The Effect of Soft Lens Manufacture on Contrast Sensitivity

Senior Project

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By Marcie Glassner

Submitted to Gerald E. Lowther OD. Ph.D.

TABLE OF CONTENTS

There are two kinds of measures used to assess the resolving power of the visual system, those being, visual acuity and contrast sensitivity. Visual acuity measuring, tests resolving power by determining the smallest detail of a pattern that can be detected. Contrast sensitivity assesses resolving power by determining the minimum contrast needed to perceive a particular pattern.[1] A sinusoidal grating pattern is commonly used, where the difference between the light and dark bars can be reduced or increased. The difference at which the gratings are just resolved is the contrast threshold, and the reciprocal of the threshold is the contrast sensitivity.[1] Contrast sensitivity is greatest for patterns of intermediate frequency only, the low spatial frequencies are attenuated due to the nonlinearity of the human visual system's transfer function.[2] Curves of contrast sensitivity functions show that grating acuity is a single point on the function. Arden gratings are commonly used in contrast sensitivity testing, but they are time consuming and difficult to quantify. In this study a computer was used with a cathode ray screen to generate the gratings and to record all data.

Soft contact lenses, can be made in a variety of fashions, and in many different polymers. This study was conducted to determine if a particular design of a soft contact lens could markedly affect a subject's contrast sensitivity, comparably to another design of soft contact lens.

The study used four different brands of soft lenses, those being Bausch & Lomb U_4, Ciba soft, American Hydron CMS, and the CSI lens. Ciba is a lathe cut lens, $U_4$is a spuncast lens, CMS uses a cast molding system, and the CSI is made of a different polymer than the HEMA content of the prior three lenses.

Methods

Subjects. Nine subjects were used in this study. Each had a moderate degree of myopia of less than 4.50 diopters, and astigmatism less than 0.50 diopters. All, at that time were soft contact lens wearers of some brand. The subjects ranged in age of from 20 to 35years. There were five males and four females comprising the group of subjects.

Testing procedure. The contrast sensitivity test was administered to all subjects by the same tester. The experimental set up consisted of a semi darkened room which contained the computer and cathode ray screen on which the gratings were presented. The room also contained a Bausch & Lomb phoropter used for over refracting the contact lenses, and an American Optical slit lamp. The illumination was kept at a constant level for each subject and trial. The distance of the subject to the screen was also set as a constant.

Each subject was fit with the four brands of lenses; U_4, Ciba, CMS, and CSI, with the order of each lens fit varying. One eye was fit on each subject, and the physical fit was checked with the slit lamp. An over refraction was performed on each fit to assure proper power selection. Each patient was able to read a 20/20 block of letters with the lens by itself. (See table 1) The best possible fit was used, however the base curve selection varied with each brand of lens, allowing some lenses to fit better than others on each particular patient. (See table 2.) There was also a slight problem with available lens powers.

The subject was then ready for the contrast sensitivity testing, which was performed with the Optronix Series 200 Vision Tester. Using the adjustment method, the subject turned the contrast up on a series of gratings from non-seeing to just barely detectable. A box which had the knob for the adjustment and a button to push to set the response and send it into the computer was used. Once the subject pushed the set button, the response went into the computer and a new trial could be made. Four trials were made for each spatial frequency, and the Vision Tester would then print out the log contrast for each response, and calculate the mean, standard deviation and sensitivity for that particular frequency. (See figure 1.) Six different spatial frequencies were presented in this order: 3, 11.4, 0.50, 6, 22.8, and 1 cycles/degree. A graph was made for each lens and subject at the time of each trial, and if a particular point appeared to be out of line with the others, that grating would be presented over again so that a new reading could be made.

Analysis of data. For each of the four lenses, a table was made of the contrast sensitivity at each frequency for all subjects. These values were then graphed, with the exception of patients 8 and 9 due to insufficient room on the graphs. (See tables 3-6 and graphs 1-4).

For each subject a table was made of the results of each particular lens. (See tables 7-15). Graphs were drawn from this data for all subjects. (See graphs 5-13). A graph was also made of the mean readings of each lens, on a 3x3 log paper and also a 2x2 log paper, allowing the differences of each curve to be noted with more ease. On the 2x2 graph the 0.50 cycles/degree point had to be dropped due to it falling off the scale. (See graphs 14-15).

Results

Graphs 1-4 indicate that there is a variability for each lens from subject to subject. There is no strong difference noted between any of the curves plotted for each lens. However, what did appear, was that the curves for the Ciba and CSI lenses demonstrated more variability than the CMS and the U_4 lenses, which appear to be more bell shaped and uniform.

Graphs 5-13. Very few graphs consistantly showed the sensitivity higher for one particular lens. On graphs 5, 6, and 7, the CSI lens appeared to have higher sensitivities, but on the remainder of the graphs a particular lens did not stand out.

Graphs 14-15. Graph 14 exhibits normal bell shaped curves for each of the four lenses. For the very low frequencies, the curves appear to be superimposed. Graph 15, eliminated the very low frequencies and allows a spreading out of the remainder of the four curves. The CSI lens appears once again to give a better sensitivity function throughout most of the curve, but when standard deviation is taken into account, the superiority no longer stands out. It is interesting to note, however that the CSI, Ciba and U_4 lenses all had a peak sensitivity at about four cycles/degree, while the CMS lens peaked at three cycles/dgree.

Discussion

The results of this study does not consistantly show one lens to be superior to another. The CSI lens appears to give a better contrast sensitivity function than the other three lenses, but one could not call it a better lens once standard deviations are taken into account. However, on certain subjects it did appear to be the lens of choice. One problem that was encountered with the CSI lens was that on some patients, it buckled no matter which base curve was selected. This buckling did not occur with any of the other three lenses.

statistics will be done. Jonathan

More testing on the theory of contrast sensitivity and contact lenses should be done before ruling out that there is statistically no difference between lens manufacture. Also, a detailed statistical analysis should be performed alongside of the graphing technique used here. It also would have been interesting to compare the contact lens contrast curves to the curves generated when the subjects wore their glasses. This might have led a clue to the variability of the curves found in this study.

REFERENCES

1. Thomas, James P.: Spatial resolution and spatial interaction. Handbook of Perception volume V pp 233-259

2. Cornsweet, Tom N.; Visual perception pp 330-337

3. Arden, G. B., and Jacobsen, J. J.; A simple grating test for contrast sensitivity: preliminary results indicate value in screening for glaucoma. Invest. Ophth. Vis. Sci. Jan 1978

Table 1. Over refractions of all lenses.

Subject	U_4	Ciba	CMS	CSI
1. M. Faber	-.25x90	+.50-.25x65	+.25-.25x10	-.25x85
2. A. Mitchell	+0.50	-.25x35	plano	.50-.25x45
3. D. Cleary	+.50-.50x130	+.25-.50x125	+.25-50x125	+.75-.50x120
4. L. Lewis	plano	plano	-50x60	-.25x65
5. T. Petito	-.25-.25x120	-.25-.50x140	-.75x140	plano
6. C. Cupal	plano	plano	-.50x120	-.25x150
7. L. Boggs	+.25-.25x90	+.25-.25x85	-.25x80	+.25-.25x75
8. S. Schaff	+.25-.50x15	-.25-.75x30	-.50x95	plano
9. L. White	+.25-.25x60	-.25x60	-.25x50	-.25x60

Table 2. Fits and powers of lenses used.

Subject	U_4	Ciba	CMS	CSI
1. M. Faber	good (pts lens) -3.00	sl. loose -3.50	sl. loose -3.00	sl. loose -3.00
2. A. Mitchell	good -2.25	good -2.00	sl. tight -2.00	buckles -2.00
3. D. Cleary	good -3.25	sl. loose -3.50	good -3.25	good -4.00
4. L. Lewis	sl. tight -2.25	good -2.00	good -2.00	buckles -2.00
5. T. Petito	good -4.50	good -4.50	not centering -4.50	good -5.00
6. C. Cupal	good -1.50	sl. loose -2.00	loose -1.75	buckles -2.00
7. L. Boggs	loose -2.25	good -2.00	sl. tight -1.75	sl. loose -2.00
8. S. Schaff	good -1.25	good -1.50	sl. tight -1.50	good -1.00
9. L. White	sl. loose (pts lens) -1.50	loose -1.50	sl. loose -1.75	good -1.00

(sl. -slightly)

Figure 1. Example of trial printout.

```
          TRIAL  1
       3 CYCLES / DEG

RESP.    LOG CONTRAST
  1          -1.98
  2          -2.16
  3          -2.22
  4          -2.25
MEAN -2.152
STD DEV    .105
SENSITIVITY  142.1
```

Table 3. Sensitivities of all subjects with the U^4 lens.

Patient	Cycles/degree					
	0.50	1.0	3.0	6.0	11.4	22.8
1. M. Faber	44.2	68.0	245.5	121.6	46.8	16.9
2. A. Mitchell	37.2	81.3	112.3	128.8	42.7	28.5
3. D. Cleary	77.6	121.7	226.5	246.9	102.9	70.4
4. L. Lewis	31.6	85.6	225.2	152.2	34.1	22.0
5. T. Petito	69.2	88.1	126.6	102.3	56.6	32.0
6. C. Cupal	18.1	39.1	83.7	87.1	46.8	12.6
7. L. Boggs	29.9	58.9	187.3	116.1	43.4	10.8
8. S. Schaff	45.2	82.7	239.9	237.1	56.6	25.6
9. L. White	70.0	95.5	223.9	188.4	71.6	22.8
MEAN	47.0	80.3	185.7	153.4	55.7	26.8
STD DEV	20.7	23.8	61.7	58.1	20.7	17.8

Table 4. Sensitivities of all subjects with the Ciba lens.

Patient	Cycles/degree					
	0.50	1.0	3.0	6.0	11.4	22.8
1. M. Faber	48.4	101.7	165.0	112.8	64.6	22.8
2. A. Mitchell	55.6	71.2	134.9	171.8	110.3	32.4
3. D. Cleary	69.2	134.9	338.8	293.4	168.8	112.8
4. L. Lewis	22.9	79.9	184.1	237.1	79.9	43.9
5. T. Petito	46.0	69.6	203.0	56.2	53.4	25.7
6. C. Cupal	17.4	33.5	91.7	104.1	46.8	16.5
7. L. Boggs	34.1	80.8	152.2	167.9	70.4	17.0
8. S. Schaff	53.7	75.0	189.5	115.5	31.3	17.0
9. L. White	28.5	76.3	191.6	116.1	51.0	6.1
MEAN	41.8	80.3	183.4	152.8	75.2	32.7
STD DEV	17.1	27.1	67.7	73.7	41.8	31.9

TABLE 5. Sensitivities of all subjects with the CSI lens.

Patient	Cycles/degree					
	0.50	1.0	3.0	6.0	11.4	22.8
1. M. Faber	27.7	75.0	207.7	94.4	56.2	15.9
2. A. Mitchell	28.7	57.2	119.5	114.2	89.6	25.0
3. D. Cleary	44.9	150.5	196.1	231.7	118.2	72.4
4. L. Lewis	41.2	79.0	180.9	288.4	146.2	36.5
5. T. Petito	78.9	92.6	305.5	208.9	93.9	38.2
6. C. Cupal	37.4	52.2	235.8	113.5	63.5	15.6
7. L. Boggs	20.5	67.2	125.2	140.4	99.4	12.2
8. S. Schaff	59.2	80.4	153.1	110.9	63.1	25.7
9. L. White	70.0	104.1	302.0	234.4	107.8	18.3
MEAN	45.3	84.2	202.9	170.8	93.1	28.8
STD DEV	19.9	29.6	68.4	70.6	29.3	18.7

Table 6. Sensitivities of all subjests with the CMS lens.

Patient	Cycles/degree					
	0.50	1.0	3.0	6.0	11.4	22.8
1. M. Faber	31.8	51.6	80.8	81.8	28.0	14.0
2. A. Mitchell	44.2	59.9	166.9	121.6	75.9	18.4
3. D. Cleary	64.2	110.9	333.0	266.1	126.6	41.7
4. L. Lewis	51.9	67.2	213.8	157.6	46.8	26.9
5. T. Petito	32.9	115.5	254.1	68.0	38.9	13.0
6. C. Cupal	20.1	50.4	87.6	71.2	38.9	12.1
7. L. Boggs	21.3	92.3	151.4	79.9	17.5	7.7
8. S. Schaff	63.1	133.4	312.6	175.8	72.0	23.0
9. L. White	30.9	65.7	190.5	97.2	40.0	12.6
MEAN	40.0	83.0	198.9	124.4	53.8	18.8
STD DEV	16.7	30.8	89.3	65.6	33.1	10.4

Table 7. Sensitivities of patient M. Faber with each lens.

Lens	0.50	1.0	3.0	6.0	11.4	22.8
U4	44.2	68.0	245.5	121.6	46.8	16.9
Ciba	48.4	101.7	165.0	112.8	64.6	22.8
CSI	27.7	75.0	207.7	94.4	56.2	15.9
CMS	31.8	51.6	80.8	81.8	28.0	14.0

Table 8. Sensitivities of patient A. Mitchell with each lens.

Lens	0.50	1.0	3.0	6.0	11.4	22.8
U4	37.2	81.3	112.3	128.8	42.7	28.5
Ciba	55.6	71.2	134.9	171.8	110.3	32.4
CSI	28.7	57.2	119.5	114.2	89.6	25.0
CMS	44.2	59.9	166.9	121.6	75.9	18.4

Table 9. Sensitivities of patient D. Cleary with each lens.

Lens	0.50	1.0	3.0	6.0	11.4	22.8
U4	77.6	123.7	226.5	246.9	102.9	70.4
Ciba	69.2	134.9	338.8	293.4	168.8	112.8
CSI	44,9	150.5	196.1	231.7	118.2	72.4
CMS	64.2	110.9	333.0	266.1	126.6	41.7

Table 10. Sensitivities of patient L. Lewis with each lens.

Lens	0.50	1.0	3.0	6.0	11.4	22.8
U4	31.6	85.6	225.2	152.2	34.1	22.0
Ciba	22.9	79.9	184.1	237.1	79.9	43.9
CSI	41.2	79.0	180.9	288.4	146.2	36.5
CMS	51.9	67.2	213.8	157.6	46.8	26.9

Table 11. Sensitivities of patient T. Petito with each lens.

Lens	0.50	1.0	3.0	6.0	11.4	22.8
U4	69.2	88.1	126.6	102.3	56.6	32.0
Ciba	46.0	69.6	203.0	56.2	53.4	25.7
CSI	78.1	92.6	305.5	208.9	93.9	38.2
CMS	32.9	115.5	254.1	68.0	38.9	13.0

Table 12. Sensitivities of patient C. Cupal with each lens.

Lens	0.50	1.0	3.0	6.0	11.4	22.8
U4	18.1	39.1	83.7	87.1	46.8	12.6
Ciba	17,4	33.5	91.7	104.1	46.8	16.5
CSI	37.4	52.2	235.8	113.5	63.5	15.6
CMS	20.1	50.4	87.6	71.2	38.9	12.1

LEGEND FOR GRAPHS 1-4

Marty Faber

Alicia Mitchell

Dave Cleary

Lorna Lewis

Tim Petito

Cindy Cupal

Louis Boggs

LEGEND FOR ALL OTHER GRAPHS

Bausch & Lomb U_4 lens

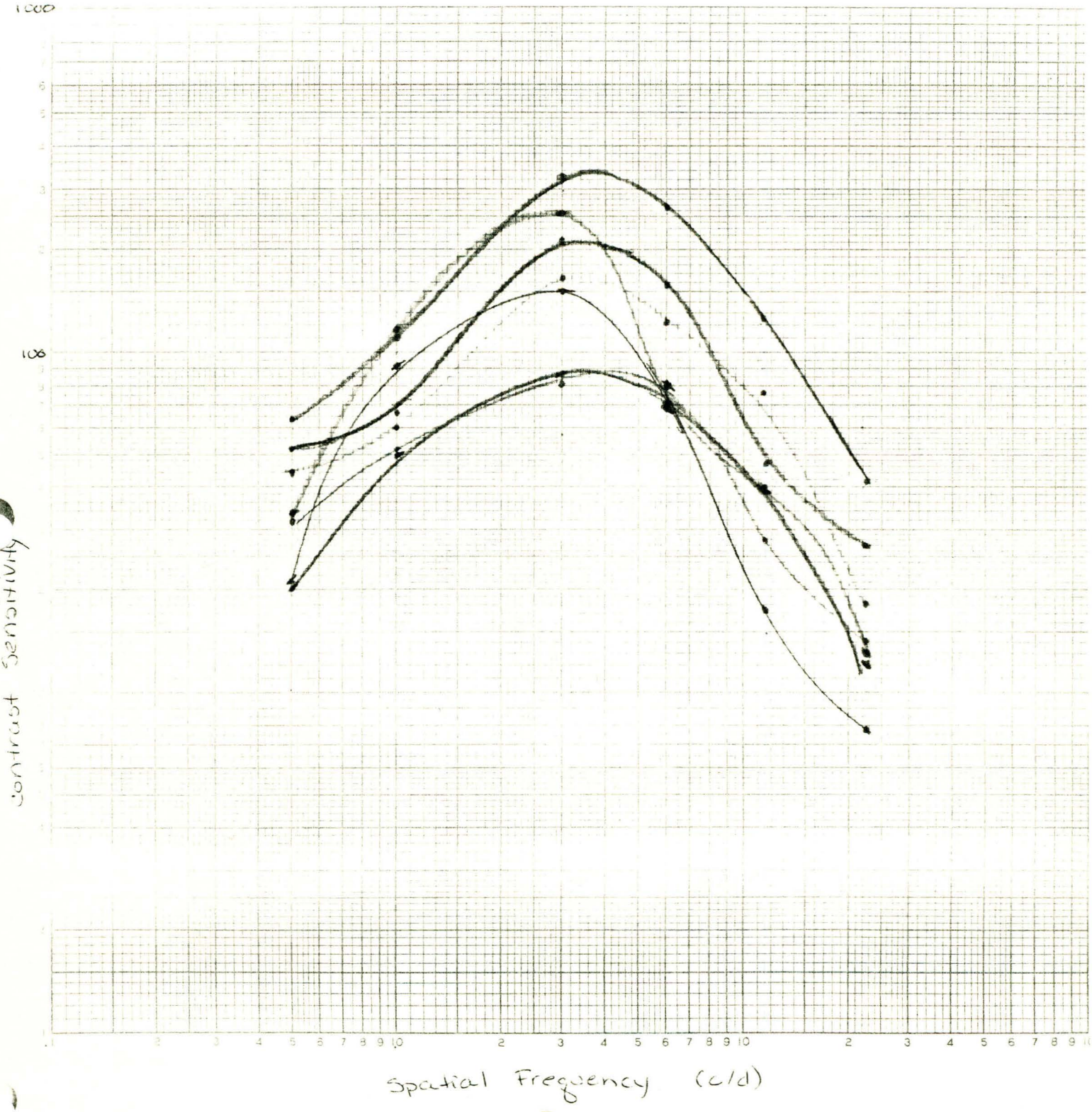
Ciba soft lens

CSI lens or

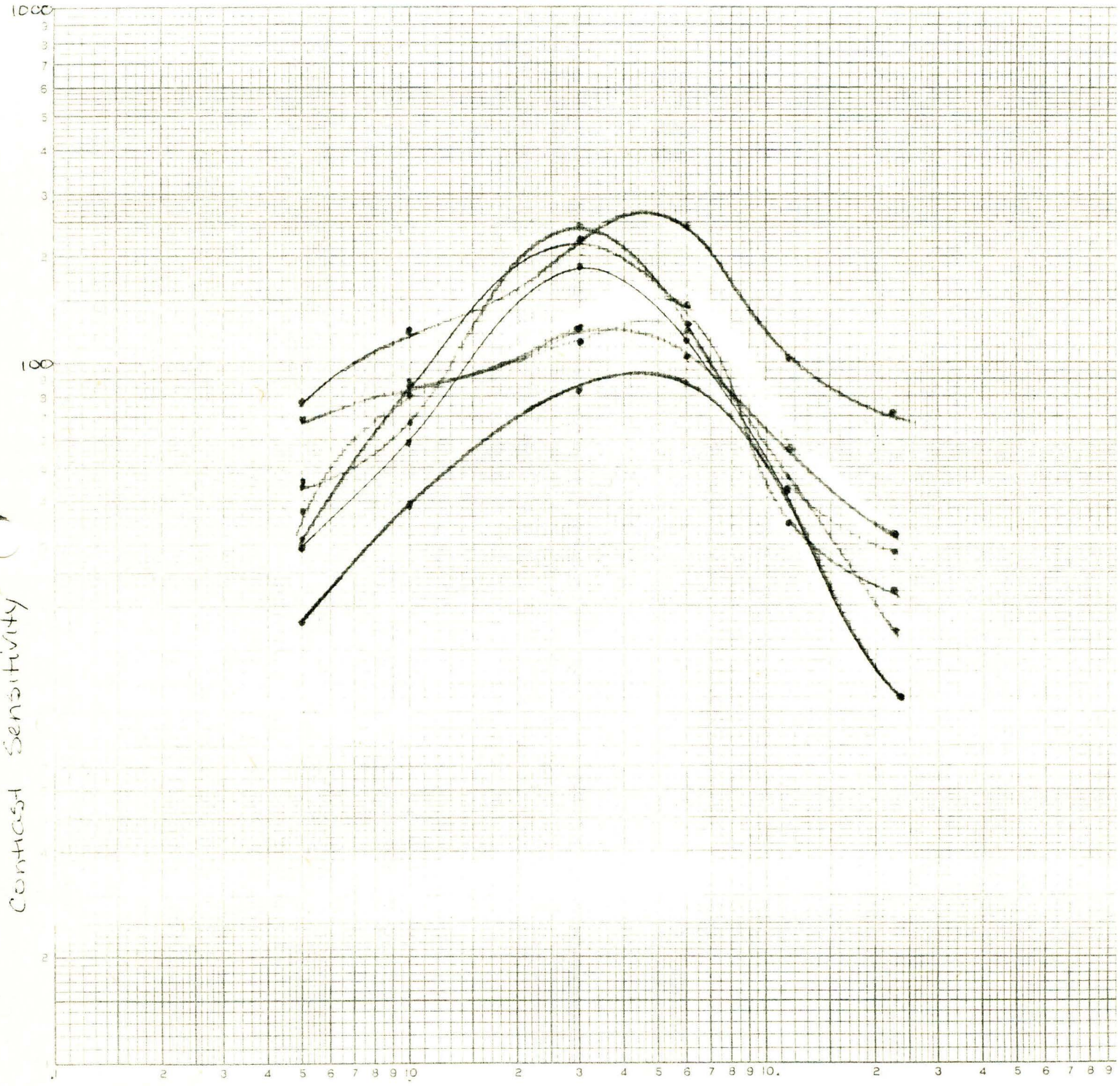
American Hydron CMS lens

Graph 1

CMS lens - first 7 patients graphed.

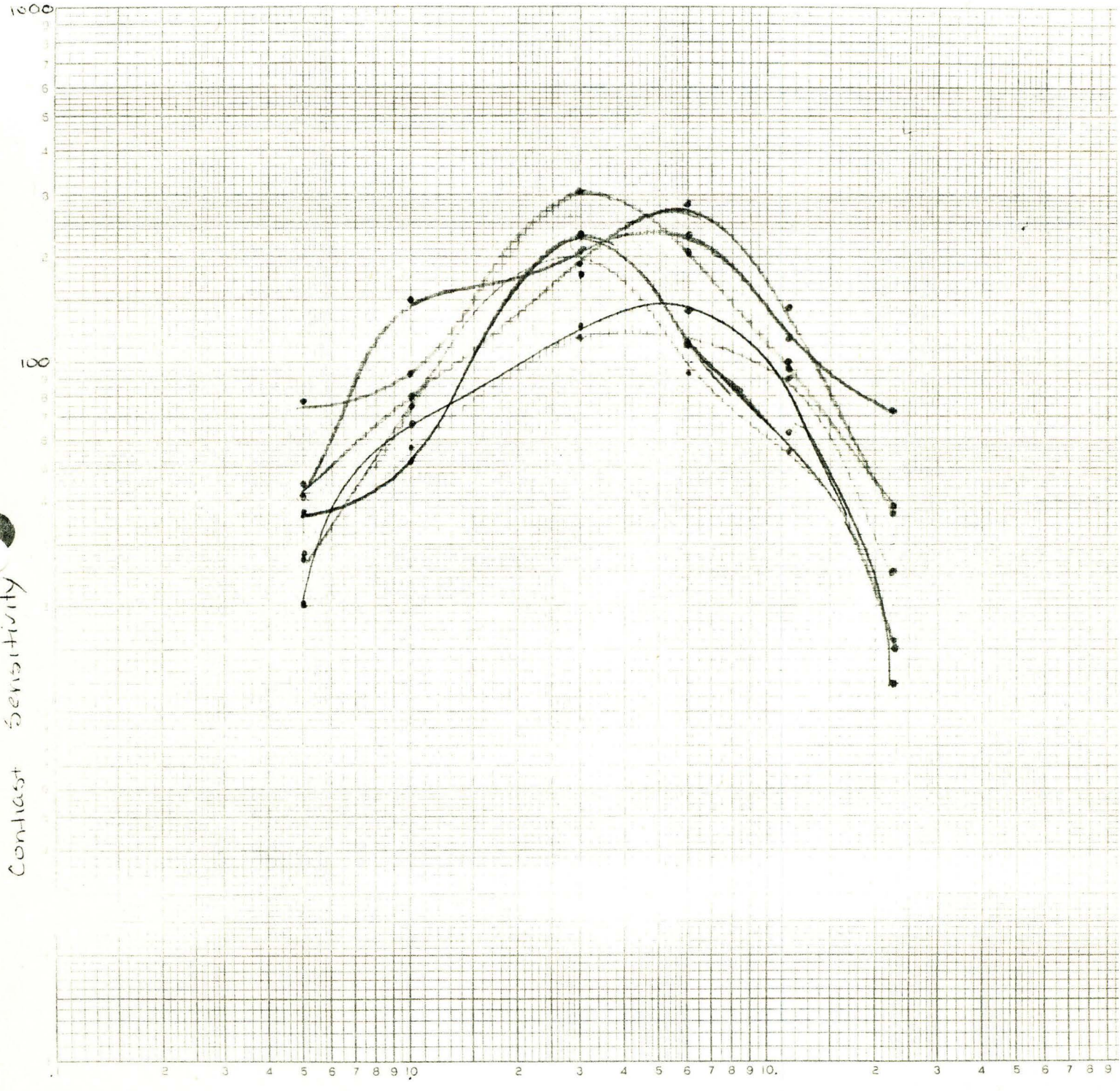


U4: lens- first 7 patients graphed



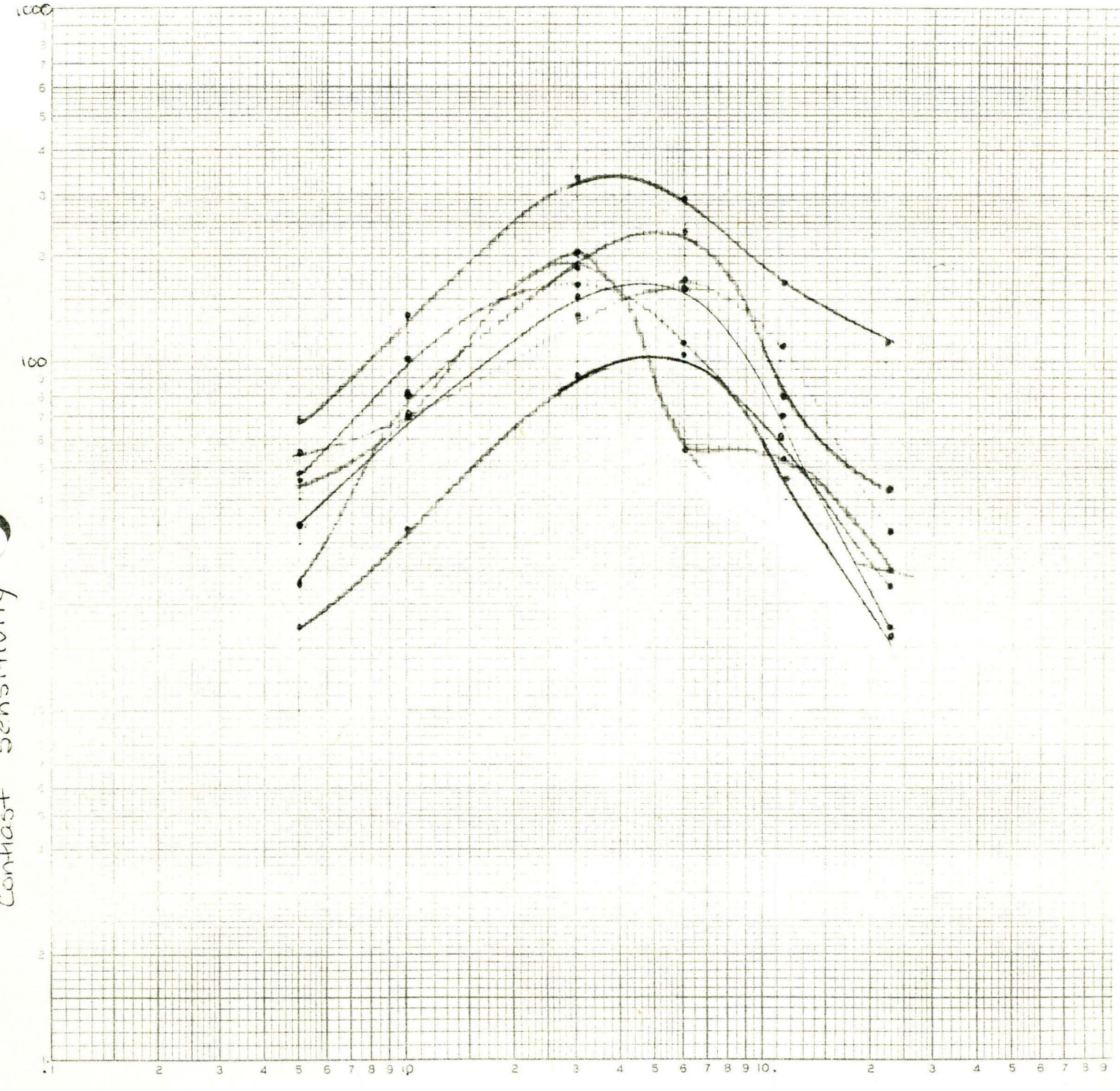
Graph 3

CSI. lens - first 7 patients graphed.



Graph H.

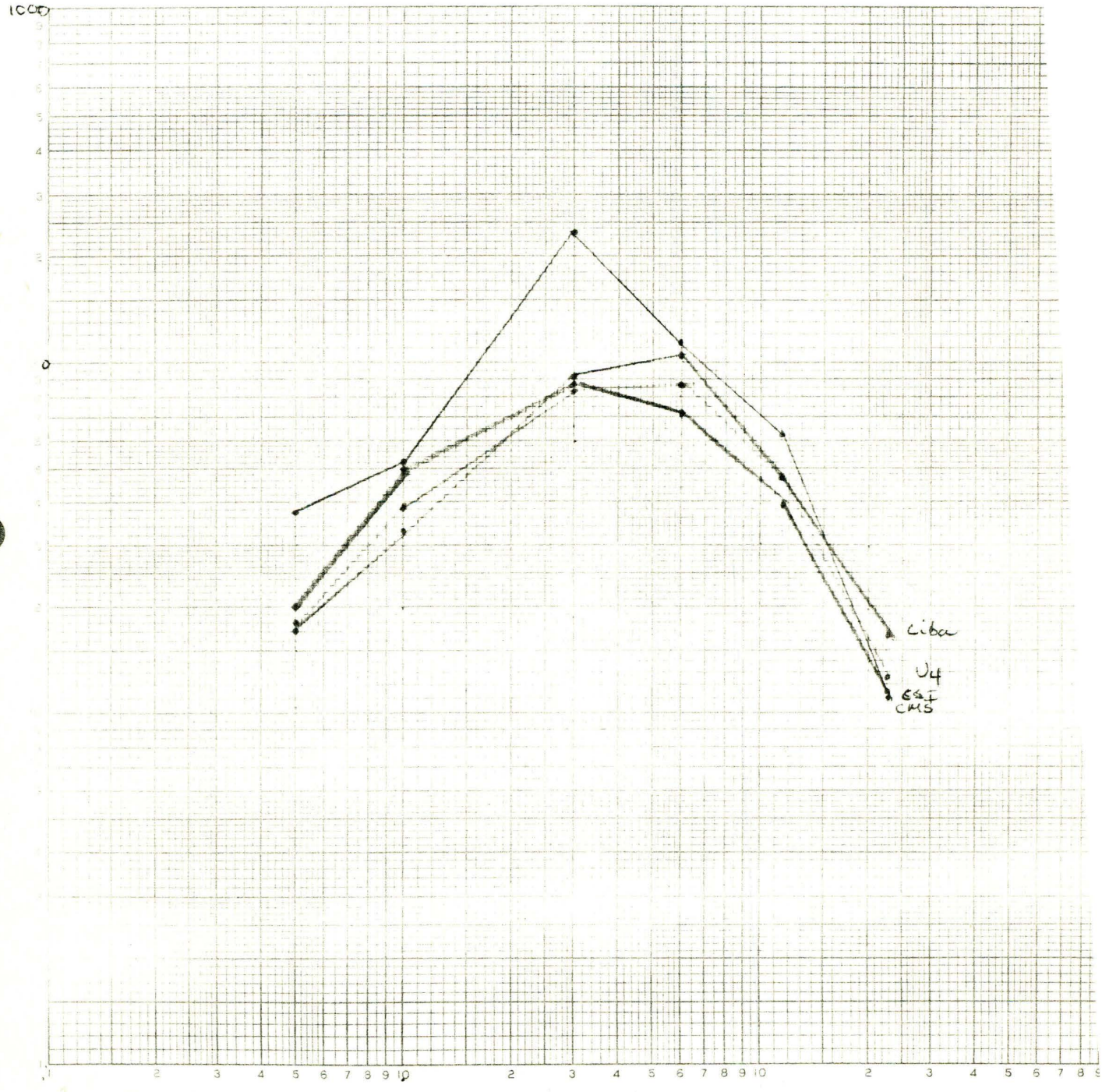
Ciba lens - first 7 patients graphed.



Graph 5

Cindy Copal

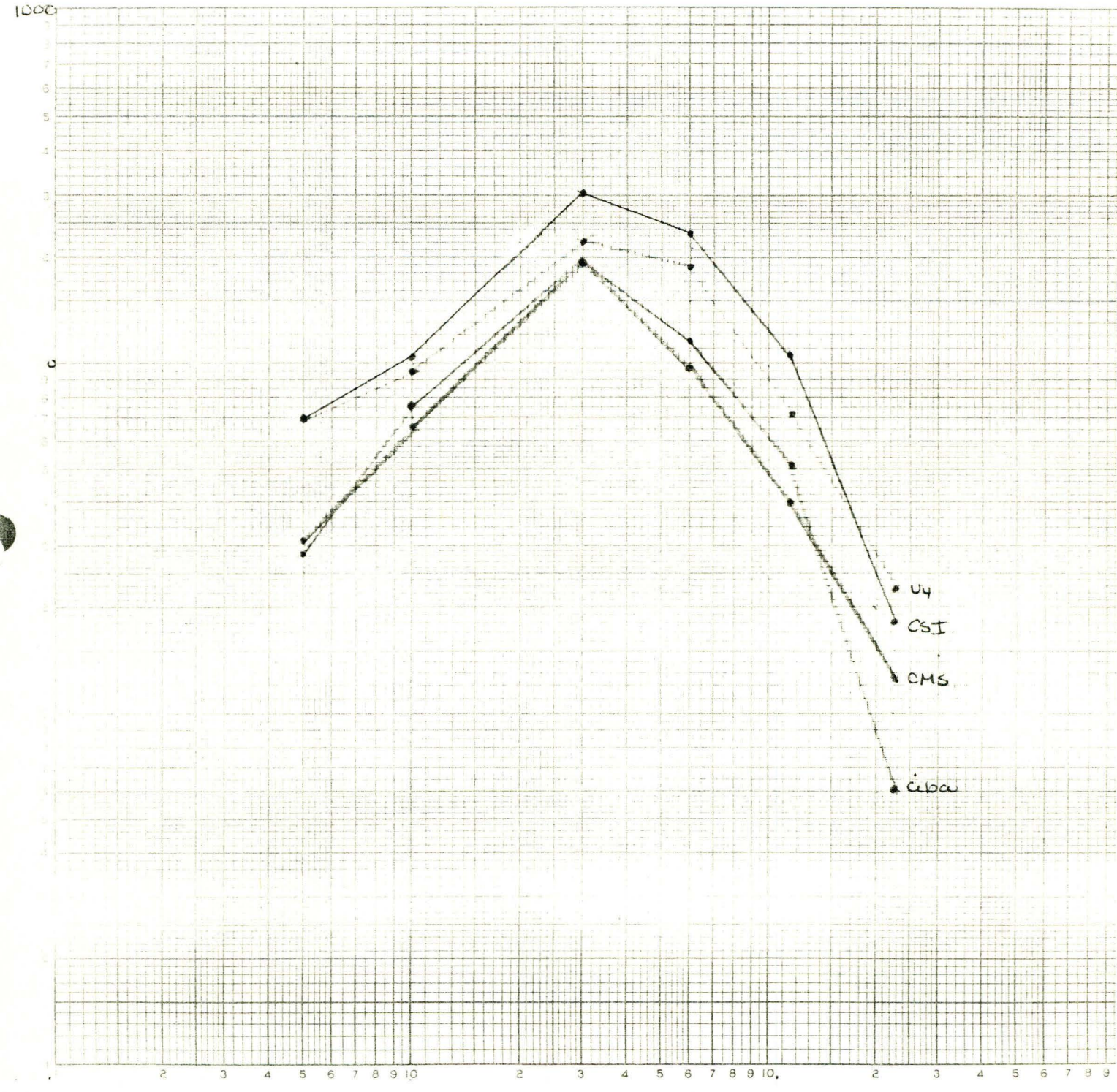
Contrast sensitivities of each lens.



Full Logarithmic, 3 × 3 Cycles

Linda White.

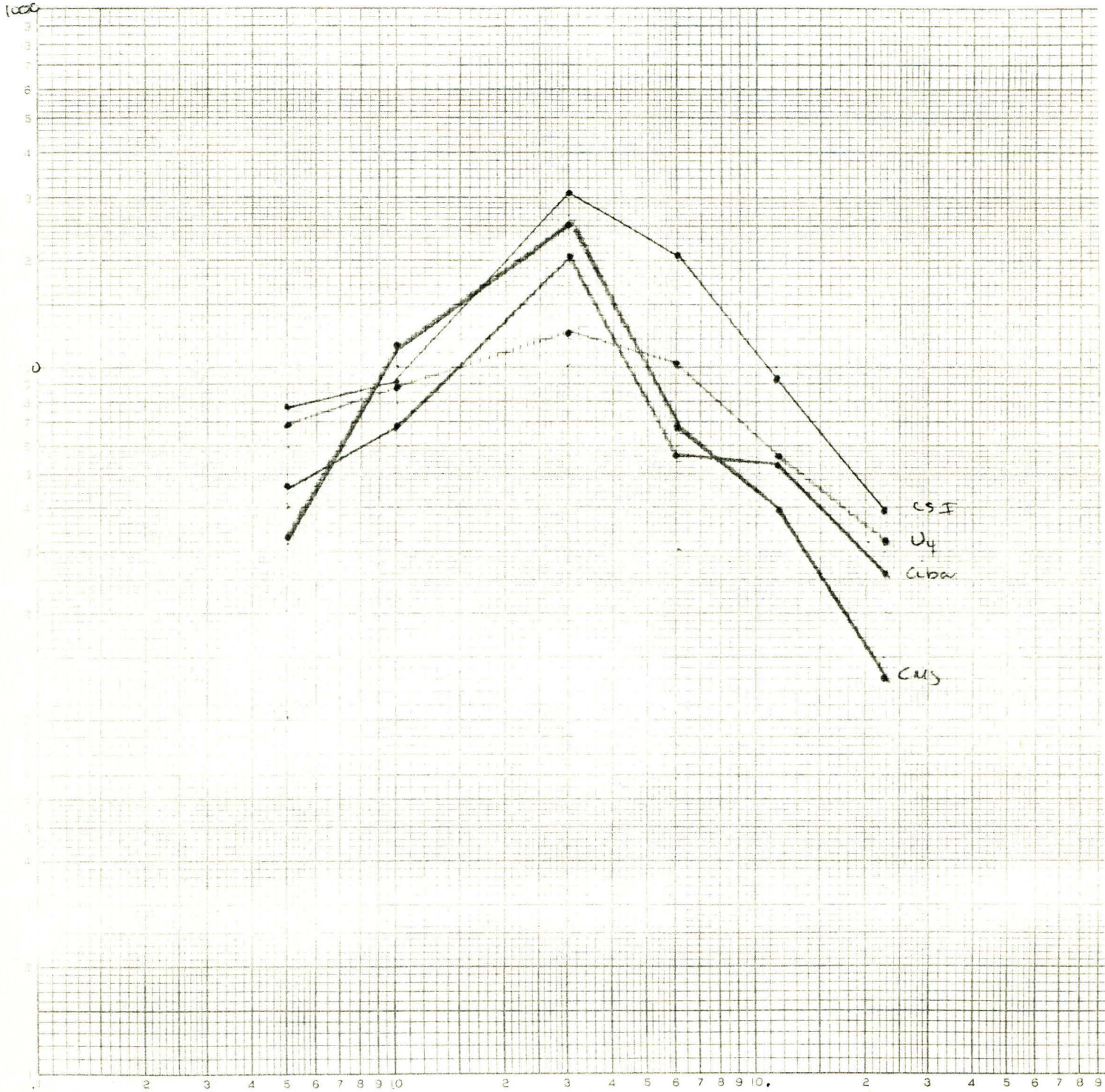
Contrast sensitivities of each lens.



Graph 7.

Tim Petito.

Contrast sensitivities of each lens.



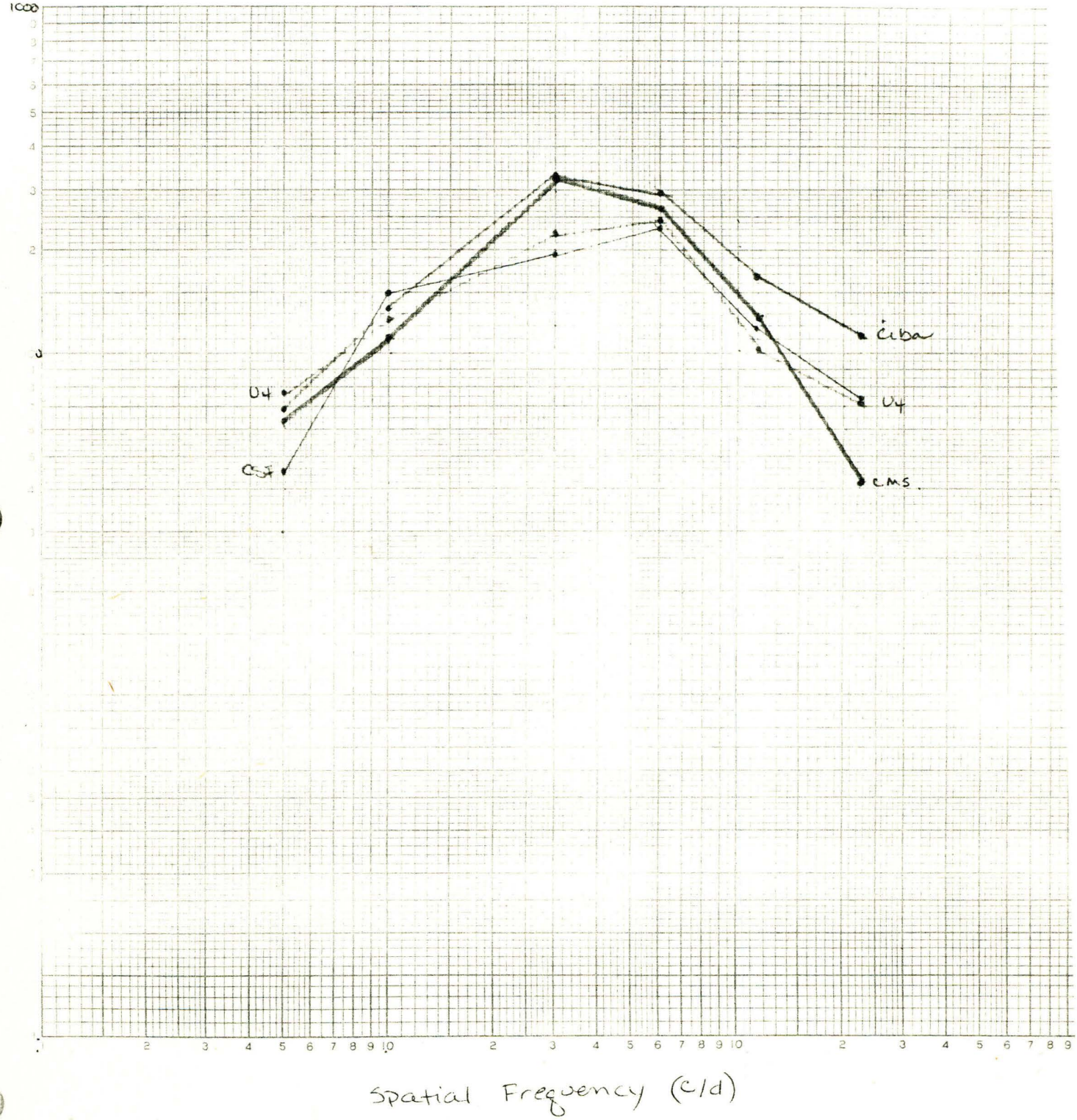
Contrast sensitivity

Spatial Frequency (c/d)

Graph 6

Dave Cleary.

Contrast sensitivities of each lens.

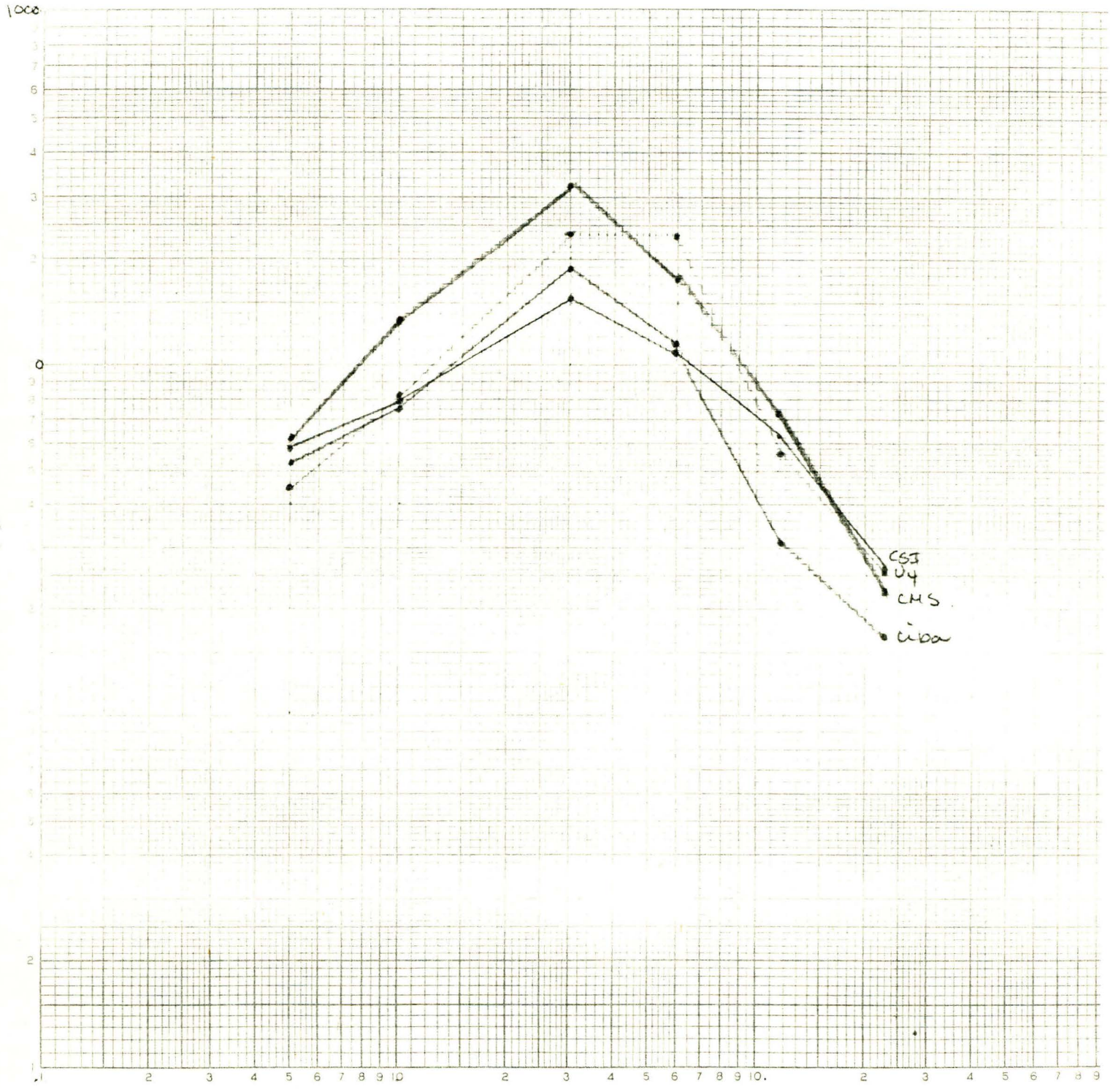


Full Logarithmic, 3 × 3 Cycles

Graph 9.

Steve Schaff.

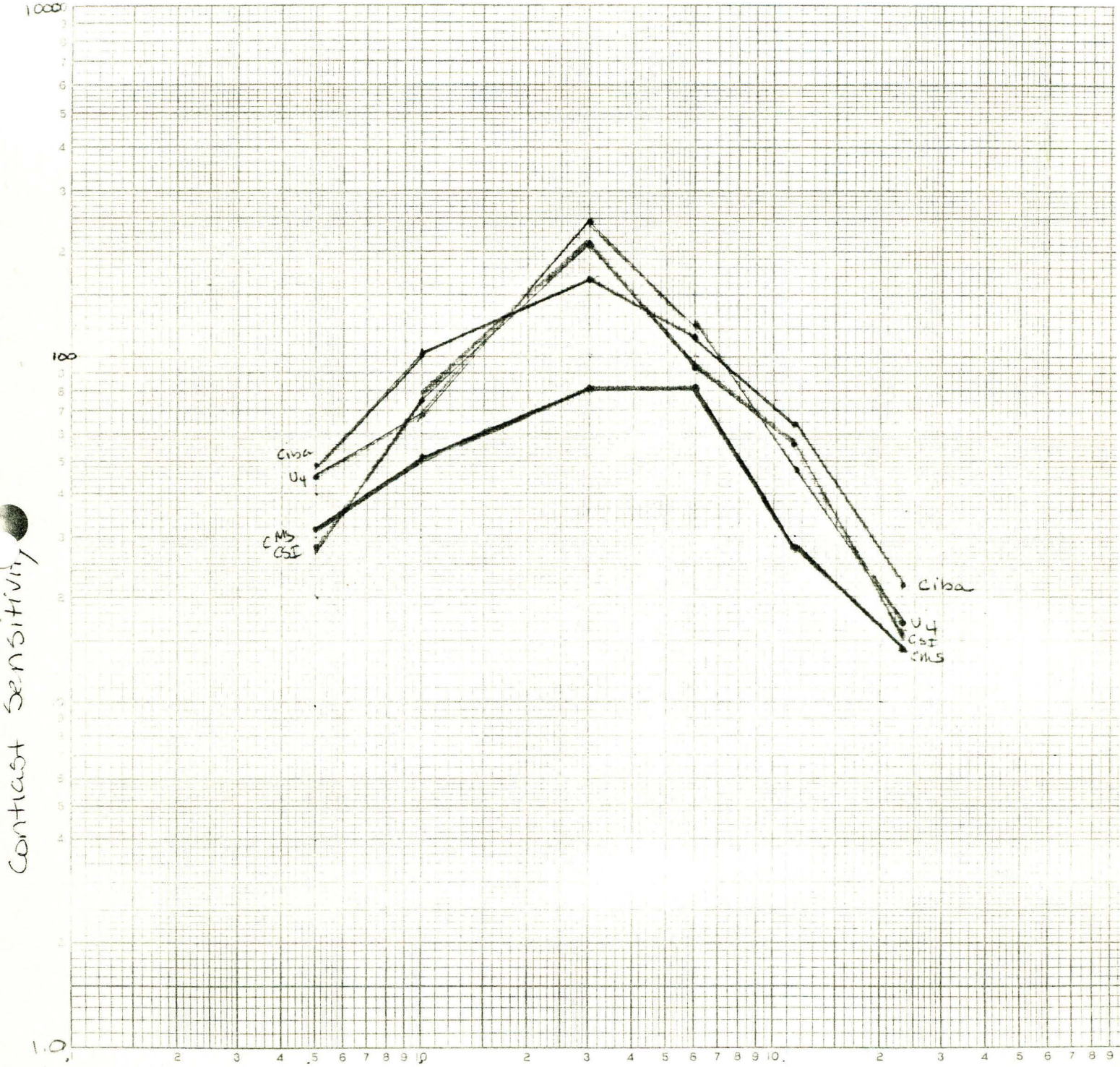
Contrast sensitivities of each lens.



Graph 10

Marty Faber

Contrast sensitivities of each lens.

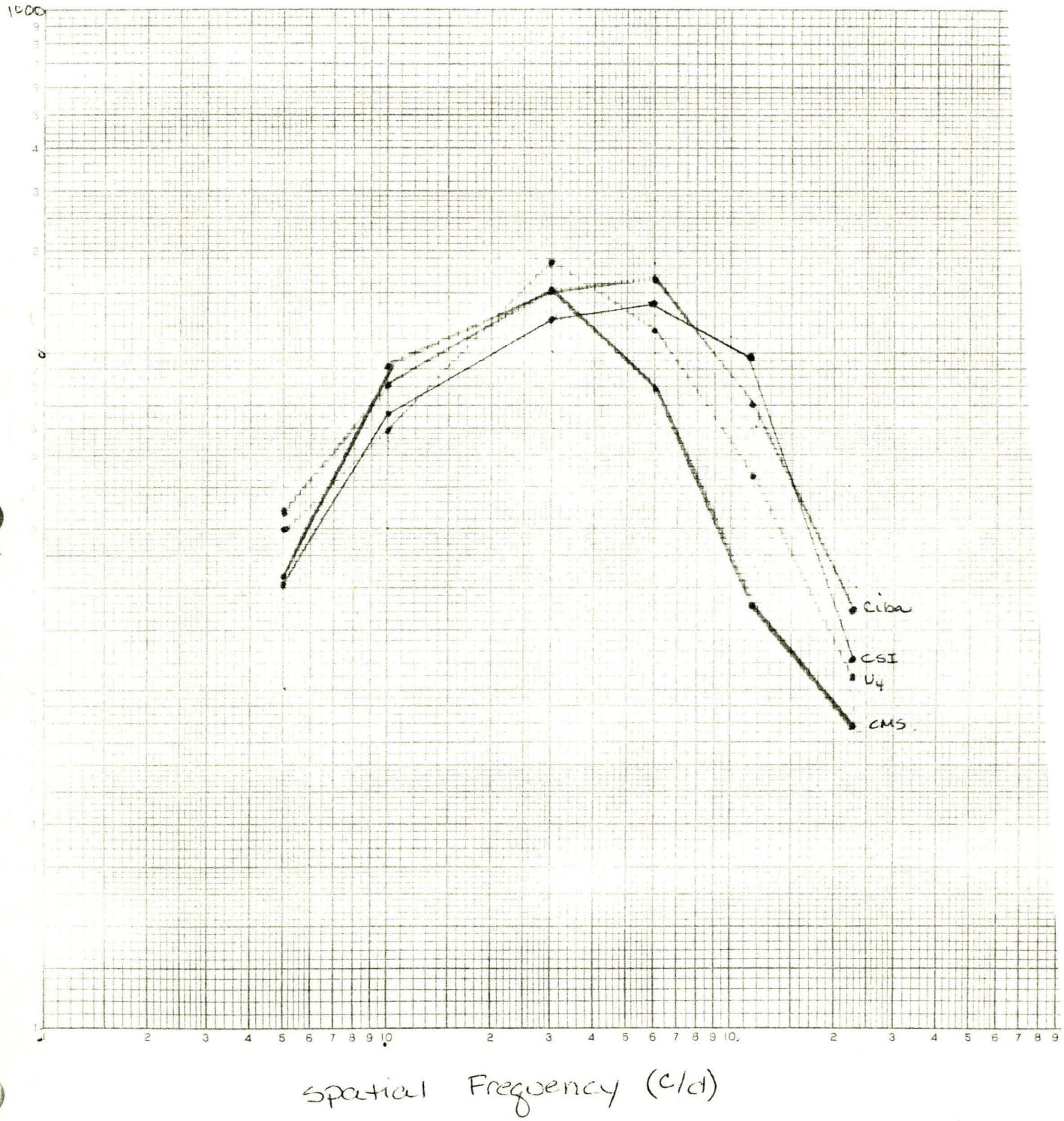


Spatial Frequency cld

Graph 11

Louis Boggs.

Contrast sensitivities of each lens

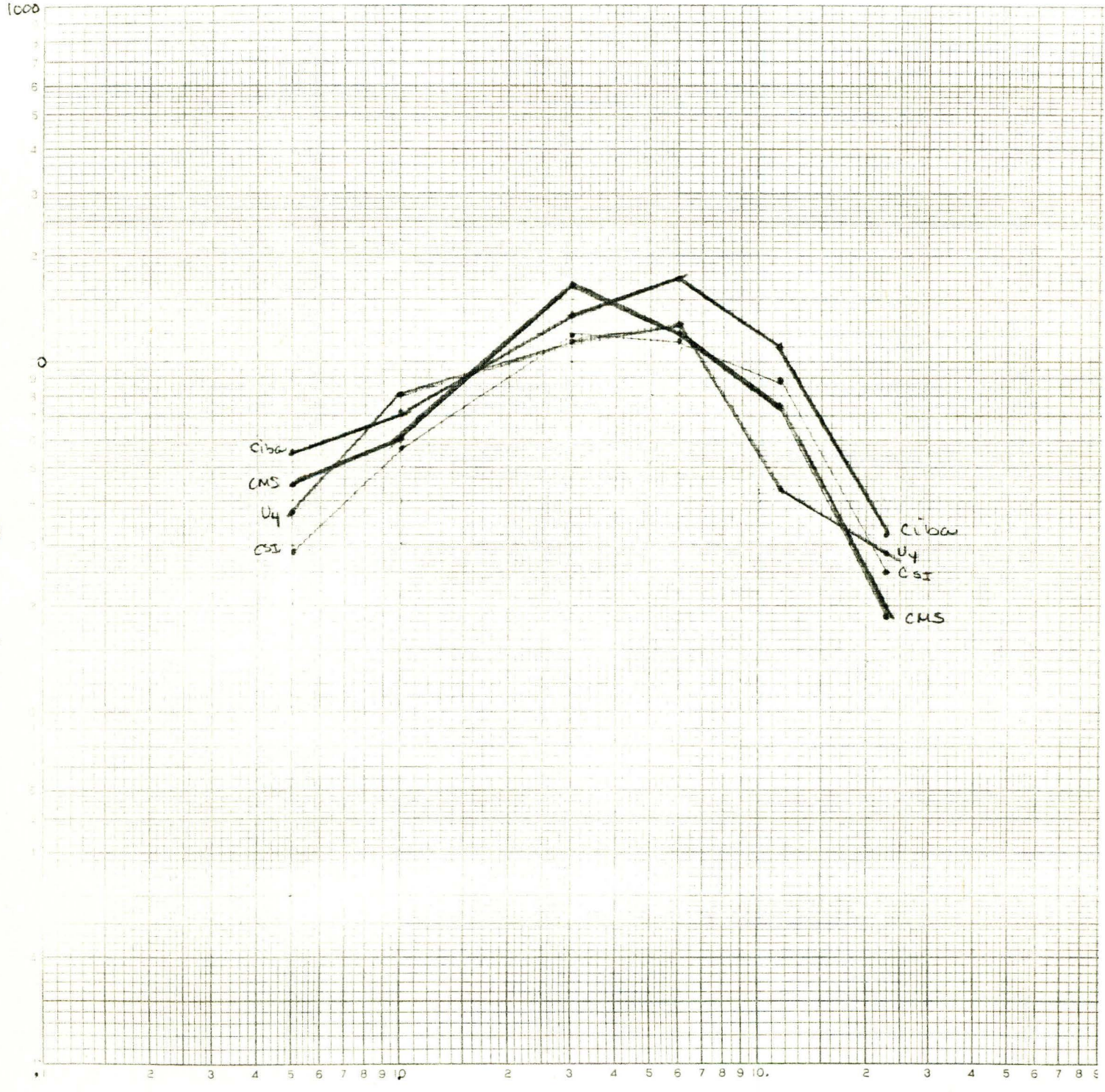


Full Logarithmic, 3 × 3 Cycles

Graph 12

Alicia Mitchell

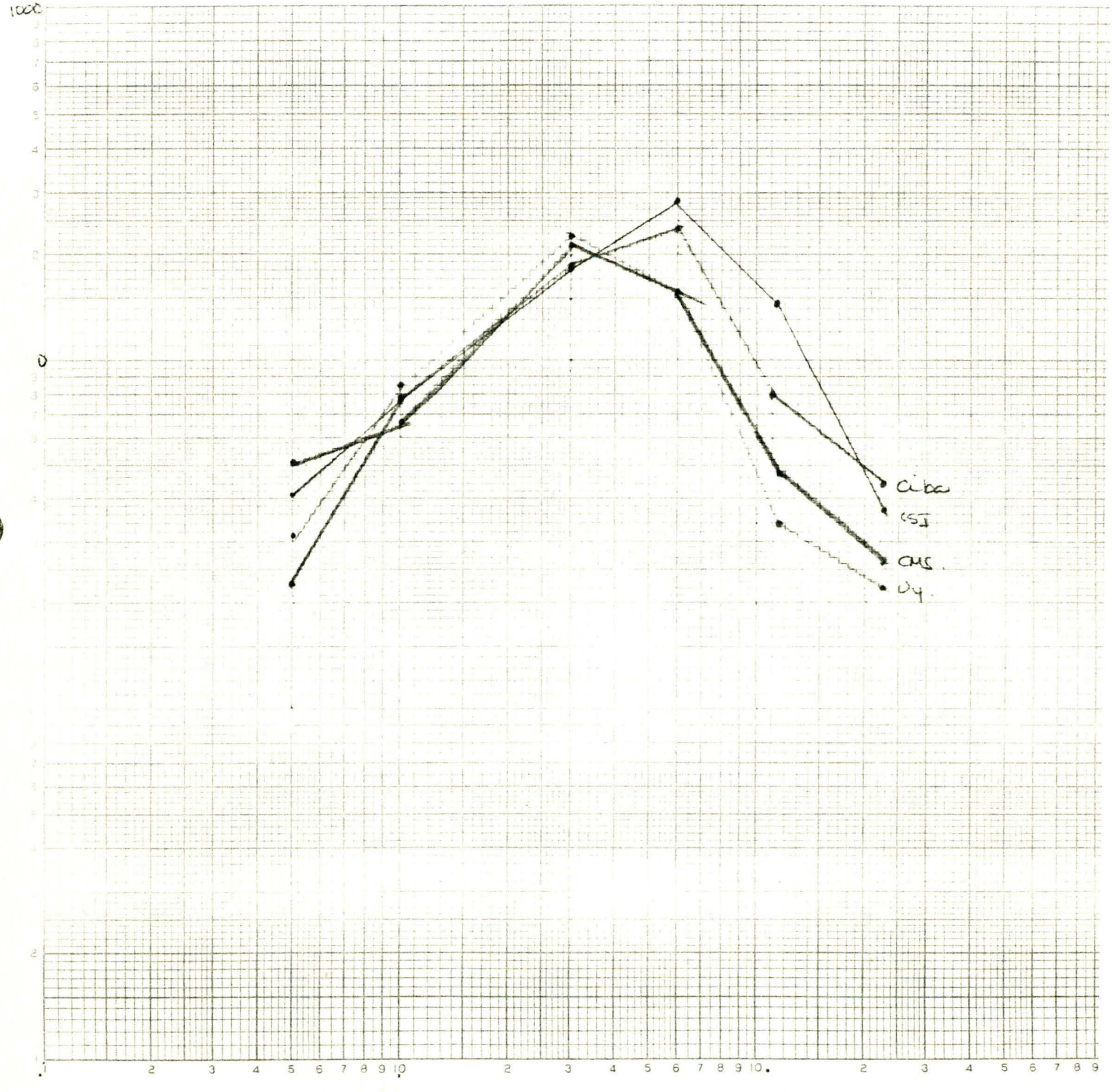
Contrast Sensitivities of each lens.



Graph 13.

Lorna Lewis.

Contrast sensitivities of each lens.

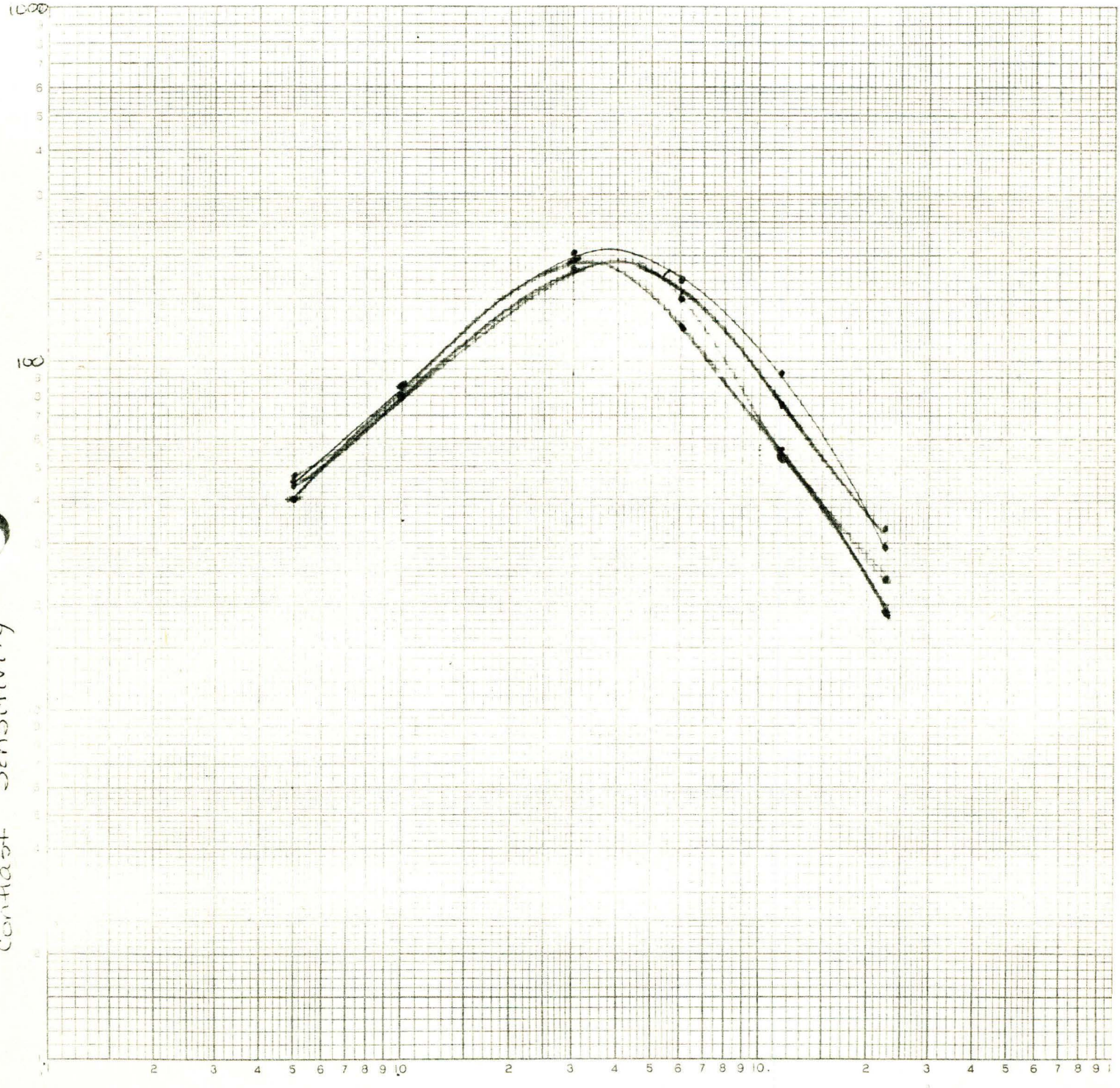


Graph 14

Means.

Contrast sensitivities of each lens' mean.

3x3



Graph 15

Means.

Contrast sensitivities of each lens' mean

2 x 2