Comparison of Fixation Disparity Parameters with the Sheedy Disparometer and the Saladin Fixation Disparity Cards

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ABSTRACT

Fixation disparity curves were obtained from the 25 subjects with the Sheedy Disparometer, the standard Saladin fixation disparity card, and the modified Saladin fixation disparity card. Although there were no big differences in the x-intercepts from the three fixation disparity devices, the y-intercepts were shifted more in the eso direction with the Sheedy Disparometer compared to the Saladin fixation disparity cards. The slopes with the Sheedy Disparometer were steeper than the slopes measured from the Saladin cards. The distribution of curve types was also different with the three different instruments; Therefore, an isolate standard must be applied to each fixation disparity measurement module.

INTRODUCTION

The neural origin of the steady-state vergence eye movement error, called binocular fixation disparity, is the difference between the position of a fixation target and the point actually fixated by the eyes[1,3,5]. The eye movement system is one of the most studied sensorimotor systems in the brain. Binocular gaze shifts in space are achieved by simultaneous operation of two classes of eye movement subsystems; conjugate and disjunctive. The disjunctive system, which is also called the vergence system, maintains optical alignment of both eyes when viewing a target binocularly[4,5].

For a gaze shift between targets at different depths, the vergence system responds in a manner that reduces the resulting binocular disparity, thus maintaining single vision. The sensorimotor architecture of the vergence system is not perfectly understood. Experience from conjugate eye movement system studies suggests that a significant understanding of the mechanism of eye movement is possible when physiological and behavioral aspects of the system are incorporated into an analytical model that provides accurate predictions of the static and dynamic oculomotor responses under a variety of stimulus conditions[1,2,4,5].

One of the most well known analytical models is the forced vergence fixation disparity curve including its parameters[3]. A fixation disparity curve is an X, Y coordinate plot of the angular amount of fixation disparity as a function of the power of prisms through which the patient views. The fixation disparity curve variables that are used to aid in the diagnosis and management of binocular vision disorders include the x-intercept, y-intercept, curve slope and curve types [1,3]. Most popular instruments used to determine fixation disparity curves are the Sheedy Diparometer and the standard Saladin Fixation Disparity Card (SNPC-1). The modified Saladin card or SNPC-2 was different from the SNPC-1 in that it had a horizontal line that serves a vertical fusion lock at each of the fixation disparity apertures. The vertical lines (nonius lines) which were used to measure fixation disparity were about 3 times thicker in the modified card than the standard card.

The goal of my research was to compare the results of fixation disparity curves parameters obtained with the three devices. We compared the three devices to know if the fixation disparity curve parameters differ or were similar.

METHOD OF DATA COLLECTION

Data were collected with the Sheedy Disparometer and the Saladin cards on church members from the Grand Rapids Grace Korean C.R.C. The twenty five subjects ranged from 10 to 50 years of age. Forty percent (10 of 25) of the subjects tested were male and sixty percent (15 of 20) were female. All subjects had a best corrected visual acuity of 20/30 or better, stereopsis of 40 seconds of arc or better, and had no strabismus or amblyopia. In order to minimize the stress, distraction, and fatigue factors during the test, the subjects were given twenty minute breaks between each test. To randomize the test as to whether the Sheedy Disparometer or the Saladin cards was tested first, the subjects elected to choose any one of the three devices. The subjects were required to wear polarizing glasses.

For the Saladin cards, the examiner held the card 40cm from the spectacle plane of the subject and illuminated the fixation target with a hand-held illuminator. The subject was asked to identify the fixation target showing perfect line-up of the two vertical nonius lines, upper and lower in each fixation target. The subjects' responses were recorded on the exam sheet. The subjects were then instructed to hold a 2-diopter loose prism in the BI direction in front of the right eye. Again, the subjects were asked to identify the perfectly lined-up fixation target, then the responses were recorded. These steps were repeated using the following prisms in this specific order: 0, 2 BI, 4 BI, 6 BI, 2 BO, 4 BO, and 6BO. The subject was given no more than 30 seconds to accomplish the task at each prism insertion. The average time required for accomplishing the task was 15 to 20 seconds.

Next, the subjects were asked to align the vertical nonius lines on the Sheedy Disparometer without a loose prism and responses were recorded. Again, the subjects were asked to align the vertical lines on the instrument with varying amounts of prism presented in the order of 0, 2 BI, 4 BI, 6 BI, 2 BO, 4 BO, and 6BO and the responses were recorded.

METHOD OF DATA ANALYSIS

The x-intercept was the amount of prism where fixation disparity was zero (i.e. the fixation disparity curve crossed the x-axis)[3]. If there were more than one prism setting where the fixation disparity was zero, the x-intercept chosen was the one with the lowest or BO prism setting. The y-intercept was the amount of fixation disparity with a zero prism. Curve slope was calculated from the points between 2 prism BI and 2 prism BO on the x-axis. The fixation disparity of 2 prism BI was subtracted from the value of 2 prism BO, and this value was divided by 4. Curve type was determined by graphing each subject' s results and then was classified by comparing them to the standard forms of types I, II, Iii and IV developed by Ogle[5]. Results that did not fall into any of these four curve types were estimated by eye to the closest curve type.

Fixation disparity curve parameters obtained from the Sheedy Disparometer and the Saladin cards were compared. The mean differences of the x-intercept, the y-intercept, and the slope between the Sheedy Disparometer and the Saladin cards were determined by subtracting the Saladin cards' values from the Sheedy Disparometer value. The standard deviation was also calculated for these differences values.

RESULTS

Means and standard deviation for each of the fixation disparity curve parameters are given in Table 1. In some cases, the curve did not cross the x-axis, so an x-intercept was not obtained for all 25 subjects. Also, some patients with the three fixation disparity devices could not fuse the target at a zero prism, so a y-intercept was not acquired (Appendix B). X-intercepts were about equally represented in the three devices but y-intercepts with Sheedy Disparometer more deviated towards eso fixation disparity than that of the Saladin cards. The standard deviation of x-intercepts was the highest with the Sheedy Disparometer and followed by SNPC-1 and SNPC-2. On the other hand, the standard deviation of y-intercepts was the highest with the SNPC-1 and followed by SNPC-2 and the Sheedy Disparometer.

The slopes with the Sheedy Disparometer were steeper than the slopes measured from the Saladin fixation cards. As the Saladin cards showed slightly negative mean value of the slopes, the Sheedy Disparometer showed slightly positive mean value of the slopes. The standard deviation of the slope was the highest with the Sheedy Disparometer and followed by SNPC-2 and SNPC-1.

Table 1 - Means (and standard deviations) for the fixation disparity curve parameters with the three cards

X-intercept	**Mean**	**Std. Dev**	**Mean Difference**	
Disparometer	2.08	2.790	Disp - SNPC-1	-0.34
SNPC 1	2.42	1.695	Disp - SNPC-2	0.16
SNPC 2	1.92	1.891	SNPC-2 - SNPC-1	-0.5
Y-intercept	**Mean**	**Std. Dev**	**Mean Difference**	
Disparometer	3.84	3.96	Disp - SNPC-1	3.34
SNPC 1	0.50	5.38	Disp - SNPC-2	2.57
SNPC 2	1.27	4.93	SNPC-2 - SNPC-1	0.77
Slope	**Mean**	**Std. Dev**	**Mean Difference**	
Disparometer	0.14	1.60	Disp - SNPC-1	0.18
SNPC 1	-0.04	0.94	Disp - SNPC-2	0.23
SNPC 2	-0.09	0.95	SNPC-2 - SNPC-1	-0.045

-X-intercept is in prism diopters, y-intercept is in minutes of arc

The distributions of the curve types are given in Table 2. All four-type curves were about equally represented with the Sheedy Disparometer. On the other hand, Type III and Type IV curves were proportionately greater in number with the Saladin card than the Sheedy Disparomter (Refer to the Fixation Disparity Curves in Appendix C).

Table 2- Distribution of the fixation disparity curve types

Curve Type	Dispa	%	SNPC1	%	SNPC2	%
Type1	4	16.0%	2	8.0%	4	16.0%
Type2	5	20.0%	5	20.0%	2	8.0%
Type3	9	36.0%	7	28.0%	9	36.0%
Type4	7	28.0%	11	44.0%	10	40.0%
Total	25	100.0%	25	100.0%	25	100.0%

In our subjective impression, the Sheedy Disparometer showed more unreliable fixation disparity curve appearance than the Saladin cards (refer to Appendix E).

DISCUSSION

This study appears to be the first comparing fixation disparity curve parameters with the Sheedy Disparometer and the modified Saladin card. As seen in this experiment, the Y-intercepts were more divergent on the Sheedy Disparometer than on the Saladin cards, especially more than the modified Saladin card. Three instruments showed variations within their measurements; however, the standard deviation of x-intercepts was highest with the Sheedy Disparometer and the old Saladin card was highest in the standard deviation of y-intercepts. The newer Saladin card demonstrated the lowest value of standard deviation in x-intercepts and 2nd highest in y-intercepts.

The reasons for the differences found in this study are unclear. Probably some features of the Saladin card provide a stronger fusion lock—the modified Saladin card appears to have a stronger fusion lock than the standard Saladin card. Perhaps the finer gradations between the test marks for fixation disparity measurement on the Saladin card promoted smaller values. The fixation disparity targets are located centrally on the Sheedy Disparometer, but the lines for differing amounts of fixation disparity on the Saladin card are placed at many different locations around the card.

CONCLUSIONS

Although there were no big differences in the x-intercepts from the three fixation disparity devices, the y-intercepts were shifted more in the eso direction with the Sheedy Disparometer compared to the Saladin fixation cards. The slope with the Sheedy disparometer was steeper than the slope measured from the Saladin fixation cards. The distribution of curve types was also different with the three different instruments; Therefore, an isolate standard should be applied to each fixation disparity measurement module.

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Appendix A

#1

Prism	Dispa	SNPC1	SNPC2
-6	0	2	1
-4	4	4	2
-2	8	4	4
0	10	6	4
2	8	2	-2
4	4	-2	0
6	0	0	1

#2

Prism	Dispa	SNPC1	SNPC2
-6	0	0	-2
-4	2	1	0
-2	2	4	1
0	0	0	4
2	-2	-2	-2
4	-6	-4	1
6	6	-2	1

#3

Prism	Dispa	SNPC1	SNPC2
-6	-12	-2	0
-4	-20	-2	0
-2	-6	0	0
0	0	1	1
2	-18	0	0
4	-12	-2	-2
6	-25	-4	-4

#4

Prism	Dispa	SNPC1	SNPC2
-6	-2	-6	-3
-4	-4	2	0
-2	2	0	2
0	0	2	0
2	0	0	-2
4	-4	-4	-4
6	0	-2	-6

#5

Prism	Dispa	SNPC1	SNPC2
-6	-4	1	2
-4	0	2	4
-2	4	4	2
0	4	4	4
2	-2	1	1
4	-8	2	-1
6	-2	1	-2

#6

Prism	Dispa	SNPC1	SNPC2
-6	-8	-5	-3
-4	-2	-6	-2
-2	0	-5	-2
0	-4	-6	-3
2	-6	-5	-3
4	0	-4	-2
6	-8	-5	-3

#7

Prism	Dispa	SNPC1	SNPC2
-6	0	-2	-2
-4	0	0	0
-2	-2	-2	0
0	-4	0	-2
2	-6	-2	2
4	-12	-2	-2
6	-12	0	1

#8

Prism	Dispa	SNPC1	SNPC2
-6	-2	-10	-13
-4	-6	-12	-16
-2	-4	-16	10
0	6	-10	8
2	-2	1	-9
4	-2	-3	-3
6	-2	5	-7

#9

Prism	Dispa	SNPC1	SNPC2
-6	-10	-6	-10
-4	-4	-8	-17
-2	-2	-7	-13
0	-2	-13	-20
2	-2	-3	-7
4	-2	-7	-3
6	-4	-3	-6

#10

Prism	Dispa	SNPC1	SNPC2
-6	12	-1	-1
-4	18	0.5	-2
-2	4	-4	4
0	10	1	0.5
2	6	-1	-2
4	18	0	-3
6	14	-1	2

Appendix A

#11

Prism	Dispa	SNPC1	SNPC2
-6	-10	-10	-6
-4	-18	-4	-13
-2	-6	-7	-6
0	-4	-14	-3
2	-4	-10	-10
4	-6	-3	-10
6	-6	1	-7

#12

Prism	Dispa	SNPC1	SNPC2
-6	-4	-4	-6
-4	0	-3	-12
-2	-2	-10	-6
0	2	-17	-17
2	-8	1	-3
4	-18	16	9
6	-18	16	12

#13

Prism	Dispa	SNPC1	SNPC2
-6	-2	1	0.5
-4	0	1	0.5
-2	-1	2	1
0	4	1	1
2	6	1	1
4	-12	0.5	0.5
6	2	-1	-2

#14

Prism	Dispa	SNPC1	SNPC2
-6	2	4	0
-4	4	2	-4
-2	8	1	-2
0	12	4	-2
2	12	1	0
4	8	2	-1
6	4	-2	-1

#15

Prism	Dispa	SNPC1	SNPC2
-6	4	2	1
-4	2	0	2
-2	4	2	4
0	4	4	4
2	4	1	1
4	4	1	0
6	9	0	1

#16

Prism	Dispa	SNPC1	SNPC2
-6	-4	0	-3
-4	-2	-2	0
-2	0	0	1
0	4	3	2
2	-6	-4	-6
4	-8	-7	-8
6	-6	-6	-9

#17

Prism	Dispa	SNPC1	SNPC2
-6	-6	-2	1
-4	-4	1	2
-2	-2	2	0
0	0	0	3
2	-12	1	0
4	-10	-2	-2
6	-20	-2	-2

#18

Prism	Dispa	SNPC1	SNPC2
-6	-2	2	1
-4	0	1	1
-2	0	4	2
0	4	4	0
2	-4	0	0
4	-8	0	1
6	-8	-2	0

#19

Prism	Dispa	SNPC1	SNPC2
-6	-14	-2	-4
-4	-14	-2	-2
-2	-18	-2	-2
0	-18	-2	0
2	-20	-2	-2
4	-20	-4	-2
6	-20	-6	-4

#20

Prism	Dispa	SNPC1	SNPC2
-6	2	2	2
-4	4	2	4
-2	6	4	6
0	7	4	9
2	2	0	1
4	2	-2	0
6	2	-2	-4

Appendix A

#21

Prism	Dispa	SNPC1	SNPC2
-6	-8	-6	-5
-4	-8	-6	-3
-2	-8	-4	-3
0	-4	-2	0
2	-4	-4	-2
4	-4	-2	-1
6	-4	-2	-2

#22

Prism	Dispa	SNPC1	SNPC2
-6	-4	-4	-2
-4	-6	-2	0
-2	-2	1	0
0	0	0	2
2	-12	-2	-2
4	-16	-6	-2
6	-25	-8	-4

#23

Prism	Dispa	SNPC1	SNPC2
-6	0	0	2
-4	-4	1	2
-2	-4	4	4
0	4	6	4
2	-12	-2	2
4	-16	0	0
6	-25	-4	-2

#24

Prism	Dispa	SNPC1	SNPC2
-6	-2	4	1
-4	-10	4	0
-2	4	4	4
0	0	8	1
2	0	1	0
4	0	0	0
6	-8	0	0

#25

Prism	Dispa	SNPC1	SNPC2
-6	2	1	1
-4	4	2	2
-2	6	4	4
0	8	4	2
2	4	1	1
4	4	0	0
6	2	0	-2

Appendix B

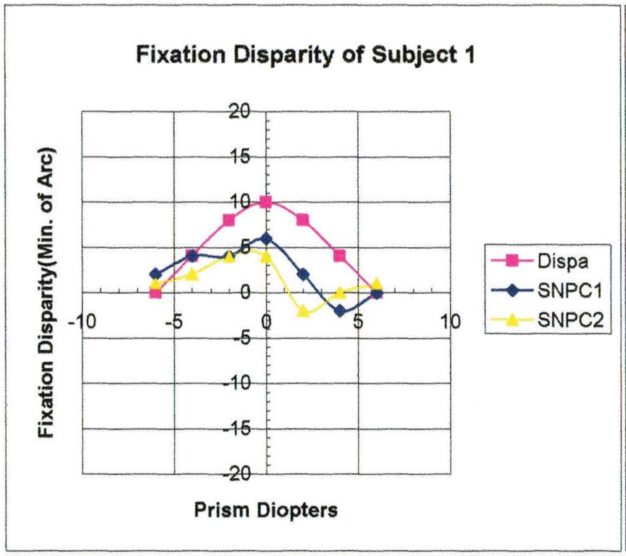
X-intercept

Subject	Disparometer	SNPC 1	SNPC2
1	6	2.4	1
2	0	0	1.2
3	0	2	2
4	2	2	0
5	1.4	2.8	2.8
6	0	0	0
7	-4	0.5	-2
8	1.7	2.8	0.8
9			
10	4	1.2	0.8
11			
12	0.6	1.8	2.4
13	2.7	4.6	4.8
14	7.7	5.2	2.2
15	7.8	6	4
16	1	1.1	0.7
17	0.2	2.8	2
18	1.2	4	6
19			
20	3	2	4
21			0
22	0	0	2.5
23	1.2	1.4	4
24	2.6	3	2
25		4	4
Mean	2.08	2.42	2.05

Y-intercept

Subject	Disparometer	SNPC 1	SNPC2
1	10	6	4
2	0	0	4
3	0	1	1
4	2	0	0
5	4	4	4
6	0	0	0
7	-4	0.5	-2.5
8	6	-10	8
9			
10	10	2	1
11			
12	2	-17	-17
13	4	1	1
14	12	4	-2
15	4	4	4
16	4	3	2
17	0.3	2	3
18	4	4	2
19			
20	7	4	9
21	4	2	0
22	0	0	2
23	4	6	4
24	0	8	1
25	8	4	2
Mean	3.70	1.30	1.39

Appendix C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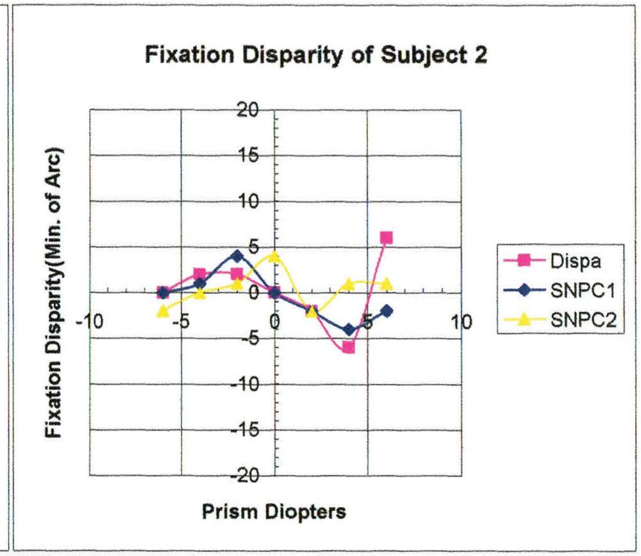
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2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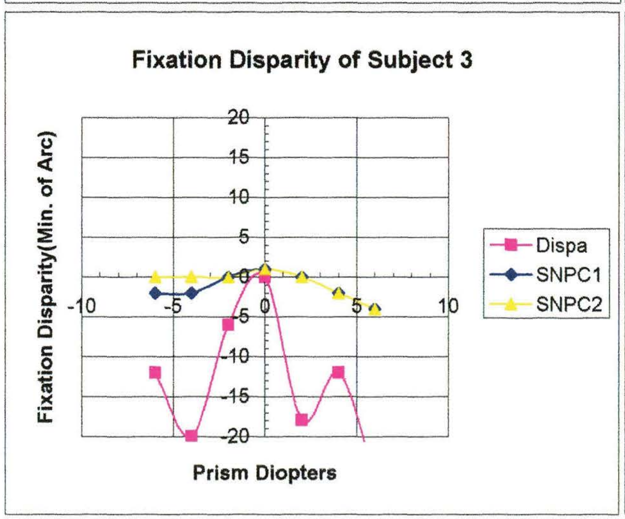
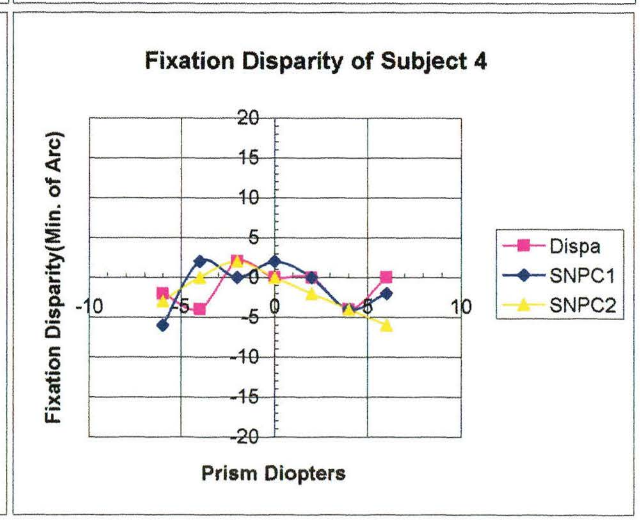
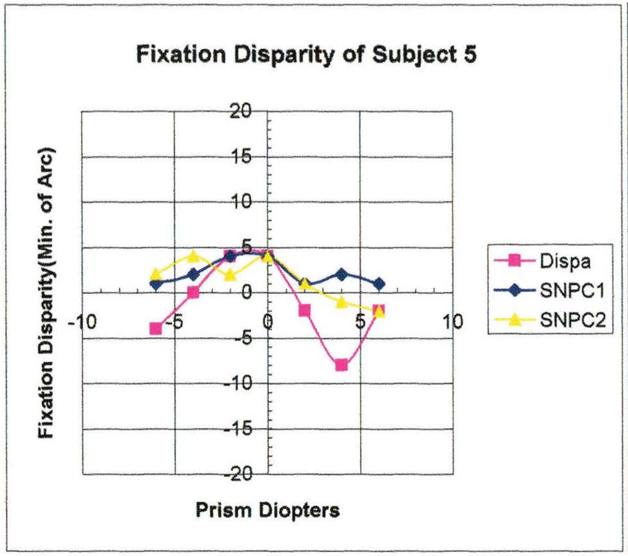
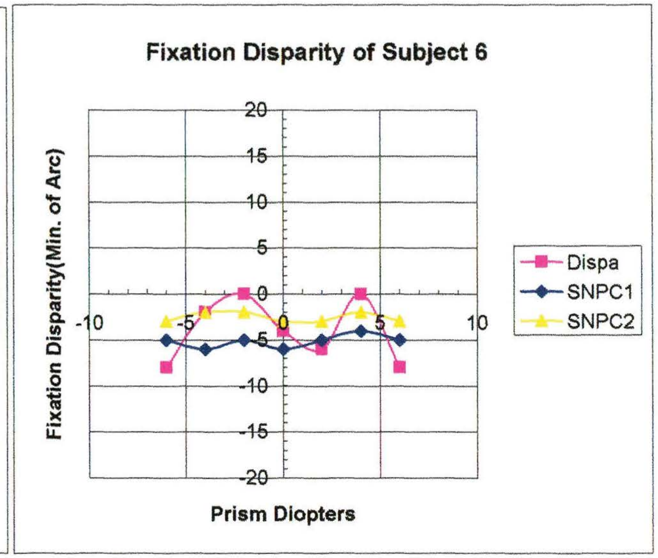
Prism Diopters
Dispa
SNPC1
SNPC2

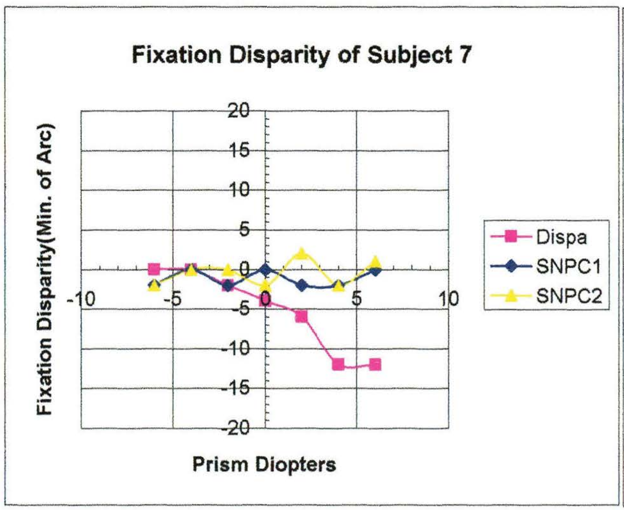

Fixation Disparity of Subject 3
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

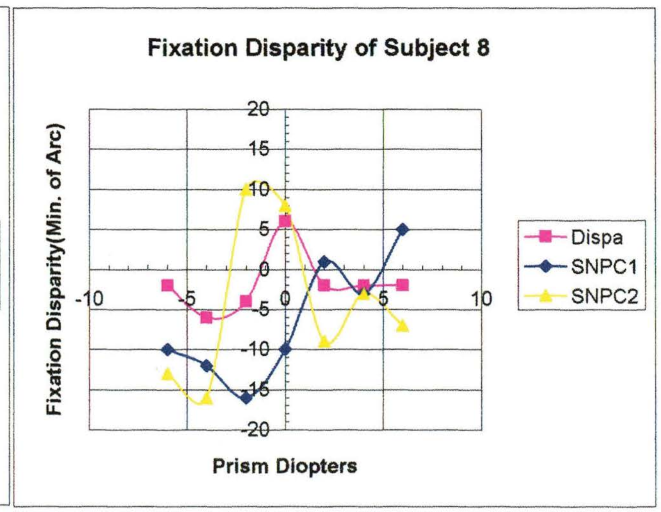

Fixation Disparity of Subject 4
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

Appendix C

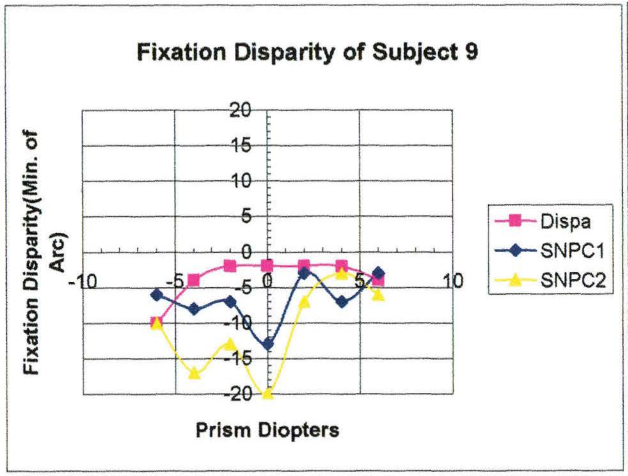

Fixation Disparity of Subject 5
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2


Fixation Disparity of Subject 6
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

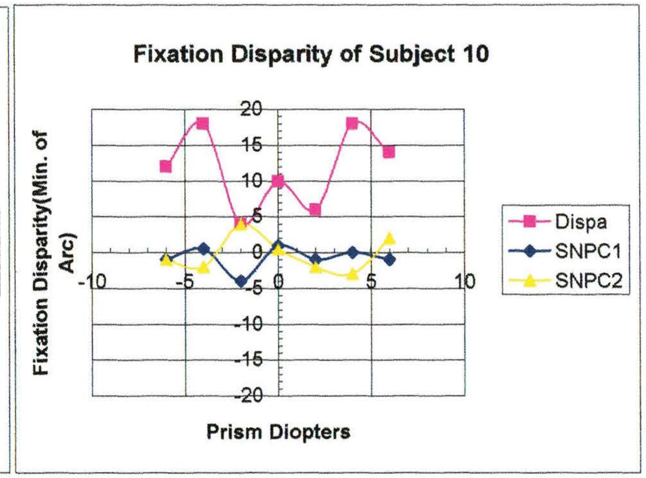

Fixation Disparity of Subject 7
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2


Fixation Disparity of Subject 8
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

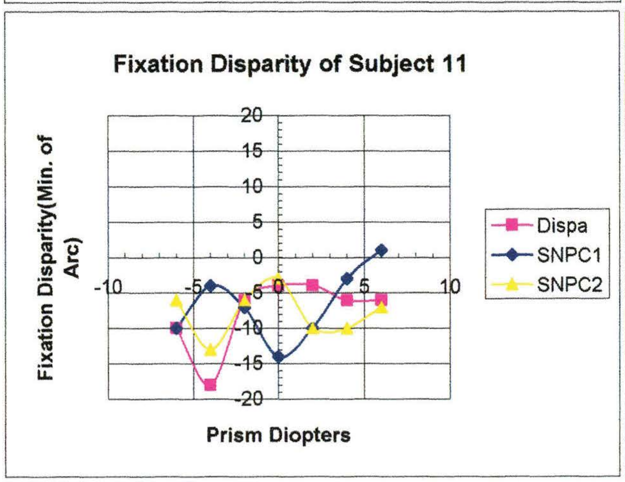
Appendix C



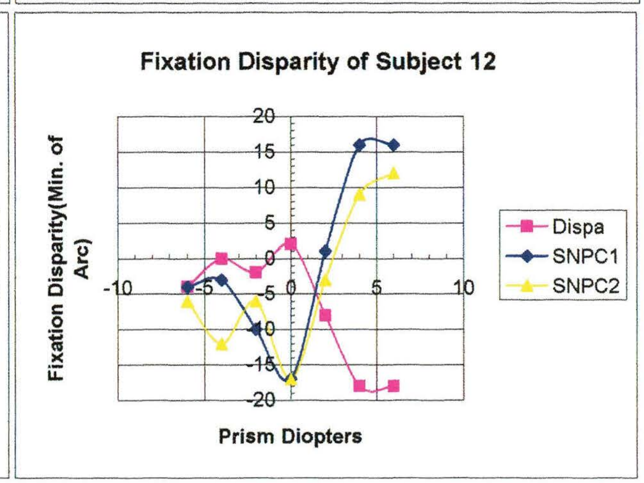
Fixation Disparity of Subject 9
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2



Fixation Disparity of Subject 10
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

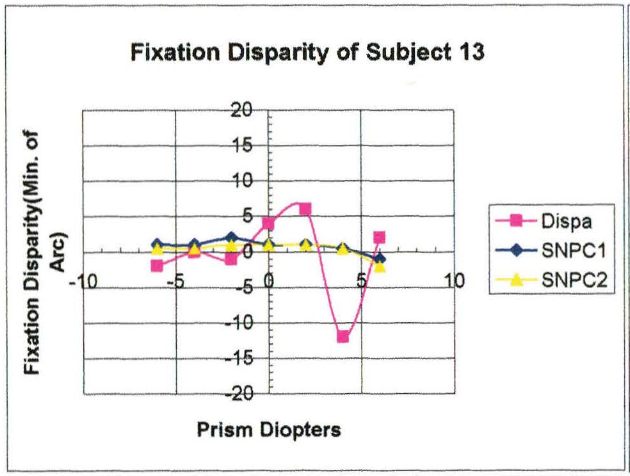


Fixation Disparity of Subject 11
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2



Fixation Disparity of Subject 12
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

Appendix C



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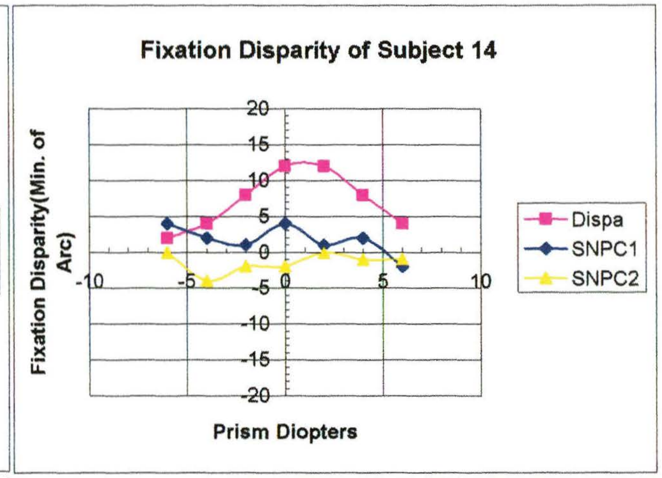
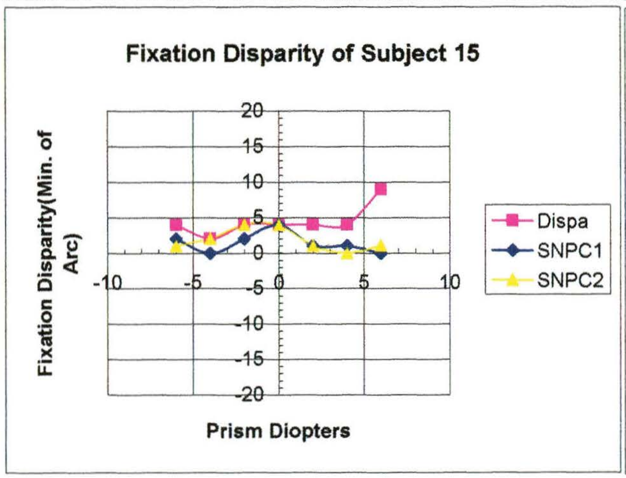
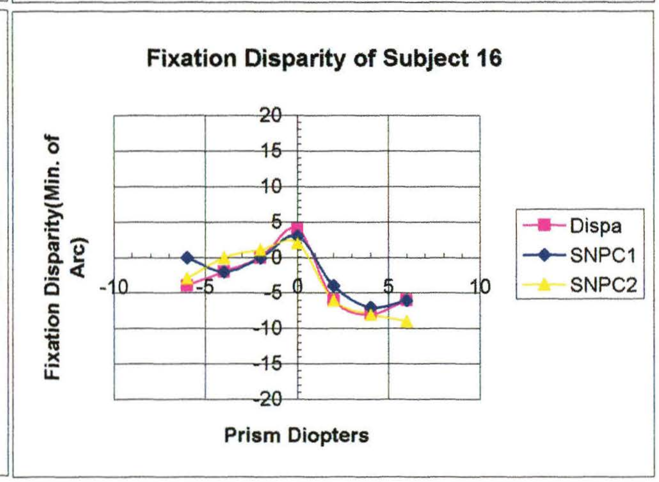
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2



Fixation Disparity of Subject 14
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

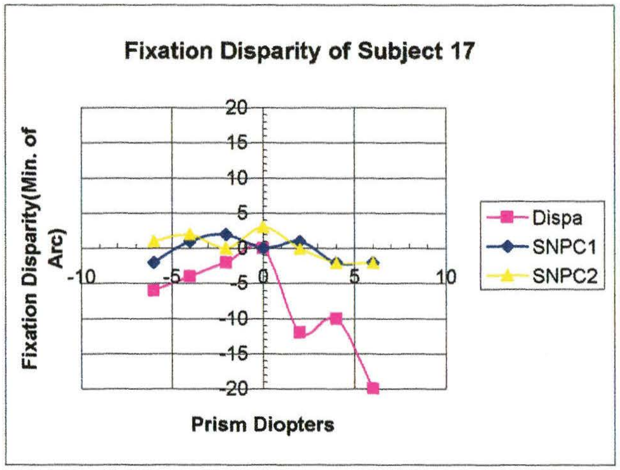


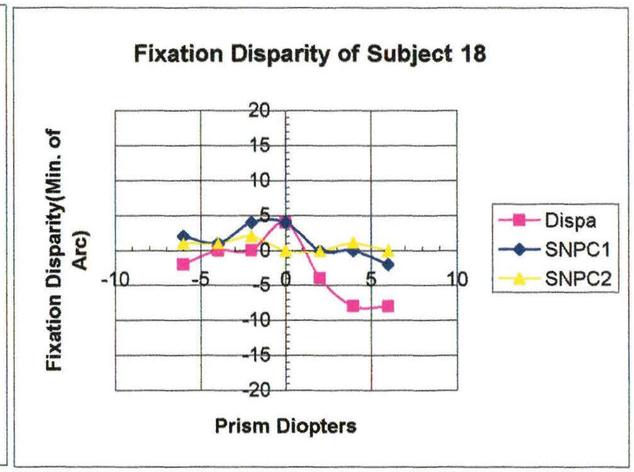
Fixation Disparity of Subject 15
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

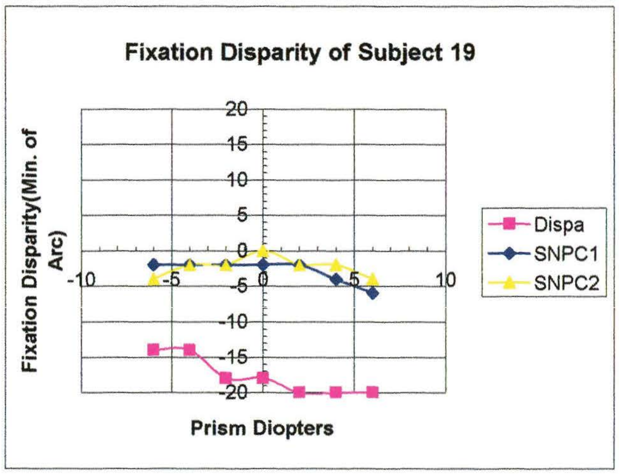


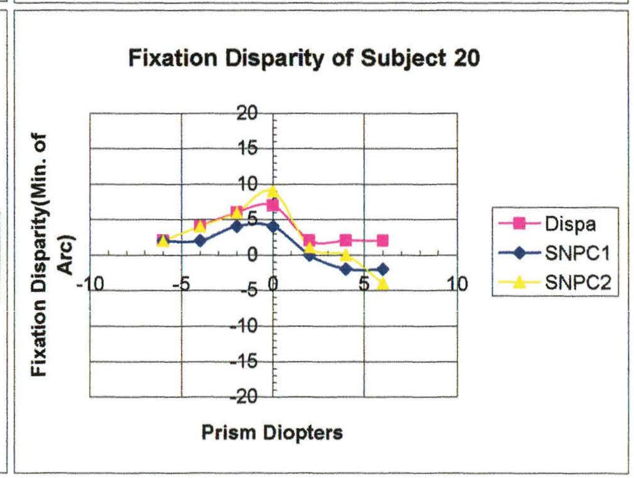
Fixation Disparity of Subject 16
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

Appendix C

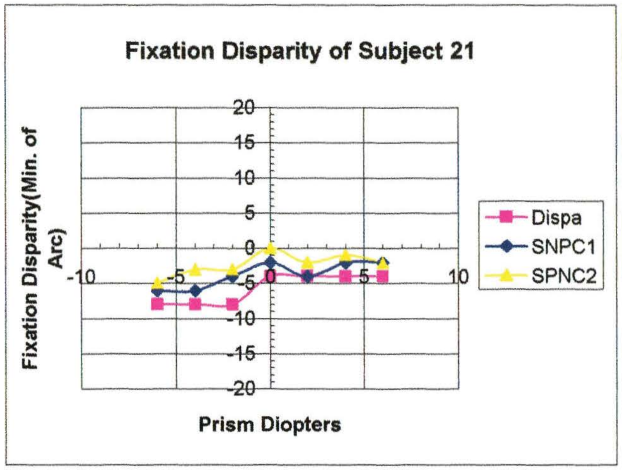

Fixation Disparity of Subject 17
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

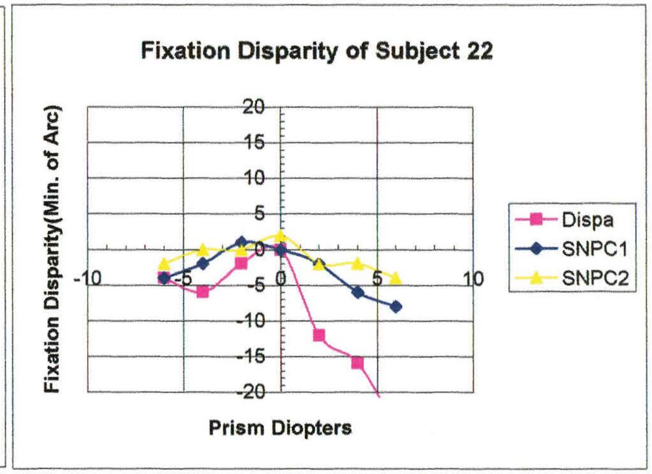

Fixation Disparity of Subject 18
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

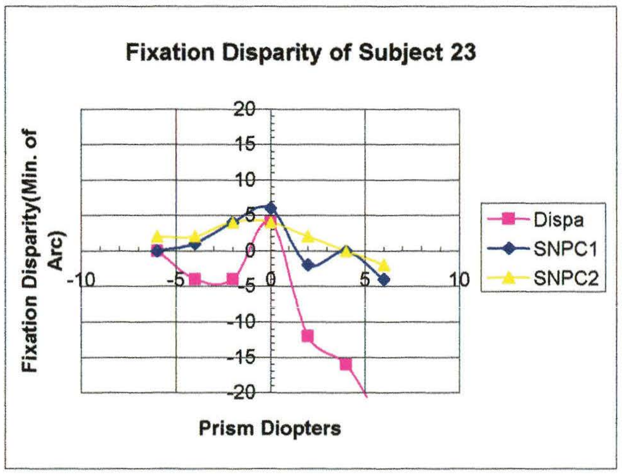

Fixation Disparity of Subject 19
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

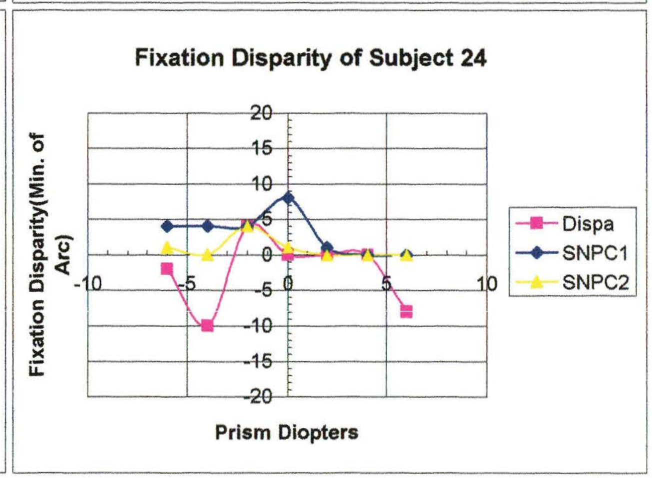

Fixation Disparity of Subject 20
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

Appendix C

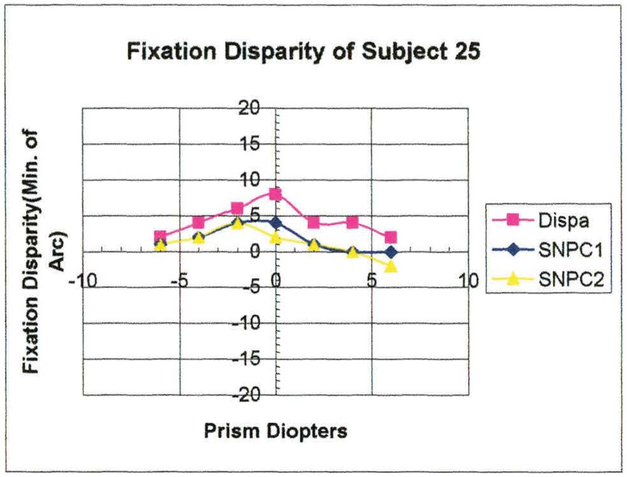

Fixation Disparity of Subject 21
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SPNC2


Fixation Disparity of Subject 22
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2


Fixation Disparity of Subject 23
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2


Fixation Disparity of Subject 24
Fixation Disparity(Min. of Arc)
Prism Diopters
Dispa
SNPC1
SNPC2

Appendix C



Fixation Disparity of Subject 25
Fixation Disparity(Min. of Arc)
20
15
10
5
0
-5
-10
-15
-20
-10
-5
0
5
10
Prism Diopters
Dispa
SNPC1
SNPC2

Appendix D

Curve Type

Subject	Disparometer	SNPC 1	SNPC 2
1	1	1	1
2	4	4	4
3	3	4	4
4	4	4	4
5	1	4	3
6	3	3	3
7	3	3	3
8	1	3	1
9	3	3	3
10	2	4	4
11	3	3	3
12	1	2	3
13	4	4	4
14	2	2	3
15	2	2	2
16	4	4	4
17	3	4	4
18	4	4	2
19	3	3	3
20	2	4	1
21	3	3	3
22	4	4	4
23	3	1	1
24	4	2	4
25	2	2	4

Appendix E

Curve Appearance

Subject	Disparometer	SNPC 1	SNPC 2
1	R	R	R
2	R	R	R
3	U	R	R
4	R	R	R
5	R	R	R
6	U	R	R
7	R	R	R
8	U	U	U
9	R	U	U
10	U	U	R
11	U	U	U
12	U	U	U
13	U	R	R
14	R	R	R
15	R	R	R
16	R	R	R
17	U	R	R
18	R	R	R
19	U	R	R
20	R	R	R
21	R	R	R
22	U	R	R
23	U	U	R
24	U	R	R
25	R	R	R
Unreliable	13	6	4
%	52.00%	24.00%	16.00%
Reliable	12	19	21
%	48.00%	76.00%	84.00%

Legend: R-Reliable, **U**-Unreliable