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BINOCULAR DETERMINATION OF ASTIGMATIC POWER AND AXIS

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Approved ______________________

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PURPOSE OF THIS STUDY

The purpose of this study is to determine if any measurable difference exists in the astigmatic correction when this correction is determined under binocular testing conditions as opposed to the more traditional approach of testing monocularly and also, to determine if this difference, if any, is statistically significant.

HISTORICAL REVIEW

The determination of the astigmatic correction has received much thought and study since Thomas Young first described this common refractive anomaly. A study of two thousand cases revealed that more than eighty-three percent of the patients examined revealed some degree of astigmatic refractive error.[1]

Knapp, in 1866, devised a method of noting the axis of the cylindrical correcting lens. This method has since been adopted as the standard means of denoting axis location.[2]

John Green was the first to produce a distance target designed primarily for astigmatic testing. One of these targets is commonly used today, namely, the familiar "Clock Dial".[3]

A wide variety of tests and targets have been devised to determine the magnitude and direction of the astigmatic error. Borish[4] has reviewed the testing techniques in common use today. One of these techniques is the Jackson Cross Cylinder test for astigmatism.[5] One of the characteristics of this technique, as well as most other techniques, is that the patient is tested under monocular conditions, that is, the axis and power of the cylinder is determined first for one eye, and then the other and at no time is the patient in a binocular state.

This raised the question in the minds of the authors of whether the cylinder manifested in the Jackson Cross Cylinder technique would vary significantly from a similar determination under binocular conditions.

Humphriss[6] became concerned with the inaccuracies that are inherent in the assumption that the correcting lenses determined with one eye occluded accurately represent the refractive error when the patient is utilizing binocular vision. In an effort to solve this problem, Humphriss developed the H.I.C. technique of binocular refraction which is based on the hypothesis that "if one eye is slightly blurred, the central cones of the fovea centralis are suspended and then any alteration made in sharpness made to the retinal images is recorded by the unfogged eye. This means that by using the right amount of fogging, the macular area of the retina of one eye can be suspended, just as though it were occluded"... by some physical septum.

This hypothesis serves as the basis for the technique developed for this study. This technique has been called the B.A.T. (Binocular Astigmatic Test) by the authors and is described in the subsequent text.

PROCEDURE

The testing procedure was divided into two series, Series A and Series B. In Series A, the correcting cylinder was determined by utilizing the Jackson Cross Cylinder (JCC) technique first followed by the Binocular Astigmatic Test (BAT). Series B reversed this sequence. These series were devised in an attempt to eliminate a possible testing bias.

Procedure for Series A

I. Clock Dial Cylinder (Monocular)

A. Obtain 20/40 Blur

1. A single row of 20/40 letters is projected at twenty feet.
2. A fogging lens is presented monocularly and of sufficient plus power to blur-out the 20/40 letters.
3. The fogging lens is reduced monocularly until the subject can first distinguish two or three letters in the 20/40 line.
4. This procedure is followed for both eyes, first one and then the other.

B. Present Sunburst Target Monocularly

1. One eye is occluded and the subject is asked to view the Sunburst target at twenty feet.
2. The subject is asked "Do any of the lines on the target appear blacker or more distinct than the others?"
3. The axis of the correcting minus cylinder lies 90° from the line reported as being darkest.

C. Present Rotary "T" Target Monocularly

1. The "stem" of the T is oriented so as to be coincident with the axis meridian of the correcting minus cylinder. The subject will now report that the stem of the T is darker and more distinct than the top of the T.

2. Minus cylinder is added in .25 diopter steps until reversal is obtained, that is, the top of the T now appears darker and more distinct.
3. Repeat steps 1 and 2 for the previously occluded eye and record the power and axis as the "Clock Dial" cylinder.

II. Red-Green Test (Monocular)

1. Room illumination is dropped to a low level and the Bichrome target is presented at twenty feet.
2. The subject is allowed to view the target monocularly and is asked "On which side of the target are the letters clearer or blacker?"
3. Since the 20/40 blur lenses are still in place, the subject will report that the red side is clearer. If not, plus spheres are added until this report is obtained.
4. Plus sphere is now reduced until the subject reports that the two sides are equally clear or, if this is not possible, until the point is reached whereby the next reduction of lens power makes the green side clearer.
5. Steps 2 through 4 are repeated for the other eye and the lens power remaining in the refractor is recorded as the "Red-Green" lens.

III. Jackson Cross Cylinder Test (Monocular)

1. The subject is allowed to view a single row of 20/30 letters monocularly at twenty feet.
2. The Cross Cylinder is moved into place with the "handle meridian" coincident with the axis meridian of the "Clock Dial" cylinder.
3. The subject is now given the following instruction: "You will be given two choices. Indicate which choice you prefer, number one or number two."

4. The Cross Cylinder is now flipped so that the meridian of plus power is now where the minus was and the minus where the plus was.
5. If a preference for one position is indicated, the axis of the minus correcting cylinder is moved 5^{o} closer to the meridian in which the "red dot" (minus cyl. axis) of the Cross Cylinder was in the preferred position. This procedure is repeated until no preference is shown for either position of the Cross Cylinder.
6. The position of the axis remaining in the refractor represents the axis of the minus correcting cylinder as determined by the JCC technique.
7. The power of the minus correcting cylinder is now determined by rotating the Cross Cylinder handle meridian 45^{o} so that the plus and minus axes of the Cross Cylinder are coincident with the axis of the refractor. The Cross Cylinder is flipped again and the subject is again given two choices. If a preference is shown when the minus axis of the Cross Cylinder is coincident with the axis of the refractor, minus cylinder is added in .25 diopter steps. Conversely, minus cylinder is reduced if the "plus axis" position is preferred. The spherical equivalent is maintained when adding and removing cylinder power.
8. The procedure in step 7 is repeated until no preference is shown for either position of the Cross Cylinder. The minus cylinder power remaining in the refractor is recorded as the power of the minus correcting cylinder as determined by the JCC technique.

9. Steps 1 thru 8 above are repeated for the previously occluded eye and the axis and power are recorded in a similar manner.

IV. Binocular Astigmatic Test

1. The refractor is now cleared and the Red-Green lens is introduced in front of the eye to be tested.
2. A 20/40 blur is obtained for the eye not being tested. This is achieved in the same manner as outlined earlier.
3. A single row of 20/30 letters is projected at twenty feet and the subject is allowed to view the letters binocularly.
4. Since the Red-Green lens is before the eye being tested, the subject will be able to see the 20/30 line clearly. However, the 20/40 blur lens in front of the other eye will not permit the subject to see this 20/30 line clearly with this eye -- the letters will appear blurred. Even though the letters appear blurred, there is still sufficient stimulus to fusion to permit the subject to perform binocularly. Thus, any judgements involving fine discrimination of the 20/30 line will be a function of the stimulus received by the testing eye.
5. The axis and power of the minus correcting cylinder is now determined for each eye in the exact same manner as outlined for the JCC technique with the exception being that the target is viewed binocularly with the proper control lens in front of each eye as outlined in step 1 and 2 above.

ORGANIZATION OF THE DATA

Forty seven subjects, ranging in age from twenty to twenty eight, participated in this study. All of the subjects were optometry students. Of the forty seven subjects tested, there was one female and forty six males.

TABLE I, page 9, is a tabulation of the raw data.

TABLE II, page 10, is a diagramatic representation of the With and Against the Rule astigmatism as determined by J.C.C. and B.A.T.

TABLE III, page 11, is a diagramatic representation of the Oblique astigmatism as determined by J.C.C. and B.A.T.

TABLE I

TABULATION OF RAW DATA

SUBJECT	J.C.C. O.D.	J.C.C. O.S.	B.A.T. O.D.	B.A.T. O.S.
1	- .87 X 90	-1.12 X 90	-1.00 X 90	-1.00 X 90
2	- .62 X 17	- .12 X 180	- .37 X 12	- .37 X 10
3	- .50 X 95	- .50 X 100	- .75 X 95	- .75 X 95
4	sphere	- .37 X 30	- .12 X 95	- .37 X 35
5	- .25 X 30	- .12 X 125	- .25 X 40	sphere
6	sphere	- .12 X 60	sphere	- .12 X 50
7	- .25 X 155	- .12 X 5	- .37 X 150	- .25 X 10
8	- .25 X 120	- .37 X 70	- .25 X 120	- .37 X 75
9	- .37 X 85	- .62 X 75	- .37 X 77	- .50 X 77
10	- .25 X 65	- .62 X 105	- .37 X 95	- .50 X 105
11	- .37 X 35	- .12 X 120	- .25 X 40	- .12 X 115
12	-1.37 X 140	-1.37 X 40	-1.25 X 140	-1.12 X 40
13	- .50 X 95	- .37 X 82	- .62 X 97	- .25 X 82
14	- .62 X 178	-1.25 X 165	- .62 X 170	-1.12 X 165
15	- .37 X 60	sphere	- .12 X 60	- .12 X 50
16	-1.62 X 88	- .75 X 80	-1.37 X 90	- .87 X 80
17	- .12 X 135	- .25 X 90	- .12 X 135	- .25 X 90
18	- .37 X 90	- .75 X 105	- .37 X 90	- .37 X 115
19	- .37 X 153	- .50 X 7	- .50 X 153	- .37 X 15
20	- .12 X 100	sphere	- .12 X 100	sphere
21	- .62 X 130	- .62 X 15	- .62 X 130	- .75 X 25
22	- .87 X 100	- .87 X 100	-1.12 X 100	- .75 X 95
23	- .37 X 105	- .62 X 73	- .37 X 110	- .62 X 75
24	- .75 X 180	-1.00 X 5	- .87 X 2	- .87 X 175
25	- .37 X 175	- .12 X 15	- .37 X 152	- .37 X 17
26	- .37 X 105	- .62 X 73	- .37 X 110	- .62 X 75
27	- .50 X 80	- .75 X 70	- .75 X 80	- .75 X 75
28	- .25 X 13	- .37 X 178	- .50 X 10	- .62 X 175
29	-1.00 X 5	- .87 X 10	- .87 X 175	-1.00 X 5
30	- .25 X 60	- .37 X 50	- .25 X 35	- .12 X 50
31	sphere	- .75 X 12	- .12 X 83	- .62 X 15
32	-1.37 X 65	- .50 X 70	-1.12 X 65	- .37 X 70
33	- .87 X 95	-1.00 X 90	-1.00 X 90	-1.00 X 90
34	- .75 X 110	- .50 X 55	- .75 X 115	- .50 X 60
35	- .37 X 178	- .37 X 10	- .37 X 172	- .37 X 13
36	sphere	- .37 X 35	- .12 X 150	- .37 X 35
37	-1.37 X 110	-1.50 X 80	- .87 X 105	-1.37 X 80
38	- .62 X 118	-1.25 X 47	- .75 X 118	-1.25 X 47
39	- .50 X 70	sphere	- .62 X 75	sphere
40	- .12 X 85	- .37 X 55	sphere	- .37 X 30
41	sphere	sphere	sphere	sphere
42	- .25 X 150	- .12 X 15	- .37 X 155	- .37 X 15
43	- .62 X 180	- .25 X 5	- .87 X 5	- .37 X 175
44	sphere	-1.00 X 175	sphere	-1.25 X 172
45	sphere	- .50 X 142	sphere	- .62 X 140
46	-1.12 X 97	- .37 X 32	- .87 X 92	- .37 X 30
47	- .50 X 15	- .37 X 25	- .50 X 18	- .25 X 45

TABLE II

SCATTER DIAGRAM OF WITH
AND AGAINST THE RULE
ASTIGMATISM AS DETER-
MINED BY J.C.C. & B.A.T.

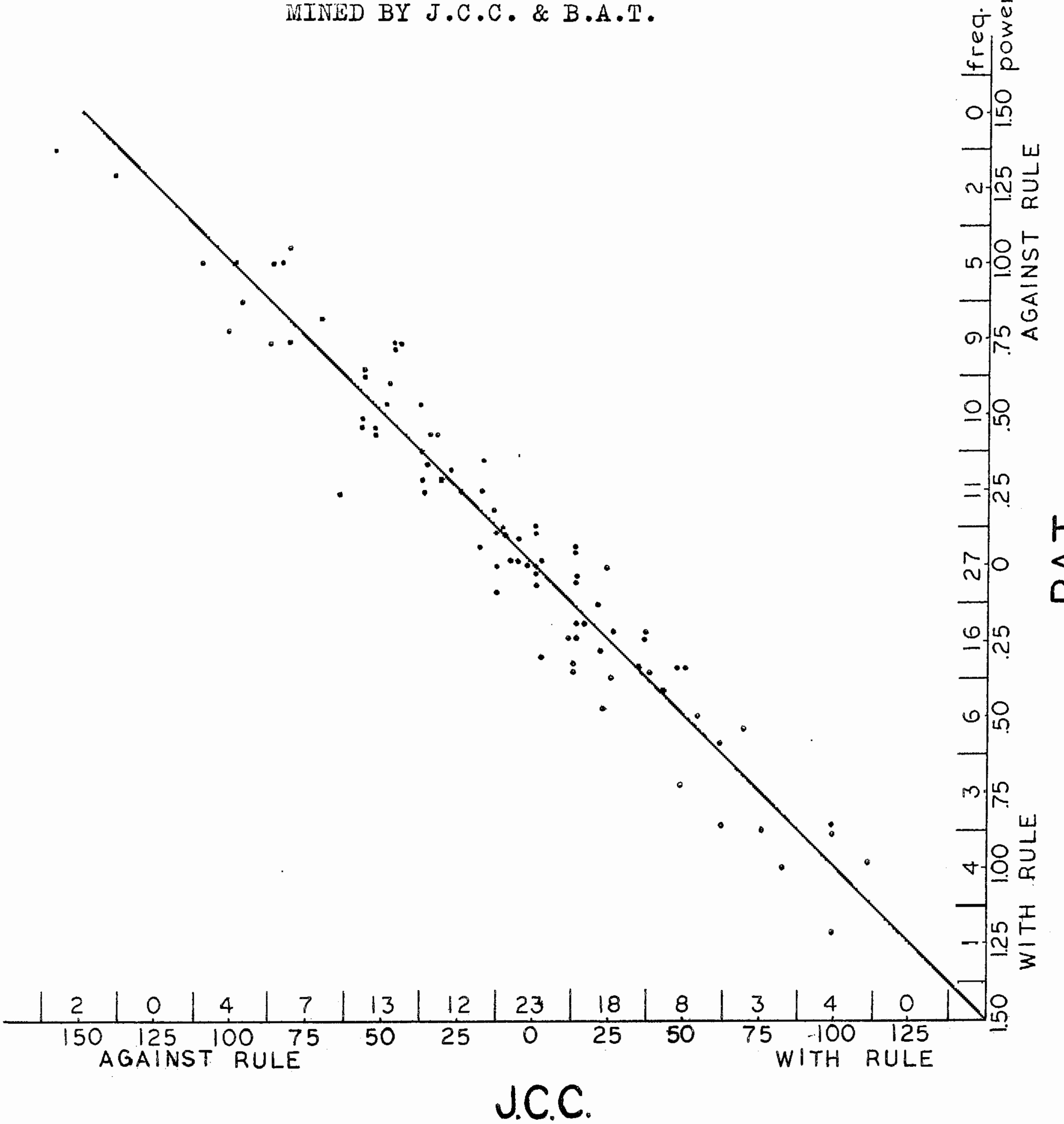
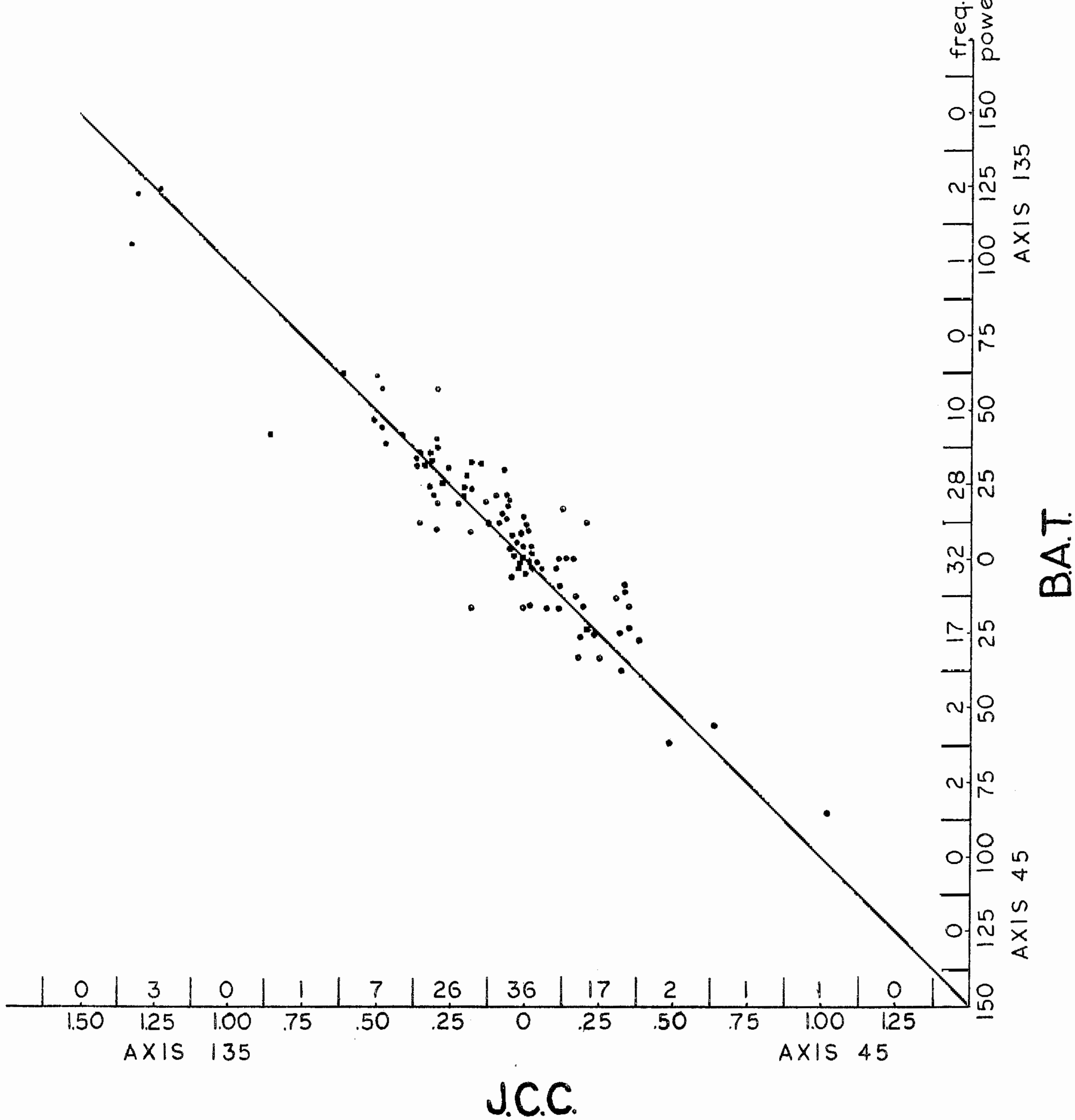


TABLE III

SCATTER DIAGRAM OF OBLIQUE ASTIGMATISM AS DETERMINED BY J.C.C. & B.A.T.



ANALYSIS OF STATISTICS

In order to facilitate the analysis of the data collected, all cylinder powers were separated into their equivalent components in the 90-180 meridians and 45-135 meridians using the $\sin^2$ function. This method permitted a breakdown of the data into two groups, With and Against the Rule cylinder and Oblique cylinder. In order to eliminate cylinder axis as a variable, axis 45 degrees for the right eye was made equal in sign to axis 135 degrees for the left eye.

The results of these calculations are represented graphically in Table II and Table III.

Results of the Statistical Analysis:[7]

With & Against Rule	MEAN	STD. DEV.	STD. ERROR OF MEAN
J.C.C. -----	.07 X 90	.28 D	0.029 D
B.A.T. -----	.08 X 90	.25 D	0.026 D
Oblique			
J.C.C. -----	.08 X 135	.25 D	0.026 D
B.A.T. -----	.09 X 135	.23 D	0.024 D

CONSIDERATION OF VARIABLES

Variables that were considered in this study:

1) Instruction to the subject -- the instructions to be given were memorized by each examiner and were presented in a standardized sequence.

2) Technique -- this remained constant for each testing sequence as outlined in the previous text.

3) Instrumentation --

   a. Refractors -- only Bausch and Lomb "Greens" refractors were used throughout this study.
   b. Projectors -- only Bausch and Lomb projectors were used throughout this study.
   c. Targets -- only Bausch and Lomb "Sunburst", "Bichrome", and "Rotary T" targets were used.
   d. Cross Cylinders -- the power of the Cross Cylinders was kept constant at $\pm$.37 diopter.
   e. Illumination -- room illumination was held constant at 15 ft. candles during astigmatic testing.

4) Age of Subjects -- the age of the subjects included in this study ranged from twenty to twenty eight years of age.

5) Number of Examiners -- three.

SUMMARY

Forty seven subjects were tested for astigmatic correction monocularly and binocularly. The data obtained from this testing was evaluated statistically by comparison of the Mean, Standard Error, and the Standard Error of the Mean of the J.C.C. and B.A.T. data. This comparison indicates that there is no measurable difference between the two testing techniques.

It is the opinion of the authors that the astigmatic correction measured binocularly is as accurate as the correction measured monocularly.

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