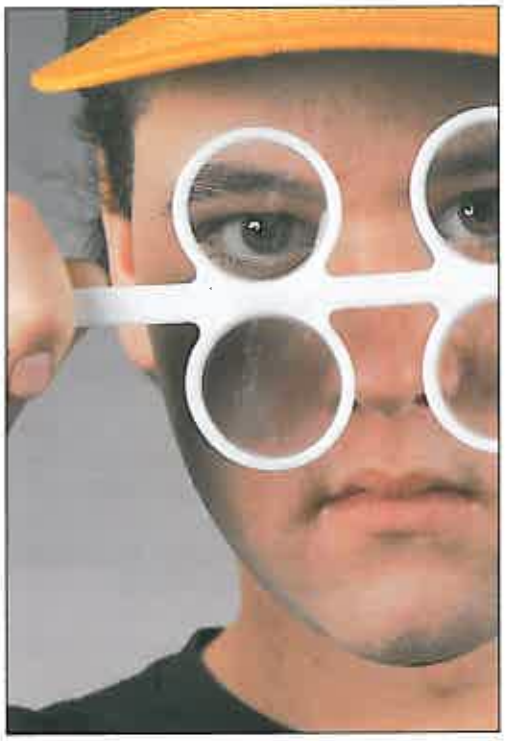

A STUDY OF BINOCULAR ACCOMMODATIVE AND VERGENCE FACILITY AND PREDICTIVE ANALYSIS OF GLOBAL STEREOPSIS

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ABSTRACT

Accommodative facility, vergence facility and random dot stereopsis were evaluated in a sample of 43 university baseball and softball players. All had previously passed a modified clinical vision screening. Seventeen subjects were categorized with low accommodative or vergence facility, but only three were low in both. Three of the subjects, including one with low accommodative facility failed the Random Dot E test.

KEYWORDS

accommodative facility, vergence facility, global stereopsis, sports vision

Accommodative and vergence facility tests have become important elements in the clinical investigation of binocular vision. Their unique method of producing step changes in the stimulus differentiates them from more traditional methods of introducing gradual or ramp-like changes usually associated with phoropter testing. Accommodative and vergence facility tests are thought to simulate real-life situations in which rapid changes in fixation distances are required. These situations extend from the classroom to the playing field. Further, many clinicians feel these step changes stress the visual system, with a resultant performance indicative of the ability to sustain effort.

For this investigation, binocular accommodative and vergence facility were evaluated in a sample of college athletes who were participating in a vision screening.

Binocular facility testing was utilized because of renewed interest in the mutual interactions between accommodation and vergence through the AC/A and CA/C ratios.[1] Anomalous interactions have can be hypothesized as important in the generation of ocular and visual symptoms and reduction of binocular efficiency.

There have been several published studies providing normative data for binocular accommodative and vergence facility but none using the same subjects.[2-9] Garzia and Richman[2] presented experimental norms for binocular accommodative facility in a sample of young adults. Zellers, Alpert and Rouse[3] presented normative binocular accommodative facility in a group of 18- to 30-year-old subjects. The sample included optometry students and clinic patients. Hennessey, Iosue and Rouse[4] demonstrated differential binocular accommodative facility between symptomatic and asymptomatic subjects in a sample of 8- to 14-year-olds. Scheiman, Herzberg, Frantz et al.[5] developed normative binocular facility in a large sample of 6- to 12-year-olds. All of these studies utilized accommodative stimulus levels created by +2.00/-2.00 diopter lenses. Targets were 20/30 reduced Snellen equivalent letters. Each of these experiments selected subjects who had passed a modified clinical screening procedure.

Buzzelli[6] evaluated the developmental changes in vergence facility in a large sample of school-aged children. There have also been several unpublished studies[7-9] of vergence facility cited by Griffin.[10]

The primary purpose of this study was to evaluate accommodative and ver-

gence facility in the same individuals to determine the degree of interrelationship between these skills. An important clinical question is to ascertain the relationship between performances in the two facility tests. Are they predictive of one another or is there a degree of independence between them? Clinicians can use this information for predictive and taxonomic purposes.

The secondary goal of this study was to assess the relationship of global stereopsis to these facility results. In addition to accommodative and vergence facility, each subject was tested for stereo sensitivity with the Random Dot E test.[a] This test has been found to be an important element in the assessment of amblyopia and strabismus in children.[11,12] It is a very effective tool for this purpose when utilized at a test distance of 1.5 meters.[13] Small angle esotropes and mild amblyopes are often capable of achieving global stereopsis but rarely at this test distance, dot density, dot size and disparity level (168 seconds of arc).

There have been attempts to incorporate random dot stereopsis testing in preschool and school vision screening programs, particularly those involving lay screeners. Rosner[14] investigated the ability of random dot testing to identify children who failed a modified clinical screening. All 10 children who failed a modified clinical screening also failed the Random Dot E test. These children had visual acuity deficits and/or binocular vision disorders (strabismus).

METHODS

Subjects

The sample consisted of 47 members of university varsity baseball and softball teams. There were 24 males and 23 females, with mean ages of 19.8 and 19.7 respectively. A modified clinical screening was performed on all subjects prior to the experimental session. The tests included distance and nearpoint visual acuity, cover test at distance and nearpoint, ocular motility, static retinoscopy, dynamic (MEM) retinoscopy with habitual correction, and direct ophthalmoscopy. If any subject failed one test based on established criteria,[b] they were excluded from the study. Four people were excluded for this reason. This reduced the sample to 43 (22 males and 21 females). All subjects used in the study had 20/20 monocular and binocular near acuity with their habitual refractive correction.

Procedure

All facility and stereopsis testing was performed by the authors. The screening procedures were performed by third and fourth year optometry students experienced with vision screening protocol. A nearpoint card with reduced 20/30 letters arranged in a 6 by 6 matrix served as the target for the facility tests. The card was held by the subjects throughout the testing at a distance of 40 cms. Full room illumination was utilized with an additional source of light from the overhead lamp of a phoropter stand.

Accommodative and vergence stimuli selected were +2.00/-2.00 diopter spheres and 8 BI/8 BO diopter prisms. In other investigations of accommodative facility, +2.00/-2.00 lenses have been used and are commonly applied for clinical assessments. There is less consensus on the magnitude and range of prism values to be used for vergence facility.[10] The 8 BI/8 BO powers chosen for this study are representative. Identical BI and BO powers were consistent with the identical values typically used in accommodative facility testing. All testing was performed under binocular conditions.

Suppression was monitored for both facility tests by a physiological diplopia technique accomplished by holding the point of a knitting needle one inch in front of the target card. None of the subjects demonstrated a significant suppression during the testing of accommodative or vergence facility.

Accommodative Facility

The subjects were instructed to read the letters silently. The +2.00 lenses were always used to initiate the procedure. After the momentary blur, the subject was to report when the letters were sufficiently clear to permit the continuation of letter identification. No other instructions were given. At this point, the lenses were "flipped," with the -2.00 lenses replacing the +2.00 lenses. This constituted one cycle.

The subjects were allowed a maximum of four seconds to respond to a given lens power. After that time, the lenses were "flipped." If these lenses were cleared, they were again "flipped." If an adequate response was not achieved in four seconds, testing was discontinued, and the number of cycles completed was recorded.

The total number of cycles completed in a 30-second time period was recorded as the accommodative facility. It was felt that 30 seconds of testing was adequate to provide sufficient stress and fatigue factors.[2]

Vergence Facility

The subjects were instructed to read the letters silently. The 8 BI prisms were always used to initiate the procedure. After the momentary diplopia, the subjects were to report when the letters were single. No other instructions were given. The prisms were "flipped," with the 8 BO replacing the BI prism when the subjects obtained single vision without suppression. This constituted one cycle.

The subjects were allowed a maximum of four seconds to respond to a given prism power. After that time, the prisms were "flipped." If this prism was fused, they were again "flipped." If an adequate response was not achieved in four seconds, testing was discontinued, and the number of cycles completed was recorded.

The total number of cycles completed in a 30-second time period was recorded as the vergence facility.

Global Stereopsis

Stereopsis was evaluated by the Random Dot E test. The test was performed at 1.5 meters from the subjects in a two alternative forced choice paradigm. The Random Dot "E" stereogram was presented alongside the blank stereogram. The Random Dot stereogram was oriented to produce temporal retinal disparity, creating the perception of a raised "E." The subjects were required to determine the correct location of the "E" (right or left stereogram). After a response, the two stereograms were removed from view, rearranged and then presented. This was continued for six trials. The sequence of exposures was identical for each subject ("E" stereogram on the right, right, left, right, left, left). Four consecutive correct responses in six presentations or five correct responses were considered passing.

RESULTS

For the purposes of this study, the subjects were dichotomized for accom-

modative facility and vergence facility performance. One standard deviation below the mean of the sample was chosen as the cut-off value. Subjects whose scores were one standard deviation or more below the mean for the sample were placed in the low facility category. Hennessey, Iosue and Rouse[4] identified this level as separating symptomatic from asymptomatic subjects. Those with scores above this criterion level were designated as high. There were eight accommodative facility and nine vergence facility scores in the low category.[c]

A 2 x 2 contingency table summarizes the data (see Table 1). The accommodative facility results are placed in the two columns, with the vergence results in the rows. The marginal frequencies give the number of subjects in the four possible categories (high and low accommodative facility and high and low vergence facility). For example, 35 subjects had high accommodative facility and 8 low. The numbers within the table represent the combined occurrences of accommodative and vergence facility performance. For example, there were 29 subjects in the high accommodative facility category that also had high vergence facility.

One-third of the sample (33%, 17/43) were in the low category for either accommodative or vergence facility. Of the 17 in the low category of either test, only three (17.6%) were low in both facility tests.

Of those in the high vergence facility category, 85.3% (29/34) also had high accommodative facility. Of those with high accommodative facility, 82.9% (29/35) also were in the high vergence facility category. Of subjects in the low vergence facility category, only 33% (3/9) also had low accommodative facility. Of subjects with low accommodative facility, 37.5% (3/8) also had low vergence facility.

A chi square analysis was unable to reject the null hypothesis of no significant differences between the expected and observed frequencies (X^2=.63, df=1, p=.20). The coefficient of contingency was C=.19, and was not significant (p=.10).[d]

Only three subjects failed the Random Dot E test. All three of them were in the high vergence facility category, with two in the high accommodative facility category. Thus, only one subject with a low facility test (accommodative) failed the stereopsis test.

CONTINGENCY TABLE DATA SUMMARY

The left vertical column indicates high accommodative facility, and the right vertical column low accommodative facility. The top horizontal column indicates high vergence facility while the bottom horizontal column indicates low vergence facility.

		Accommodative Facility: High	Accommodative Facility: Low		
Vergence Facility	High	29	5	34	Total High Vergence Facility
	Low	6	3	9	Total Low Vergence Facility
		35 Total High Accommodative Facility	8 Total Low Accommodative Facility		

Table 1.

DISCUSSION

The results suggest that there is generally good concordance between accommodative facility and vergence facility, at least for those in the high facility categories. If a subject was in the high category for one facility test, there was over an 80% probability of being in the high category for the other test. If a subject had high accommodative facility, there was an 83% probability that vergence facility was also high. Conversely, of subjects with high vergence facility, there was an 85% probability that accommodative facility would also be high.

However, low performance in one test was a poor predictor of performance in the other. This is because most subjects were in the low category of only one facility test (14/17). Only three had low accommodative and vergence facility. If one facility test was low, there was approximately only a one in three probability that the other test would also be low (3/8 accommodative facility, 3/9 vergence facility). As a result, the chi square analysis indicated that there was a degree of independence between accommodative and vergence variables, which are poorly correlated. This is reflected in the low contingency coefficient that was not significant.

The results of the stereopsis testing were consistent with clinical intuition and other reports relating stereopsis to typical vision screening.[12,14] All the subjects passed a modified clinical vision screening, and 93% (40/43) passed the Random Dot stereo test. Two of the three subjects failing the stereopsis test were in the high facility category for both accommodative and vergence facility. Only one individual in a low facility category (accommodative) also failed the stereopsis test. This suggests two conclusions.

First, the Random Dot E stereopsis test is correlated to performance on our modified clinical screening. All of the subjects in the present study were preselected by having passed a vision screening. Therefore, most of these subjects were expected to pass the stereopsis test. This one-way analysis should not be interpreted to mean that these results support the power of Random Dot stereopsis to detect those individuals who would have failed a vision screening. Random Dot stereopsis has been very useful in the detection of amblyopia and strabismus in children, if used under the proper stimulus conditions.

Second, the results showed that Random Dot stereopsis testing did not detect those individuals with low accommodative or vergence facility. Of the 17 subjects with a low facility test, only one (6%) also failed the Random Dot stereopsis test. Stereopsis testing would not be an effective substitute for facility testing. This is

not an entirely unanticipated result. Although stereo sensitivity is dependent on sensory-motor integrity of the binocular system, it is determined under steady state conditions. Accommodation and vergence remain at constant levels. In contrast, binocular facility testing forces the accommodative and vergence systems to detect and respond to rapid and frequent changes in the stimulus. These results support the clinical impression that stereopsis as a metric of sensory-motor status does not always mirror binocular function under more dynamic conditions, such as facility.[2]

FOOTNOTES

a. Random Dot E Test, Stereo Optical Co., Chicago, IL.
b. Orinda criteria for distance visual acuity, refractive status, binocularity and ocular health. Greater than or equal to +.75 for dynamic (MEM) retinoscopy.[2]
c. Facility test data is not thought to be normally distributed, but rather, skewed and kurtotic. Using the published raw data from two large studies, the distribution of binocular accommodative facility was skewed slightly positively in one[3] and negatively in the other[5] but severely platykurtotic in both.
d. The upper limit of C for a 2 x 2 contingency table is .707.

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