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Comparative anisometropic study between the Turville infinity balance test and the monocular negative relative accommodation test

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Abstract

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APPROVED

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PURPOSE

Many times at the end of an examination, the optometrist looks at his findings and notes that a different aniso balance value is indicated by different tests. It is important to prescribe the most valid value, otherwise the patient may have asthenopic problems, or may complain of a slight blur in one eye.

Arnot, Watts, and Goodwin, in separate previous research studies, compared the validity of various tests indicating aniso values. While Goodwin did not check the validity of the 21m, Arnot and Watts did. Arnot concluded that the 21m was invalid, whereas Watts concluded it was valid.

Our project was an attempt to show whether the 21m was valid or not. We wanted to see if the 21m could be used with confidence in a general clinical routine as an index of the accommodation balance between the two eyes.

RELATED RESEARCH

Many clinicians use the 21m as a source to dictate the amount of aniso to be prescribed. Work has been done to check the validity of this finding in two previous thesis projects. One project claiming it to be valid, the other not valid.

Arnot, et al, at Pacific University, investigated the validity of the #14A complex, 20/40 equalization, 20/25 recovery, bichrome, far point cross cylinder, and the 21m tests. They used as their "true" aniso findings the average value indicated by the six tests. They concluded that the 21 had a higher variance than the others and therefore the least validity. In their paper, they suggested that a follow-up study be done to investigate if the validity really existed.

Watts, et al,[5] followed a similar technique in judging the validity of the same tests. Watts' group also used as their standard aniso the average value of six tests. However, they concluded the 21m to be as valid as the others.

Since both previous studies had undertaken to solve the problem, used identical techniques, and came out with different conclusions, we decided to try and resolve the problem by different techniques and thus avoid the pitfalls in their research.

Gentsch and Goodwin[2] tried to answer the question of what is the most suitable method for the determination of the binocular refractive balance. They studied static retinoscopy, monocular comparison of visual acuities at twenty feet, acuity under prism dissociation and the Turville infinity binocular balance. They used a haploscope with a Nagel optometer system to determine the relative positions of the conjugate foci for each retina. The value obtained by the haploscope was considered the "true" aniso. The other four tests were then compared with it and the Turville balance test showed the highest agreement and had the best correlation coefficient of predictability.

The Turville infinity balance test was introduced in 1946 by A. E. Turville. The apparatus was made up of a test chart which consisted of a double vertical column of test letters. The letters were viewed in a mirror which had a central opaque strip attached to it. This strip served as a septum which was so placed as to allow each eye to see only one-half of the test chart. This enabled the subject to compare the two halves in the presence of peripheral fusion and under binocular viewing conditions. Turville felt that his technique enabled balancing of the accommodative effort in both eyes and gave a reliable balance finding.[4]

Morgan[3] in 1949, using the Bobinson-Cohen Slide with the project-o-chart, described a modification of Turville's technique. His technique did not employ the mirror but, instead, utilized a septum which was located between the patient and the projected chart. The Morgan-Turville arrangement is illustrated in Figure 1.

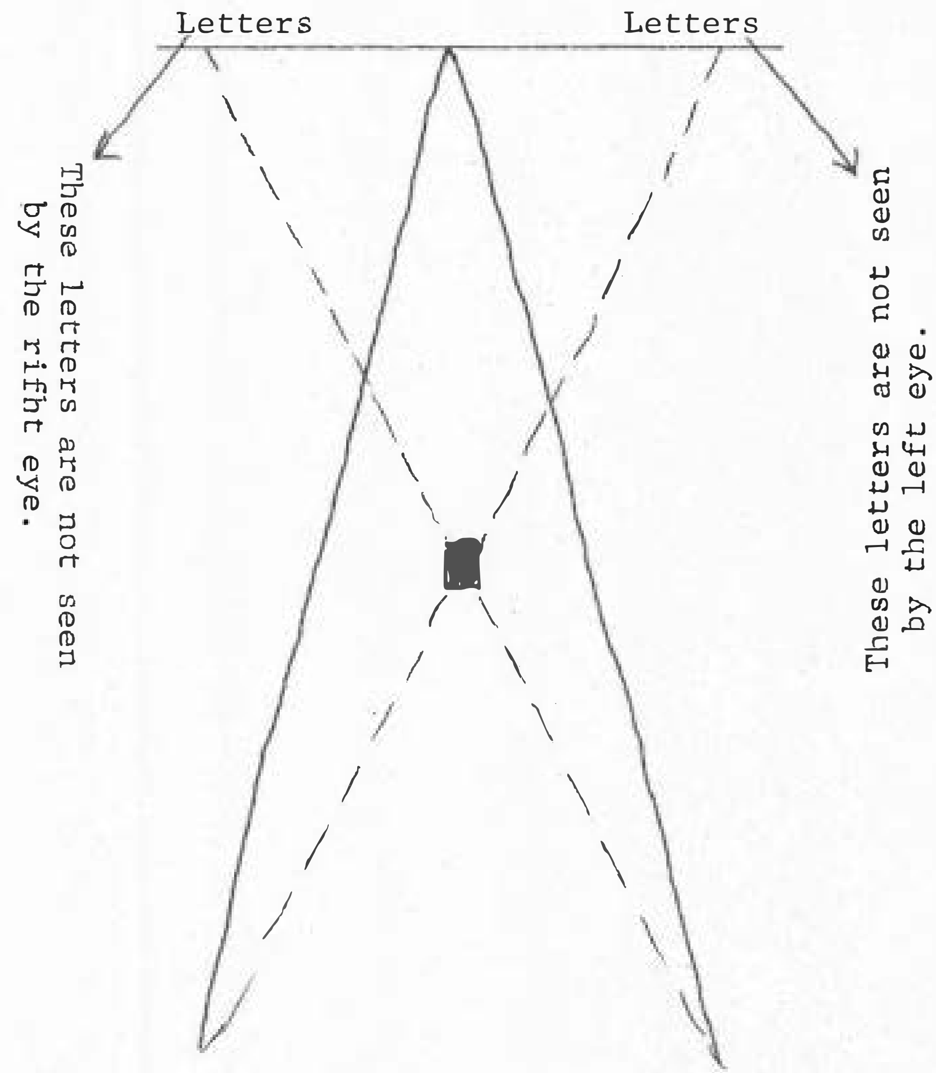
Assuming that a problem may have arisen in the Arnot and Watts study due to the fact they did not have a standard base aniso finding, but used instead an average aniso as the true value, we chose the most valid technique (as indicated by Gentsch and Goodwin) that was available to us--the Turville Infinity Balance--for the basis of comparison.

Therefore, our study consisted of using the Turville as our true aniso value to compare and check the validity of the monocular #21.

Figure 1

Diagram of the Turville

Set-up Used in the Testing



METHOD

The method for performing the monocular 21 was the standard procedure as taught at Pacific University. With correct cylinder in place, plus was increased binocularly until the 20/20 line on the near point Snellen card was completely blurred out, and then decreased monocularly until approximately two-thirds of the 20/20 line could be read. The test was run three times on each eye for comparison, with the final recovery value being taken as an indicator of the aniso.

The binocular refraction technique used in this study consisted of the Morgan method of anisometropic comparison, as illustrated in Figure 1, page 5. A septum 33 mm. in width was placed halfway between the patient and the chart so he could see the right side of the chart only with his right eye, and the left side only with his left eye. Morgan used a 20/40 line, as did we for our project. A +.25D was added to both eyes alternately (from the 7A) until equal blur was reported.

Blur values were recorded to the nearest quarter diopter value in both the Turville and the 21m findings.

SUBJECTS

Forty-four subjects participated in this study. Forty-one were run once on the Turville and once on the 21m. Approximately half of the forty-one subjects were sixth-year optometry students; the other half were patients from the Pacific University clinic population. Three subjects were run three times a day for three weeks so we could get an idea as to the variability, if any, of the accommodative balance as measured by this test.

All subjects were functioning at 20/25 visual acuity or better. Strabismic patients, patients with high exophoria (above 9x0 at far or near) or esophoric patients greater than four prism diopters, or patients with any binocular dysfunction were excluded from the study.

RESULTS AND DISCUSSION

In part A of our project, forty-four patients were tested on the 21m and the Morgan-Turville Infinity Balance. This data is shown in Table 1. The results show the 21m to have a very high correlation coefficient of .97 with the Turville. The mean difference in aniso indicated for the forty-four patients was .127 diopters. In twenty-five of the cases, the same aniso value was indicated by both tests. In sixteen cases there was a .25 diopter difference in aniso, with the Turville indicating less aniso in nine tests, and more aniso in the remaining seven. In the three cases showing a .50 difference, the Turville showed less aniso for two and more for one.

The difference in the aniso values had a variance of .0247 and a standard deviation of .157.

In part B of the project, three patients were run three times a day for fifteen days, a total of 45 runs per patient. Here we were attempting to check the reliability of the aniso shown. For the first subject, the mean aniso indicated by the Turville was .14D, while the 21m had a mean aniso of .15D, the 21m showing a standard deviation of .12D. In the second patient, the Turville indicated a mean aniso of .096, while it was .021 for the 21m. The 21m aniso showing a standard

Table 1

Patient	eye	Turville Finding	21m Finding	Aniso indicated	
1	OD	+1.75	+2,50	T aniso	zero
	OS	+1.75	+2,50	21 aniso	zero
2	OD	+1.75	+2.75	T. aniso	+.50
	OS	+1.25	+2,50	21 aniso	+.25
3	OD	-3.00	-1.00	T aniso	+.75
	OS	-3.75	-1.75	21 aniso	+.75
4	OD	+2.50	+4.25	T aniso	zero
	OS	+2.50	+4.00	21 aniso	+.25
5	OD	+4.00	+5,25	T aniso	-.25
	OS	+4,25	+5,50	21 aniso	-.25
6	OD	-4.50	-3.00	T aniso	-.25
	OS	-4.25	-2.25	21 aniso	-.75
7	OD	+1,25	+3.00	T aniso	-,25
	OS	+1.50	+3,25	21 aniso	-,25
8	OD	+4.00	+5,25	T aniso	-,25
	OS	+4.25	+5.50	21 aniso	-,25
9	OD	-.50	+1.00	T aniso	zero
	OS	-.50	+1.00	21 aniso	zero
10	OD	+1.25	+3.00	T aniso	-,25
	OS	+1.50	+3.00	21 aniso	zero
11	OD	+1.00	+3.50	T aniso	zero
	OS	+1.00	+3.25	21 aniso	+.25
12	OD	-1.25	+1.00	T aniso	+1.00
	OS	-2.25	-.50	21 aniso	+1.50
13	OD	-1.75	plano	T aniso	-1.00
	OS	-.75	+1.00	21 aniso	-1.00
14	OD	+1.50	+2.75	T aniso	+.50
	OS	+1.00	+2.75	21 aniso	zero
15	OD	+1.75	+4.50	T aniso	zero
	OS	+1.75	+4.50	21 aniso	zero
16	OD	-.75	+.25	T aniso	+.50
	OS	-1.25	+.75	21 aniso	+.50
17	OD	+1.50	+3.00	T aniso	+.25
	OS	+1.25	+3.00	21 aniso	zero
18	OD	+1.25	+2,50	T aniso	+.25
	OS	+1.00	+2,50	21 aniso	zero
19	OD	+.50	+2,00	T aniso	-.25
	OS	+.75	+2,25	21 aniso	-.25
20	OD	+1.00	+2,00	T aniso	-.25
	OS	+1.25	+2.00	21 aniso	zero
21	OD	+.25	+2.25	T aniso	zero
	OS	+.25	+2.00	21 aniso	+.25
22	OD	+1.00	+2.50	T aniso	-.25
	OS	+1.25	+2.75	21 aniso	[illegible]

Patient	eye	Turville Finding	21m Finding	Aniso indicated	
#23	OD	+1.25	+2,75	T aniso	+.25
	OS	+1.00	+2,50	21 aniso	+.25
#24	OD	-2.50	-2,25	T aniso	-.50
	OS	-3.00	-1.75	21 aniso	-.50
#25	OD	+2.75	+4.25	T aniso	+.25
	OS	+2.50	+4.00	21 aniso	+.25
#26	OD	-.25	+1.25	T aniso	+.50
	OS	+.25	+1.75	21 aniso	+.50
#27	OD	+2.25	+4.25	T aniso	-.25
	OS	+2.50	+4.50	21 aniso	-.25
#28	OD	-1.75	-.25	T aniso	-.25
	OS	-1.50	plano	21 aniso	-.25
#29	OD	+2.25	+4.00	T aniso	zero
	OS	+2.25	+4.00	21 aniso	zero
#30	OD	+1.25	+3.50	T aniso	zero
	OS	+1.25	+3.50	21 aniso	zero
#31	OD	+.50	+2,50	T aniso	-.25
	OS	+.75	+2.75	21 aniso	-.25
#32	OD	+.75	+3.00	T aniso	-.25
	OS	+1.00	+3.25	21 aniso	-.25
#33	OD	+1.00	+2.25	T aniso	+.25
	OS	+.75	+2.25	21 aniso	zero
#34	OD	+1.25	+3.00	T aniso	zero
	OS	+1.25	+3.00	21 aniso	zero
#35	OD	+.75	+2.25	T aniso	+.25
	OS	+.50	+1.25	21 aniso	zero
#36	OD	-.50	+1.75	T aniso	-.50
	OS	zero	+2.50	21 aniso	-.75
#37	OD	+1.75	+3.25	T aniso	zero
	OS	+1.75	+3.00	21 aniso	+.25
#38	OD	+1.25	+3.50	T aniso	zero
	OS	+1.25	+3.50	21 aniso	zero
#39	OD	+1.25	+3.25	T aniso	zero
	OS	+1.25	+3.50	21 aniso	-.25
#40	OD	+2.25	+4.25	T aniso	+.50
	OS	+1.75	+3.75	21 aniso	+.50
#41	OD	+.75	+2,75	T aniso	+.25
	OS	+.50	+2.25	21 aniso	+.50
#42	OD	+.25	+2.50	T aniso	+.25
	OS	plano	+2.25	21 aniso	+.25
#43	OD	+1.00	+2.00	T aniso	zero
	OS	+1.00	+2,25	21 aniso	-.25
#44	OD	+1.00	+2.75	T aniso	+.25
	OS	+.75	+2.75	[illegible]	[illegible]

deviation of .128. For the third patient, the mean aniso indicated by the Turville was .16D, while it was .021 for the 21m. The 21m aniso showing a standard deviation of .156.

The following two formulas were used to calculate the standard deviation and the Pearson r (correlation coefficient).

$$S.D. = \sqrt{\frac{n \sum_{i=1}^{n} Xi^2 - (\sum_{i=1}^{n} Xi)^2}{n\,(n-1)}}$$

$$r = \frac{\sum_{i=1}^{n} (Xi-\bar{X})\,(Yi-\bar{Y})}{\sqrt{\sum_{i=1}^{n} (Xi-\bar{X})^2 \cdot \sum_{i=1}^{n} (Yi-\bar{Y})^2}}$$

Part B results are shown in Table 2.

Table 2

	Patient 1				Patient 2			
Test	Day	Morning	Noon	Evening	Day	Morning	Noon	Evening
Turville 21 m	1	OD +1.00 OS +1.25 OD +2.50 OS +2.75	+.75 +1.00 +2.50 +2.75	+.75 +1.00 +2.50 +2.75	1	1.00 1.00 2.00 2.00	1.00 1.00 2.00 2.25	.75 .75 1.50 1.75
Turville 21 m	2	OD +1.00 OS +1.25 OD +2.50 OS +2.75	+1.00 +1.00 2.50 2.50	.75 1.00 2.75 2.75	2	1.00 1.00 2.25 2.25	1.00 1.00 2.00 2.25	.75 .75 2.00 2.00
Turville 21 m	3	OD 1.25 OS 1.25 OD 2.70 OS 2.75	1.00 1.25 2.50 2.75	1.00 1.25 2.75 2.75	3	.75 .75 2.50 2.50	.75 .75 2.25 2.25	.75 .75 2.25 2.25
Turville 21 m	4	OD 1.00 OS 1.25 OD 2.50 OS 2.75	1.00 1.00 2.75 2.75	1.00 1.00 2.25 2.75	4	.50 .50 2.00 2.50	.75 .50 2.00 2.25	.75 .75 2.00 2.00
Turville 21 m	5	OD 1.00 OS 1.25 OD 2.50 OS 2.75	1.00 1.00 2.50 2.75	1.00 1.25 2.50 2.75	5	.75 .75 2.50 2.50	.75 .75 2.25 2.25	.75 .75 2.00 2.25
Turville 21 m	6	OD 1.00 OS 1.00 OD 2.50 OS 2.75	1.00 1.00 2.50 2.50	1.00 1.00 2.50 2.50	6	.75 .50 2.50 2.50	.75 .75 2.25 2.25	.75 .75 2.00 2.25
Turville 21 m	7	OD 1.00 OS 1.25 OD 2.75 OS 2.75	.75 1.00 2.50 2.75	.75 1.00 2.75 2.75	7	.75 .50 2.25 2.50	.75 .75 2.25 2.25	.75 .75 2.25 2.25
Turville 21 m	8	OD 1.00 OS 1.00 OD 2.50 OS 2.75	1.00 1.00 2.50 2.75	1.00 1.25 2.50 2.75	8	.75 .75 2.00 2.00	.75 .75 2.00 2.25	.75 .50 2.00 2.25
Turville 21 m	9	OD 1.00 OS 1.00 OD 2.50 OS 2.25	1.25 1.25 2.50 2.75	1.00 1.25 2.50 2.75	9	.50 .50 2.25 2.50	.75 .75 2.00 2.25	.75 .75 2.25 2.50
Turville 21 m	10	OD 1.00 OS 1.25 OD 2.50 OS 2.75	1.00 1.25 2.50 2.50	1.00 1.00 2.50 2.50	10	.75 .75 2.50 2.75	.75 .75 2.25 2.50	.75 .75 2.00 2.50
Turville 21 m	11	OD 1.00 OS 1.25 OD 2.75 OS 2.75	1.00 1.25 2.50 2.75	.75 1.00 2.75 2.75	11	1.00 1.00 2.00 2.25	1.00 1.00 2.00 2.25	1.00 1.00 2.00 2.00
Turville 21 m	12	OD 1.00 OS 1.25 OD 2.50 OS 2.75	1.00 1.00 2.50 2.75	1.00 1.25 2.75 2.75	12	.75 .75 2.00 2.00	1.00 1.00 2.00 2.25	1.00 1.00 2.25 2.50
Turville 21 m	13	OD .75 1.00 OS 2.50 OD OS 2.75	.75 1.00 2.50 2.75	1.00 1.25 2.50 2.75	13	.75 .75 2.00 2.25	.75 1.00 2.00 2.25	.75 1.00 2.00 2.00
Turville 21 m	14	OD 1.00 OS 1.25 OD 2.50 OS 2.75	1.00 1.00 2.75 2.75	1.00 1.00 2.75 2.75	14	.75 .75 2.00 2.50	.75 .50 2.75 2.75	.75 .75 2.25 2.50
Turville 21 m	15	OD 1.00 OS 1.00 OD 2.50 OS 2.50	1.00 1.00 2.50 2.75	1.00 1.00 2.50 2.50	15	.75 .75 2.25 2.25	1.00 .75 2.75 2.75	1.00 .75 2.75 2.75
Turville 21 m								

Table 2

Patient 3

Test	Day	Morning	Noon	Evening
Turville 21m	1	OD .75 OS 1.00 OD 3.00 OS 2.75	1.00 .75 2.75 2.75	1.00 .75 2.75 2.75
Turville 21m	2	OD 1.25 OS 1.00 OD 3.00 OS 2.75	1.00 .75 3.00 3.00	1.00 .75 3.00 3.00
Turville 21m	3	OD 1.25 OS 1.00 OD 2.50 OS 2.50	1.25 1.00 2.75 2.75	1.25 1.00 2.75 2.75
Turville 21m	4	OD 1.25 OS 1.25 OD 2.50 OS 2.00	1.25 1.00 2.50 2.50	1.25 1.25 2.75 2.75
Turville 21m	5	OD 1.25 OS 1.25 OD 2.75 OS 2.75	1.25 1.25 3.00 3.00	1.25 1.00 2.75 2.75
Turville 21m	6	OD 1.00 OS .75 OD 2.75 OS 2.75	1.00 .75 2.75 2.75	1.25 1.00 2.75 3.00
Turville 21m	7	OD 1.00 OS .75 OD 3.00 OS 2.75	1.00 .25 3.00 2.75	1.25 1.00 2.75 2.75
Turville 21m	8	OD 1.25 OS 1.00 OD 2.75 OS 2.75	1.25 1.00 2.75 2.50	1.25 1.25 3.00 2.75
Turville 21m	9	OD 1.25 OS 1.25 OD 2.75 OS 2.75	1.25 1.00 2.75 2.75	1.25 1.25 2.50 2.50
Turville 21m	10	OD 1.25 OS 1.25 OD 2.50 OS 2.50	1.00 1.00 2.75 2.75	1.00 1.00 2.75 2.75
Turville 21m	11	OD 1.00 OS .75 OD 2.75 OS 2.75	1.00 .25 2.75 2.50	1.25 1.00 2.75 2.50
Turville 21m	12	OD 1.00 OS 1.00 OD 2.50 OS 2.25	1.25 1.00 2.50 2.50	1.00 .75 2.50 2.50
Turville 21m	13	OD 1.00 OS .75 OD 2.75 OS 2.50	1.00 1.00 3.00 2.75	1.00 1.00 3.00 3.00
Turville 21m	14	OD 1.25 OS 1.00 OD 3.25 OS 2.75	1.25 1.00 2.75 2.75	1.00 1.00 2.75 2.50
Turville 21m	15	OD 1.00 OS .75 OD 2.50 OS 2.25	1.00 1.00 2.50 2.50	1.25 1.00 2.50 2.50

Table 3 is a chart showing a comparison of results from Gentsch and Goodwin.

The optometer readings for 27 members of the group provided a measure of accommodative response to which the results of all their tests could be compared.

As can be seen in Table 3, the monocular occlusion and prism dissociation gave better agreement than the bichrome and retinoscopy balances. The Turville Infinity Balance showed the highest agreement (48 percent) with the best correlation coefficient of 0.69. The smallest mean deviation from the haploscopic response (.22D) and variance (0.09D) occurred again with the Turville.[2]

From this information, one can see that the 21m is a very reliable test showing a variance of .0247 and a correlation coefficient of 0.97.

TABLE 3

Binocular Refractive Balance - Gentsch and Goodwin

Balance Test	Frequency of dis-agreement with haploscopic balance	r_p	Mean deviation from accommodation response balance	Variance
1. Retinoscopic Balance	82%	.44	.29	.26
2. Monocular Occlusion	63%	.61	.24	.18
3. Prism Dissociation	63%	.61	.24	.23
4. Bichrome Technique	71%	.54	.32	.44
5. Turville Infinity Balance	52%	.69	.22	.09
6. 21M compared to Turville in Baker & Fee Study		.97		.0247

CONCLUSIONS

Our project showed the 21m to be a valid aniso indicator. The Pearson's r of .97 shows an almost perfect correlation between the 21m and the Turville. So, the 21m is nearly as valid as the Turville, which was shown to be a good aniso indicator by the work of Gentsch and Goodwin.

The 21m was also shown to be a reliable (repeatable) indicator of the amount of aniso. The standard deviation of the aniso for each of the three subjects was .12D, .128D, and .156D.

It should be noted that no one test should be used as "the" test to indicate the prescribed aniso. The proper aniso should be derived by examining all the various tests.

We conclude that for patients falling within the limitations imposed in the present study, that the 21m is a valid and reliable aniso finding, and the clinician may put faith in the finding.

The Gentsch and Goodwin study showed monocular occlusion to have variance of .18, prism dissociation had a variance of .23, the Turville technique was the best with a variance of .09. Since our study showed a high Pearson's r of .97, it could be concluded that the 21m is as good or better than any of the techniques studied by Gentsch and Goodwin, with the exception of the Turville.

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