Speed of Stereopsis and Educational Performance: Is There a Correlation?

by

Matthew J. Maki, B.S.

for

Daniel Wrubel, O.D.
College of Optometry
Ferris State University

Abstract

Speed of stereoacuity and educational performance have been shown to be related in previous research. This study examines this relationship while also assessing response time. Forty-five fifth grade students were evaluated for stereoacuity speed, educational performance, and response time. Results showed no significant correlation between any of these factors.

Key Words: stereopsis, speed of stereoacuity, response time, educational performance.

Introduction

Several aspects of the visual system have been shown to have a relationship with educational performance. These include distance visual acuity, refractive status, and fixation disparity.[1] Stereopsis, the finest level of binocular vision, has long been utilized to evaluate the binocular vision system[2,3] and recently it has been postulated that the speed of this visual skill can be related to educational achievement.

The role that vision plays in intelligence, learning, and reading skill, has been vastly explored. Gottfreid and Gilman[4], in a longitudinal study of infants aged twelve to forty-two months, concluded that there is a definite correlation in the development of visual skills such as convergence, ocular motility, stereopsis, and form perception with intellectual development. Stereopsis and form perception showed the highest correlation to the development of intellect. Vision therapy has also been shown to play a role in improving the learning ability in learning disabled children.[5] The importance of vision and binocular anomalies as they relate to reading skills has been investigated thoroughly with no extensive direct correlational evidence being found.[6-9]

Does response time play a role in school achievement? We hypothesized that slow responders would show a lower level of performance in school. In a study of twenty learning disabled children matched for mean age and IQ against a group of twenty non-learning disabled children, it was found that the learning disabled group were much faster and more prone to errors than the control group.[10] This data tends not to support our original premise, although measures were taken in our testing to assess the response time of each student.

It would be ideal if we in the vision care field could have an easily administered test that would serve as a predictor or barometer to a child's educational performance. Stereopsis tests, namely the Random Dot E[11], have been proven to be reasonably accurate as well as economical methods for detecting refractive and binocular anomalies.[2,12,13] We have attempted to determine if the speed of stereoacuity can be used as this prognosticator for educational achievement. Super[14] has shown a correlation between the speed and accuracy of stereoacuity to achievement in school. He concluded that children that are fast and accurate in completing stereopsis tasks will perform superiorly in school. The fundamental question addressed in this study is whether the speed of correctly identifying stereo targets can be correlated to educational prowess, while taking into account response time.

Randot stereograms have been shown to be the most sensitive of the stereopsis tests utilized in a clinical setting[15], thus they were used to determine stereopsis. School performance was determined by obtaining scores for each of the students on the

Stanford Achievement Test. This is a standardized test that was administered to the students while they were in the fourth grade, assessing ability in eleven subject areas: reading comprehension, word study skills, concepts of number, mathematics computation, mathematics applications, spelling, language, social science, science, vocabulary, and listening comprehension.

Methods

Sixty-one fifth grade students participated in this study. Of these sixty-one, nine did not pass our screening criteria and complete school information was not received for seven students, leaving a total of forty-five students.

The screening tests that we performed were distance visual acuity, distance and near cover test, and stereoacuity. Visual acuities were taken monocularly and required the student to see 20/20 with each eye on the Broken Wheel Acuity Cards.[16] The cover test at distance and near was utilized to exclude anyone with a heterotropia. A Randot stereotest[11] was used to determine each student's stereoacuity level. This test consists of three circles within each of ten rectangles. (Fig. 1) Only one of the circles in each rectangle has crossed disparity and represents various levels of stereoacuity. We required that each student be able to determine which circle "floated" or appeared different in each of the ten rectangles with the tenth being a stereoacuity level of twenty seconds of arc. This not only allowed us to assess each student's stereo, but also served to familiarize the students with the test.

Upon completion of our screening procedure, we began testing in two areas: speed of correctly identifying stereo targets and response time. Determining stereo speed was done by presenting each of the ten targets separately in a random fashion and then asking the student to identify the circle that floated as quickly as possible. Isolation of each target was achieved by using ten pieces of black construction paper with openings cut in them corresponding to each of the ten targets. (Fig. 2) A black cover paddle was then used to cover the target until testing started.(Fig. 3) We then handed the stereo card and construction paper to the student while keeping the target hidden with the cover paddle. The student was then instructed to identify which ring floated as quickly as they could when the target was revealed. The time between uncovering the target and the student's response was then recorded in hundredths of seconds. The targets were presented in random order by "shuffling" the black construction paper cards before each different student and after each subsequent target presentation. If the student incorrectly identified which circle floated, the black card corresponding to that level was put back in with cards that had not yet been tested. The targets were numbered one through ten and corresponded to 400, 200, 140, 100, 70, 50, 40, 30, 25, and 20 seconds of arc, respectively.

Response time was determined using a computer. The students were seated at the computer and instructed that a small cross would appear on the screen. (Fig. 4) They were then told that this cross would change into a long horizontal bar. (Fig. 5) The students were then instructed to push the space bar on the keyboard as quickly as possible when they saw the cross change into the bar. We did a "practice" run to acquaint each student with the task. After ten practice trials, we then administered the "real thing", which also consisted of ten trials. If the student pushed the space bar prematurely, the program would default, the student was reinstructed to wait until the cross changed into the bar, and then the test or trial run was re-administered.

The stereo speed and response time tests were alternated in presentation for each student so as to further randomize the test. No information regarding health history, visual history, or school performance was made available to us prior to completion of the testing. Also, only the two authors were involved in the visual screening procedure and the actual data collection.

Results

Statistical analyses were made using the Number Cruncher Statistical System.[17] Response time was measured in computer "time" and percentile rank values were used for the educational performance data. The means (and standard deviations) for each of the areas tested were: response time, 178.7 (33.3); stereo speed, 2.46 seconds (1.04 seconds); reading comprehension, 58.1 (26.1); word study skills, 47.9 (21.7); concepts of number, 56.8 (26.1); mathematics computation, 29.0 (22.4); mathematics applications, 54.6 (29.4); spelling, 44.3 (27.3); language, 45.2 (24.2); social science, 48.4 (27.7); science 47.6 (25.5); vocabulary, 54.3 (25.3); and listening comprehension, 62.8 (25.8). These values are also found in Table 1.

Table 2 shows the correlation coefficients (r values) between stereo speed and each of the eleven areas on the achievement test. Table 3 shows the r values for response time versus each of the eleven testing areas. The r value comparing response time to stereo speed was 0.1589.

Discussion

The r values between stereo speed and each of the eleven areas on the achievement test exhibit very little correlation. This data leads us to believe that our initial goal of showing a relationship between the two was not attained. We had proposed that testing response time would give us another piece of information to assist making this association, however, there also appears to be little connection between response time and educational performance. This information further sustains the conclusions made in the earlier mentioned study of learning disabled children.[10] Perhaps the most interesting of our findings was the fact that response time showed minimal correlation to the speed of stereoacuity. It would seem that students acting quickly on the response time test would do the same on the stereo speed test.

The information generated from this study indicates that it may not be necessary to have good stereopsis to function or perform well in school. It has been shown that strabismics often do not experience marked reading difficulties and that monocular reading is superior to binocular reading under experimental conditions.[6,8] In two studies mentioned earlier,[1,6] stereopsis was demonstrated to have little effect on reading ability, which inclines to uphold our data. The visual skills that were found in the two studies to have some correlation with reading, namely distance visual acuity, refractive error, and fixation disparity are all dependent upon a clear retinal image, whereas nearpoint stereopsis tests are not as extensively subject to this distinct retinal image.[2,18]

Vision is essential for the assimilation of the myriad of printed information encountered in the traditional educational setting. The level at which vision must be functioning to adequately input and use this information is not fully understood. Perhaps vision is more than just the input of data; how information is seen may be equally essential as the analytical and interpretive procedures that are carried out. The question now is to determine which specific visual skills have a deleterious effect not only on the capability to read and to input data but the ability to process this information at a higher cognitive level.

Conclusions

Our findings indicate that little significant relationship exists between the speed of stereoacuity and educational achievement. There also appears to be minimal correlation between response time and school performance, which indicates that slow responding students may not perform at a lower level in the educational setting. Interestingly, we also found little correlation between stereo speed and response time. More research needs to be done in this and other visual areas in hopes to discover some easily administered test to assess or predict educational performance.

Acknowledgements

We would like to thank the faculty, staff, and students at Northwest Elementary School for their assistance and participation in this study. Also, thank you to the Stereo Optical Company for the donation of materials used in the stereopsis testing.

References

1. O'Grady J. The Relationship between Vision and Educational Performance; A Study of Year 2 Children in Tasmania. Aust. J. Optom. 1984, 67(4): 126-140.

2. Griffin JR. Binocular Anomalies: Procedures for Vision Therapy, Second Edition. New York: Professional Press Books, 1982.

3. Rosner J, Rosner J. Pediatric Optometry, Second Edition. London: Butterworths, 1990.

4. Gottfried AW, Gilman G. Visual skills and intellectual development: A relationship in young children. J. Amer. Optom. Assoc. 1985, 56(7): 550-555.

5. Keogh BK, Pelland M. Vision Training Revisited. J. Learning Disabil. 1985, 18(4): 228-236.

6. Simons HD, Gassler PA. Vision Anomalies and Reading Skill: A Meta-Analysis of the Literature. Amer. J. Optom. Physiol. Opt. 1988, Nov; 65(11): 893-904.

7. Rosner J. A Comparison of Two Stereo-Recognition Tasks as Predictors of Performance in a Reading-Like Visual Task. Aust. J. Optom. 1984, 67(4): 151-154.

8. Simons HD, Grisham JD. Binocular anomalies and reading problems. J. Amer. Optom. Assoc. 1987, 58(7): 578-587.

9. Bond GL, Tinker MA. Reading Difficulties: Their Diagnosis and Correction. New York: Appleton Century Crofts, 1957.

10. Bolster B, Marshall W, Bow J, Chalmers N, Stubel M. Visual Selective Attention and Impulsivity in Learning Disabled Children. Dev. Neuropsychology. 1986, 2(1): 25-40.

11. Stereo Optical Company, Chicago, Illinois 60641.

12. Rosner J. The effectiveness of the random dot E stereotest as a preschool vision screening instrument. J. Amer. Optom. Assoc. 1978, 49(10): 1121-1124.

13. Williams S, Simpson A, Silva P. Stereoacuity levels and vision problems in children from 7 to 11 years. Ophthal Physiol. Opt. 1988, Vol 8(Oct): 386-389.

14. Super S. Presentation at the American Academy of Optometry Meetings 1986, 1987, 1988.

15. Cooper J, Feldman J, Medlin D. Comparing stereoscopic performance of children using the Titmus, TNO, and Randot stereo tests. J. Amer. Optom. Assoc. 1979, 50(7): 821-826.

16. Copyright (c) 1984, 1985 by Dr. Jerry L. Hintze, 865 East 400 North, Kaysville, Utah, 84037.

17. Richman JE, Petito GT, Cron MT. Broken Wheel Acuity test: A new and valid test for preschool and exceptional children. J. Amer. Optom. Assoc. 1984 55(8):561-565.

18. Pearlman JT. Stereoscopic Vision Testing: A Review. Amer. Orthop. J. 1969 Vol. 19:78-86.

Table 1: Means and standard deviations of each testing area.

	Mean	Standard Deviation
Response Time	178.7	33.3
Stereo Speed	2.46 seconds	1.04 seconds
Reading Comprehension	58.1	26.1
Word Study Skills	47.9	21.7
Concepts of Number	56.8	26.1
Mathematics Computation	29.0	22.4
Mathematics Applications	54.6	29.4
Spelling	44.3	27.3
Language	45.2	24.2
Social Science	48.4	27.7
Science	47.6	25.5
Vocabulary	54.3	25.3
Listening Comprehension	62.8	25.8

Table 2: Correlation Coefficients for Stereo Speed and

Percentile Rank Values on the Stanford Achivement Test

Reading Comprehension	-0.24
Word Study Skills	-0.14
Concepts of Number	-0.0486
Mathematics Computation	-0.32
Mathematics Applications	-0.2118
Spelling	-0.298
Language	-0.3423
Social Science	-0.2675
Science	-0.3059
Vocabulary	-0.0868
Listening Comprehension	-0.1411

Table 3: Correlation Coefficients for Response Time and _Percentile Rank Values on the Stanford Achievement Test_

Reading Comprehension	-0.0441
Word Study Skills	-0.0150
Concepts of Number	-0.0425
Mathematics Computation	-0.1310
Mathematics Applications	-0.1927
Spelling	0.0310
Language	-0.0006
Social Science	-0.1585
Science	-0.0334
Vocabulary	-0.2732
Listening Comprehension	-0.1287

Figure Legend

Figure 1. Stereo Target used in screening procedure and data collection.

Figure 2. Achieving isolation of each target.

Figure 3. Using a cover paddle to conceal the isolated targets.

Figure 4. Small cross on computer screen for response time testing.

Figure 5. Horizontal bar on computer screen for response time testing.

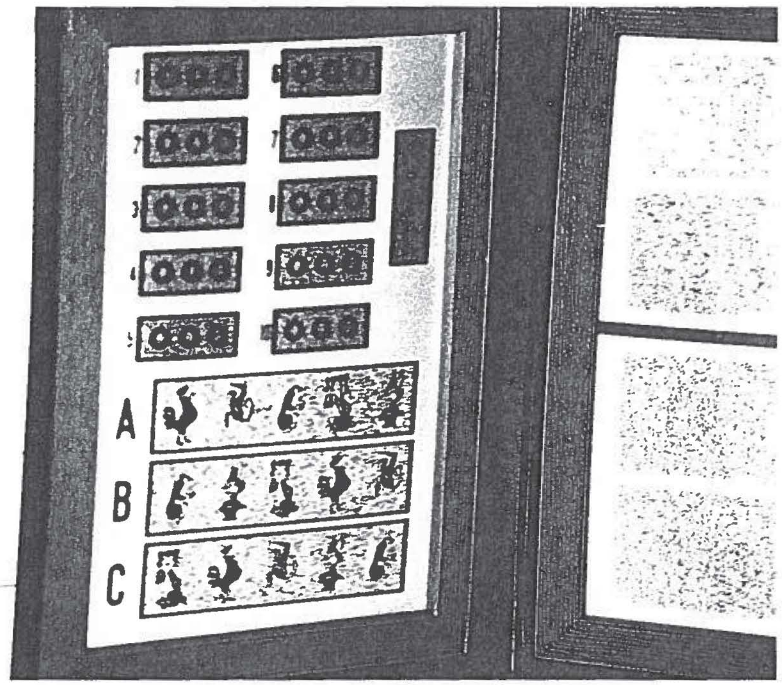

Figure 1

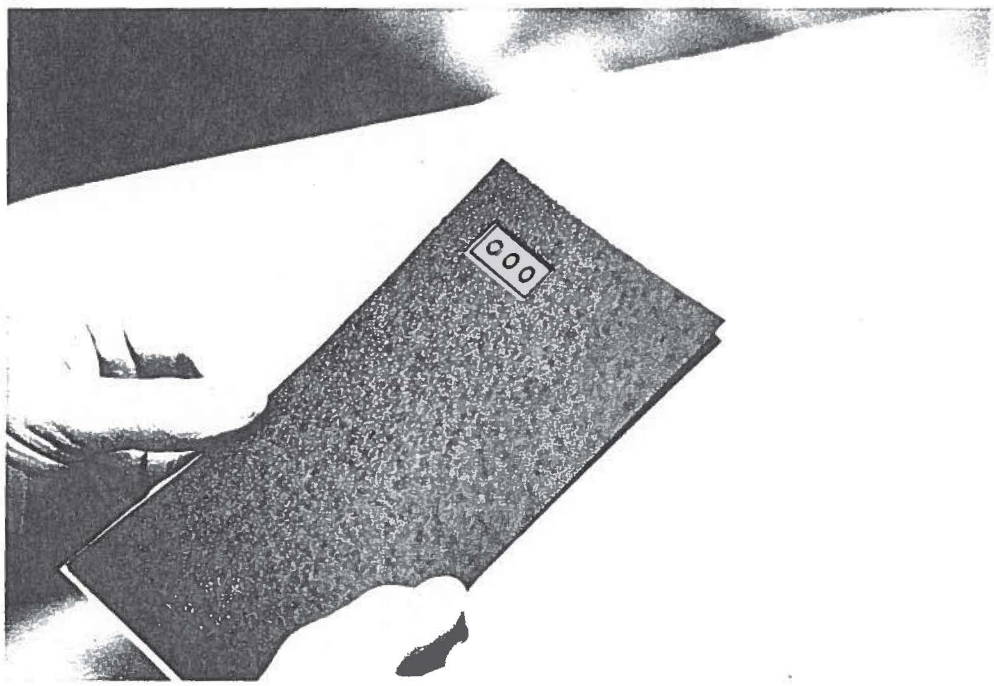

Figure 2

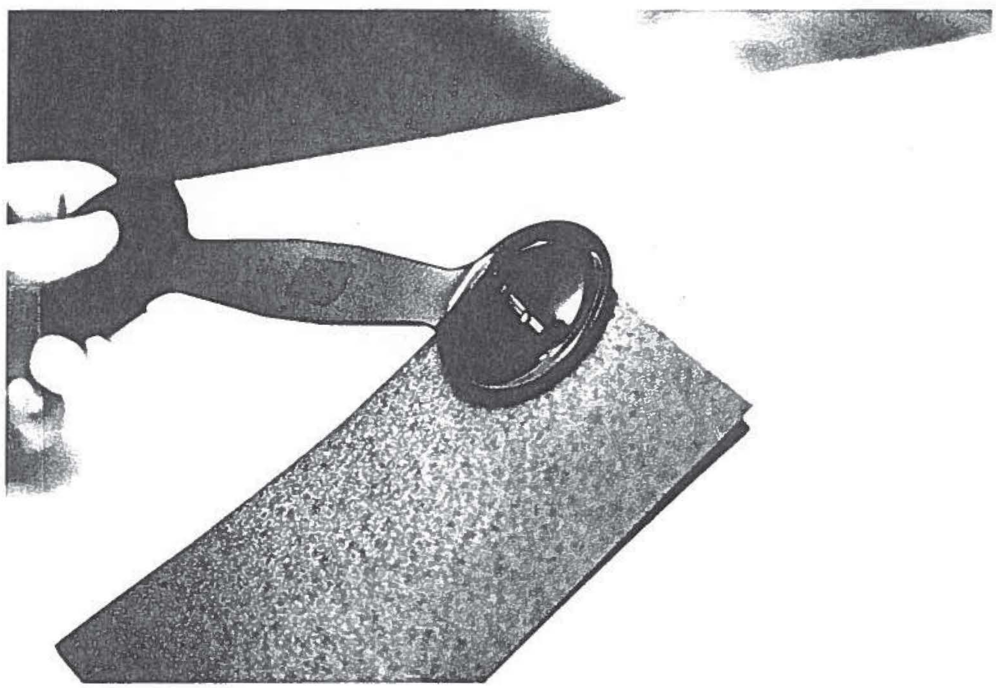

Figure 3

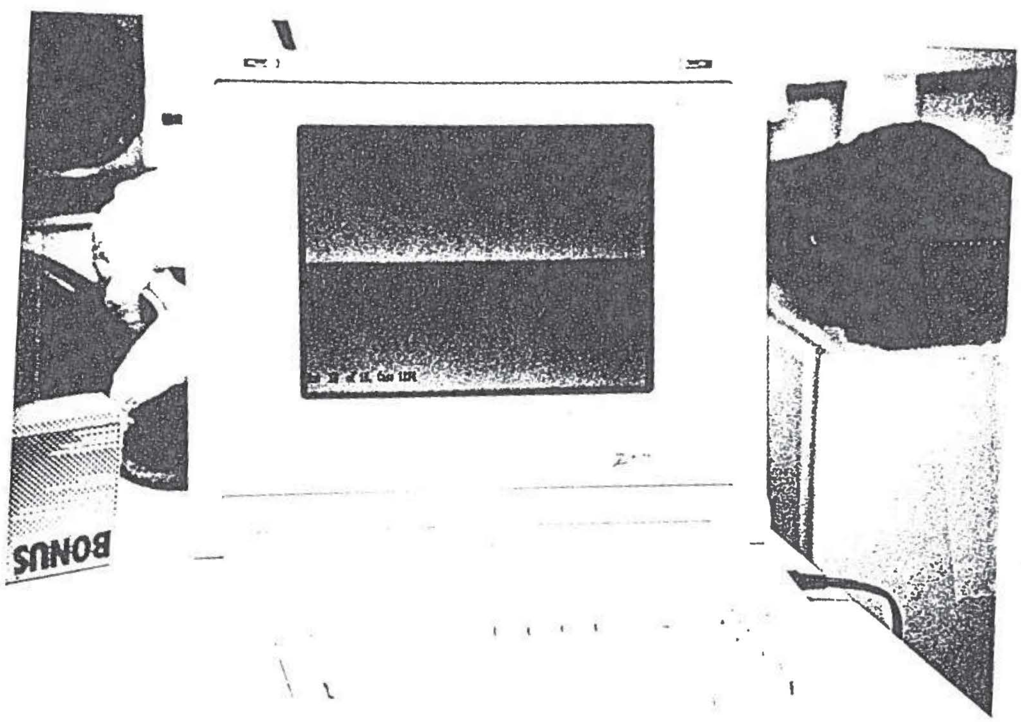

Figure 4

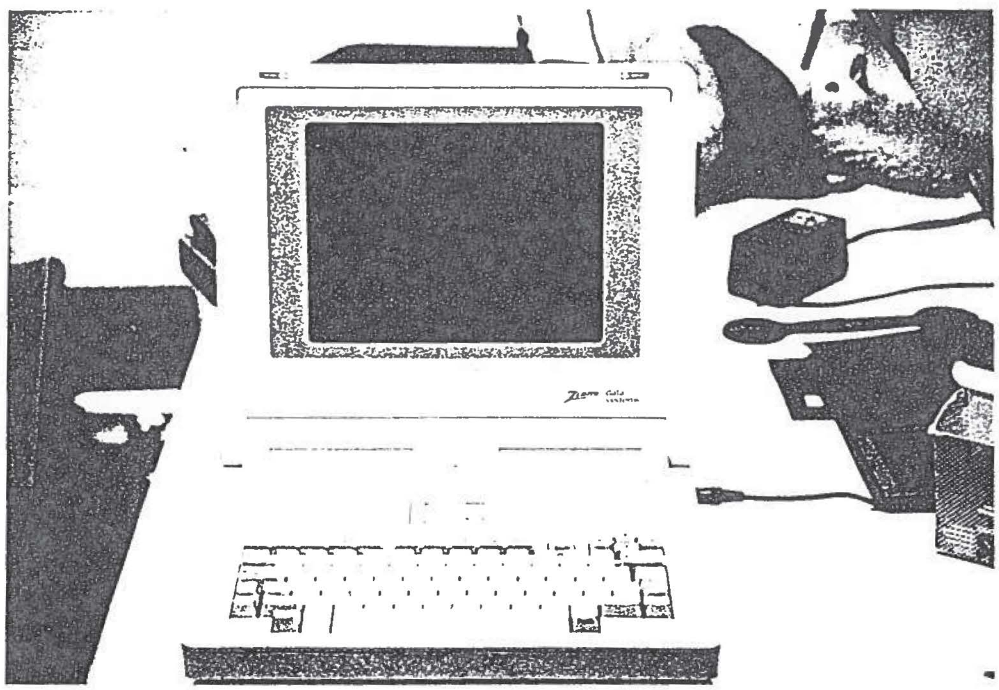

Figure 5