Visual factors that significantly impact academic performance

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Background: Both race and socio-economic status are correlated to performance in the classroom. These two factors are inter-related, since minorities, proportion-wise, are more highly represented in the lower socio-economic strata. Inefficient visual skills have been shown to be more prevalent among minority groups and in low socio-economic groups. These inefficient visual skills impact the students' learning. This study was undertaken to discover the visual skills that were significantly correlated with academic performance problems.

Method: A total of 2,659 examinations were performed on 540 children over the course of six examination periods, which were administered over three consecutive school years. Socio-economic, racial, and standardized academic performance data (Iowa Test of Basic Skills—ITBS) were furnished by the families and the school system. The visual and demographic data from the examinations were then compared to performance on the 21 subtests of the ITBS.

Results: Some visual factors were found to be a much better predictor of scores on the ITBS than either race or socio-economic status. Even though the significance of these two demographic variables was small, race and socio-economic variables were each significant in about a third of the 21 ITBS scores.

Conclusion: Visual factors are significantly better predictors of academic success as measured by the ITBS than is race or socio-economics. Visual motor activities are better predictors of ITBS scores than are binocularity or accommodation. These latter skills were significant predictors also, but to a lesser degree.

Key Words: Academic performance, accommodation, binocularity, children, education, learning, race, minorities, testing

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The academic performance of children is recognized as one of the major indicators of a strong society.[1-23] Historically, the western world's educational system was designed to supply workers for an industrial society. Now, a more service-oriented work force is needed. If children are not prepared for the changing service-oriented society, they may not be able to adequately compete for jobs in the global economy.[1]

Not only have the educational needs of Western society changed, but the speed at which the world moves is taking its toll on both the child and the adult. Our society's pace is much faster today than it was in previous generations.[6] Parents who once were involved in child-oriented and school activities find their time taken up with other endeavors. It is clear that education must adapt to the sociological changes in order to address the needs of this society in the twenty-first century.

Changes are indeed being instituted in education.[3-5,7,8,10-12] Teacher certification and re-certification, school vouchers for private schools, mandatory standardized testing, and political debate at the highest levels clearly demonstrate that a problem is recognized and solutions are being pursued.[4,7-12]

Experts agree that educational levels must be comparable from school to school and region to region.[7,8,10,11] Unless educators recognize how their schools are ranked in relation to other schools, they will not be able to direct needed changes. Standardized test scores indicate each school's academic health as well as areas of strength and weakness.[2,3] SATs and ACTs are popular standardized tests at the high school level. The score achieved on these tests can have a

tremendous influence on the young adult's future.

For many children, these standardized tests begin in elementary school. One of the elementary school standardized tests is the Iowa Tests of Basic Skills (ITBS).[24-27] It consists of twenty-one subscores. The test sections are administered based on the academic grade of the child. Appendix A provides an annotated description of each of the subtests.[25-27] This test has a long tradition (1935) and is periodically re-assessed to ensure that norms are kept current.[24] The test is appropriate to be administered to children from kindergarten to the eighth grade. It has demonstrated reliability and validity.

Low socio-economic status has been suggested as a causative factor in lowered academic performance.[13-21] Racial status and low socio-economic status are correlated with one another and with poor academic scores.[22] It does not follow that the variables of race and low socio-economic status cause poorer academic performance, since poor visual skills have been shown to be a predictor of academic performance and these, in turn, are correlated with race and socio-economic variables.[22] Visual factors appear to be more susceptible to positive modification than are either variables of race or socio-economics. It is possible that, by improving visual skills in these groups, academic scores might increase.

Data points collected during each visual evaluation

1. Study site and coded representation for each subject
2. Date of birth, age, grade, primary race and sex
3. Dominant eye, dominant hand, and if/when optical prescription is worn
4. Visual acuity both far and near with each eye and binocularity and habitual correction. All subsequent testing was performed through this prescription. If the prescription was full time, the lenses were worn full time. If the prescription was only for near, the prescription was worn only for near testing.
5. Disease screening with binocular loupe, transilluminator, and direct ophthalmoscope
6. Cover test both far and near with notation of phoria or tropia
7. Phoria both far and near with the Howell Card (Modified Thorington Technique) and Binocular ±1 D AC/A at near with the near Howell Card
8. Near Stereo with Wirt circles and autorefractor, each eye
9. Near point of accommodation blur out and recovery with the dominant eye (NPA)
10. Accommodative Rock ±2 D Flippers, monocularly and binocularly with Polaroid suppression check for binocular testing
11. Nearpoint of convergence break and recover [3 measures (NPC)]
12. Nott retinoscopy
13. Prism bar ranges base in/base out at near
14. Prism flippers 8 base out/8 base in at near
15. Maples Ocular Motor Test, both pursuits and saccades
16. Developmental Eye Movement Test (DEM)
17. Motor Free Visual Perception Test (MVPT)
18. Wold Sentence Copy Test
19. Visual Motor Integration Test (Beery)
20. COVD Quality of Life Checklist from both Parent and Teacher
21. Socio-Economic Checklist Information
22. Relative placement in class as judged by the teacher
23. Iowa Test of Basic Skills in the Spring of each year

Box

A previous study had demonstrated that certain visual skills scores were better predictors for four ITBS subscores than were race and socio-economic groups.[22] Race was found to be a small but significant predictor for three variables, and socio-economic status was found to be a small but significant predictor for two of the four subscores. The purpose of this study was to evaluate the correlations between the 21 ITBS subscores and the results of a three-year longitudinal, prospective study of visual skills at the elementary school level. A secondary goal was to compare the relative significance of visual factors to demographic factors—specifically, race and socio-economic status. The study included demographic and visual data of children who are attending public school, first through fifth grades. This article is limited to reporting of the analysis of only the demographic and visual factors that significantly correlated to the ITBS. Further, a regression analysis was performed to investigate the relative significance of these visual variables to each of the ITBS subscores. Only those meas-

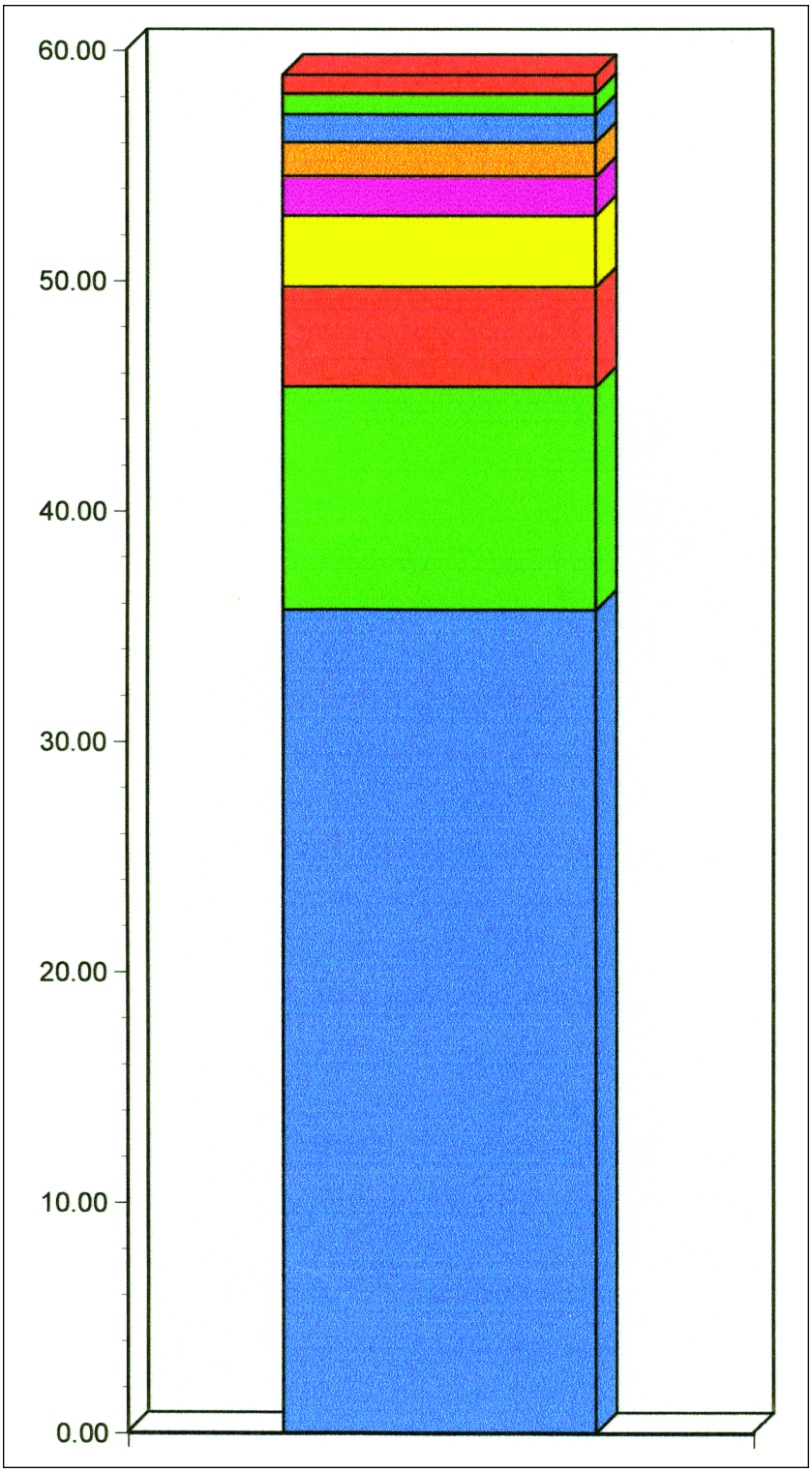

Figure 1 Regression analysis graph of significant factors related to core battery.

ures that showed significance when compared to a subscore of the ITBS at the 0.05 level were considered.

Methods

A three-year prospective, longitudinal study was undertaken to evaluate the visual and academic performance of 540 students in three elementary schools in Tahlequah, Oklahoma. The students, who were in the first, second, and third grades, were followed for three years. Testing of individual children was completed when most were in the first through the fifth grades. The visual testing was performed by licensed optometrists. The same optometrist performed the same set of tests during each test period, minimizing inter-examiner bias. The examiner did not have access to previous test scores. A list of the data points gathered on each evaluation can be found in the Box. The testing was performed once in the fall and once in the spring for three years. Over the three-year period, 2,659 evaluations were performed. The subjects were primarily white (401), followed by Native American (121), black (9), Hispanic (8), and one Oriental. *T*-tests were performed on the parametric test data, which allowed comparison of mean scores. For the nominal data represented by the socio-economic, racial, and gender factors, a Chi square (χ^2) analysis was used. This statistical tool is useful when named groups are being compared but the groups do not have a measured and standard interval between them. A Likert scale was assumed for the Maples Ocular Motor Test and Visual Motor Integration Test (VMI). The Likert scale allows the use of interval level statistics (*t*-test) by assuming standard distances between data points.[28-30]

Table. Visual and demographic variance of significant factors compared to individual ITBS scores

Test data / ITBS	Wold	VMI	DEMVert	DEMRatio	MFVPClos	MFVPMem	Race	NPA1Rec	PhoriaPlus1	MFVPFig	StereoNear	ARSphereOD	SES	NSUPurBody	PriBrBaseOut	ARAxisOD	NSUPurAC	PhoriaMinus1
Core Battery	35.7	9.7	3.1	4.3	—	0.8	1.7	—	—	—	—	—	1.5	—	—	0.9	—	—
Math Total	34.7	11.2	2.0	3.8	—	0.8	2.2	0.8	—	—	—	—	—	—	—	0.9	—	—
Language Total	35.2	7.3	4.2	2.5	0.9	—	—	—	—	—	—	2.7	0.5	1.3	—	—	—	—
Reading Total	1.7	11.0	24.8	7.7	2.7	0.6	0.4	—	0.6	—	—	1.5	0.5	1.1	—	0.4	—	—
Listening Gr Eq	24.3	1.2	—	—	16.1	—	—	—	—	—	—	—	—	—	—	1.0	—	4.4
Vocabulary Gr Eq	0.4	24.5	10.5	6.1	3.8	1.2	1.6	0.5	—	—	—	—	0.9	—	—	—	—	—
Math Computations	32.4	8.8	2.9	5.2	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Concepts/Estimate	25.9	10.9	2.9	5.6	1.2	—	1.9	—	—	—	—	—	—	—	—	—	—	—
Problem/Data	23.6	8.4	2.1	1.9	—	1.7	4.1	0.9	—	—	—	—	—	—	—	—	—	—
Lang Expression	23.7	9.7	3.5	4.3	0.9	0.6	0.4	0.7	—	—	—	2.2	1.0	—	—	—	—	—
Comprehens Gr Eq	0.9	5.9	21.6	10.1	1.5	—	—	—	0.8	—	—	2.2	0.6	0.6	—	0.4	—	—
Composite Gr Eq	—	21.4	7.9	6.5	—	1.8	1.5	—	3.0	—	—	—	1.9	—	—	—	—	—
Word Analysis	26.3	4.8	—	—	1.9	2.7	—	—	—	8.2	—	—	—	—	—	—	—	—
Maps/Diagrams	—	13.6	—	—	—	5.9	—	7.1	—	—	3.4	—	—	3.3	—	—	—	—
Punctuation	—	17.9	7.0	—	2.0	—	2.2	—	—	3.3	—	—	—	—	—	—	—	—
Info Source Total	—	16.5	3.9	3.8	—	1.7	—	2.0	5.0	—	—	—	—	—	—	1.4	—	—
Science	—	14.5	6.9	4.3	—	2.1	—	—	—	—	—	—	—	—	—	—	—	—
Capitalization	—	5.2	12.2	—	—	—	—	—	—	—	2.2	—	—	—	—	—	—	—
Ref Materials	—	7.9	11.3	—	—	—	—	2.8	—	—	4.0	—	—	—	—	—	—	—
Spelling	—	—	15.2	—	8.4	—	—	—	2.1	—	—	—	—	—	—	—	—	—
Social Studies	—	—	—	—	3.8	—	—	—	—	—	—	—	—	—	5.4	—	4.6	—
TOTALS	**264.8**	**210.4**	**142.0**	**66.1**	**43.2**	**19.9**	**16.0**	**14.8**	**11.5**	**11.5**	**9.6**	**8.6**	**6.9**	**6.3**	**5.4**	**5.0**	**4.6**	**4.4**
No. of significant factors	12	19	17	13	11	11	9	7	5	2	3	4	7	4	1	6	1	1

Results

The Table contains the 21 ITBS subcategories, along with the results of the analysis of significant test data. Only factors that were found significant at the 0.05 level or better, using the appropriate statistical instrument, were analyzed. A total of 39 screening factors were found to be significantly related to at least one of the 21 ITBS subfactors. Appendix B lists significant examination data, while Appendix C lists each of the examination abbreviations used in the Table. A regression analysis of these significant screening variables was performed. Each column labeled as an examination data category in the Table contains a number. Each line represents a ITBS subscore. The presence of a number in a line/column indicates that the examination category was significant. The value of the number represents the percentage of the ITBS test variance that was accounted for by that particular visual test result. The sum variance—found at the end of each line—represents the total amount of variance explained by the significant factors discovered in predicting ITBS performance. The bottom numbers of each column represent *first*, the summed variance for that particular test and *second*, the number of ITBS subscores that were found to be significant for that particular test.

The ITBS subscores in the Table are listed in order, from the largest-pooled predictive subfac-

Table continued

	NPA2Rec	NSUSacAC	AccRockOU	AccRockOD	ARAxisOS	PriRecBaseOut	NSUSacBody	PhoriaNear	VANearOU	PriRecBaseIn	VAFarOD	NSUPurHead	ARSphereOS	NPC1Rec	VANearOS	MFVPDisc	Nott	NPA2Blur	ARCylOS	PhoriaFar	NPA1Blur	Total	No. of significant factors
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.2	—	—	—	58.9	9
	—	—	—	—	—	—	—	—	0.9	—	—	0.7	—	—	—	—	—	—	—	—	—	58.0	10
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.8	55.4	9
	—	—	—	—	—	—	0.6	—	—	—	—	—	—	—	—	—	0.5	—	—	0.6	—	54.7	15
	—	—	—	—	—	—	1.8	—	—	—	—	—	—	2.0	2.0	—	—	—	1.1	—	—	53.9	9
	—	1.0	—	—	—	—	—	—	—	—	—	—	—	—	—	—	0.8	—	—	—	—	51.3	11
	—	—	—	1.3	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	50.6	5
	—	1.0	1.1	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	50.5	8
	—	—	2.8	—	—	—	—	—	1.6	—	—	1.6	—	—	—	—	—	—	—	—	—	48.7	10
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	47.0	10
	—	—	—	—	—	—	0.5	—	—	0.6	—	—	—	—	—	—	—	—	—	0.4	—	46.1	13
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	44.0	7
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	43.9	5
	2.6	—	—	—	—	—	—	2.7	—	—	2.4	—	—	—	—	—	—	—	—	—	—	41.0	8
	—	—	—	2.4	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	34.8	6
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	34.3	7
	1.7	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	29.5	5
	—	—	—	—	3.5	—	—	—	—	1.8	—	—	2.1	—	—	1.8	—	—	—	—	—	28.8	7
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	26.0	4
	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	25.7	3
	—	2.0	—	—	—	3.5	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	19.3	5
	4.3	**4.0**	**3.9**	**3.7**	**3.5**	**3.5**	**2.9**	**2.7**	**2.5**	**2.4**	**2.4**	**2.3**	**2.1**	**2.0**	**2.0**	**1.8**	**1.3**	**1.2**	**1.1**	**1.0**	**0.8**		
	2	3	2	2	1	1	3	1	2	2	1	2	1	1	1	1	2	1	1	2	1		

tor to the least-pooled predictive factor. These scores range from a high of 58.9% (*Core Battery*) to 19.3% (*Social Studies*). Figures 1 and 2 graphically represent this regression analysis data for these high and low subscores of the ITBS.

The largest-pooled predictive category, *Core Battery*, had nine variables that were significant markers. The sum total of the variance accounted for was 58.9% (*see* Table). This category was followed by seven other ITBS categories in which at least 50% of the variance was accounted for by the evaluation. These seven categories were *Math Total* (58.0%, 10 variables); *Language Total* (55.4%, nine variables); *Reading Total* (54.7%, 15 variables); *Listening Grade Equivalent* (53.9%, nine variables), *Vocabulary Grade Equivalent* (51.3%, 11 variables); *Math Computations* (50.6%, five variables); and *Concepts and Estimation* (50.5%, eight variables). *Social Studies*, on the other hand, with its five variables, was predicted only 19.3% of the variance. Figure 3 visually represents these ITBS subscores, which were predicted by this school examination protocol at least 50% of the time.

The ITBS subscore with the largest number of significant variables was the *total reading score*, which was predicted by 15 factors (54.7%). *Vocabulary grade equivalent* was the next most fre-

quently predicted ITBS skill by the test data. The eleven test scores predicted 46.1% of the variance. Other ITBS subscores predicted by 10 tests were *total math score* (58.0%), *problem solving/data* (48.7%), and *language expression* (47.0%). The ITBS scores that had the fewest significant screening correlations were *reference materials* (with 4) and *spelling* (with 3).

Of the 21 ITBS variables, *race* was significant in nine and *socio-economic status* was significant in seven. None of the *race* or *socio-economic status* regression scores was highly predictive of any of the ITBS items. The ITBS item that scored the highest when compared to *race* was *problem solving/data*, with 4.1% of the total variance being predicted by *race*. *Socio-economic status* (SES) correlations were even lower. Of the seven significant (SES) screening factors, the highest regression variance was 1.9%, with *composite grade equivalent*.

The *Wold Sentence Copy* was the most-robust overall predictor, with a cumulative predictive value of 264.8 and 12 ITBS factors. The average variance for this test was 22.1%. The VMI predicted some measure of performance on 19 of the 21 ITBS scores, with a sum predictive value of 210.4. The average variance for these 19 items was 11.1%. The *race* factor was predictive on nine of the 21 ITBS subscores. It had a cumulative predictive score of 16.0%. The average for the nine ITBS scores was 1.8%. The variable of *socio-economic status* was predictive on seven of the 21 ITBS categories and a sum variance of 6.9%, for an average variance on these seven scores of 1%.

There were six factors that predicted at least 11 or more of the ITBS subskills. These were, in decending order, the VMI (19), DEM Vertical Score (17), DEM Ratio Score (13), Wold Sentence Copy (12), and the Motor Free Visual Perception Memory Sub-Test and Motor Free Visual Perception Closure Sub-Test, each with 11.

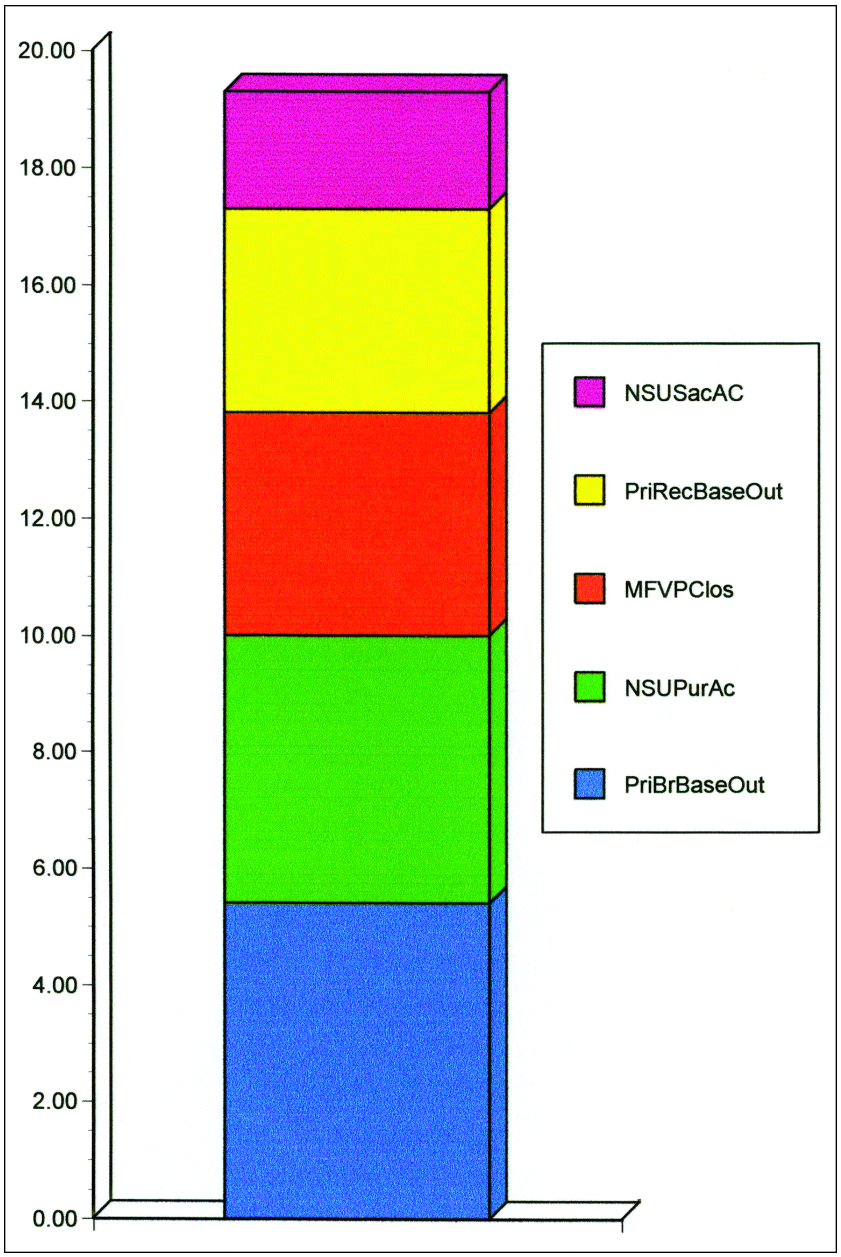

Figure 2 Regression analysis graph of significant factors related to Social Studies.

Discussion

The two visuo-motor tests, the VMI and the Wold Sentence Copy, were the most-robust predictors of academic success in this study of children in

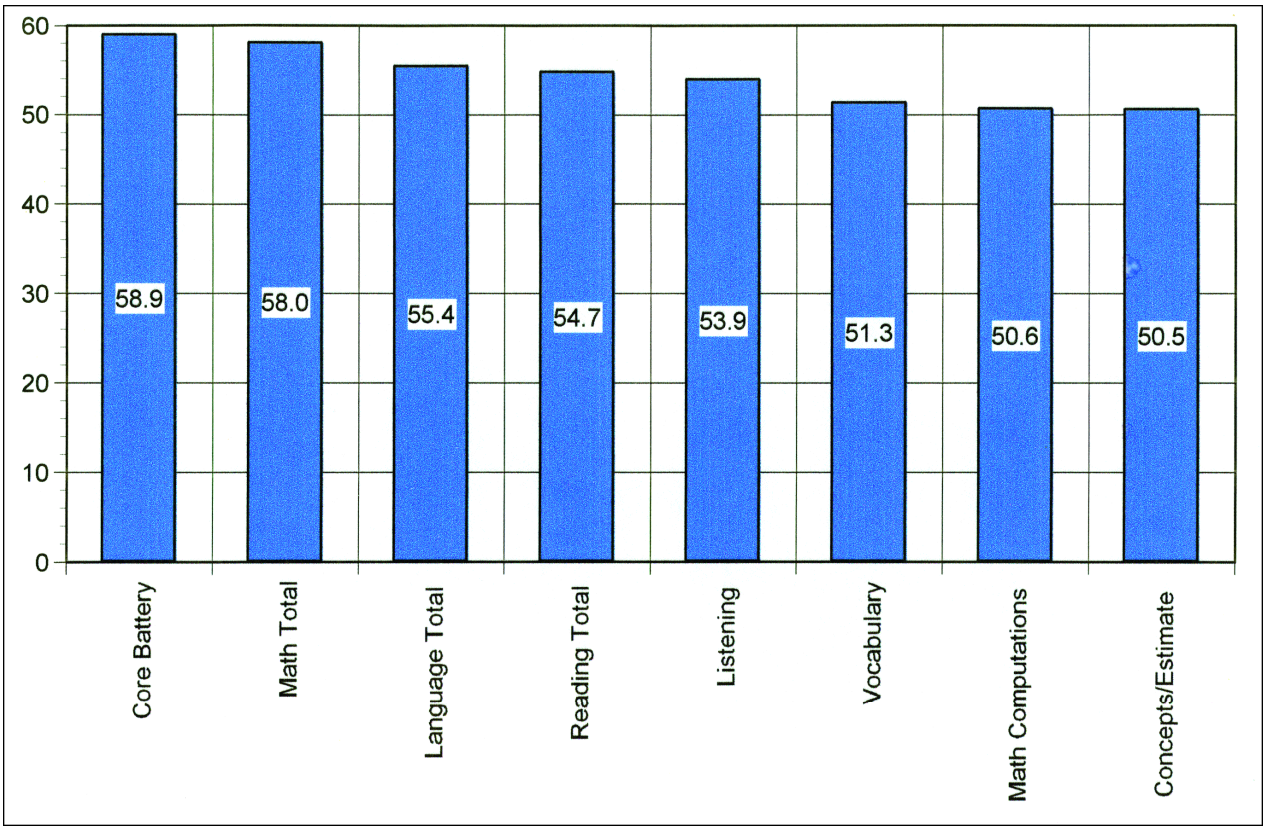

Figure 3 Total variance of Iowa Tests of Basic Skills, accounted for by visual evaluation scores.

the first through fifth grades. Race was the seventh-best predictor and socio-economic status was the eighth-best predictor. The predictive ability of the VMI and the Wold Sentence Copy were far better than the factors of race or socio-economic status. The Wold Sentence Copy, a one-minute test, is a 16.55 times better predictor of scores on the ITBS than race and a 38.4 times better predictor of scores on the *ITBS* than *socio-economic factors*. Likewise, the VMI predicts performance on the ITBS at a 13.15-fold rate better than does *race*. The *VMI* prediction rate, when compared to *socio-economic status*, is 30.48 greater rate.

Other visual tests were also significant predictors of ITBS scores, though less robust than the Wold and VMI. These include *visual acuity*, *visual-auditory processing*, *ocular motor*, *binocular skills*, *accommodative skills*, and *refractive status*. Both *near and far visual acuity* and *auto-refractor* (AR) scores were found to correlate with some academic scores. *Visual-verbal processing*, measured by the Developmental Eye Movement Test (DEM) vertical time score. The vertical DEM score requires the individual to look at the digit and then recall the name of the digit. This automaticity skill requires a visual symbol to be converted into a verbal response, a rudimentary form of reading. *Ocular motor* skills, as measured by the DEM horizontal score/ratio and the Maples Ocular Motor Test, were also correlated. In the realm of *binocular measures*, the Howell Card (out of phoropter phorias), near point of convergence and stereo acuity were correlated to scores on the ITBS. Lastly, all three measures of *accommodation*—*amplitude*, *lag*, and *facility*—were found to correlate to the academic scores.

An earlier paper reported on four of these 21 ITBS subscores. It demonstrated the significance of vision skills in prediction of academic performance.[22] The earlier data were collaborated and dramatically expanded by these findings. Moreover, this information points to a solution hitherto not universally considered: improving visual function to impact learning. Visual skills, and the symptoms associated with these deficient skills,[31] can be easily measured and modified by optometric techniques.[32-36]

A controlled study should be undertaken to evaluate if treatment of the visual factors identified in this study would make an impact on academic scores. Therapy would include optical prescriptions, ergonomics, and specialized therapeutic procedures. Such a study would demonstrate if such treatment would have a statistically significant impact on the ITBS scores or on some comparable standardized academic test.

Visual skills can be improved.[37-39] It is possible that improvement of visual skills would be a signficicant part of the solution for this very complex problem of academic under-performance. Clearly, this problem is multi-factorial, but the improvement of ocular motor, binocular, accommodative and particularly visual motor and visual perceptual skills could only help the overall picture.

Conclusions

This article gives evidence that visual motor, ocular motor, binocular, accommodative, and visual perceptual skills are significant factors in children who score poorly on the standardized Iowa Test of Basic Skills educational test. Race and socioeconomic factors are less-significant predictors of some of the scores on the ITBS.

This article also indicates the need to institute a multi-site, prospective, randomized study to investigate if children who received optimum optometric care would improve in their academic standing, as measured by the ITBS.

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Appendix A

Iowa Basic Skills Tests for the Different Grades Represented in this Study

First Grade

Vocabulary: Pictorial and written stimulus are given with a written response. The test is untimed.

Word Analysis: Evaluates letter-sound relationships.

Reading: A variety of test designs:

A. Print and context clues are tested to deduce meaning of unfamiliar words.
B. Pictures to tell a story and which the student discusses.
C. Written stories are followed by multiple choice questions.

Listening: Short oral sentences are followed by multiple choice questions.

Language: A variety of test designs:

A. Oral language questions are given and linguistic classification tasks.
B. Spelling.
C. Capitalization.
D. Punctuation.
E. Skill in usage and writing.

Mathematics Concepts: Test is orally administered and answers are either pictorial or numerical.
Tests the understanding and ability to apply a variety of math concepts, including numbers, geometry measurements, fraction currency, and number sentences.

Social Studies: Oral questions are presented with pictorial responses in geography, history, government, economics, sociology, and the other social sciences.

Sources of Information: Questions are presented orally and the student responds with words/responses read by the student.

Second Grade

Vocabulary, Word Analysis, Listening, Mathematics Concepts, Social Studies, and Sources of Information: are essentially same as First Grade.

Mathematics Problem Solving: The test is administered orally:

A. Brief problems are given with multiple choice answers.
B. Interpretation of graphs and tables requires the location, comparison, and generalization of data in the tables and graphs.

Mathematics Computation: The test is administered orally:

A. Problems in addition and subtraction are given. The use of scratch paper is allowed to solve the problem.
B. Addition and subtraction problems are found in a test booklet. The test is timed.

Science: The test is administered orally and the responses are pictorial. The test questions areas are life sciences, earth, space, physical science, as well as methods and processes.

Third Through Eighth Grades

Vocabulary: Multiple choice questions present a word in context. The student is required to identify the most similar word.

Reading Comprehension: Reading passages consist of from a few lines to a full page. Most questions require the drawing of inferences or ability to generalize answers about the passage.

Spelling: Four words are presented, one of which is misspelled (or sometimes all are correct). The student identifies the misspelled word.

Capitalization: The test requires errors of capitalization to be identified.

Punctuation: The test requires errors of punctuation to be identified.

Usage and Expression:

A. One or two sentences arranged and the student is asked to identify usage error (or no error).
B. The student chooses best way to express an idea in a sentence/ paragraph.

Math Concepts/Estimation:

A. This area tests the understanding of math ideas, relationships, visual representations, number systems, integers, geometry, etc.
B. Computational estimation, number sense and mental arithmetic are tested.

Math Problem Solving and Data Interpretation:

A. This tests consists of word problems with one or more steps.
B. In this test, data are presented in tables/graphs and computation, estimations, comparisons, trends, and relationships are noted.

Math Computation: Arithmetic, (addition, subtraction, multiplication, division) are evaluated.

Social Studies: This test evaluates the understanding of concepts, principles, and selected types of visual materials in the areas of history, geography, political science, economics, sociology, and anthropology.

Science: Tests the knowledge of life sciences, earth, space, and physical science, including methods and processes.

Maps/Diagrams:

A. Authentic maps/locations are presented and the test requires solving location, direction, distance, and interpreting data by making inferences.
B. Charts and diagrams to measure visually presented information are presented, which include locating, explaining, inferences, and comparisons.

Reference Materials: The skill of the student in the use of reference materials and libraries to obtain information is tested. This includes the use of dictionaries, card catalogs, and general reference materials.

Core Battery: This aspect is a compilation of scores from the subscores of Vocabulary, Word Analysis, Reading, Listening, Language, Mathematics Concepts, Mathematics Problems, and Mathematics Computation.

Composite Grade Equivalent: This score is a compilation of all the subscores.

Appendix B

Visual and Demographic Data Points Found to Be Significantly Correlated to the ITBS

Wold Sentence Copy: A visual motor test in which a child is asked to copy as quickly and accurately as he or she can, a sentence printed on the top fourth of a page.

Visual Motor Integration Test: A visual motor test of 24 symbols which become increasingly complex. The child is asked to reproduce each symbol until two consecutive symbols are missed.

Developmental Eye Movement Test: A series of digits which are quickly read. It consists of three pages. Two of the pages contain vertical digits (20 per column) on each side of the paper (80 total for the two sheets). The third sheet consists of 80 digits, arranged in 16 lines of 5 digits each. The middle three digits are randomly spaced across the page. The vertical time, the horizontal time, and the ratio (a corrected horizontal time divided by the vertical time) are considered in the scoring. The corrected time allows for errors made while performing the horizontal test.

Motor Free Vision Perception Test: A non-motor visual perception test that evaluates, visual memory, visual discrimination, visual figure-ground, and visual closure. The child is asked to point to a correct answer among the answers shown in the test booklet.

Near Point of Accommodation: The accommodative push-up amplitude both to blur out and to recover readability. This test was performed three times.

Far and Near Phoria and through +1 D and –1 D Spheres: A Howell Card (Modified Thorington Technique) performed at distance and near to measure the respective phorias. Along with the near phoria, phorias were measured through a pair of +1 D Spheres and –1 D Spheres.

Wirt Stereo at Near: The Standard Wirt Circle Stereo Test scores.

AutoRefractor: Sphere, cylinder, and axis measures.

The Maples Ocular Motor Test: The pursuit and saccade Ability, Accuracy, and Head and Body Movements were observed and recorded in the standard manner.

Prism Bar Break and Recovery at Near: Base-out and Base-in break and recovery using a prism bar and a near target.

Accommodative Rock (+2/–2 D): The Monocular and Binocular function, performed with a reduced Snellen target and a suppression check.

Near Visual Acuity: The Monocular and Binocular functions were measured using a reduced Snellen card.

Far Visual Acuity: The Monocular Visual Acuity functions were measured using a distance Snellen chart.

Near Point of Convergence: The break/recovery of binocularity was performed three times.

Dynamic (Nott) Retinoscopy: The lag of accommodation, as measured by Nott Retinoscopy.

Appendix C

Explanation of abbreviated titles used in Table

Wold = Wold Sentence Copy Test
VMI = Visual Motor Integration Test
DEM = Developmental Eye Movement Test
- **Vert** = Vertical
- **Ratio** = Ratio

MFVP = Motor Free Visual Perception Tests
- **Clos** = Closure
- **Mem** = Memory
- **Fig** = Figure Ground
- **Disc** = Discrimination

NPA = Near Point of Accommodation (Performed three times)
- **1Rec** = First Recovery from blur
- **2Rec** = Second Recovery from blur
- **2Blur** = Second Blur Out
- **1Blur** = First Blur Out

Phoria
- **Plus 1** = Near Phoria through +1 D spheres
- **Minus 1** = Near Phoria through –1 D spheres
- **Near** = Near Phoria
- **Far** = Far Phoria

Stereo = Wirt Stereo Circles
AR = AutoRefractor
OD = Right Eye
OS = Left Eye
OU = Both Eyes
- **Sphere** = Sphere
- **Cyl** = Cylinder
- **Axis** = Axis of Cylinder

NSU = Maples Ocular Motor Test
- **PurBody** = Pursuit Body Movement
- **PurAC** = Pursuit Accuracy
- **PurHead** = Pursuit Head Movement
- **SacAC** = Saccade Accuracy
- **SacBody** = Saccade Body Movement

SES = Socio-Economic Status
PriBrBaseOut = Near Prism Bar Break to Diplopia Base Out
PriRecBaseOut = Near Prism Bar Recovery from Diplopia Base Out
AccRock = Accommodative Rock
VA = Visual Acuity
NPC = Near Point of Convergence (performed three times)
- **1Rec** = First Recovery from diplopia

Nott = Nott Dynamic Retinoscopy