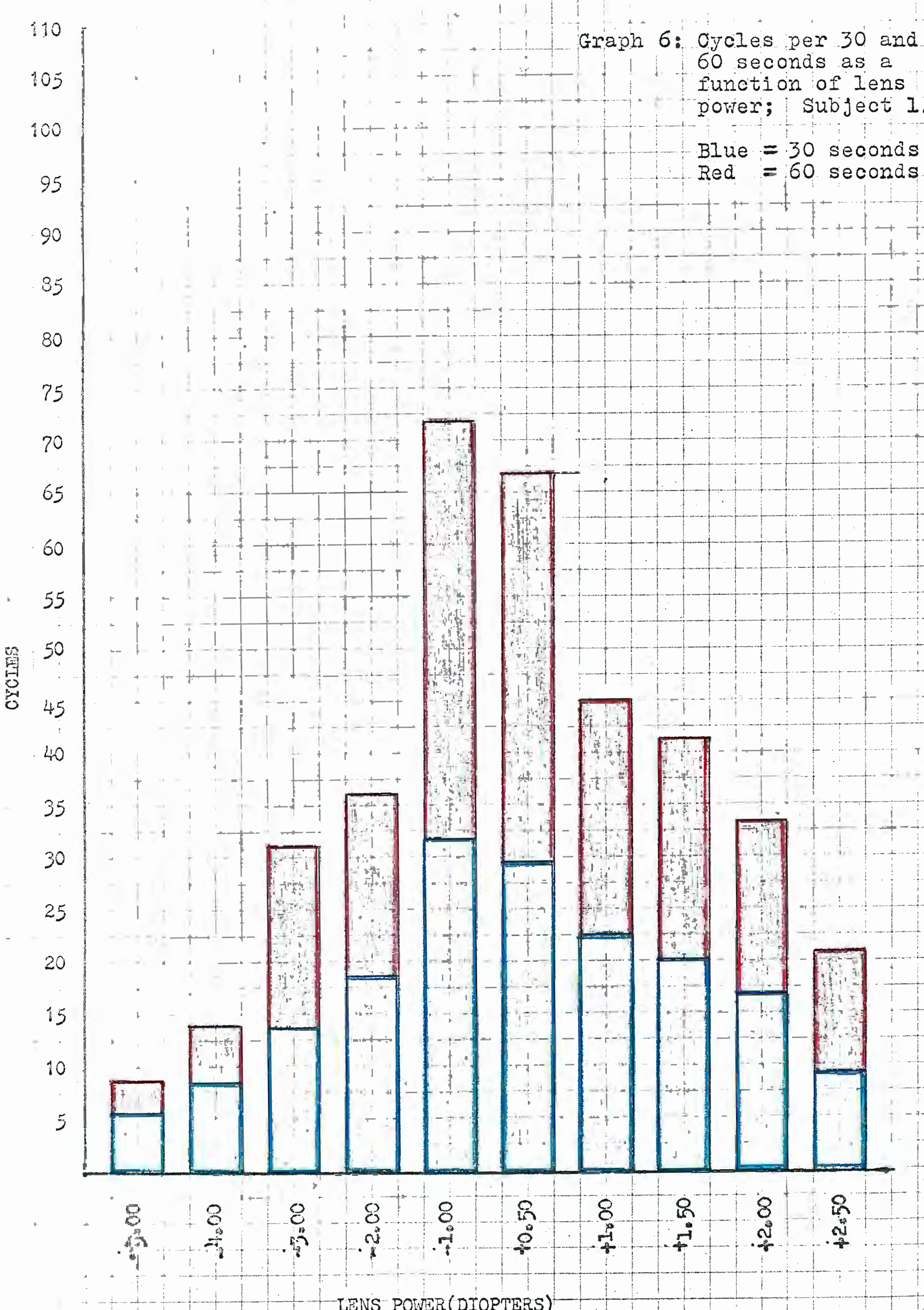
Graph 3: Plot of individual subject's cycles per 60 seconds as a function of lens power with respect to mean cycles per 60 seconds; minus phases



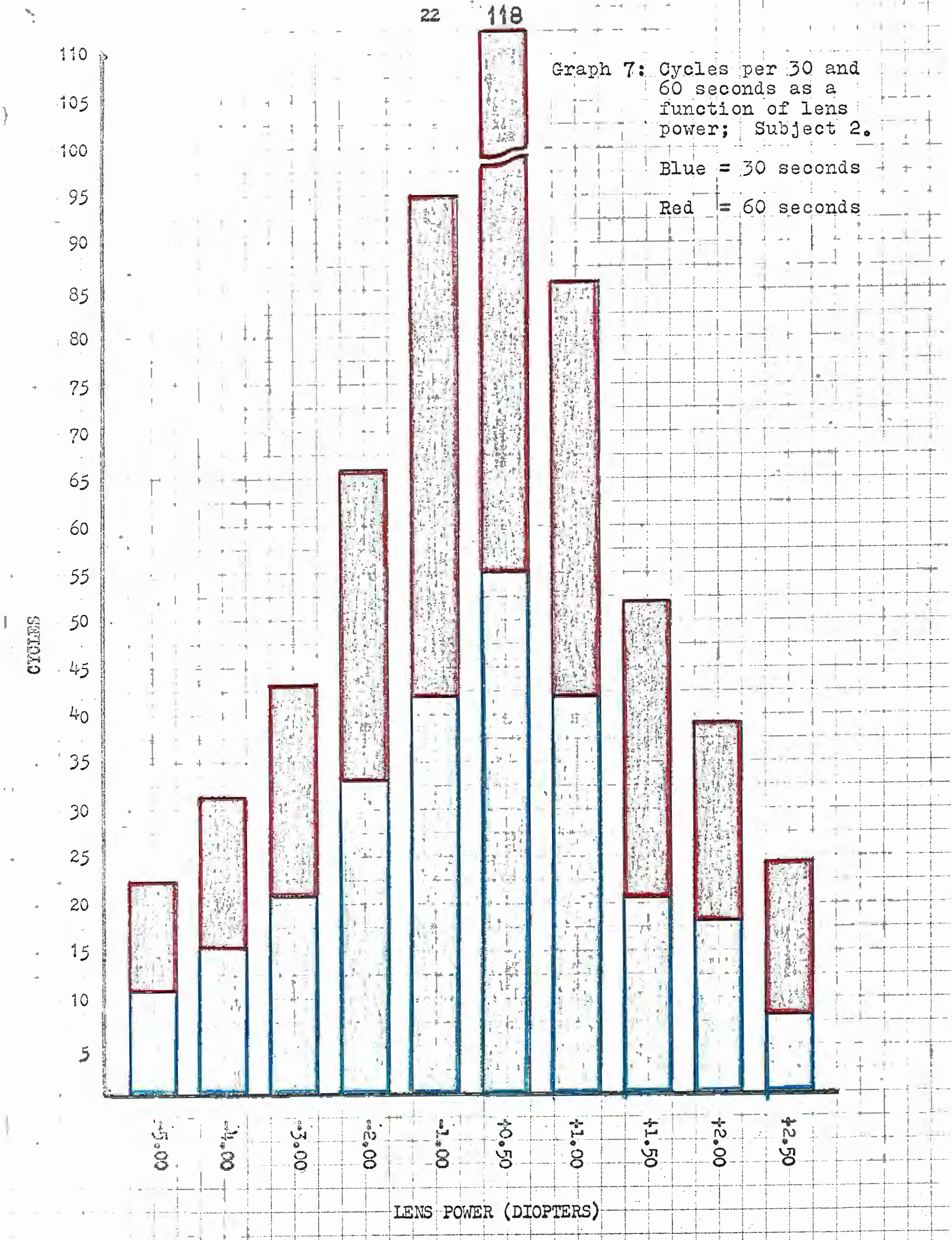
Black - Mean
Red - Subject 1
Green - Subject 2
Blue - Subject 3
Orange - Subject 4
Brown - Subject 5
Pink - Subject 6
Yellow - Subject 7
Gray - Subject 8

Graph 4: Plot of individual subject's cycles per 60 seconds as a function of lens power with respect to mean cycles per 60 seconds; plus phases

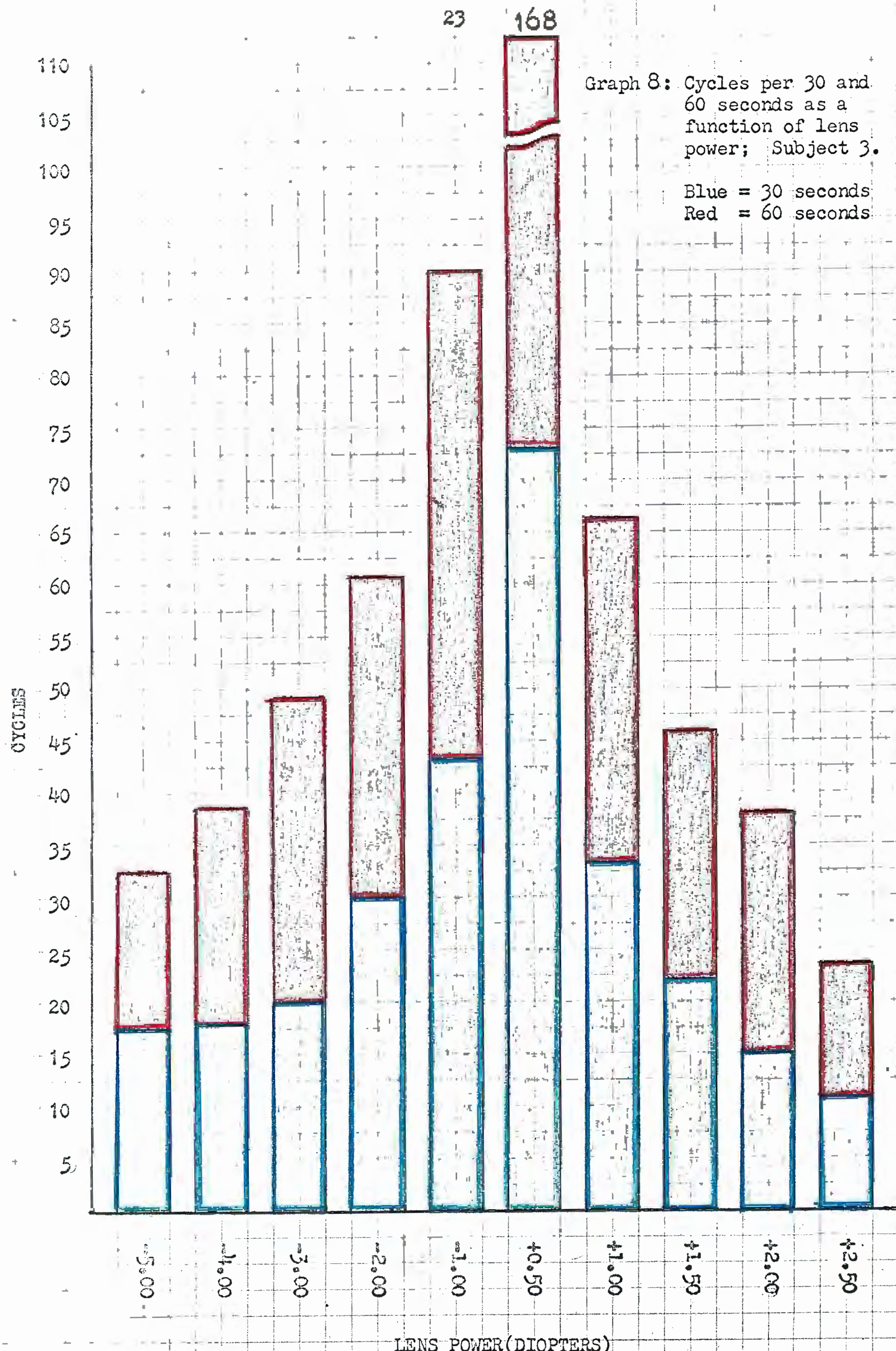

Graph 5: Mean cycles per 30 and 60 seconds as a function of lens power.
Blue = 30 seconds
Red = 60 seconds
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
CYCLES
-5.00
-4.00
-3.00
-2.00
-1.00
+0.50
+1.00
+1.50
+2.00
+2.50
LENS POWER(DIOPTERS)



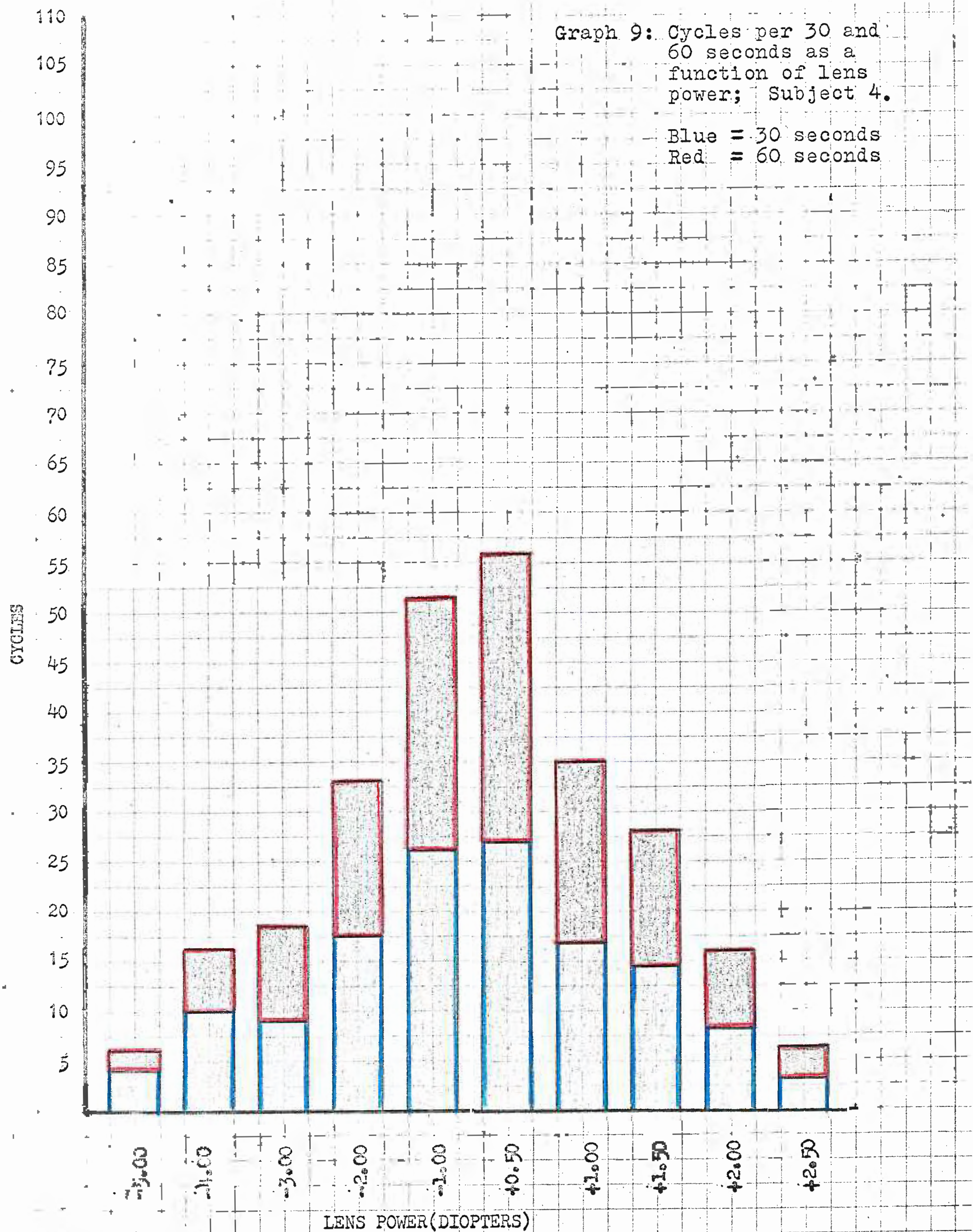
Graph 6: Cycles per 30 and 60 seconds as a function of lens power; Subject 1.

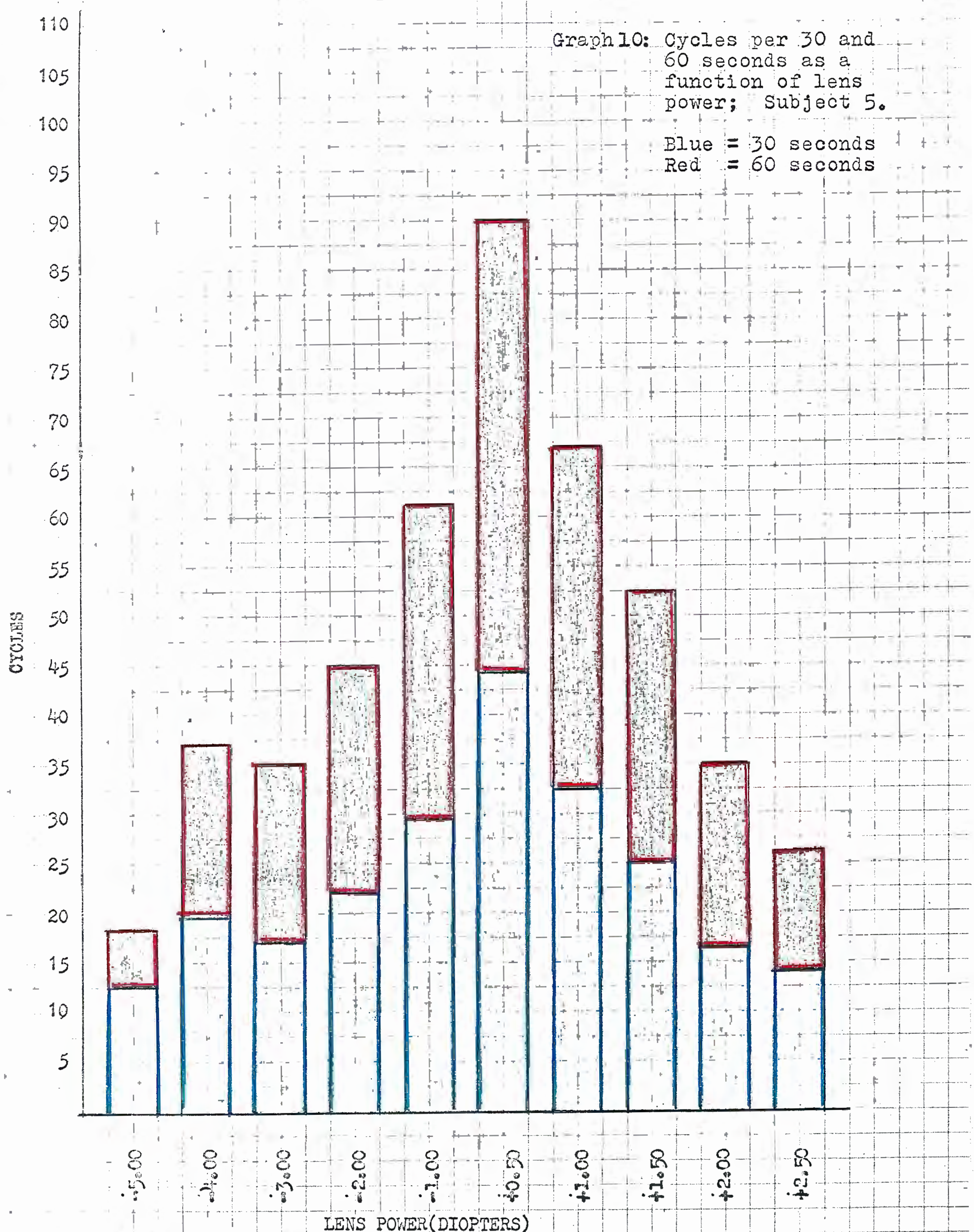


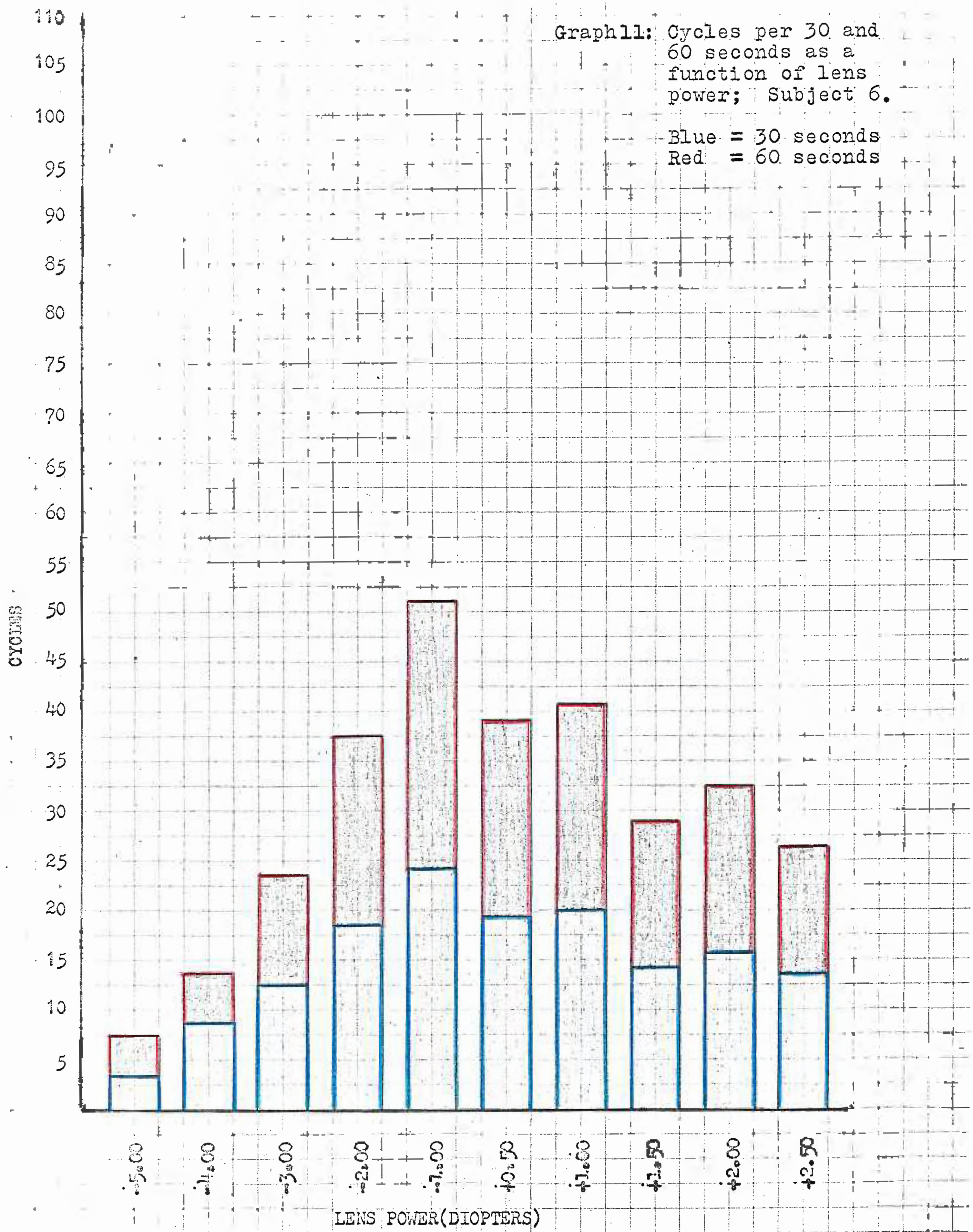
Graph 7: Cycles per 30 and 60 seconds as a function of lens power; Subject 2.



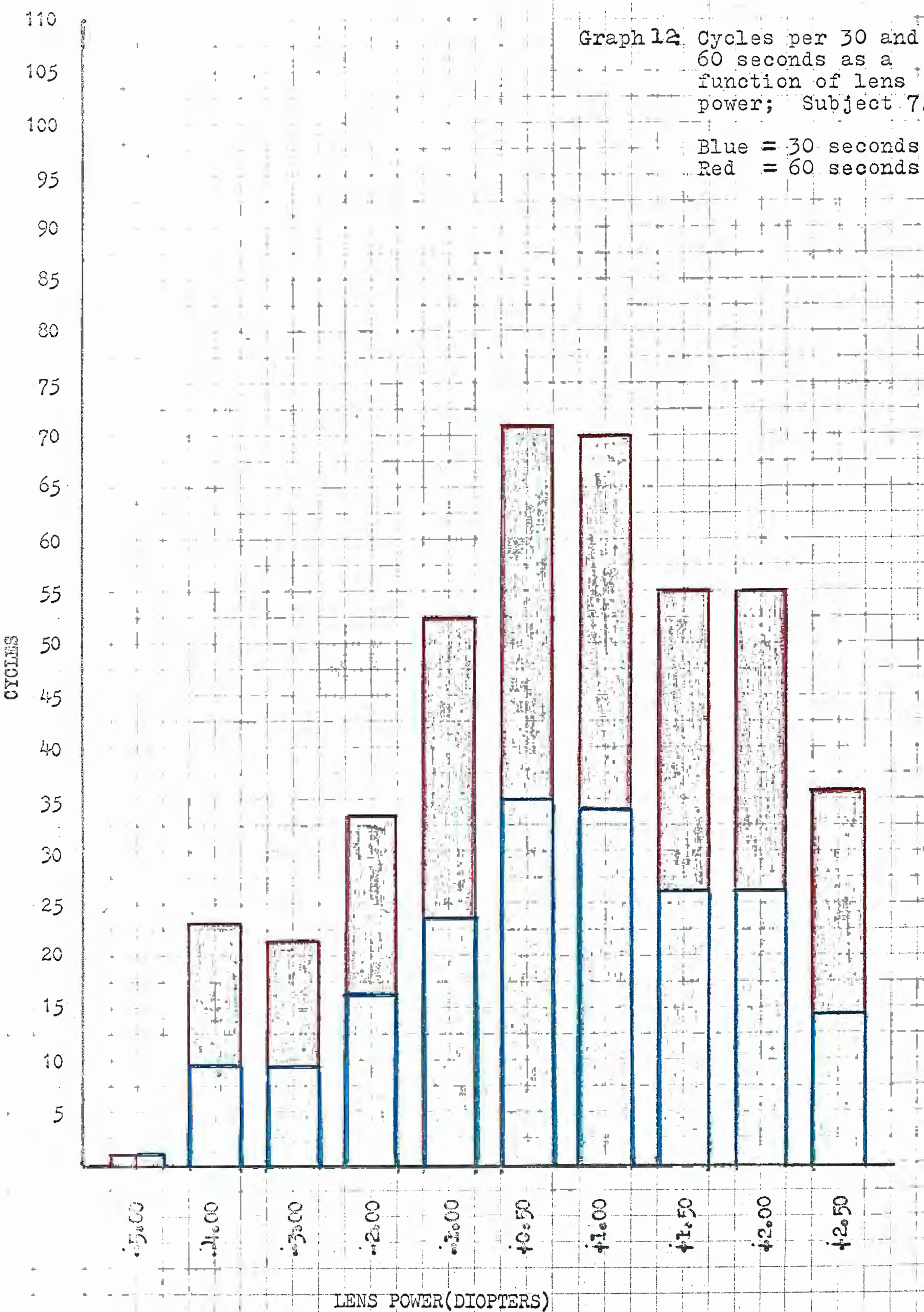
Graph 8: Cycles per 30 and 60 seconds as a function of lens power; Subject 3.
Blue = 30 seconds
Red = 60 seconds
23
168
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
CYCLES
-5.00
-4.00
-3.00
-2.00
-1.00
+0.50
+1.00
+1.50
+2.00
+2.50
LENS POWER(DIOPTERS)


Graph 9: Cycles per 30 and 60 seconds as a function of lens power; Subject 4.
Blue = 30 seconds
Red = 60 seconds
CYCLES
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-5.00
-4.00
-3.00
-2.00
-1.00
+0.50
+1.00
+1.50
+2.00
+2.50
LENS POWER(DIOPTERS)

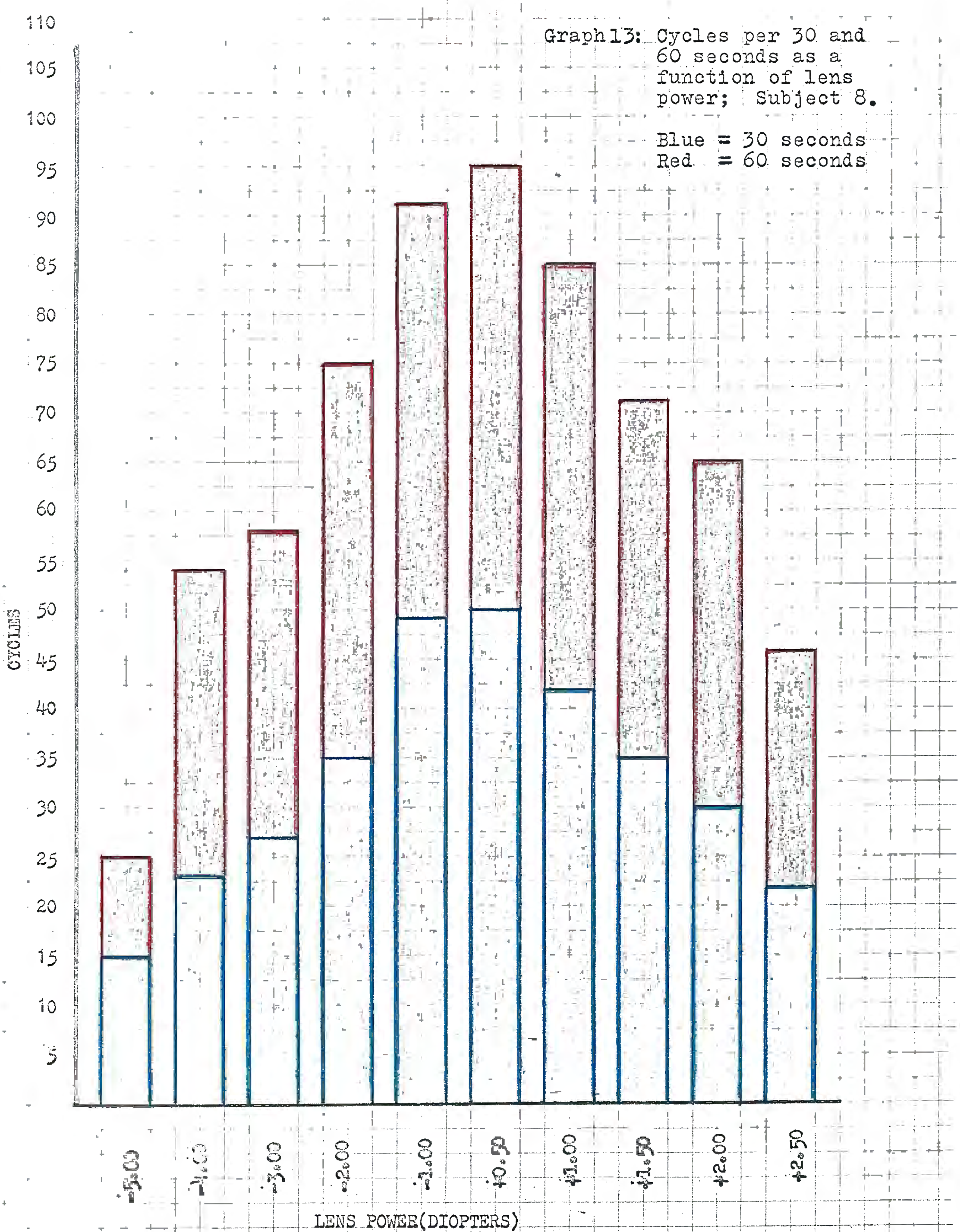

Graph 10: Cycles per 30 and 60 seconds as a function of lens power; Subject 5.
Blue = 30 seconds
Red = 60 seconds
CYCLES
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-5.00
-4.00
-3.00
-2.00
-1.00
+0.50
+1.00
+1.50
+2.00
+2.50
LENS POWER (DIOPTERS)



Graph 11: Cycles per 30 and 60 seconds as a function of lens power; Subject 6.



Graph 12. Cycles per 30 and 60 seconds as a function of lens power; Subject 7.


Graph 13: Cycles per 30 and 60 seconds as a function of lens power; Subject 8.
Blue = 30 seconds
Red = 60 seconds
CYCLES
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
-5.00
-4.00
-3.00
-2.00
-1.00
+0.50
+1.00
+1.50
+2.00
+2.50
LENS POWER(DIOPTERS)

Footnotes

1. Milne, Donald J., A Normative Study Of Students Selected At Random On The H. M. H. Plus And Minus Binocular Rock Test. Thesis, Pacific University.

2. Lecture supplement and unpublished lecture notes from Harold M. Haynes, O.D.

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