A COMPARISON *of* VISUAL ABILITIES, RACE *and* SOCIO-ECONOMIC FACTORS *as* PREDICTORS OF ACADEMIC ACHIEVEMENT

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Abstract

It has long been recognized that the lower socio-economic groups of society do poorer in academics. Previous studies have demonstrated that Native American and low socio-economic children do poorer in school than Caucasians and middle/high socio-economic children respectively. A prospective, three-year longitudinal study was completed. Elementary school children in the Tahlequah, Oklahoma Public School System were the subjects. Subjects were separated into Caucasian and Native American racial groups as well as high/medium socio-economic and low socio-economic groups. A total of 1329 evaluations over six test periods were made. A regression analysis was performed to ascertain if the variables of race, socio-economic level or visual skills were significant predictors of performance on four or the sub-tests of the Iowa Test of Basic Skills (ITBS). Visual factors were more robust predictors of scores on the ITBS than were factors of race or socio-economics. Visual factors were the most significant variables in all four academic areas. The racial variable was small but significant in three of the four ITBS sub-skills. Socio-economic factors were also significant but small, in only two of the four sub-skills. Thus, although race and socio-economic status are significant factors in academic performance, visual skills appear to play a larger roll. Since these visual skills are more accessible to change than are race or socio-economic factors, emphasis should be placed upon improving these visual skills to ascertain if such improvement may also positively impact academics.

Key Words

Iowa Test of Basic Skills (ITBS), Math, Native Americans, ocular motor, reading, socio-economic, visually-related learning problems, visuo-motor

It is well accepted in the educational community that, as a whole, the lower socio-economic strata of society does poorer in academics than the middle and higher socio-economic groups.[1-10] African Americans, Hispanics, Native Americans and others tend to be in the lower socio-economic group and therefore tend to do poorer in academics than Caucasians. The minorities also have a much higher percentage of their population on welfare and within the prison systems than do their Caucasian counterparts.[11]

The assumption has been that the socio-economic environment has been the prime variable, causing these lower socio-economic groups to perform poorer, academically. Neither genetics nor the socio-economic variables are readily accessible to change. The socio-economic environment may not, however, be the only factor impacting these minorities. It is possible that physical and/or physiological characteristics, found more frequently in some low socio-economic groups, might be a significant factor in their under-achievement. Furthermore, if variables were found that were deficient and are correctable, it might cause the lower socio-economic children to perform better in their academic endeavors.

Orientals, African Americans, Australian Aboriginals and Native American tribes have different visual characteristics.[12-34] The Orientals have a much higher prevalence of myopia[24-27] while African Americans have a higher prevalence of hyperopia.[22,23,27] Orientals tend to do well academically. Western Native American tribes, as opposed to the more eastern tribes, are known for the high prevalence and mean amount of with-the-rule astigmatism.[14-20] Uncorrected astigmatism could have devastating effects on academic endeavors since astigmatism allows the person some measure of visual acuity but places the individual under stress when attempting reading or nearpoint activities.

In an earlier study comparing the scores on the Iowa Test for Basic Skills (ITBS) of low socio-economic and middle/high socio-economic groups of Caucasian and Native American elementary school children, the following conclusions were reported.[10]

1. The low socio-economic groups scored poorer than the middle/high groups.
2. Native American children, as a group, scored poorer than Caucasian children.

3. Low socio-economic Caucasians scored poorer than middle/high socio-economic Caucasians.
4. Low socio-economic Native American children did not score poorer than the middle/high socio-economic Native American in most ITBS scores.
5. High/middle socio-economic Caucasians did better than high/middle socio-economic Native Americans
6. Low socio-economic Caucasians did better than low socio-economic Native Americans.

Since, as discussed above, it is also known that children who belong to minority and low socio-economic groups tend to have a high prevalence of visual problems, it was hypothesized that the poorer visual functions of these children might be impacting their academic performance and might therefore be one of the reasons that these two groups tend to do poorer academically. The research questions to be answered here are; do visual variables predict academic achievement and if so, are the racial and socio-economic variables better markers for the child at risk to exhibit poor academic performance than are visual factors?

Table 1
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 Binocularly 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[a] (Modified Thorington) and Binocular +/-1 AC/A at near with the Howell Card
8. Near Stereo with Wirt Circles and Auto-Refractor, Each Eye
9. Nearpoint of Accommodation Blur Out and Recovery (3 measures) with the Dominant Eye (NPA)
10. Accommodative Rock +/- 2D Flippers, Monocularly and Binocularly
11. Nearpoint of Convergence Break and Recovery (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,[a] both Pursuits and Saccades
16. Developmental Eye Movement Test (DEM)[b]
17. Motor Free Visual Perception Test (MFVP)[a]
18. Wold Sentence Copy Test[c]
19. Visual Motor Integration Test (Beery)[a]
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 Scores in Spring of Each year

Materials and Method

A three year prospective, longitudinal study was undertaken to evaluate the visual and academic performance of 536 students in three elementary schools in Tahlequah, Oklahoma. The data points collected on each of the students are listed in Table 1. Students who were in the first, second and third grade were followed for three years. Testing on the individual children was completed when most were in the first through the fifth grades. The visual testing was performed once in the fall and once in the spring, yielding a total number of 2688 evaluations because not every student was available during each of the testing sessions. Hispanics, African Americans, Orientals, Caucasians and Native Americans were evaluated. Only Caucasian and Native American children, however, were considered for this study for a total of 2575 evaluations. The elementary school assisted in defining both race and socio-economic level based upon school records. The parents also completed a questionnaire, which assisted in the evaluation of socio-economic status.

These children were separated into high/middle and low socio-economic levels. Of the two races represented in this study, a total of 1329 Caucasian and Native American children were identified in whom socio-economic status could be verified at each evaluation. Of these 1329 students, Caucasians made up 82.2% and Native American made up the remaining 17.9%. Demographic data and standardized academic scores from the Iowa Test of Basic Skills (ITBS), independently administered by the elementary schools in the spring of each school year, were made available to us.

A number of tests in the visual battery are not routinely used by optometrists (see Table 1). The Howell Card[a] is a modified Thorington technique to measure distance and near phorias in real space.[35] An oval target with a downward pointing arrow bisects the oval. When viewed with disassociating prism (base down over the right eye), the subject saw two ovals, one above the other. The subject then reported to which side and to what number the top arrow was pointing in respect to the bottom oval. Depending upon the location of the top arrow in relation to the bottom oval, the phoria was ascertained. The test has both distant and a near targets so that both distant and near phorias can be measured. The AC/A was also calculated by viewing the near target through a pair of +1D and −1D lenses. The subject then reported the near phoria under these two conditions. The difference between the two phoria measures were then divided by two to calculate the AC/A.

Two ocular motor tests were employed. The Maples Ocular Motor Test[a] (NSUCO) is a traditional saccade and pursuit test which has been standardized and normed.[36] Four variables were graded under each test; ability to sustain attention, accuracy of movement, head movement and body movement observed during the ocular motor activity. The tests do not have a significant verbal aspect as does the other ocular motor test which was employed, the Developmental Eye Movement Test (DEM).[b]

Table 2
Variables in the Visual Examination Which Predicted Total Reading Score Performance

Visual Test	% Variance Accounted by the Test	Cumulative Percentage
DEM Vertical	24.8%	24.8
Beery	11.0	35.8
DEM Ratio	7.7	43.5
MFVP Closure	2.7	46.2
Wold Sentence Copy	1.7	47.9
Auto-refractor Sphere (OD)(More myopic does better)	1.5	49.4
Maples Pursuit Body Movement	1.1	50.5
Maples Saccade Body Movement	0.6	51.1
Howell Phoria (+1D) (Higher exo does better)	0.6	51.7
Distance Phoria (Higher exo does better)	0.6	52.3
MFVP Memory	0.6	52.9
Socio-Economic Group (Higher group does better)	0.5	53.4
Race (Caucasians do better)	0.5	53.8
NOTT Retinoscopy	0.4	54.3
Auto-refractor Axis of Cylinder (Higher Axis poorer grade)	0.4	54.7

Table 3
Variables in the Visual Examination Which Predicted Total Composite Grade Performance

	% Variance Accounted by the Test	Cumulative Percentage
Beery	21.4	21.4
DEM Vertical	7.9	29.3
DEM Ratio	6.5	35.8
+ 1 Phoria	3.0	38.8
Socio-Economic	1.9	40.7
MFVP Memory	1.8	42.5
Race	1.5	44.0

Table 4
Variables in the Visual Examination Which Predicted Total Math Grade Performance

	% Variance Accounted by the Test	Cumulative Percentage
Wold	34.7	34.7
Beery	11.2	45.9
Race	2.2	48.1
DEM Vertical	2.0	50.1
DEM Ratio	3.8	53.9
Auto Refractor Axis OD	0.9	54.8
Visual Acuity Near OU	0.9	55.7
MFVP Memory	0.8	56.5
Maples Pursuits Head Movement	0.7	57.2
NPA 1 Recovery	0.8	58.0

Table 5
Variables in the Visual Examination Which Predicted Total Information Grade Performance

	% Variance Accounted by the Test	Cumulative Percentage
Berry	16.5	16.5
Plus 1 Phoria	5.0	21.5
DEM Vertical	3.9	25.4
DEM Ratio	3.8	29.2
MFVP Memory	1.7	30.9
NPA 1 Recovery	2.0	32.9
Auto Refractor Axis OD	1.4	34.3

The DEM is a normed test which does have a significant verbal component.[37] The subject was required to call out digits as quickly as possible from two pages containing non-randomly spaced digits placed vertically on each side of the page. The subject called out the digits from top to bottom beginning with the left column and ending with the right column. The time to complete each of the two vertical columns on each page, a total of 80 digits for the two tests, were added together for the Vertical time. The Horizontal time was noted when the subjects subsequently named the digits from randomly spaced digits placed horizontally on a page (a total of 80 digits). A comparison of the vertical to the horizontal scores allows one to calculate a ratio between the two scores. A slow vertical and horizontal score indicates a problem in visual-verbal processing. A normal or fast vertical score combined with a slow horizontal score and subsequent high ratio score would indicate a problem in eye movements alone.

Several perceptual tests were employed. The Motor Free Visual Perception Test[a] (MFVP) is a forty-item test which evaluates visual discrimination, visual figure-ground, visual memory and visual closure. The MFVP does not require a visual motor response. Rather, the subject is only required to point or to state their answer. The Developmental Test of Visual-Motor Integration,[a] is often referred to as the Beery Test after Keith E. Beery who developed the administration and scoring protocol.[38] This test consists of 24 symbols which gradually become more complex. The subject is asked to copy each symbol as accurately as possible without erasing.

The Wold Sentence Copy Test[c] is also a visual-motor test which requires the subject to copy a printed sentence on the lower half of a sheet of paper. The sentence is printed on the upper third of the page. The number of characters copied in one minute was recorded. The COVD Quality of Life Checklist was also employed to investigate possible visual symptoms.[39] This thirty item checklist has been shown to have high test re-test reliability and has been shown to identify children who have problems with learning.[40] Both teacher and parent/guardian were asked to complete the checklist.

All visual measures were analyzed for four of the twenty-one ITBS sub-scores; total reading score, total math score, total information score and total composite academic scores. Significant visual findings, which correlated with lowered academic performance in the total sample of children in the study, were identified and regression analyses were performed with the variables, including socio-economic status and race.

Results

The regression analyses, based upon adjusted values for goodness of fit, showed that several of the visual tests were significant when compared to these academic areas. Eleven visual/socio-economic/racial variables accounted for 54.7% of the variance in the total reading score performance. (Table 2 & Figure 1) Seven of these variables accounted for 44% of the composite academic performance (Table 3 & Figure 2), while 10 of the variables accounted for 58% of the total math performance. (Table 4 & Figure 3) Lastly, 34.3% (7 variables) of academic performance which considered total information knowledge was accounted for by visual factors alone. (Table 5 & Figure 4)

Race was a significant factor in three of the variables. These ITBS sub-scores where race was a factor were total reading score (0.5%), total composite grade performance (1.5%) and total math grade performance (2.2%). Socio-economic factors were a significant factor in only two variables. The ITBS sub-scores where socio-economics was a factor were total reading score (0.5%) and total grade composite grade performance (1.9%).

Discussion

Analysis of academic performance and visual factors would indicate that, in this sample, and for the four items considered in this study, race and socio-economic factors, although important predictors of academic performance, were not as robust predictors as selected visual factors. Socio economic and racial factors were significant predictors of performance in reading and composite grade scores (Reading for both variables: 0.5%, Composite Grade: Socio-Economic 1.9%; Race 1.5%). Race, but not socio-economic level, was a significant factor in math performance (2.2%) and neither race nor socio-economic factors were significant in total information knowledge for the children in this study.

There were four visual tests which were particularly significant as predictors for all four scores investigated in this study. The Beery, the most complex of the visual-motor tests, was the best predictor of the ITBS scores of all the visual tests. The predictive values of the Beery for ITBS scores were; 21.4% for total composite score, 16.5% for total information score, 11.2% for total math score and 11.0 for total reading score. This implies that visual motor function is an important skill for overall academic success. The Wold

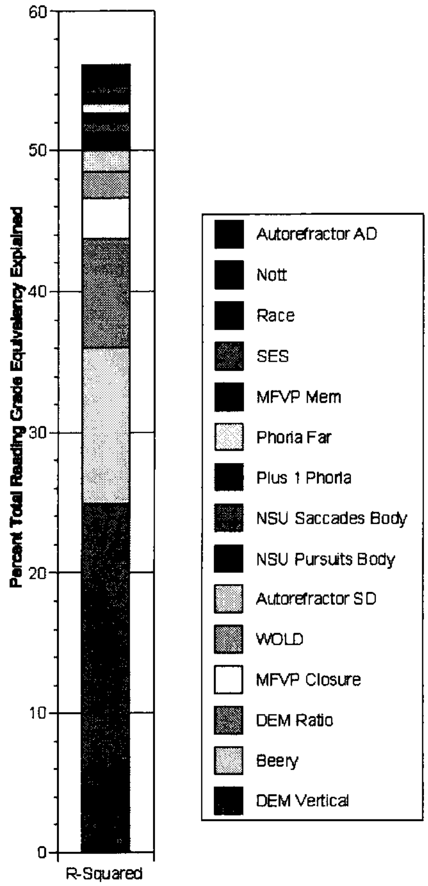

Figure 1.

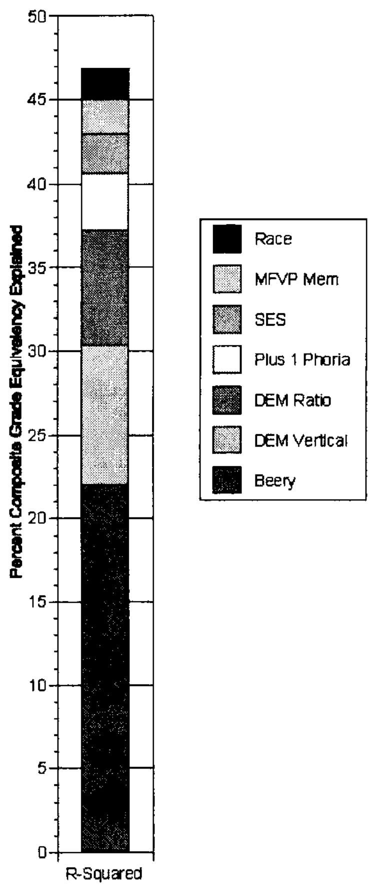

Figure 2.

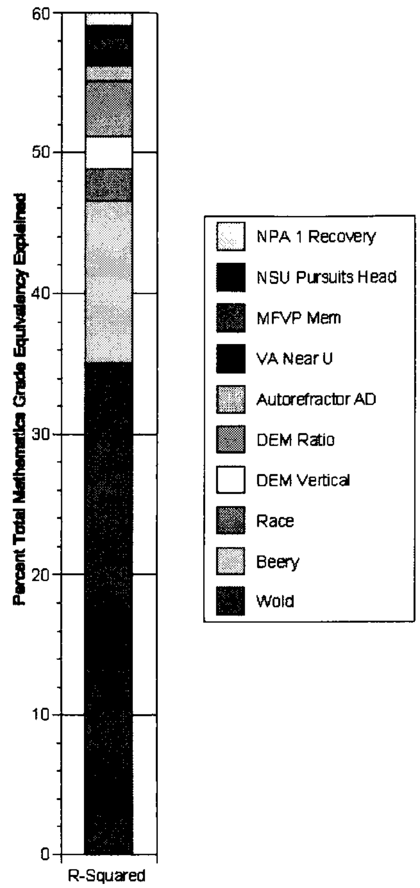

Figure 3.

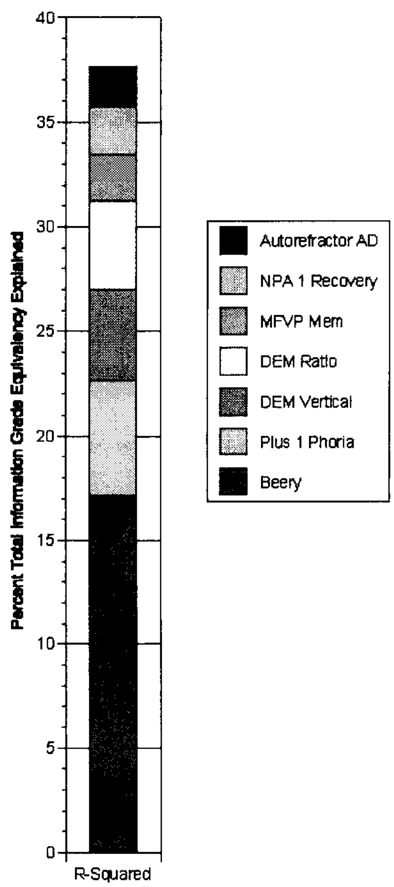

Figure 4.

Sentence Copy Test, also a visual-motor test, was highly predictive of performance on the math portion of the ITBS (34.7%) and somewhat predictive on the total reading score (1.7%). The prediction value of these two visual-motor tests emphasize the value of visual-motor skills in predicting academic performance.

The DEM Vertical was the next best predictor of the four ITBS scores. This test predicted 24.8% of the variance in total reading, 7.9% of total composite score, 3.9% of the total information score and 2.0% of the total math score. It must be kept in mind that this part of the DEM is utilized as a measure of the automaticity of visual-verbal integration, i.e., the efficiency to accurately translate a visual symbol into a verbal response. Thus, when the DEM Vertical is compared to the Maples Saccade Test, there is an indication that the visual-verbal function is more significant than pure ocular motor function in academic achievement. Visual-verbal integration obviously involves more than visual skills. It certainly involves visual information processing, particularly in the associative areas of the brain.[41]

The Motor Free Visual Perception Test (Memory) was the third visual test that was predictive of performance on each of the four ITBS sub-scores. Its predictive value was considerably less than either of the first two visual tests. The maximum predictability of this test was 1.8% for the total composite score, followed closely by the total information score at 1.7%. The total math score was predicted 0.8% of the time with this test while the total reading score was predicted 0.6% of the time.

Visual motor skills, visual-verbal skills, ocular motor skills and visual perceptual skills were the best predictors of academic performance, of the areas tested in this study. However, these are by no means all of the visual skills, which we found to be significant (Tables 2-5 and Figures 1-4). Other visual tests accounting for some variance on the four ITBS scores were the Maples Ocular Motor Test, various phoria measures, refractive error, sustained accommodative amplitude, accommodative lag and near visual acuity.

It is known that certain Native American tribes have significantly different visual profiles from other tribes and other races.[14-20,28-34] Notably, some Native American tribes have a high prevalence and high mean amount of with-the-rule astigmatism.[15-20] Refractive error was a significant but not dominant factor in three of the four Iowa Test score categories reported here. Only Composite Grade Equivalency was not significantly impacted by refractive error. Refractive error is the visual finding most investigated when a child is examined.

It is interesting that most of the best predictors of academic achievement on the ITBS are visual skills, which are usually not performed during routine testing.[42] It is important that the profession places greater emphasis on the testing and treatment of these very important visual skills with school aged children and particularly if there is a history of academic underachievement. Recent actions by the profession to require a visual examination for school age children is a step in the right direction.

There is a very important therapeutic question to be asked. If one can positively impact any of these predictive factors, would the academic performance of the child improve? The least modifiable of all the predictive factors is of course race, followed by socio-economic factors. Visual variables identified as markers in this study are relatively easily and positively modified in most cases. If controlled studies can demonstrate that improving these visual skills positively impacts academic performance, it would then follow that our schools should have the resources and means to identify the visual factors which might impact learning. It would then follow that education and optometry implement therapeutic procedures to alleviate these visual problems.

It may be that the low socio-economic factor is a precursor of poor vision development or of poor visual health. The next question to be logically addressed is then: if these identified visual factors are corrected in our minority and low socio-economic groups, will the discrepancy in academic performance between these groups and their Caucasian more economically well-to-do counterparts decrease?

Fortunately, the factors of refractive error, oculomotor, visual motor, visual perceptual and visual-verbal integration are considered to be more easily modified with a relative minimal amount of parental and social support. Community health education directed at parents of preschool children could prophylactically improve each child's readiness for school. Severe cases could then be identified by present optometric testing and be remediated by lens/prism prescriptions and/or optometric vision therapy.

Conclusions

It can be concluded from the sample of Native Americans and Caucasian subjects in this research that:

- ➔ Certain visual areas are better predictors of academic performance than either race or socio-economic status.
- ➔ Optometrists should more actively incorporate visual motor, visual-verbal, ocular motor and visual perceptual skills testing into the examination of a patient who is in an academic environment and particularly, if a history of underachievement is reported
- ➔ An extensive academic history should become the standard of care for patients in an academic environment
- ➔ A study which addresses correction of the identified visual predictors of ITBS scores should be undertaken to ascertain if improvement in visual skills will have a positive impact upon academics.

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