THE RANGE OF ALIGNMENT
AND ITS CORRELATION TO:
VERGENCE FINDINGS
AND
THE FIXATION DISPARITY CURVE

Joseph J. Lawless
May, 1980
In the research of binocular vision, many tests have been developed to aid in the diagnosis and treatment of oculomotor related anomalies. These include phoria measurements, vergences, and fixation disparity. Through the efforts of Donders, Morgan, Ogle, Percival, Sheard, Saladin and Sheedy, as well as many others, the results of these tests have been organized and correlated to aid in the analysis of oculomotor related symptoms.

The purpose of this study was to bring forward another type of oculomotor test, and correlate the results with the results of other, more familiar tests, in which the diagnostic implications have already been established.

The test that I am referring to is a form of forced vergence test, utilizing a polarized fixation disparity target. The test is conducted, such that the patient observes the fixation disparity target through polarizing filters as the examiner gradually introduces lateral prism, bilaterally, until a misalignment of the upper and lower nonius lines is perceived. I will refer to this point as the point of "just noticeable misalignment". Following this reading, the amount of prism is reduced until the nonius lines again appear aligned. I will refer to this point as the point of "fixation realignment". The amount of prism required to elicit the point of just noticeable misalignment will be termed "the range of alignment".
METHODS

The sample used in this study consisted of 26 subjects. These subjects came from a mixed clinical and non-clinical population. All of the subjects were pre-presbyopic with ages ranging from 12 to 33 years of age.

All tests were performed through a refractor, with the subjects' refractive correction in place. Stereo acuity testing was performed both at distance and near to demonstrate binocularity at the respective testing distance. All subjects exhibited stereo acuity of at least 60 seconds of arc at both distance and near. The following tests were performed on each subject at distance (4M) and near (40 cm): phorias, positive and negative relative vergences, and the positive and negative ranges of alignment, as well as the respective fixation realignment. The fixation disparity curve was plotted for each subject at a testing distance of 40 cm.

The phoria reading was taken at distance and near using the von Graefe technique. Positive and negative relative vergence readings were obtained by having the subject fixate a vertical line of letters as lateral prism was slowly introduced bilaterally. The subject reported when the target was perceived to blur, break apart, and (as the amount of prism was reduced) form back into one. Base in measurements were taken first.
The points of just noticeable misalignment and fixation realignment were obtained as previously described. At distance the target used was the fixation disparity target on the A.O. vectographic slide. The Borish card, with its' fixation disparity target, was used at near. Again, base in readings were taken before the base out readings. The fixation disparity curve was plotted, utilizing a target which contained two vertical lines, polarized perpendicular to each other, one placed above the other. By rotating a dial the horizontal separation of these lines could be varied in increments of one minute of arc. On either side of this central target, a small chart of letters was located, to aid in the control of accommodation. In performing the test, polarizers were placed in front of the subjects eyes so that each vertical line was seen by only one eye. Different pairs of lines were presented to the subject until they reported that the lines were horizontally aligned. The test was then repeated introducing lateral prism in increments of 3pd. Measurements were taken in this manner until the amount of prism had been introduced which elicited diplopia. The sequence of introducing prism was again, base in before base out.
CALCULATIONS

For all calculations, and graphs, the points of just noticeable misalignment (JNM) and the points of fixation realignment (FR) were assigned values on the X axis. The correlations were all calculated on the basis of predicting Y from the value of X.

The coefficient of correlation (r) was calculated utilizing the Deviation Score Formula: \[ r_{xy} = \frac{\sum xy}{n \cdot S_x \cdot S_y} \]

where: \( x = (x - \bar{x}) \) \( S_y = S_x = \text{std. deviations of the distribution} \)
\( y = (y - \bar{y}) \)

\( r^2 \) = the coefficient of determination. This value gives the proportion of variance in Y which is associated with changes in X. 100\( r^2 \) gives this value as a percentage.

The standard error of estimate of Y based on the value of X (\( S_{yx} \)) is given by the following formula: \( S_{yx} = S_y \sqrt{1 - r_{xy}^2} \)

when \( r = 0 \) : \( S_{yx} = S_y \)
when \( r = 1 \) : \( S_{yx} = 0 \) \{ assumes a normal distribution \}

This value acts as the standard deviation for predicting Y from X. 68% of obtained Y values fall within the limits of \( \pm 1 S_{yx} \) from the line of best fit (of Y on X).

The slope of the fixation disparity graph was calculated by the Method of Least Squares, utilizing the points associated with 3pd BI, Opd, and 3pd BO. The slopes calculated for either the base in or base out side of the graph were calculated by the same method, utilizing all plotted points between Opd and the break point.
Name: Deanna Stininger
Age: 21

Refraction:
-0.25 sph
-0.25 sph
PD: 56

BVA: 2% 3% 2% 2%

Stereo Acuity:
Distance: 6/60
Near: 40 sec (EO)

Phoria:
Distance: ±
Near: ±2 BI

Vergences:

Distance:
BI: 11/19
BO: 11/19
Near:
BI: 12/15
BO: 12/15
(40 cm)

Range of Alignment:

Distance:
BI: 1/4
BO: 5/3
Near:
BI: 13/0
BO: 4/1
(40 cm)

Fix Disp. Near: 2 BI
Dist: 2 BI
Name: Doug Lee  Age: 22

Refraction: PL  BVA: 2/15

Stereo Acuity:
Distance: 2mm  Near: 40

Phoria:
Distance: 0  Near: 180

Vergences:
BI  BO
Distance: 4/17/19  2/12/18
Near: 6/11/21  1/12/17
(40 cm)

Range of Alignment:
BI  BO
Distance: 13/12  15/12
Near: 13/11  13/12
(40 cm)

FOC On Near 180
Name: _______________  Age: 22

PO: 6/4

Refraction
-3.00
-2.25 -0.50 x 160

BVA: 20/20

Stereo Acuity:
Distance: 3mm
Near: 6/60

Phoria:
Distance: 0
Near: 6/60

Vergences:
Distance: BI
BO

Near: 4/18/13
6/18/16
(40 cm)

Range of Alignment:
Distance: BI
BO

Near: 4/18/15
6/17/14
(40 cm)

FDO @ DIST: 1/2 BO NEAR
Name Ciranna

Age 21

Refraction
+0.75 sph
+0.75 sph

BVA

Stereo Acuity:
Distance 60 Near 60

Phoria:
Distance 285 Near 285

Vergences:
BI BO

Distance 612 14 612 14
Near 126 14 1612 11
(40 cm)

Range of Alignment:
BI BO

Distance 2111 1110
Near 12101 1210
(40 cm)

F.D. DIST 1/2 BI
NEAR 1 8F
Name: Connie Schieler  Age: 23

Refraction:
-0.50
-0.50 -0.25 x 30

BVA: 20/15 6/6

Stereo Acuity:
Distance: 60  Near:

Phoria:
Distance: 0  Near: 0 1/25c

Vergences:
BI  BO

Distance:
6/1 4/1 4
7/1 4/3

Near:
16/18 11/6
12/4 13/5
(40 cm)

Range of Alignment:
BI  BO

Distance:
13/12 13/12

Near:
115/115 18/115
(40 cm)

F.O. Dist 0
Near 6
Name  Jon Sapp  Age  15  

Refraction  
-2.25 -0.50 x 175  
-2.25 -0.50 x 180  

BVA  20/15  

Stereo Acuity:  Distance  60  Near  40  

Phoria:  Distance  0  Near  1/2 80  

Vergences:  
BI  BO  
Distance  1614  511214  
Near  12113111  12114115  (40 cm)  

Range of Alignment:  
BI  BO  
Distance  1011 B0  1312  
Near  1412  15102  (40 cm)  

FD Dist  180  
Note  0
Name: MARY KNIGHT

Age: 15

Refraction:
- 40.50 = 0.50 x 95
- 10.75 = 0.50 x 85

BVA: 20/15

Stereo Acuity:
- Distance: 60
- Near: 40

Phoria:
- Distance: 280
- Near: 0

Vergences:
- BI
  - Distance: 71.80
  - Near: 41.80
  - (40 cm)
- BO
  - Distance: 1.18
  - Near: 1.18
  - (40 cm)

Range of Alignment:
- BI
  - Distance: 16/10
  - Near: 114/14
  - (40 cm)
- BO
  - Distance: 110/12
  - Near: 114/14
  - (40 cm)
Name: Sandy Hill SESSION
Age: 25

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<thead>
<tr>
<th>Refraction</th>
<th>BVA</th>
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<tbody>
<tr>
<td>+0.75</td>
<td>50/20</td>
</tr>
<tr>
<td>1.00</td>
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<table>
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<th>Near</th>
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<tbody>
<tr>
<td></td>
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<td>80</td>
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<table>
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<td></td>
<td>280</td>
<td>10.85</td>
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<thead>
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<th>Vergences:</th>
<th>BI</th>
<th>BO</th>
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<tbody>
<tr>
<td>Distance</td>
<td>x1413</td>
<td>161214</td>
</tr>
<tr>
<td>Near</td>
<td>10122118</td>
<td>9171-2</td>
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<tr>
<td>(40 cm)</td>
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<thead>
<tr>
<th>Range of Alignment:</th>
<th>BI</th>
<th>BO</th>
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<tbody>
<tr>
<td>Distance</td>
<td>1211</td>
<td>101-1</td>
</tr>
<tr>
<td>Near</td>
<td>11113</td>
<td>1210</td>
</tr>
<tr>
<td>(40 cm)</td>
<td></td>
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</table>
Name: Helen Wilson  
Age: 21

Refraction: em.  
BVA: 20/15
PD: 60

Stereo Acuity: Distance Near 40
Phoria: Distance Near 8X

Vergences: BI BO

Distance 6/2/4 8/1/2
Near 1/8/12 10/12/8
(40 cm)

Range of Alignment: BI BO

Distance 13/12 8/17
Near 11/10 110/12
(40 cm)
Name: Rick Bright
Age: 24

Refraction: +1.25 +0.75 over 0.00

BVA: 20/15

PD: 60

Stereo Acuity:
Distance: 60 Near: 40

Phoria:
Distance: 0 Near: 180

Vergences:
BI
BO

Distance:
X10 14
201/21/12

Near:
14 20/18
14/20/13
(40 cm)

Range of Alignment:
BI
BO

Distance:
13 12
19 13

Near:
14/12
6 19
(40 cm)

FP D = 0
N = 0
Name: Linda Cooley
Age: 33

Refraction:
-0.50
+ 0.50 - 0.50 x 50

BVA: 20/20

Stereo Acuity:
Distance: 60
Near: 40

Phoria:
Distance: \\/\
Near: 8\0\2

Vergences:
- BI
- BO

Distance:
12 13
5 17 6

Near:
22 12 4 118
12 \1/61 \10
(40 cm)

Range of Alignment:
- BI
- BO

Distance:
13 12
17 6

Near:
24 15 13
17 0 12
(40 cm)

FO = \pod\ OD VA
Name: John Marcin
Age: 23

Refraction:
-2.25 -100 x 20
-2.00 -0.75 x 155

BVA: 20/18

Stereo Acuity:
Distance: 60
Near: 40

Phoria:
Distance: 13E
Near: 7EC

Vergences:
BI
BO

Distance:
161-27-25
Near:
24-26-11

(40 cm)

Range of Alignment:
BI
BO

Distance:
1/10
Near:
1/21/1

(40 cm)

PD: 66
Name: Dan Flick  Age: 25

Refraction:  Pl - 0.75 x 80  BVA -0.25 - 0.50 x 85  20/25

Stereo Acuity:  Distance: 60  Near: 40

Phoria:  Distance: 2 BI  Near: 6

Vergences:  BI  BO
  Distance: XN0 1/6  81/31/15
  Near: 1/16 1/12  20/22/13 (40 cm)

Range of Alignment:  BI  BO
  Distance: 121/1  151/4
  Near: 161/4  1/0/18 (40 cm)

PD @ Distance: ø
  ø @ Near: ø
Name: Joe Kristovich  
Age: 26

<table>
<thead>
<tr>
<th>Refraction</th>
<th>BVA</th>
</tr>
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<tbody>
<tr>
<td>-2.00 -0.50 x 180</td>
<td>80/60</td>
</tr>
<tr>
<td>-2.00 -0.75 x 180</td>
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<table>
<thead>
<tr>
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<tr>
<td>Distance: 60 Near 40</td>
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<table>
<thead>
<tr>
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<tr>
<td>Distance: 20 Near 110</td>
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<table>
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<tr>
<th>Vergences:</th>
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<tr>
<td>BI</td>
</tr>
<tr>
<td>Distance: 6/17 17</td>
</tr>
<tr>
<td>Near: 12/13 13</td>
</tr>
<tr>
<td>(40 cm)</td>
</tr>
<tr>
<td>BO</td>
</tr>
<tr>
<td>Distance: 20/15 34/35</td>
</tr>
<tr>
<td>Near: 18/13 18/13</td>
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<table>
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<tr>
<th>Range of Alignment:</th>
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<tbody>
<tr>
<td>BI</td>
</tr>
<tr>
<td>Distance: 14/13 14/13</td>
</tr>
<tr>
<td>Near: 13/12 11/18</td>
</tr>
<tr>
<td>(40 cm)</td>
</tr>
<tr>
<td>BO</td>
</tr>
<tr>
<td>Distance: 19/13</td>
</tr>
<tr>
<td>Near: 11/18</td>
</tr>
</tbody>
</table>

| PD 65                  |
| Range: 20 30/15        |
| Age: 20                |
| 34/20                  |
| 18/13 30              |
| 70                     |
Name: Thomas Lee
Age: 20

Refraction:
-0.50
-0.75

BVA: 2/15

Stereo Acuity:
Distance: 60
Near: 60

Phoria:
Distance: 2/50
Near: 3/50

Vergences:
BI
BO

Distance:
Distance: 1/213
Near: 1/261/2
(40 cm)

Range of Alignment:
BI
BO

Distance:
Near:
Distance: 1/413
Near: 1/019
(40 cm)
Name: Pat Lyons
Age: 29

Refraction:
-1.75 - 1.25 x 113
-1.00 - 1.50 x 60

BVA: 2/15

Stereo Acuity:
Distance: 60
Near: 40

Phoria:
Distance: 180
Near: 680

Vergences:
BI
BO

Distance:
X1714
151>40135

Near:
1812/11/1
211>40135
(40 cm)

Range of Alignment:
BI
BO

Distance:
2101
3121

Near:
1611/1
1181
(40 cm)

F.O. @ near 9
Name: Suzanne Maystead  
Age: 24

Refraction:  
OVER GL'S:  
-0.25
+0.25 -0.25 x 11
BVA: 20/15
PO: 65

Stereo Acuity:  
Distance: 60  
Near: 1/6

Phoria:  
Distance: 380  
Near: 980

Vergences:  
BI  
BO

Distance: 4/17/14  
12/19/11
Near: 6/13/24  
11/133/26  
(40 cm)

Range of Alignment:  
BI  
BO

Distance: 2/1/1  
9/18/1
Near: 2/1/1  
22/12/1  
(40 cm)

F.O.: Distance: 380  
Near: 280
Name: Germaine Santorelli  
Age: 18

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<th>Refraction</th>
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<th>PD</th>
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<tr>
<td>OCVS: p - 0.50 x 95</td>
<td>20/</td>
<td>60</td>
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Stereo Acuity:  
Distance: 60  
Near: 60

Phoria:  
Distance: 90  
Near: 110

Vergences:  
BI  
BO  
Distance: 17/4  
Near: 1/10/0  
(40 cm)

Range of Alignment:  
BI  
BO  
Distance: 21/31  
Near: 310/1  
(40 cm)

FOOCST: 380  
@ Near
Name: Clare Tomaselli  Age: 18

Refraction:  
-4.25  
-2.50  

BVA: 20/15  
PD: 62

Stereo Acuity:  
Distance: 60  
Near: 40

Phoria:  
Distance: 600  
Near: 380

Vergences:

BI  
BO

Distance:  
\( \frac{11}{0.18} \)  
\( \frac{11}{24.16} \)

Near:  
\( \frac{18}{26.13} \)  
\( \frac{18}{24.17} \)  
(40 cm)

Range of Alignment:

BI  
BO

Distance:  
15/3  
13/1

Near:  
15/3  
15/4  
(40 cm)

FOO  Dist: 18
Name: Dale Massingham  Age: 22

Refraction:
- +0.75 sph
- +0.50 sph

BVA: 20/15

Stereo Acuity:
- Distance: 60
- Near: 40

Phoria:
- Distance: 0
- Near: 18E

Vergences:
- BI
  - Distance: 18/15
  - Near: 124/16
  (40 cm)
- BO
  - Distance: 16/11/12
  - Near: 126/20

Range of Alignment:
- BI
  - Distance: 13/12
  - Near: 116/15
  (40 cm)
- BO
  - Distance: 112/11
  - Near: 16/15
Name: Joe Trujillo
Age: 22

Refraction: Over +1.5's plano

BVA: 20/15

Stereo Acuity:
Distance: 60
Near: 40

Phoria:
Distance: 200
Near: 500

Vergences:
BI
BO
Distance: X16 14 18 29 27
Near: 718 101 221 271 18
(40 cm)

Range of Alignment:
BI
BO
Distance: 13 12 1.2 26
Near: 15 13
(40 cm)

FD @ Dist 180
@ Near 180
Name: Mike Patterson Age: 25

Refraction: +1.00
Over +0.25

Stereo Acuity:
Distance: 60 Near: 40

Phoria:
Distance: 6 Near: 180

Vergences:
BI: BO
Distance:
18/18/18
18/18/19
Near:
18/18/12
28/30/15
(40 cm)

Range of Alignment:
BI: BO
Distance:
3/12/1
10/11/1
Near:
15/14/1
15/13/1
(40 cm)

BVA: 20/15
F.O. O른쪽 8
<table>
<thead>
<tr>
<th>Name</th>
<th>Age</th>
</tr>
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<tbody>
<tr>
<td>Greg Nicholas</td>
<td>22</td>
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<tbody>
<tr>
<td>pl</td>
<td>20/15</td>
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<tr>
<td>over CL's</td>
<td>-0.25</td>
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<table>
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<tbody>
<tr>
<td></td>
<td>60</td>
<td>40</td>
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<td>182</td>
<td>580</td>
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<th>BO</th>
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<tr>
<td>Distance</td>
<td>±18 16</td>
<td>±16 26</td>
</tr>
<tr>
<td>Near</td>
<td>±12 18</td>
<td>±24 30</td>
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<tr>
<td>(40 cm)</td>
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<th>BO</th>
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<tbody>
<tr>
<td>Distance</td>
<td>13 12</td>
<td>14 13</td>
</tr>
<tr>
<td>Near</td>
<td>15 14</td>
<td>12 21</td>
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<tr>
<td>(40 cm)</td>
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E.O. @ near 180