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Correlation of the Jackson cross cylinder test and the Matsuura autocross test as to cylinder axis and power, subject preference, and administration time

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Abstract

The purpose of this study is to compare the efficiency of the Matsuura AutoCross with that of the Jackson Cross Cylinder (JCC) in revealing the existance of astigmatism, its axis and amount in the human eye, and to determine if the AutoCross technique was a valid one and could be a practical substitution for the Jackson Cross Cylinder test.

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CORRELATION OF THE JACKSON CROSS CYLINDER TEST
AND THE MATSUURA AUTOCROSS TEST AS TO CYLINDER
AXIS AND POWER, SUBJECT PREFERENCE, AND ADMINIS-
TRATION TIME

by

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ACKNOWLEDGEMENT

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PURPOSE

The purpose of this study is to compare the
efficiency of the Matsuura AutoCross with that of the
Jackson Cross Cylinder (JCC) in revealing the existance
of astigmatism, its axis and amount in the human eye,
and to determine if the AutoCross technique was a
valid one and could be a practical substitution for
the Jackson Cross Cylinder test.

REVIEW OF THE LITERATURE

Matsuura states that "when a person is asked to differentiate between two objects that differ only slightly, it is much simpler if they are both viewed at the same time."[1] The author has devised an instrument which will allow the patient to see both of the JCC images at the same time. The instrument couples to the eyepiece of the refractor so that as the axis knob of the refractor is turned, the dual crossed cylinders rotate with the axis of the correcting cylinder. The testing was done in the usual manner after the tentative cylinder and axis had been determined by other methods.

The author states that "the instrument has been valuable in hundreds of cases. Even in low astigmatic errors, the axis and power were determined quite readily."[2] Matsuura also states that "patients find it simple to understand, and its use eliminates tedious repetition and thus significantly shortens the time required for this phase of the refraction."[3] The optical principles of the instrument were not given.

In 1965 Robert E. Vaughn[4] developed a similar instrument with which to measure the astigmatism—called the Bi-Cross Cylinder. The cylinder optics of this instrument are as follows:

The Bi-Cross cylinder testing device makes use of two lenses:
    A. Maddox prism.
    B. Bi-Cross cylinder lens.
The Maddox prism produces the monocular diplopia necessary for the successful use of this instrument.

The Bi-Cross cylinder lens is so constructed and arranged in this instrument that the two images produced by the Maddox prism are viewed in such a manner as to be similar to the two positions considered when using the JCC technique. The lens is mounted so it may be placed in one of two positions; axis determination or power determination.

A similar instrument was devised by W.J. Biessels which he called the Cross Cylinder Simultan test.[5] It is a tiny instrument to be attached to a phoropter or inserted into a trial frame. Like the two previously mentioned techniques, the patient no longer sees the cross-cylinder images in succession but simultaneously. Since they are juxtaposed and contiguous, Biessels states that "the patient can compare the images easily, with the least possible concentration and effort of memory."[6]

The optics of the Simultan are similar to those employed in Vaughn's Bi-Cross cylinder. The housing of the instrument consists of a tube which fits into the front entrance portal of a phoropter. The doubling device consists of two parallel prismatic mirrors so arranged that the image of a distant object is doubled

vertically. The entering rays must pass through two
lenses similar·to the Bi-Cross cylinder lenses of
Vaughn. These two images viewed are similar to the
two positions considered when using the JCC technique.
The whole device may be rotated for axis determination
or power determination. Biessel states that "this
method is very comfortable for the patient in that
he does not have to exert himself to give the true
answers, and that the most complicated cases only take
a few minutes to test."[7]

PROCEDURE

A total of fifty-five subjects were tested by the three exaiminers.

The instruments used in this study were the Bausch and Lomb Green's refractor, the Bausch and Lomb projector, and the Matsuura AutoCross.*

All testing procedures were done at distance as outlined below. The subject's farpoint interpupillary distance was measured and the refractor adjusted accordingly.

I. Jackson Cross Cylinder Method:

A. With spheres only the subject's vision was blurred until one or two letters of the 20/40 horizontal Snellen letters could be called monocularly by both the right and left eyes.

B. The clock dial was presented monocularly, first to the right eye and then to the left, and the subject was asked to indicate which line appeared blackest and most distinct.

C. The cylinder axis was placed perpendicular to the blackest line and minus cylinder power was added in .25 D. steps until the line 90 degrees removed from the original black line appeared most distinct.

D. The red-green control target was next presented before the right eye and the subject was asked to report on which side the letters appeared clearer and blacker. The plus power was reduced until the subject reported the green side better. The procedure was repeated on the left eye.

* Distributed in the U.S. by Dr. Morton K. Greenspoon, O.D., 14635 Ventura Blvd., Sherman Oaks, California, under the trade-name of Topcon

E. The JCC was placed monocularly before the right eye so that the two meridians of power were bisected by the axis of the correcting cylinder. The JCC was flipped so that the meridians of plus power (white dots) and minus power (red dots) exchanged places. The subject was asked to select the position of best acuity as he viewed the horizontal 20/40 Snellen letters. If one position was preferred, the axis of the minus correcting cylinder was then placed 5 degrees closer to the meridian in which the red dots were in the preferable position. The JCC was realigned so that the new axis position bisected it and the test was repeated until a position of the correcting cylinder was found at which no preference was shown for either position of the JCC.

F. The handle of the JCC was shifted 45 degrees so that the power was placed in the axis and perpendicular to the axis of the cylinder. The handle was rotated and the position of the dots was reversed. The subject was asked to determine, by viewing the 20/40 test type, which position seemed preferable. If the preferable position was that in which the red dots coincided with the axis of the minus cylinder the power of the cylinder was increased in .25 D. steps and the test was repeated. If the preferable position was the opposite, then the power was reduced. This was repeated until the subject reported equality of the simultaneously presented acuity material.

G. This axis and power refinement was then repeated for the left eye.

II. AutoCross Method:

A. The lens control was replaced to the
    clockdial cylinder axis and power and
    the red-green sphere combined with
    -.50 D.
B. The AutoCross eyepiece was inserted
    into the right accessory cell of the
    refractor while the left eye was
    occluded.
C. The subject reported monocular dip-
    lopia of the 20/40 horizontal Snellen
    letters.
D. The AutoCross was set for axis deter-
    mination and the subject was asked to
    report which image appeared clearer.
    If the right image was clearer, the
    axis knob was turned in the direction
    of the arrow marked around it until
    the left image appeared clearer. The
    direction was reversed until the images
    appeared equal in acuity. The cylinder
    axis was recorded.
E. The AutoCross was set for power deter-
    mination and the subject was again
    asked to report the better of the two
    images seen. If the right image was
    better the power of the correcting cyl-
    inder was decreased. If the left
    image was better the cylinder power
    was increased. The cylinder power
    which equalized the two images was
    recorded.
F. The procedure was repeated for the
    left eye.
G. The subject was asked to report whether
    he preferred the alternate method (JCC)
    or the simultaneous method (AutoCross).
H. To eliminate examiner bias, the JCC
    technique preceded the AutoCross tech-
    nique for the first twenty eight sub-
    jects and then this sequence was
    reversed so that the AutoCross tech-
    nique was run first on the remaining
    twenty seven subjects.

I. A record of the elapsed time to ad-
minister the JCC test and the admin-
istration time of the AutoCross test
was kept on the last forty subjects.

AUTOCROSS
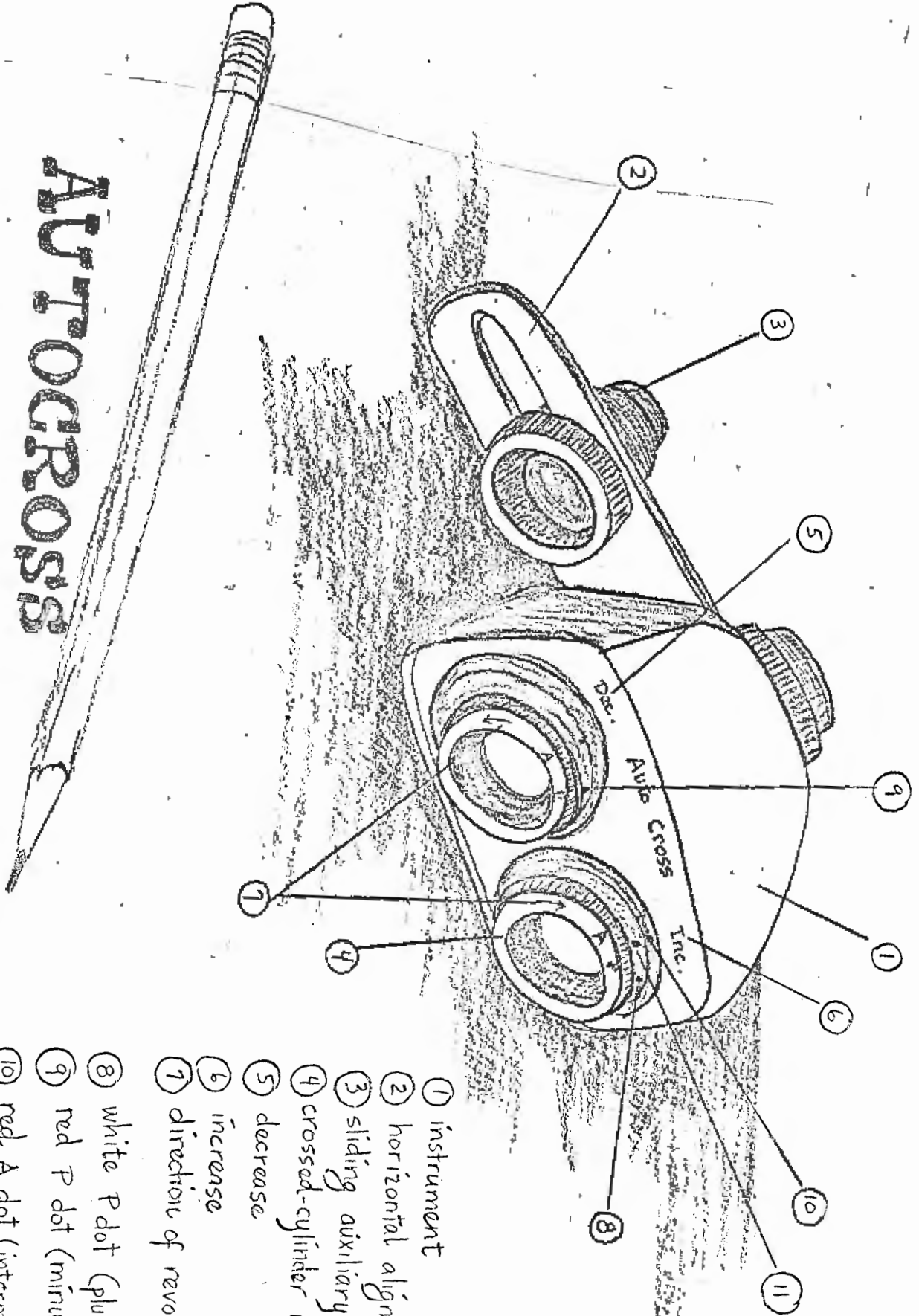
① instrument
② horizontal aligning arm
③ sliding auxiliary eyepiece
④ crossed-cylinder rings
⑤ decrease
⑥ increase
⑦ direction of revolution
⑧ white P dot (plus axis)
⑨ red P dot (minus axis)
⑩ red A dot (intermediate axis)
⑪ alignment dot

ORGANIZATION OF THE DATA

Fifty five subjects, both male and female, were tested. The first twenty eight subjects were given the JCC test first followed by the Matsuura AutoCross test. In order to eliminate examiner bias, this sequence was reversed for the remaining twenty seven subjects who were given the AutoCross test first followed by the JCC test.

Table I, page 11, is a tabulation of the raw data which includes subject preference.

Table II, page 14, is a comparison of the administration time between the JCC and Auto-Cross.

Scattergram I, page 15, is a comparison of the cylinder power of the right eye as done by the JCC and AutoCross.

Scattergram II, page 16, is a comparison of the cylinder power of the left eye as done by the JCC and AutoCross.

Scattergram III, page 17, is a comparison of the cylinder axis of the right eye as done by the JCC and the AutoCross.

Scattergram IV, page 18, is a comparison of the cylinder axis of the left eye as done by the JCC and the AutoCross.

TABLE I

RAW DATA

Case No.	JCC		AutoCross		
	OD	OS	OD	OS	Preference
1	-.75 x 23	-.75 x 160	-.75 x 23	-.62 x 163	JCC
2	-1.00 x 18	-.87 x 1	-1.12 x 18	-.87 x 3	A
3	-.75 x 135	-.62 x 25	-.75 x 135	-.62 x 25	A
4	-.25 x 5	-.62 x 5	-.25 x 5	-.62 x 12	A
5	-.37 x 65	-.25 x 45	-.37 x 62	-.25 x 45	Equal
6	-.25 x 5	-.25 x 125	-.37 x 5	-.25 x 147	A
7	-.37 x 142	-.50 x 135	-.37 x 144	-.50 x 38	A
8	-.25 x 55	-.25 x 30	-.25 x 60	-.25 x 34	A
9	-.37 x 15	-.12 x 180	-.37 x 15	-.12 x 10	A
10	-.25 x 42	-.75 x 2	-.25 x 45	-.75 x 10	A
11	-.25 x 135	-.50 x 55	-.25 x 135	-.50 x 53	A
12	-.50 x 145	-.25 x 20	-.50 x 150	-.37 x 16	A
13	-.25 x 105	-.12 x 45	-.25 x 105	-.25 x 55	Equal
14	-.75 x 90	-1.00 x 95	-.75 x 87	-1.00 x 96	A
15	-.37 x 105	-.25 x 77	-.25 x 105	-.25 x 75	A
16	-.87 x 5	-.87 x 175	-1.25 x 1	-1.00 x 177	A
17	-.25 x 180	-.25 x 95	-.25 x 5	-.25 x 92	A
18	-1.00 x 100	-.62 x 85	-1.00 x 96	-.62 x 83	A
19	-.25 x 180	-.25 x 15	-.25 x 180	-.12 x 45	A
20	-.12 x 85	-.37 x 55	-.12 x 98	-.50 x 60	A
21	-.50 x 47	-.75 x 170	-.50 x 44	-1.00 x 170	A
22	-.75 x 80	-.75 x 80	-.62 x 85	-.62 x 8	A

TABLE I (con't.)

Case No.	JCC		AutoCross		Preference
	OD	OS	OD	OS	
23	-1.25 x 135	-1.50 x 35	-1.25 x 138	-1.37 x 35	A
24	-.75 x 150	-.12 x 74	-.62 x 149	-.12 x 75	JCC
25	-.75 x 170	-.75 x 3	-1.00 x 170	-1.00 x 3	A
26	-.75 x 110	-.50 x 52	-.87 x 111	-.62 x 55	A
27	-2.00 x 180	-1.00 x 65	-2.00 x 2	-1.12 x 65	JCC
28	-.75 x 121	-.25 x 90	-.87 x 120	-.12 x 101	Equal
	AutoCross		JCC		
29	-.25 x 74	-1.00 x 95	-.37 x 85	-.50 x 92	Equal
30	-.50 x 75	-.25 x 55	-.50 x 77	-.12 x 60	Equal
31	-.12 x 130	-.62 x 175	-.37 x 135	-.62 x 180	A
32	-.50 x 110	-.12 x 20	-.50 x 105	-.12 x 45	A
33	-1.00 x 2	-.75 x 160	-1.00 x 180	-1.00 x 160	A
34	-1.25 x 82	-.50 x 80	-1.25 x 89	-.75 x 78	JCC
35	-.37 x 14	-.12 x 62	-.50 x 15	-.25 x 65	A
36	-.25 x 76	-.24 x 14	-.50 x 79	plano	JCC
37	-.12 x 170	-.12 x 5	-.12 x 170	plano	A
38	-.25 x 85	-.12 x 45	-.25 x 92	plano	A
39	-.12 x 90	-.25 x 57	-.12 x 100	-.37 x 29	A
40	-1.37 x 85	-1.12 x 90	-1.37 x 83	-1.12 x 90	A
41	-.50 x 110	-.75 x 105	-.37 x 110	-.37 x 117	A
42	-1.75 x 119	-1.50 x 55	-1.75 x 116	-1.37 x 57	JCC
43	-.62 x 105	-1.37 x 43	-.62 x 105	-1.25 x 45	JCC
44	-.12 x 75	plano	-.12 x 75	plano	JCC

TABLE I (con't.)

Case No.	AutoCross		JCC		
	OD	OS	OD	OS	Preference
45	-.62 x 127	-.50 x 71	-.62 x 127	-.62 x 72	JCC
46	-1.25 x 88	-.75 x 95	-1.37 x 90	-.87 x 103	Equal
47	-1.00 x 105	-.25 x 107	-.87 x 105	-.50 x 109	A
48	-.37 x 100	plano	-.37 x 105	plano	A
49	-.25 x 5	-.37 x 40	-.12 x 90	-.37 x 45	JCC
50	-.62 x 17	-.25 x 170	-.75 x 20	-.12 x 165	A
51	-.75 x 5	-1.25 x 180	-.75 x 5	-.87 x 7	Equal
52	plano	plano	plano	-1.75 x 172	JCC
53	plano	-.25 x 100	plano	-.37 x 95	A
54	-.25 x 107	plano	-.62 x 45	-.37 x 110	JCC
55	-1.75 x 45	-1.50 x 170	-1.62 x 47	-1.50 x 170	JCC

TABLE II

Administration Time
(to nearest .5 minute)

Case No.	Jackson Cross Cylinder	Matsuura AutoCross
16	6	5
17	4	4
18	4	3.5
19	2.5	3.5
20	5.5	8.0
21	5	5.5
22	5	5
23	4	4
24	3.5	3
25	2.5	3
26	3.5	4
27	3	3
28	3	5
29	4	3
30	4	3.5
31	4	2.5
32	3	3
33	4	3.5
34	2.5	3
35	4	4
36	5	3.5
37	4	3
38	4	4
39	4	3
40	3.5	4
41	4.5	3.5
42	3.5	2.5
43	3	3.5
44	3.5	3
45	4	5.5
46	4	3
47	4	4
48	5	4.5
49	4	3.5
50	5	4
51	4	3
52	4	3
53	3	2.5
54	4	6
55	4	4

SCATTERGRAM I

Power of the cylinder of the right
eye as done by the JCC and AutoCross
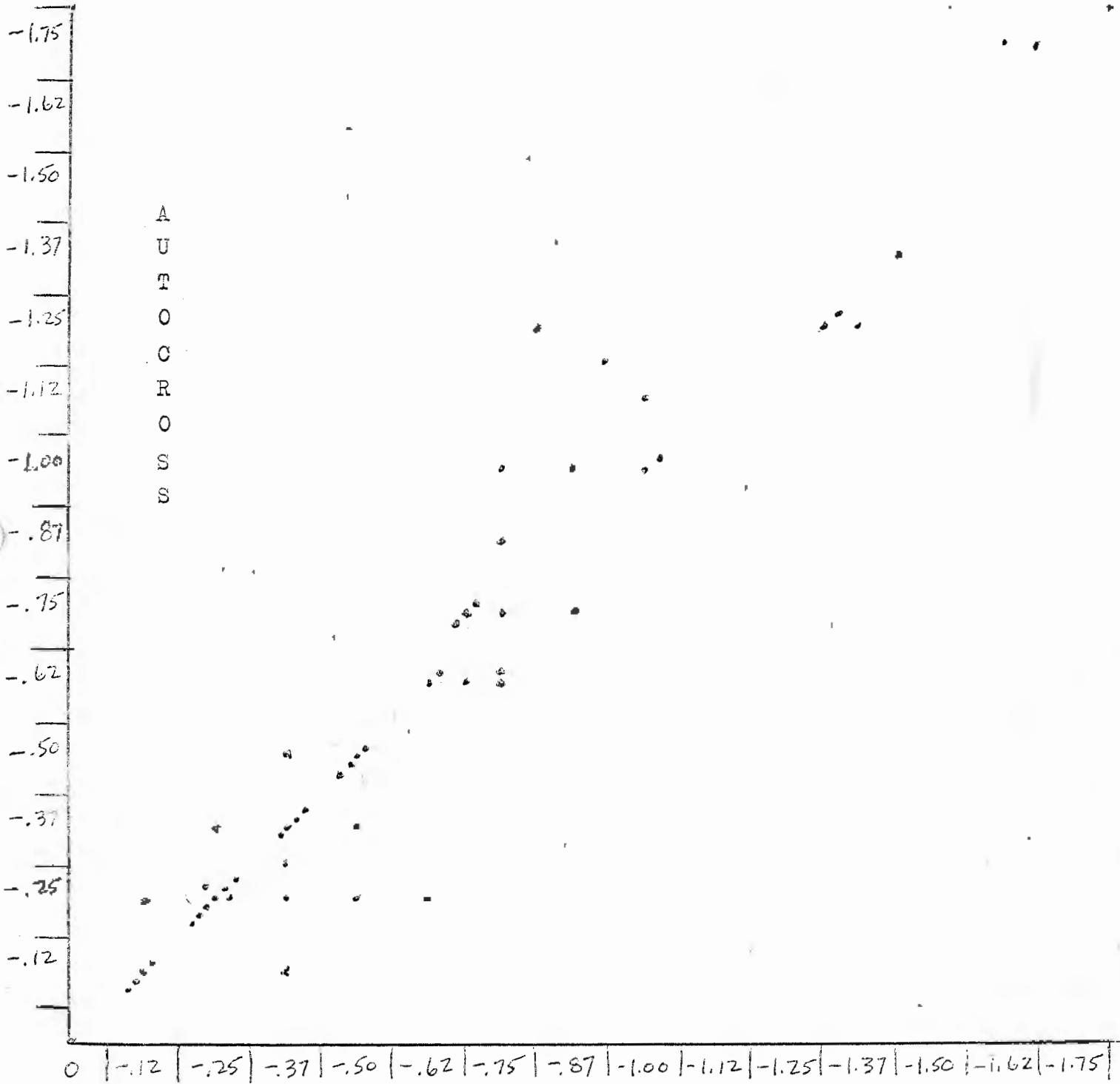
Jackson Cross Cylinder

SCATTERGRAM II

Power of the cylinder of the left
eye as done by the JCC and AutoCross

A
U
T
O
C
R
O
S
S

-1.75
-1.62
-1.50
-1.37
-1.25
-1.12
-1.00
-.87
-.75
-.62
-.50
-.37
-.25
-.12

0   -.12 -.25 -.37 -.50 -.62 -.75 -.87 -1.00 -1.12 -1.25 -1.37 -1.50 -1.62 -1.75
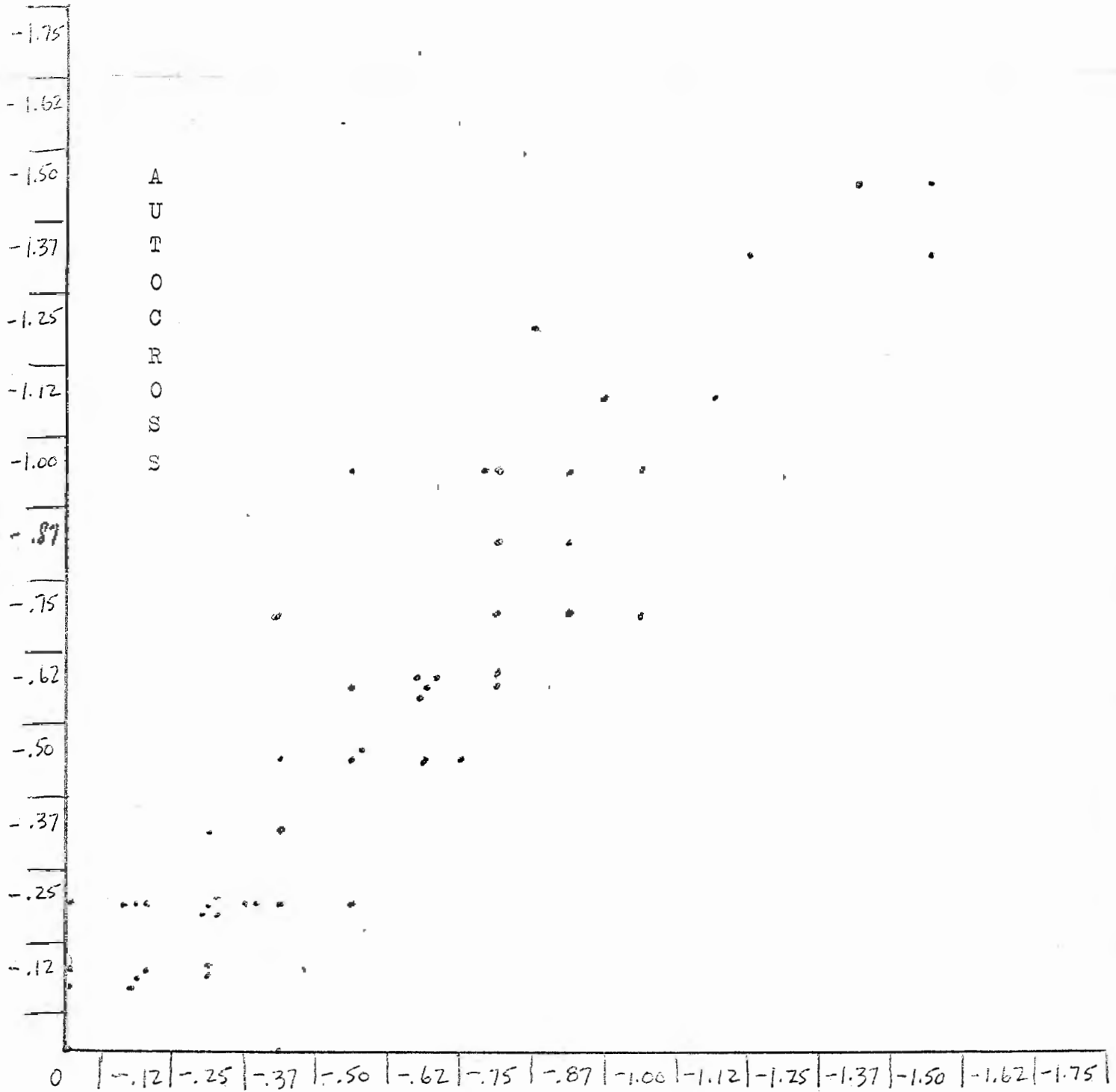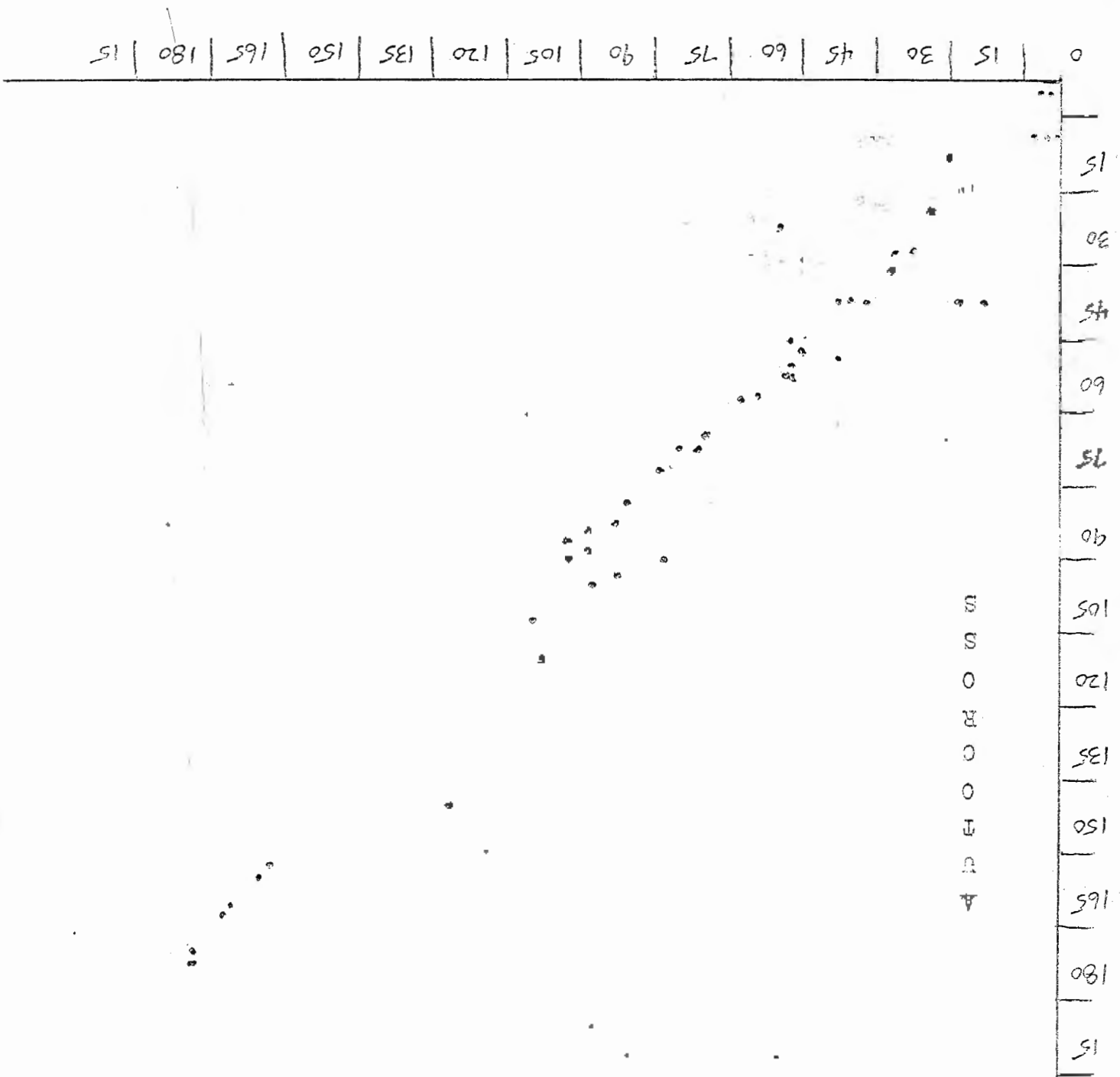
Jackson Cross Cylinder

Axis of the cylinder of the right
eye as done by the JCC and AutoCross

Jackson Cross Cylinder

SCATTERGRAM IV

Axis of the cylinder of the left
eye as done by the JCC and Autocross

Jackson Cross Cylinder

15 | 180 | 165 | 150 | 135 | 120 | 105 | 90 | 75 | 60 | 45 | 30 | 15 | 0

15
30
45
60
75
90
105
120
135
150
165
180
15

A U T O C R O S S

STATISTICAL ANALYSIS OF THE DATA

Fromulae utilized in the statistical analysis of the data are as follows:

Mean:[8]

$$M = \frac{EX}{N}$$

where M = the arithmetic mean
X = a score or other measure
N = the number of scores
E = denotes "sum of"

Standard Deviation:[9]

$$S = \sqrt{\frac{Ex^2}{N-1}}$$

where S = standard deviation
x^2 = the square of the deviation from the mean
E = denotes "sum of"
N = number of cases

Correlation Coefficient:[10]

$$r = \frac{Exy}{\sqrt{(Ex^2)(Ey^2)}}$$

where Exy = sum of the products of deviations x and y
Ex^2 = sum of the squared deviations in x from M_x
Ey^2 = sum of the squared deviations in y from M_y

Chi Square[11] Analysis of Test Preference (JCC and AutoCross):

$$X^2 = E \frac{(\ [o-e]\ -0.5)^2}{e}$$

where X^2 = chi square
     E = number of categories or groups
     o = observed frequency in a category
     e = expected frequency in a category

T-Test[12] for Significance of the Difference Between Means for Administration Time:

$$t = \frac{\bar{d}}{Sd}$$

where t = t score
    $\bar{d}$ = mean of the differences
    $S\bar{d}$ = standard error of d = $\frac{Sd}{\sqrt{n}}$
    Sd = standard deviation of sample
    n = number of times

STATISTICAL ANALYSIS RESULTS

Means:

Power of the cylinder

	JCC	AutoCross
O.D.---------.610		.608
O.S.---------.540		.544

Axis of the cylinder

	JCC	AutoCross
O.D.---------77.00		78.10
O.S.---------71.54		72.48

Administration time

JCC	AutoCross
3.92 minutes	3.75 minutes

Standard Deviations:

Power of the cylinder

	JCC	AutoCross
O.D.---------.443		.469
O.S.---------.430		.425

Axis of the cylinder

	JCC	AutoCross
O.D.---------50.19		50.96
O.S.---------51.56		51.81

Administration time

JCC	AutoCross
.75 minutes	.83 minutes

Correlation Coefficient:

1. power O.D. = .966
2. power O.S. = .883
3. axis O.D. = .983
4. axis O.S. = .976

Chi Square Analysis of Test Preference:

$x^2 = 8.01$ this rejects the null hypothesis at the 1% level that there exists no preference between the two techniques. (the AutoCross test is statistically preferred)

T-Test for Significance of the Difference Between Means for Administration Time:

$t = 1.12$ There exists no significant statistical difference between the administration time of the two techniques.

DISCUSSION

Matsuura states that his AutoCross technique has been shown to be superior to the JCC technique in that the former is less tedious to administer, is more acceptable to the patient, and that a substantial reduction in the refraction time could be appreciated.

This study was undertaken by the authors to, not only determine if statistically similar results could be achieved by the two methods of determining cylinder axis and power, but also to gather information which might support or reject Matsuura's statement.

After the administration of both tests, each subject was asked to give his personal opinion of the two methods and to state which he preferred. Seventy per cent of the subjects preferred the Auto-Cross technique as it was felt that the simultaneous presentation of the images reduced the "guess work" involved and also eliminated the memory factor involved when the image was alternately viewed.

Test administration time was recorded for both techniques on the last forty subjects only. This was done in order to eliminate practice effect until the examiner could become equally adept with both techniques.

SUMMARY AND CONCLUSIONS

Practitioner evaluation of the AutoCross can be summarized in these Pro's and Con's.

Con's:

1. A time element was involved when inserting the AutoCross into the phoropter. The clock dial axis had to be changed to 180 degrees when inserting the AutoCross and then had to be replaced to its original position.
2. The practitioner cannot see the position of the left axis dial due to obstruction of the AutoCross.
3. The patient must look from side to side when making a comparison and some found this more difficult than remembering both responses as in the JCC.

Pro's:

1. The AutoCross proved to be a faster process than the JCC.
2. The AutoCross proved to be statistically valid compared to the JCC.
3. The subjects statistically preferred the AutoCross over the JCC.
4. The memory of the first presentation was not a factor in the AutoCross as in the JCC technique.

In conclusion, the AutoCross may be substituted for the JCC procedure and is subjectively preferred by a substantial majority of the subjects. Opinion of the observers was divided as to preference.

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