Binocular Facility of Accomodation Testing:

Comparison of the Vectogram #9 Target/Method vs. the Polaroid Bar Reader/Rock Card Method

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Abstract

Normative values have been established for accommodative facility by using the Vectogram Target #9. However, in clinical practice, the Polaroid Bar Reader with Bernell Rock Card is a method more regularly used for this purpose. We established binocular accommodative facility normative values for the Polaroid Bar Reader/Rock Card Method and compared them to the established norms for the Vectogram #9 Method. Data were collected on 166 optometry students between the ages of 21-33, 72 of whom passed both tests. For these 72 subjects the mean accommodative facility rate for the Polaroid Bar Reader/Rock Card Method was lower than that of the Vectogram #9 Method at a statistically significant level. However, for the total sample the failure rate for the Polaroid Bar Reader/Rock Card Method was more than three times higher. Further testing needs to be done to include younger subjects and subjects who are not familiar with the testing procedures. This would increase the sample size, the diversity of the subjects' tested and greater validity to the normative values.

Keywords

binocular facility of accommodation, Vectogram Target #9, Polaroid Bar Reader, Rock Card, third degree fusion

A vision/eye health evaluation of a non-presbyopic patient involves assessment of refractive error, internal and external ocular health, binocularity, and nearpoint visual skills. Accommodative facility testing is an integral part of this evaluation. Accommodative facility is the rate at which accommodation can be repeatedly stimulated and inhibited over a specific period. This is evaluated binocularly while maintaining a constant angle of convergence, or monocularly with elimination of convergence.[1] Hennessey et al.[2] have shown that accommodative infacility is associated with asthenopic symptoms, and therefore these patients should be tested for deficits in this area. Pierce and Greenspan[3] reported deficits in this area result in headaches and blurred vision. These findings support the need for including facility testing in the nearpoint test battery.

In the past, normative values of accommodative facility have been an issue of debate. More recently, several well designed studies controlling such variables as suppression and refractive error, have developed normative data in young adults.[1,2,4] Several different targets have been used with the attempt to simulate a "normal" reading task. The most common method used is that of the lens flipper and the Bernell Polaroid Vectogram Acuity/Suppression Slide[a] (SO/V9) method (see Figure 1). This technique has been used to establish the normative data for adults and children in the majority of studies in this area. However, this is not the

Figure 1. Bernell Polaroid Vectogram Acuity/Suppression Slide (SO/V9)

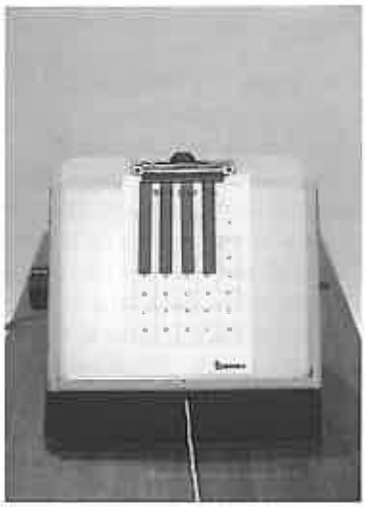

Figure 2. Polaroid Bar Reader with Bernell Rock Card and lens flippers.

Figure 3.Fusion lock of the Bernell Polaroid Vectogram Acuity/Suppression Slide (SO/V9)

method routinely used in the clinical setting. Currently, practitioners use the Polaroid Bar Reader placed over a Bernell Rock Card[a] with the lens flippers (see Figure 2). At this time, no normative values exist for the Polaroid Bar Reader/Rock Card Method, but values established by Zellers et al.[1] have been extrapolated for this purpose.

A difference exists between the target design of the Vectogram #9 and the Polaroid Bar Reader with Rock Card. The Vectogram #9 target has a two-dimensional chart of various size letters with an added third dimension; 3-D concentric rings surrounding the letters to serve as a fusion lock (see Figure 3). These rings can only be perceived as having depth if the patient is capable of 3rd degree fusion. The letters are arranged in seven lines with Snellen acuity equivalents of 20/100 to 20/30. As a patient views the target with cross-polarizing filters on, lines #1, 2, 3, 5, and 7 can be seen by both eyes with line #4 only seen by the left eye and line #6 seen by the right eye. The Snellen equivalent of lines #4, 5, and 6 are 20/40.

The Polaroid Bar Reader/Rock Card Method is a purely 2-dimensional set-up of same size letters which may be thought to more closely approximate a normal reading demand. The unit consists of four strips of polaroid material through which printed material can be viewed. The first and third strips allow viewing by one eye and the second and fourth strips allow viewing by the other. Each strip is separated with clear acetate to serve as a 2-dimensional fusion lock. When used, the Polaroid Bar Reader Unit is laid in a vertical orientation over a Rock Card of 20/40 letters to serve as a suppression check (see Figure 2). Before testing it is important to determine which eye views the printed material under strips 1 and 3 vs. 2 and 4 so that if suppression occurs, the appropriate eye is noted.

The goal of this project was to compare the results for the Vectogram #9 Method (established norms) with the more popular method to assess accommodative facility, the Polaroid Bar Reader/Rock Card Method (no established norms). If a statistically significant difference prevailed between the two methods, it was the intent to collect data to establish normative binocular values for the Polaroid Bar Reader/Rock Card Method. The effect of the added third dimension of the Vectogram #9 Method was addressed to establish whether or not the fusion lock results in higher binocular facility rates.

Literature Review

Several studies have been designed to investigate accommodative facility testing. Burge[4] showed the importance of monitoring suppression during binocular accommodative facility testing using a Spirangle Vectogram. He conducted a study with a sample size of thirty (N=30) subjects ages 6-30. The subjects were nonstrabismic, non-presbyopic, and correctable to 20/20 OD, OS.[4] He demonstrated the importance of monitoring for suppression to ensure bifoveal fusion, and also determined mean accommodative facility rates to be 12.6 cpm (cycles per minute) OD, 11.6 cpm OS, and 7.0 cpm OU. Because of the small sample size, his work led to further investigation by Zellers et al.,[1] whose findings closely paralleled Burge's[4] work.

Zellers, Alpert, and Rouse[1] conducted a study screening 100 subjects (N=100) ages 18-30 to establish normative facility rate values. The subjects were non-presbyopic, non-strabismic, and correctable to 20/30 monocularly and with good binocularity.[1] Their methods were patterned after Burge,[4] utilizing a Vectogram target placed 40 centimeters with attention on 20/40 size letters. Burge[4] used the Vectogram #5 (Spirangle) and Zellers et al.[1] used the Vectogram #9 (Acuity-Suppression). Both have a 3-D component. The letters were viewed alternately through ± 2.00 lens flippers for one minute monocularly, and then binocularly with polaroid filters. This study found a mean accommodative facility rate of 11.59 OD, 11.09 OS, and 7.72 cpm OU. With the creation of alternative methods to monitor for suppression during accommodative facility testing, the Bernell Rock Card and Polaroid Bar Reader Method were developed. However, what has occurred is the extrapolation of the results of these studies using the Vectogram Targets to the Bernell Rock Card and Polaroid Bar Reader Method.

Hennessey et al.[2] studied the relation of symptoms to accommodative infacility of school-aged children. They determined that failure to achieve 8 cpm binocularly or 11 cpm monocularly was associated with asthenopic symptoms. They also determined mean accommodative facility rates utilizing the Vectogram #9 Method, with results similar to Zellers et al.[1] The mean values for monocular facility were 11.8 cpm OD, and 12.7 cpm OS using the Vectogram #9 Method target. The mean binocular accommodative facility rate was found to be 7.8 cpm.[2]

McKenzie et al.[5] and Cline and Smith[6] reported on accommodative facility testing and reliability. McKenzie et al.[5] found a significant mean increase in cycles per minute from initial to subsequent testing periods. Cline and Smith[6] determined that subjects having adequate baseline facility do not significantly change over time. They assessed accommodative facility rates using the Vectogram #9 Method.

Scheiman et al.[7] demonstrated that those monocular and binocular facility rates for children between the ages of 6 and 12 are lower than the expected findings of adults. They found that the mean binocular facility rate for children age 6 to be 3.0 cpm with a standard deviation of 2.5 cpm using the Vectogram #9 Method target. Children ages 8-12 were determined to have a mean rate of binocular facility of 5.0 cpm with a standard deviation of 2.5 cpm.

Siderov and Johnston[8] studied the importance of test parameters in the assessment of accommodative facility. They found that binocular facility decreases with increasing lens power and decreasing target size. The targets used were letters of either 20/25 or 20/63 Snellen equivalent at 40 centimeters. Suppression was monitored with a white metal rod to the left of the target only seen by the left eye and a black metal rod to the right of the target only seen by the right eye. It was also demonstrated that decreasing test distance resulted in proximal awareness, increased

relative magnification, and improved rates. Their study showed the importance of maintaining consistent parameters while testing facility.[8]

Kostelnik et al.[9] assessed monocular and binocular accommodative facility using a single line of 20/30 letters at 40 centimeters without suppression control. The reason for not incorporating suppression control was that current methods negatively alter the naturalness of the task.

Jackson and Goss[10] in their 1991 study of accommodative facility used a target of 20/20 size Snellen equivalent letters held at the subject's habitual reading distance. When binocular facility was performed, suppression was not monitored; however, the subject was instructed to indicate if diplopia was ever noticed.

The 1994 study of accommodative facility by Jackson and Goss[11] had the subject wearing cross-polarizing filters while viewing a target of 20/30 size Snellen equivalent letters. The target was surrounded by a 3-D fusion lock that was part of a Bernell BC 29 target held at a 40 centimeters test distance. This method is very similar to the Vectogram #9 method used by the majority of other accommodative facility studies.

Lastly, Pica et al.[12] compared two methods of suppression control (polaroid vs. anaglyph) during accommodative facility assessment. Both methods used bar reading units oriented vertically over a Bernell Rock Card while wearing the corresponding filters and alternately flipping a ±2.00 flipper for one minute. The results indicated that the form of suppression control was critical to the valid interpretation of the results with polaroid material having the greatest validity. Due to the significant variance in transmission properties of anaglyph materials, a greater number of false positives occurred. The red material transmits almost twice as well as the green material. This lead to a greater occurrence of left eye suppression.

Methods

One hundred and sixty-six subjects were chosen from the Illinois College of Optometry's student population to be tested for binocular accommodative facility using two different polaroid methods. Subjects were between the ages of 21-33. Written informed consent was obtained from each participant. Each subject was required to be best corrected with monocular Snellen visual acuities of 20/25 or better, and less than one line difference between the two eyes. Best visual acuity was achieved by either spectacle or contact lens correction. In addition, subjects were non-strabismic. One examiner tested 66 subjects while another tested 100 subjects. Both examiners' results were analyzed statistically and found to be equivalent minimizing inter-tester variability.

Figure 4. Accommodative facility testing set up.

Subjects were randomly assigned to one of two groups. Group 1 performed facility testing with Vectogram #9 Method first, followed by testing with the Polaroid Bar Reader/Rock Card Method. Group 2 performed testing with the Polaroid Bar Reader/Rock Card Method first, followed by testing with the Vectogram #9 Method. Each test was performed for one minute with a break of approximately 30 seconds between trials.

All testing was performed on a Franzblau Unit in order to keep the testing distance constant at 40 centimeters (see Figure 4). The unit also allowed for a constant reading distance and viewing angle. A portable photometer was used to ensure luminance was held constant at 90-100 cd/m.^{2} The use of an overhead lamp and the light source of the Franzblau Unit accomplished this.

Procedure

The purpose of the test and procedure were initially explained to each subject. The procedure was then demonstrated. The subject was positioned so that the spectacle plane was 40 centimeters from the testing plane. Cross-polarizing filters were worn over the subject's habitual correction. A loose lens flipper was utilized with the wells on one side containing +2.00 D lenses, and -2.00 D lenses on the other.

For testing with the Vectogram #9 Method, subjects were instructed to fixate line #5 which was seen by both eyes, while monitoring for the presence or absence of line #4, seen by the left eye, and line #6, seen by the right eye. Subjects were to inform the examiner if line #4 or #6 ever disappeared, indicating suppression, or if line #5 split into two lines, indicating diplopia. If either occurred, the test was stopped, and a failure was recorded. The test began with the +2.00 D lenses placed in front of the subject's eyes. The subject was instructed to say "clear" when line #5 was focused clearly. At this time, the lenses were flipped to the -2.00 D lenses by the examiner. Alternation of the flippers proceeded for 60 seconds and the number of successful cycles per minute was recorded.

Testing with the Polaroid Bar Reader/Rock Card Method began with the 20/40 Bernell Rock Card of single letters placed on the Franzblau Unit at 40 centimeters from the spectacle plane. A Polaroid Bar Reader unit was then oriented vertically with the strips over columns 1-4 of the Rock Card. The subject was then instructed to place on the polaroid glasses. The right eye saw through the polaroid strips #1 and #3 while the left eye saw through strips #2 and #4. At any time the subject reported that the letter directly viewed could not be seen due to the column darkening or turning black (indicating suppression) or if 5 lines were seen (indicating diplopia), the test was stopped and a failure was recorded. The testing began with +2.00 D lenses placed in front of the subject's eyes. The letter in box # 1 was read aloud when clear, and then the flipper was alternated to the -2.00 D well. The letter in box #2 was then stated aloud when clear and the flipper was alternated back to the +2.00 D well. One cycle constituted going from the plus side to the minus side and back to the plus side. This continued for 60 seconds, and the number of cycles per minute were recorded.

Results

Subjects were required to perform both methods, even if failure occurred on one of the methods. Group 1 completed the Vectogram #9 Method first, immediately followed by the Polaroid Bar Reader/Rock Card Method. Group 2 performed the Polaroid Bar Reader/Rock Card Method first, immediately followed by the Vectogram #9 Method. Table 1 lists the pass rate for

those who could perform the Vectogram #9 Method and the Polaroid Bar Reader/Rock Card Method (PBR/RC) in both groups. No significant difference was found between the two groups. Group 1 had a total of 49 failures and Group 2 had a total number of 45 failures. Therefore, the two groups were analyzed together as one. With respect to the individual tests, 3/166 (1.81%) failed the Vectogram #9 Method but passed the Polaroid Bar Reader/Rock Card Method. More interestingly, 68/166 (40.96%) failed the Polaroid Bar Reader/Rock Card Method yet passed the Vectogram #9 Method. Those who failed to qualify to perform either test numbered 23/166 (13.85%). A total of 72/166 (43.37%) subjects passed both tests. The data from these 72 subjects was used to determine the normative values for the binocular accommodative facility.

Table 2 shows the binocular facility rates from Zellers et al.,[1] Hennessey et al.[2] and for those subjects passing the two methods in our study. We found the mean binocular accommodative facility rate for the Vectogram #9 Method was 11.02 cpm with a standard deviation of 3.30 cpm. The mean rate for binocular facility using the Polaroid Bar Reader/Rock Card Method was 8.56 cpm with a standard deviation of 3.45 cpm. Our smaller standard deviations indicate that the variance was lower between individual test rates of our study as compared with the findings of Zellers et al.[1] and Hennessey et al.[2] However, the mean rate of binocular facility for the Vectogram #9 was statistically greater than the mean rate of binocular facility for the Polaroid Bar Reader/Rock Card Method ($p<.0005$).

Table #1
Pass and fail rates of accommodative facility comparing two different targets.

	Total N	Passed both methods	Failed both methods	Failed only the Vectogram #9 Method	Failed only the PBR/RC Method
Group #1	83	34	10	3	36
Group #2	83	38	13	0	32
Totals	166	72	23	3	68
Percentages		43.37%	13.85%	1.81%	40.96%

Table #2
Comparison of accommodative facility rates with previous studies

Study	Mean Facility Rate OD	Mean Facility Rate OS	Mean Facility Rate OU	Standard Deviation OU
Zellers et al[1]	11.59 cpm	11.09 cpm	7.72 cpm	±5.15 cpm
Hennessey et al[2]	11.80 cpm	12.80 cpm	7.80 cpm	±8.00 cpm
Zost et al (Vectogram #9)	N/A	N/A	11.02 cpm	±3.30 cpm
Zost et al (Polaroid Bar Reader / Rock Card)	N/A	N/A	8.56 cpm	±3.45 cpm

Discussion

The act of changing focus from one distance to another or between two accommodative stimuli has significant impact on the visual system of anyone that does close work. It can be implied that the more efficiently a person can change focus, the more stable and capable is that visual system to handle a greater array of visual demands. This then would allow for greater comfort, productivity, and possibly enjoyment from a visual task. Assessing binocular accommodative facility can provide significant insight into the quality of function of the accommodative system. Assessing it for a given period also provides an indirect assessment of this system's sustainability.

For the population of 72 subjects passing both tests, the mean facility rates found for the individual tests were relatively higher than the findings from Zellers et al.[1] and Hennessey et al.[2] If taking into consideration the standard deviations, then all the rates fall within close proximity. The mean rate of binocular facility of 11.02 cpm found during our study with the Vectogram #9 Method is higher than the that of the other two cited studies. This may be attributed to the fact that all subjects were optometry students who may be more familiar with the testing concept of accommodative facility. In comparing the mean rate of binocular facility found with the Polaroid Bar Reader/Rock Card Method, the value of 8.56 cpm is also higher than the findings by Zellers et al.[1] This again could be due to the use of optometry students.

A comparison of the mean rates of binocular facility between the Vectogram #9 Method and the Polaroid Bar Reader/Rock Card Method from our study indicates a statistically significant difference. The main concern of this study then appears to be the high fail rate when testing with the Polaroid Bar Reader/Rock Card Method as compared to the Vectogram #9 Method. Some 40.96% failed to complete the Polaroid Bar Reader/Rock Card Method for one minute because of either suppression or diplopia, but did not manifest similar difficulty on the Vectogram #9 Method (1.81%). This raises the issue of which method has the greater validity to assess binocular accommodative facility.

The results suggest that the concentric rings of the Vectogram #9 Method act as a 3rd degree fusion lock and influence accommodative performance in a positive manner as opposed to the Polaroid Bar Reader Method. Further, the Vectogram #9 Method is more representative of a general mix of environmental visual stimuli with its cross section of 2nd and 3rd degree fusion components. On the other hand, the Polaroid Bar Reader/Rock Card Method presents a better stimulus to mimic the reading task which is solely a flat fusion task. However, this may not be as representative of how patients use their eyes during the primary duties of their occupation (work or school) or through out the course of a normal day. Consequently, we suggest that the two methods represent different scenarios of testing accommodative facility and these should be considered in terms of the particular patient's symptomatology and lifestyle needs.

Comparison of the cost to actually obtain the materials to provide either test is similar (approximately $33.00 for the Polaroid Bar Reader/Rock Card Method and $34.00 for the Vectogram #9 Method). These figures do not include the cost of a ±2.00 lens flipper. We recommend that further testing be done to include subjects representing a greater age range and are not as familiar with the testing procedures. This would increase diversity of the subject mix and add greater validity to the normative values. Until then, we recommend that binocular accommodative facility be clinically assessed for diagnostic purposes by using the Vectogram #9 Method with the use of our corresponding normative values.

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