The Analysis of the Results From Two Commonly Used Optometric Tests as They Relate to Patient's Binocular Vision Symptoms

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Abstract

For the study we looked at horizontal phorias, accommodative and vergence facility, horizontal vergence ranges, accommodative state and amplitude, near point of convergence, and various tests of fixation disparity. In addition we evaluated refractive error, vertical phoria, anisophoria, aniseikonia, and cyclophoria. From this large battery of test data we chose to analyze the results of two tests, which are commonly used in the assessment of patients with binocular vision symptoms. This paper focuses on the results of accommodative facility and the patients near phoria and examines those results in the light of items from a symptoms questionnaire.

Introduction

Accommodative facility testing is a measure of the patient's ability to make rapid and accurate accommodative changes.[1] This type of testing is commonly done in many routine eye exams. The testing can be done under monocular or binocular conditions. Typically the patient is tested first under binocular conditions. If they were to fail the test the examiner would then perform the test monocularly. This would enable the tester to differentiate between a primary accommodative problem and a primary binocular problem

Accommodative problems can be broken into four categories: insufficiency, excess, infacility, and ill-sustained. Even though they are separate two or more can occur in the same patient. It should be obvious that while the accommodative facility test primarily looks at the flexibility of the accommodative system, it can also be used to diagnosis other accommodative problems. For instance, if a patient has insufficient accommodation they will struggle with the test, failing the minus portion. Furthermore, those patients with ill-sustained accommodation will show fatigue as the infacility test proceeds. Additionally, the accommodative excess patient may struggle with the plus portion of the test because they will fail to relax their system. Therefore, accommodative facility testing can be used to diagnosis most patients with accommodative problems. As a safeguard, we also performed a refractive analysis and MEM retinoscopy to insure that all accommodative problems would be discovered.

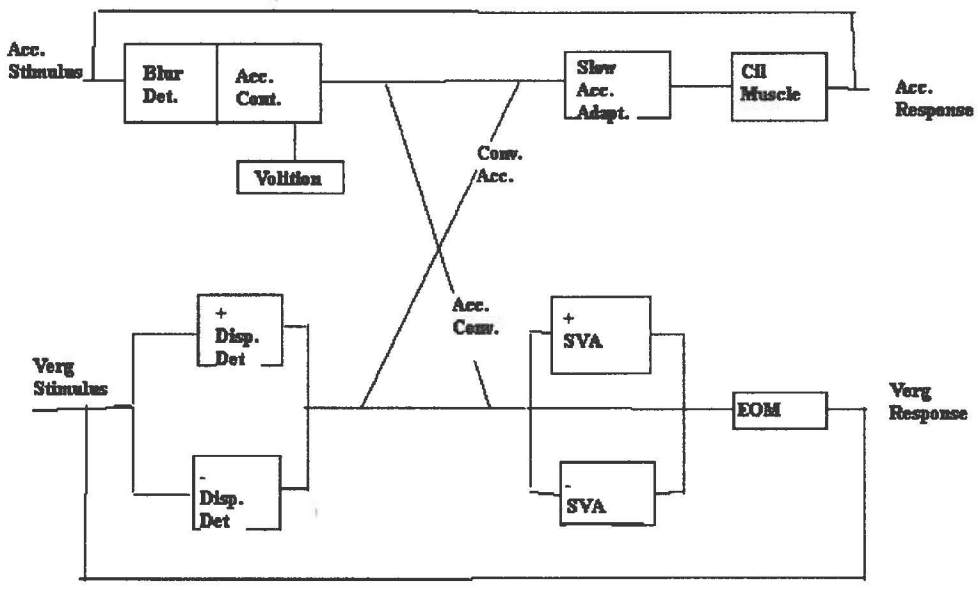

Figure 1

But the usefulness of the accommodative facility test does not stop at accommodative problems alone. Under binocular conditions the patient is also called upon to use their positive and negative fusional vergence systems during the accommodative facility test. As you can see in figure 1, inserting minus lenses in front of a patient causes them to accommodate, and also causes positive accommodative convergence that turns the eyes inward.[2] However, the target remains in the same location, and unless the negative fusional vergence system comes into play, the patient will have diplopia. The opposite is true upon inserting plus lenses in front of the patient. The plus lenses cause the accommodative system to relax which, in turn, leads to a decrease in accommodative convergence.[2] In this case, the patient is forced to use positive fusional vergence to avoid diplopia.

Heterophoria is the tendency of the lines of sight to deviate from the relative positions that are necessary to maintain a single binocular image for a specific distance.[2] In this case we elected to look at the near or 40 cm phoria 40 cm. Phoria testing can be done using many different techniques. We chose to use the Modified Thorington method. The near phoria is the result of an inappropriate amount of innervation and is comprised of the innervational total from the tonic, accommodative, and proximal vergence systems. The expected phoria at near ranges from 6 exophoria to orthophoria.[3]

The overall goal of this research project is to determine which group of tests will provide the clinician with the ability to decide if the patient will have binocular vision induced problems. This paper will look statistically at the two tests mentioned above in order to determine how well the results match up with the patients' reported complaints based on their survey.

Method

We obtained data from 49 subjects from the second and third year classes of the Michigan College of Optometry. The subjects ranged in age from 22 to 36. They were all given a questionnaire that had been developed for the purpose of determining the presence of symptoms related to binocular vision problems. The survey was then divided into different subsections in order to further focus on the oculomotor-specific aspects of the patient complaints. The results of the survey were then scored and the subjects ranked in order of their reported symptoms. In order to add to the validity of the data the subjects were broken into three subgroups using the overall score . The middle group was then omitted from the statistical analysis in order to lessen the effect of the more ambiguous scores.

The accommodative facility testing was performed using the near chart of the Saladin Near Point Card. The patients were instructed to read the letters on the chart as the examiner turned the flipper lenses; each flip was performed after a letter was read correctly. The examiner also watched the subject's eyes to ensure motor fusion was maintained. The patient was initially started using ±2.00 flippers. If they were unable to perform the task the test was then administered using ±1.50 flippers. The tests were carried out for 1 minute with the examiner also noting the progress at 30 seconds of time. The results can be seen in figure 2.

The near phoria was determined using the Modified Thorington technique. Again we were able to make use of the Saladin Near Point Card. A Maddox rod was held in front of the subject's right eye such that it would create a vertical streak. The subject was then

asked to look at the letters and numbers that surround the small hole in the center of the Modified Thorington portion of the chart. When they were clear, the patient was asked to look at the light in that small hole and state which number the vertical streak passed through. The numbers on the chart are equal to prism diopters. These results were then recorded and can be found in figure 3.

In an effort to control the effects of overall fatigue on the subjects, we administered the battery of tests using two different orders. Half the subjects were tested using a form with near testing being preformed first; the other half was given the distance portion of the testing battery first. A sample of the forms can be found in appendix A.

Results

The results for the accommodative facility testing from both the "asymptomatic" (Asymp) group, those with a low overall or red score, and the "symptomatic" (Symp) group, those with a high red score, can be found in figure 2.

Asymp	Acc Fac 30 sec	Acc Fac 60 sec	Red Score	Symp	Acc Fac 30 sec	Acc Fac 60 sec	Red Score
	9	18	3		6	11	36
	9	15	7		7	11	30
	10	21	3		10	20	28
	10	23	10		11	20	36
	12	25	1		11	19	41
	12	25	3		12	19	28
	12	23	7		12	23	39
	13	25	2		12	21	43
	15	28	1		13	27	31
	15	28	2		13	24	36
	15	30	5		13	22	39
	16	31	0		13	25	46
	16	32	10		14	27	37
Mean	12.61538462	24.92307692			14	28	42
		Sd = 5.0			15	29	30
					19	37	47
				Mean	12.1875	22.6875	Sd = 6.5

Figure 2

The mean number of flips for the healthy group at the 30 second interval was 12.6. The result at 1 minute was 24.9, showing only a slight drop off in the number of flips per second. The Symptomatic group had a 30 second time of 12.18 and a 1 minute time of 22.7, here the drop off due to fatigue was slightly larger then that of the Asymptomatic group. The Asymptomatic group also exhibited a lower standard deviation over the one minute time - 5.0 compared to the 6.5 of the Symptomatic group. In order to further analyze the data, a Pearson product moment correlation coefficient analysis was preformed. The correlation results for the 30 second facility and 1 minute facility data for the Asymptomatic group were similar, -.022 and -0.14 respectively. The Symptomatic data was also similar between the two time periods with -.043 for 30 seconds and -0.41. This shows that having a lower number of flips in the facility testing and a higher score on the symptoms survey is more likely than a lower number of flips and a lower score on the survey.

Asymp	Red Score	Near Hor. Phoria		Symp	Red Score	Near Hor. Phoria
	0	6			28	0
	1	-3			28	5
	1	2			30	-3
	2	0			30	3
	2	6			31	-2
	3	2			36	2
	3	1			36	5
	3	-2			36	1
	5	3			37	-1
	7	-6			39	-1
	7	-2			39	-1
	10	1			41	4
	10	5			42	7
	11	2			43	3
					46	4
					47	-4

Figure 3

The near phoria results from both the Asymptomatic and Symptomatic groups can be found below in figure 3. The negative values in the figure represent exophorias and the positive values are esophorias. In order to run the initial Pearson product moment correlation coefficient analysis on the phoria and the red survey score, the phoria data was viewed as an absolute value. The Asymptomatic results were -.006, which means there is very little association, however for the Symptomatic group the Pearson result was 0.29. This means that there is more of an association with the Symptomatic group and the respective phoria scores. In order to dig a little deeper we looked at exo and eso deviations in relation to the survey score. For subjects with exophoria , there is not as strong of a relation between the healthy and sick groups. For the subjects with esophoria, the Asymptomatic group's results showed that as the phoria increased the red score paradoxically decreased giving a Pearson score of –0.29. The Symptomatic group showed just the opposite, as their phoria increased so did their red scores with a Pearson value of 0.14. It would be expected that the red scores would increase (indicating more symptoms) as the amount of the phoria increased.

Discussion

The results show that, as expected, those who report problems with their visual systems do not fare as well when performing the two tests that were evaluated in this study. Interestingly, there is currently a second study that is ongoing which involves a slightly different set of test subjects. The new group of test subjects consists of students earlier in their optometric careers. This is of more importance when one investigates the current curriculum at the Michigan College of Optometry. During their second year, as part of the vision therapy course, students perform VT on one another. The data in this

study was gathered after this VT had been conducted, which leads me to believe that the symptoms related to the situation before the VT and the test results to the situation after the VT. Therefore, those people with visual complaints to scored better on our tests than if the VT had not taken place. The new group of data seems to show more of a difference in the results of the two groups of test subjects. I believe that this new data will serve to strengthen the assumptions made in this study.

It is also important to remember that the subjects in the study are experienced in not only taking but also performing the two tests in the study. This is relevant because they have learned the "tricks of the trade" so to speak. This knowledge matters more during the accommodative facility testing as opposed to the phoria testing. I believe that students with knowledge of the inner workings of the accommodative system and experience in the facility testing itself, will be able to perform better than the average patient off the street. Because of this, the general public will probably exhibit a larger degree of difference between the Asymptomatic and Symptomatic groups.

Lets now take a look at the individual tests themselves, first the accommodative facility test results. While the Pearson value for the tests were not extremely high, that pf the Asyptomatic group was only half that of the Symptomatic group. This suggests that accommodative facility testing alone will not detect all of the Symptomatic individuals, However, when combined with a few other tests, it will serve to illicit it's share of those with binocular dysfunction. It is also important to note that the 1 minute data showed a greater amount of difference. Traditionally, accommodative facility testing is done for only 30 seconds; in light of this study, it might be more informative to perform the

testing over a full minute with fatigue being a clue to the examiner that further testing is warranted.

The phoria data is not as clearly definitive, although the Pearson value shows a relationship between symptoms and results. Those individuals with higher overall or red scores tend to show an increase in the phoria amount, this is evident by the Pearson value of 0.29. The Asymptomatic group showed a Pearson value of only –0.06, basically showing no relationship between the two values. More importantly it should be noted that comparing the phorias of the Asymptomatic and Symptomatic groups is of little value because they are very similar. The statistics only show that those in the Asymptomatic group have an increased amount of phoria as their symptoms increase. This tells us to expect a higher phoria in those individuals with a higher degree of complaints, but not that simply having a high phoria alone will cause those complaints.

Conclusion

In conclusion, while these two standard tests used in everyday optometric examination of patients are very useful, they will not be able to differentiate all those patients who have binocular vision problems. However, when used with a few other tests they can have the ability to draw out those with problems associated with using their eyes. These two tests have been used and investigated for a very long time. The ultimate goal of this project is to choose a few tests from a large battery in our optometric arsenal. In order to accomplish this goal more research is required, both with these two tests as well as the others is the larger study. First of all, as mentioned early is this paper, other studies are currently underway. They are being conducted on a slightly different group of subjects - those who haven't been through VT. It can be argued that because our subjects have

already been through VT their data is somewhat tainted. Other testing on these subjects, such as the fixation disparity data, suggests that the VT might have influenced the overall results. The curves produce by these subjects were much flatter then those expected from a normal population. This could probably serve as evidence that VT does work; however, in this instance it only causes the data to be less compelling. On a brighter note, because this data still manages to show some statistical significance, the newer study that is currently ongoing on pre-VT subjects should be even more significant.

Another possible source of error in our data could have occurred due to patient fatigue. Ideally we should have broken the testing down into smaller, less draining sessions. This is hard to do when dealing with the busy schedules of the average optometry student.

Overall the data found in this study shows some promising results. This was meant to be more of a pilot study, thereby laying the ground work for future investigation. This investigation is currently being carried out and the findings are eagerly awaited.

1. Carlson N, Kurtz D, Heath D, Hines C. *Clinical Procedures for Ocular Examination 2nd ed.* Appleton & Lange, Stamford, Connecticut; 1996
2. Benjamin, William J. *Borish's Clinical Refraction,* W.B. Saunders Company, Philadelphia, Pennsylvania; 1998
3. Griffin, John R and Grisham, J David, *Binocular Anomalies: Diagnosis and Vision Therapy 3rd ed.* Butterworth-Heinemann, Boston, Massachusetts; 1995
4. Cotter, Susan and London, Richard. *Clinical Uses of Prism: A Spectrum of Applications.* Mosby-Year Book, St. Louis, Missouri; 1995

Name: _____ Date: _____

Check the column that best represents the occurrence of each symptom.

		Never	Seldom	Occasionally	Frequently	Always
1.	Blurred vision at near					
2.	Double vision					
3.	Headaches with near work					
4.	Words run together when reading					
5.	Burning, stinging, watering eyes					
6.	Falling asleep when reading					
7.	Vision worse at end of day					
8.	Skipping or repeating lines when reading					
9.	Dizziness or nausea associated with near work					
10.	Head tilt or closing one eye when reading					
11.	Difficulty copying from the chalkboard					
12.	Avoidance of reading and near work					
13.	Omitting small words when reading					
14.	Writing uphill or downhill					
15.	Misaligning digits in columns of numbers					
16.	Reading comprehension declining over time					
17.	Inconsistent/poor sports performance					
18.	Holding reading material too close					
19.	Short attention span					
20.	Difficulty completing assignments in reasonable amount of time					
21.	Saying "I can't" before trying					
22.	Avoiding sports and games					
23.	Difficulty with hand tools, scissors, screwdriver, calculator, keys					
24.	Inability to estimate distance accurately					
25.	Tendency to knock things over on desk or table					
26.	Difficulty with time management					
27.	Difficulty with money concepts, making change					
28.	Misplaces or loses papers, objects, belongings					
29.	Car sickness/motion sickness					
30.	Forgetful, poor memory					

RELATIVE DIAGNOSTIC POWER STUDY (ver. 4/15/03)
(RDS STUDY)

NAME: _____ AGE: _____

PERSONAL CASE HISTORY NOTES _____

6m. VISUAL ACUITIES THROUGH HABITUAL: OD _____ 0S_____

40cm. VISUAL ACUITIES THROUGH HABITUAL: OD _____ 0S_____

REFRACTION BALANCE AND HYPEROPIA CHECK: OK? _____

Hold the + 0.50 D. side of the ± 0.50 D. flipper lenses in front of both eyes of the subject. Alternately expose the right and left eyes. Ask the subject if both eyes are equally blurred on the 20/20 line on the distance VA chart. If both eyes do not suffer decreased clarity, or if there is more than one line difference in acuities, the subject does not meet VA/refraction criteria for this research.

OVER REFRACTION: OD _____ VA _____
(if necessary)
OS _____ VA _____

40 cm DATA

Modified Thorington: Flash the penlight. *Notice the row of numbers and read the letters around the flashing light. When they are clear, look at the light and tell me which number the vertical streak goes through or is closest to going through. Now look at the flashing light again and tell me which number in the column of numbers the horizontal streak goes through.*

PHORIAS: HORIZONTAL _____ VERTICAL _____

While measuring the near point phorias with the BV card, record the variation in the horizontal (30 degrees to right and left) and vertical meridians (20 degrees up and down). Tell me how much the streak varies as I move the card horizontally and vertically.

ANISOPHORIA (VARIATION OVER FIELD in Δ): HOR: _____ VERT: _____

Bar vergences: Use the block of letters on the Near Point Balance Card for fixation. Increase the prism power in front of the right eye at the rate of two prism diopters every two seconds. Watch the subject's eyes to confirm the subjective responses. Record the subjective responses. *Keep the letters in the block clear and single as long as possible. Tell me when the chart blurs and/or breaks into two or begins to move. Now tell me when it goes back into one.*

VERGENCES: BI ___/___/___ BO ___/___/___

Vergence facility: Use the block of letters for fixation. Objectively evaluate the subject's responses. Starting with 3 BI, flip back and forth. Count the number of successful fusion responses in 30 and 60 seconds. *Do your best to keep the block of letters single as I put prism in front of your right eye. Count each time you fuse the target.*

VERGENCE FACILITY (3 BI / 12 BO; flips) _____ 30 sec _____ 60 sec

FIXATION DISPARITY MEASUREMENT:

Familiarize the subject with the task, first without polarizing goggles, and then with. Keep the letters in the words above the circles in focus and tell me when the two vertical lines in the circles are one over the other.

0Δ _____ MINUTES OF ARC

4Δ BI _____ MINUTES OF ARC

4Δ BO _____ MINUTES OF ARC

Try to measure FD at ½ the bar vergence limit (break) and at/or near the bar vergence limit.

_____ Δ BI _____ MINUTES OF ARC

_____ Δ BI _____ MINUTES OF ARC

_____Δ BO _____ MINUTES OF ARC

_____Δ BO _____ MINUTES OF ARC

FIXATION DISPARITY NEUTRALIZATION:

Mount the BV card on the nearpoint rod at 40 cm and have the subject look at the circle labeled D. Introduce BI prism (Risley) in front of the left eye until the top line is seen to the right of the bottom line. Reduce the prism until the subject reports alignment; note that prism amount (BI neutral), and proceed introducing BO prism until the subject reports misalignment with the top line to the left. Reduce until alignment is noted; note that prism amount (BO neutral). It is possible that both BI neutral and BO neutral are accompanied by the same base direction but different amounts of prism. Look at the circle labeled D and clear the letters in the word above the circle. Tell me when the top line in the circle is seen to the right of the bottom line. Now tell me when it is aligned again. Now tell me when the top line is seen to the left of the bottom line. Now tell me when it is aligned again. Record in the WITHOUT CENTRAL FUSION LOCK spaces.

	BI Side NEUTRAL	BO Side NEUTRAL
WITHOUT CENTRAL FUSION LOCK	_____ Δ	_____Δ

Repeat with the central fusion lock:

WITH CENTRAL FUSION LOCK	_____ Δ	_____Δ

Accommodative facility: (GREATEST OF ± 2.00, 1.50, 1.00 D FLIPPERS) Use the block of letters for fixation. Objectively evaluate the subject's responses. Starting with +2.00, have the subject read one letter per flip. Count the number of successful responses (flips) in 30 and 60 seconds. Start in the upper left of the block of letters and read the letters, one at a time, as I flip these lenses in front of your eyes.

ACC FACILITY:

Power used: _____ _____ 30 sec _____ 60 sec

Slow on ? _____

6 METER DATA

Modified Thorington: *Look at the light at the center of the row of numbers and tell me which letter the vertical streak goes through or is closest to going through. Now look at the same light in the center of the column of letters and tell me which letter the horizontal streak goes through.*

PHORIAS: (MT) HORIZONTAL _____Δ VERTICAL_____Δ

Cover test: Using the modified Thorington results as an estimate, modify the prism required for neutralization of the horizontal and vertical phoric movements. Have the patient actively reading the letters on full distance VA chart. *Read the letters on the visual acuity chart.*

PHORIAS: (CT) HORIZONTAL _____Δ VERTICAL_____ Δ

Bar vergences: Use the full distance VA chart for fixation. Increase the prism power in front of the right eye at the rate of two prism diopters every two seconds. Watch the subject's eyes to confirm the subjective responses. Record the subjective responses. *Keep the letters on the VA chart clear and single as long as possible. Tell me when the chart blurs, breaks and/or begins to move. Now tell me when it goes back into one.*

VERGENCES: BI ___/___/___ BO ___/___/___Δ

Vergence facility: Use the full distance VA chart for fixation. Objectively evaluate the subject's responses. Starting with 3 BI, flip back and forth. Count the number of successful fusion responses in 30 and 60 seconds. *Do your best to keep the chart single as I put prism in front of your right eye. Count each time you fuse the target.*

VERGENCE FACILITY (3 BI / 12 BO; flips) _____ 30 sec _____ 60 sec

OTHER DATA:

PD F/N _____ mm

NPC _____cm Use the tip of a pen as a fixation point. Instruct the subject to look at the tip and keep it single as long as possible. Record the distance (from the spectacle plane) at which fixation is objectively lost.

RANDOT SCORE _____ rectangle Have the subject report which of the circles stands in front of the other two in all ten rectangles. Give the subject no more than 5 seconds to make the determination. Record the number of the last successful rectangle determination.

MEM RET: RE_____ LE _____ Have the subject hold the BV card at 40 cm in primary position and read the letters around the retinoscopy aperture. Perform MEM ret on both eyes. Neutralize with the lens bar.

ANISEIKONIA: (AMOUNT AND RANGE in %): _____ Teach the subject to perform the task using the practice card. Ask the subject to "Find the circle in which the upper two lines are the same distance apart as the lower two lines". Caution the subject, "Do not make the match by trying to align the upper and lower lines."

ACCOMMODATIVE AMPLITUDE: _____cm Measure the binocular amplitude of accommodation with the push up method. Keep the letters clear as long as possible and tell me when they are no longer clear. Use the push-up stick with the VA chart provided.

CYCLOPHORIA (ESTIMATED DEGREES): _____ Have the patient hold his/her head with the eyebase parallel to the floor and hold the BV card parallel to the floor at 40cm straight ahead. Shine the penlight through the pinhole in the BV card. Adjust the Maddox rod in front of the right in the trial frame such that the patient sees a vertical streak parallel to the vertical column of numbers on the card. Tell me when the vertical streak is parallel to the vertical column of letters. Estimate the cyclophoric amount.

NAME _____

CALCULATED FACTORS:

AC/A CALC _____ AC/A GRAD _____

SHEARD'S 6m _____ 40 cm _____

PERCIVAL'S 6m _____ 40 cm _____

1:1 6m _____ 40 cm _____

FIXATION DISPARITY DEVIATION (absolute amount, subtract actual from ideal)

40 cm _____ MINUTES OF ARC

S FACTOR (RATIO OF BO BLUR TO NPC) _____ Δ/cm

FD CURVE SLOPES:

BI SLOPE _____ '/Δ

BO SLOPE _____ '/Δ

THREE POINT SLOPE _____ '/Δ

FD CURVE TYPE _____

FD CURVE VARIABILITY (SMALL, AVERAGE, LARGE)

DEVIATION FROM NORMS (LIST ALL ITEMS THAT DEVIATE FROM NORMS):