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# Vision, Visual-Information Processing, and Academic Performance Among Seventh-Grade Schoolchildren: A More Significant Relationship Than We Thought?

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**OBJECTIVE.** To compare visual and visual-information processing skills between children with and without mild reading and academic problems and examine the incidence of visual deficits among them.

**METHOD.** Seventy-one seventh graders classified as proficient ( $n = 46$ ) and nonproficient ( $n = 25$ ) readers were compared with respect to scores on an accepted vision screening, on tests of visual-perception, visual-motor integration, and academic performance. Further, academic performance and visual-information processing were compared between children who failed and passed the vision screening.

**RESULTS.** Visual deficits were found in 68% of the participants, and among significantly more boys than girls. Nonproficient readers had significantly poorer academic performance and vision-screening scores than the proficient readers. Participants who passed the visual screening performed significantly better in visual perception than those who failed.

**CONCLUSION.** Visual function significantly distinguishes between children with and without mild academic problems, as well as on visual-perception scores. The high occurrence of visual deficits among participants warrants consideration of vision deficits among schoolchildren with academic performance difficulties.

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## Introduction

Pediatric occupational therapists are concerned with the ability of children to participate effectively in all areas of occupational performance, including self-care, play, school participation, and academic performance (American Occupational Therapy Association, 2002; Kramer & Hinojosa, 1999). Although the expertise of school occupational therapists is widely recognized with regard to the nonacademic components of school performance such as daily-life activities and mobility, they have much to contribute in dealing with student disability in academic performance as well (Clark, Mailloux, Parham, & Primeau, 1991; Hanft & Place, 1996). The importance of providing support services and intervention for children who are experiencing academic difficulties cannot be overstated, because these can have serious ramifications in limiting occupational participation well beyond the school years (Brody, 1993; McLaughlin & Wehman, 1992).

Sensory abilities, as well as perceptual and perceptual-motor performance components, have long been considered as body functions that are vital for the attainment of emergent end-product abilities necessary for participation in school (Ayres, 1979; Dunn, 1992; Hanft & Place, 1996; Kramer & Hinojosa, 1999). A review of the literature reveals much support for the contention that visual-information

processing (i.e., visual perception and visual-motor integration) plays an important role in aspects of academic performance, such as reading and handwriting (Case-Smith, Rogers, & Haas-Johnson, 1996; Chu, 1997; Dunn, 2000; Kimball, 1999; Schneck, 2001). In fact, when Australian occupational therapists were surveyed with regard to the performance components they would evaluate in a child with learning disabilities and perceptual motor deficits, 100% of the respondents listed visual-perceptual abilities and 57% included visual-motor integration skill (Wallen & Walker, 1995). In an earlier study, Kavale (1982) performed a meta-analysis of 161 major studies relating visual perception and reading performance. His results indicated that visual perception is a significant correlate of reading achievement, and is predictive of reading performance in school, especially during the preschool and primary school grades (1982).

However, the belief that adequate visual-information processing underlies academic functioning is not universal. In fact, some researchers found that the visual-perceptual and spatial abilities of learning disabled students were not significantly different than those of typical students (Snowling, 2001; Vellutino, 1987).

In recent years professionals across multiple disciplines, including occupational therapists, have attempted to impress upon clinicians the importance of considering the influence of visual skills other than higher-level visual-information processing ability on their client's ability to function. They have emphasized that to establish best practices clinicians should also consider the status of their client's basic visual skills, such as oculomotor and binocular visual function (Birnbaum, 1993; Bouska & Galloway, 1991; Chaikin & Downing-Baum, 1997; Koslowe, 1991, 1995; Scheiman, 1997; Schneck, 2001; Warren, 1993a, 1993b). These are skills that are thought to be responsible for the ability to gather visual input accurately, efficiently, and comfortably from the surrounding environment (Erhardt & Duckman, 1997; Scheiman; Schneck). In fact, some professionals who value a holistic model of human performance, regard vision as the point of entry into the total process of intellectual development that is composed of "effective reception of information, the integration of that data with all other relevant data, and the observable performance that is demonstrated in the decisions of the individual" (Getman, 1984, p. 15). Moore (1996) echoes this belief in her statement that "vision is our most important sense for learning, memory, and interacting with our environment" (p. 16). The contention of these professionals is that the quality of visual input is primary to the perceptual process and they have gone to some lengths to delineate the direct influence that visual skills have on various occupational per-

formance skills (Bouska & Galloway; Erhardt, 1990; Titcomb, Okoye, & Schiff, 1997; Toglia, 1989; Warren, 1993a, 1993b). For example, Kulp and Schmidt (1996) emphasize the importance of accurate and efficient oculomotor skills for daily functional tasks such as reading, copying from the blackboard, taking tests, and activities requiring eye-hand coordination. In fact, research has indicated that the influence of oculomotor behaviors on reading ability remains significant even when controlling for language and attentional deficits (Eden, Stein, Wood, & Wood, 1994; Poynter, Schor, Haynes, & Hirsch, 1982).

The literature also supports the finding that a significant association exists between binocular vision and reading deficiencies as well (Grisham, Sheppard, & Tram, 1993; Krumholtz, 2001; Stein, Richardson, & Fowler, 2000). If so, this is relevant information for the occupational therapist school practitioner, since the binocular visual status of students could be one of the underlying components affecting their reading performance (Schneck, 2001).

However, the relationship between visual function and academic performance is the subject of much controversy. In fact, in a policy statement by the American Academy of Pediatrics Committee on Children With Disabilities, the American Association for Pediatric Ophthalmology and Strabismus, and the American Academy of Ophthalmology (1992) it was stated that "visual problems are rarely responsible for learning difficulties" (p. 125). This view was refuted in turn by a joint statement issued by the American Academy of Optometry and the American Optometric Association (1999), and by a critical review in which the scholarship and arguments of the aforementioned policy statement were questioned (Bowan, 2002). Thus, despite a preponderance of research that exists that supports the belief that visual function plays a role in ensuring academic performance, the exact nature of the relationship between basic visual skills and academic abilities remains a complex and controversial topic.

A number of occupational therapy clinicians and researchers have voiced their concern that basic visual skills needed for accurate and efficient reception of visual input (such as oculomotor function and binocular vision), should be routinely considered when children with academic performance difficulties are referred for occupational therapy evaluation and treatment (Bouska, 1991; Schneck, 2001; Tsurumi & Todd, 1997). In fact, a number of authors have even included detailed recommendations and resources for the performance of specific vision screening techniques by occupational therapists, to encourage them in this practice (Chaiken & Downing-Baum, 1997; Scheiman, 1997; Schneck). Furthermore, it has been suggested that visual problems that remain undetected may result in invalid

assessment results, inaccurate clinical reasoning, and ineffective treatment regimens (Bouska & Galloway, 1991; Koslowe, 1991; Scheiman).

Another reason for consideration of visual problems in occupational therapy practice is that studies have indicated that some children with visual problems may have to work harder than their peers to perform well in school (Birnbaum, 1984, 1993; Bullimore & Gilmartin, 1988; Cooper et al., 1987; Perreault, 1992). In fact, since students spend from 30%–60% of their school day on sustained reading, writing, and other near-point tasks (McHale & Cermak, 1992; Ritty, Solan, & Cool, 1993) some children with “hidden” visual deficits may become discouraged, perhaps even responding to their difficulties by avoiding the performance of tasks they find difficult to perform (Castanes, 2003; Garzia, 1994; Solan, 1985, 1993). In a recent study, Castanes emphasizes that failure to detect visual deficits may even affect long-term vision outcomes, education achievement, and self-esteem. Moreover, empirical studies have revealed that covert visual deficits that interfere with children’s ability to take in information may cause them to behave in ways reminiscent of children with behavioral, emotional, or attention problems. As a result, these children are often misunderstood and misjudged by their teachers and parents (Daniels & Ryley, 1991; Johnson, Nottingham, Stratton, & Zaba, 1996; Zaba, 2001). Therefore, because occupational therapists are ideally suited and positioned to take note of potential visual problems and are experienced observers of human performance, they may play a significant role in the early identification of unrecognized visual deficits and thereby help prevent the development of potential secondary behavioral and emotional sequel (Titcomb et al., 1997).

Further, since the visual system is enormously complex and integrates with a vast number of human body functions, visual disorders often accompany a wide variety of developmental anomalies found within the populations of children who are frequently referred for occupational therapy evaluation and treatment (Roley & Schneck, 2001). These include children born prematurely and/or of very low birth weight (Mozlin, 2001; Powls, Botting, Cooke, Stephenson, & Marlow, 1997) as well as children with physically and mentally handicapping conditions (Erhardt, 1987; Farrar, Call, & Maples, 2001; Horowitz, Oosterveld, & Adrichem, 1993; Roley & Schneck). It has also been found that undetected visual problems are significantly prevalent among populations of academically and behaviorally at-risk children (Festinger & Duckman, 2000; Johnson, Blair, & Zaba, 2000; Maples, 2003). Moreover, it is important to note that even among the nonhandicapped school population, a staggering number of children have

been reportedly identified as having visual problems; up to 20% of preschoolers and from 13%–29% of school-age children (Krumholtz, 2001; Preslan & Novak, 1996; Rouse et al., 1999; Zaba, 2001). Consequently, the vision of many children in school is insufficient for the task demands required of them (Gilligan, Mayberry, Stewart, Kenyon, & Gaebler, 1981; Weber, 1980). As such it is incumbent upon therapists to gain a better understanding of visual deficits, and how they may limit children’s academic performance. In this way clinicians can be better prepared to plan appropriate interventions so as to optimize children’s participation in relevant occupational areas in the future.

Finally, an issue of great import to occupational therapists who service children is the significance of the visual-information processing tests often administered as part of evaluation and treatment outcome test batteries. Therapists need to be sure that what appear to be visual-perceptual or visual-motor integrative deficits, do not potentially stem from other underlying visual anomalies (Bouska & Galloway, 1991; Warren, 1993a, 1993b). In fact, a significant association was revealed between visual-motor integration scores and binocular visual function in a study performed on a cohort of 141 six-year-old children who were born prematurely (Jongmans et al., 1996). In a related study, Tassinari and Eastland (1997) report an 85% success rate in improving scores from passing to failing on the Developmental Test of Visual-Motor Integration (Beery, 1989) among patients who were treated for deficient functional visual skills that included oculomotor and binocular visual skills. In contrast, when Brodney, Pozil, Mallinson, & Kehoe (2001) examined children who had undergone treatment of visual efficiency skills, they found that despite an improvement in the children’s oculomotor and binocular visual functioning, no significant changes were found in their scores on visual perception or visual-motor integration assessments.

In summary, it appears that although the literature as a whole supports the view that deficits in visual efficiency skills (i.e., binocular vision and oculomotility) may have a negative effect on school performance, this issue remains fraught with controversy. Furthermore, there is insufficient data with regard to the possible effect that visual deficits may have on performance on higher-level visual-information processing assessments, such as those that evaluate visual-motor integration and visual perception.

Therefore, the current study was designed with the following purposes in mind. The first was to assess the vision of seventh-grade students in an urban middle school and to determine the overall incidence and gender distribution of visual skill deficits. The second purpose was to compare the visual skill and visual-information processing abilities of

schoolchildren with and without mild reading and academic difficulties. This was accomplished by administering a well-recognized optometric vision screening and visual-information processing assessments to children who passed a reading screening test as well as to classmates who failed this screening, and whose reading problems were confirmed through an in-depth reading assessment. The participants' classroom teachers were also asked to rate the children's academic performance in order to examine whether the group division according to reading status also reflected differences in academic achievement. Another purpose of this research was to compare the mean academic performance and scores on standardized visual-information processing assessments between children who passed the vision screening and those who failed the vision screening.

## Method

This study used a group comparison design to identify possible differences in visual skills and visual-information processing assessment scores between children with and without mild reading and academic problems. Next, academic performance and visual-information processing test scores were compared between children with and without visual deficits. In addition, the incidence and gender distribution of visual deficits of all the seventh-grade participants were examined.

### *Participants*

This study used a convenience sample of 71 seventh graders (average age 12 years and 7 months) in a middle school in Jerusalem. Subject selection was the task of the school's learning disabilities education specialist. Out of the 180 seventh-grade students who took the *Altalef Reading Screening Test* (Altalef, 1994) at the beginning of the school year, 25 students failed the exam. These students, whose difficulty in reading was then confirmed through the *Tikva Reading Test* (Altalef, 1982), an in-depth reading evaluation, comprised the nonproficient readers group. Each nonproficient reader was matched according to class membership, age, and socioeconomic status (Hartman, 1975) to two students who passed the Reading-Screening Test ( $n = 50$ ), forming the proficient-readers group. Students receiving support services (including remedial education, occupational, physical, or speech therapy), new immigrants to the country (whose command of Hebrew reading is expected to be poor), and students with significant visual impairments were excluded from the study. As a result of this, four students from the proficient readers group were dropped from the study, resulting in final counts of 46 proficient readers

(25 male, 21 female), and 25 nonproficient readers (16 male, and 8 female).

### *Instruments*

*The Altalef Reading Screening Test* (Altalef, 1994) is a quick screening for overall Hebrew reading ability. It is composed of six paragraphs, after each of which the examinees are asked four multiple choice questions regarding the content of the paragraph. The cut-off point for passing was established to be correct responses to 15 of the 24 screening items, as determined through the population standardization by the Henrietta Szold Institute: Israeli National Center of Behavioral Sciences and Pedagogy Administration under whose auspices the test was designed. This tool is designed for group screening and is administered routinely to each new seventh-grade class in most Israeli middle schools.

*The Tikva Reading Test* (Altalef, 1982) was used in this study to confirm the existence of reading dysfunction among the students who failed the Reading Screening Test. An in-depth assessment of reading ability, the *Tikva* is a diagnostic-didactic evaluation developed by "Shiluvim," the Israeli Center for Educational Evaluation. The tool is designed to analyze basic phonological skills as well as comprehension and proficiency in silent reading and recitation in Hebrew language. Test items were targeted to address reading ability of typical seventh-grade Israeli students. The *Tikva* is scored according to precise criteria as determined by the test developers, and examinees' performance is compared to a standardized profile to determine if they passed the test.

*The Modified Clinical Technique (MCT)* (Blum, Peters, & Bettman, 1959) was the optometric vision screening chosen for this study. Specifically, the 12 MCT subtests administered included: visual acuity far, visual acuity near, retinoscopy, ophthalmoscopy, color vision, cover test far, cover test near, near point of convergence (NPC), stereopsis, suppression (Worth 4-Dot), visual tracking, and saccades. Items are scored individually as 2 = pass, or 1 = fail, as determined by criteria determined by the test developers. In addition, the MCT developers set the cut-off criteria for overall performance on the screening to be the failure on one or more of the subtests. Optometrists report that the MCT is a valid and reliable tool that can detect visual problems with great accuracy (sensitivity = 0.96, specificity = 0.98) and has a 97% accuracy rate in determining whether a child needs further visual assessment (Blum et al., 1959; Hammond & Schmidt, 1986; Peters, 1984; Schmidt, 1990, 1997).

To enable a more focused investigation of the visual abilities of the study participants, the MCT items were

divided into two functional categories: (1) Visual Efficiency (i.e., saccades, visual tracking, cover test far, cover test near, near point of convergence, suppression [Worth 4-Dot] and stereopsis), and (2) Visual Health (i.e., visual acuity far, visual acuity near, retinoscopy, ophthalmoscopy, and color vision). Total Vision refers to the participants' performance on the total MCT screening, as opposed to performance in the items within the categories of Visual Efficiency and Visual Health. In comparing participants' performance, Total Vision was defined as the total number of MCT screening test items in which the child failed (i.e., did not meet pass criteria). The participants' scores on Visual Efficiency and Visual Health were defined as the number of test items failed in each of these categories respectively.

*The Developmental Test of Visual-Motor (VMI) Integration, 4th Edition, Revised* (Beery & Buktenica, 1997) contains a series of 24 geometric forms that are to be copied with pencil in the protocol book. Scoring is obtained based on the number of forms correctly copied according to the author's specific criteria, up to three consecutive failures. The new supplemental subtests in this edition of the VMI (Visual Perception and Motor Coordination) were not administered. The VMI was normed on 3–18-year-olds and have been demonstrated to have content, concurrent, and construct validity through extensive investigation. Test–retest, interrater, and internal reliability for the visual-motor integration component were determined to be  $r = .92$  (Beery & Buktenica).

*The Motor-Free Visual-Perception Test (MVPT-R)* (Colarusso & Hammill, 1996) is a quick non-motor measure of visual-perceptual ability. It is a standardized multiple choice test whose norms were determined on children from 4–11 years of age, however test developers report the recently restandardized edition includes new items appropriate for use with adults. Scoring requires adding the number of correct choice responses. The MVPT–R was found to have high test–retest reliability ( $r = .81$ ) as well as internal reliability ( $r = .88$ ). Criterion validity was determined relative to academic performance ( $r = .38$ ) and to intelligence ( $r = .31$ ).

*The Revised Conners Parent and Teacher Rating Scale* (Goyette, Conners, & Urlick, 1978) is one of the most widely used behavioral checklists used to collect information about a child's activity and attentional levels. It was designed to be completed by teachers and/or parents. For this study, the Conners was administered to control for the contribution of attention to academic performance. Teachers were asked to complete the checklist for their student subjects, by indicating whether each of 10 behaviors was problematic for the child in question on a 4-level Likert scale (where "0" indicates that the behavior is not a problem

at all, and "3" indicates that the behavior is very much a problem). Point scores for all the responses were summed and used in data analysis.

*The Academic Performance Questionnaire* was designed by the study's researchers to collect information regarding the subjects' academic performance. Each classroom teacher was asked to divide the class into quadrants according to their academic performance in reading, spelling, mathematics, composition, and general academic success. For each academic subject, participants who performed within the top quadrant of the class were given a score of "4," those in the second quadrant were given a score of "3," those in the third quadrant were given a score of "2," and those in the lowest quadrant were given a score of "1."

This technique for measuring academic performance was used since it had been found in previous studies to be equally or more accurate than standardized academic achievement measures (Cole, Martin, Powers, & Truglio, 1996; Feinberg & Shapiro, 2003; Gresham, Reschly, & Carey, 1987; Mercer, Algozzine, & Trifiletti, 1988; Teisl, Mazzocco, & Myers, 2001).

The participants' mean academic performance was operationally defined as the average value of their scores on these academic subjects.

The questionnaire form included a segment in which general demographic information was obtained, including questions about parents' education and fathers' occupation, for the calculation of subjects' socioeconomic status (SES) according to Hartman's (1975) formula:  $SES = \{ME + FE\} / 2 + FO / 2$  (Hartman, 1975).

This segment of the questionnaire was also used to identify students receiving support services (occupational, physical, or speech therapy) and those who were new immigrants to the country, defined as exclusionary criteria to determine students' eligibility for participation in the study.

### *Procedure*

The Altalef Reading Screening Test (Altalef, 1994) was administered by the classroom teachers at the beginning of the school year. Over the course of the first 2 months of the school year, two expert reading examiners administered the Tikva Reading Test (Altalef, 1982) to the 25 students who received scores below the cut-off point for passing the screening test. The Tikva test results confirmed these students' reading problems. Each nonproficient reader was then matched according to class membership, age, and socioeconomic status (Hartman, 1975) to two proficient readers. The proficient and nonproficient readers formed the study comparison groups. All students and their parents gave their consent to participate in this study.

All of the 71 students (46 proficient and 25 nonproficient readers) who participated in the study underwent a 1/2-hour visual screening and a 1/2-hour session during which visual-information processing was tested. The MCT (Blum et al., 1959) was administered by fourth-year optometry students under the supervision of experienced optometrists. Any participant who required eyeglasses and did not wear them during the testing procedure was eliminated from the study.

The assessment of visual-information processing (i.e., the MVPT-R, Colarusso & Hammill, 1996, and the visual-motor subtest of the VMI, Beery & Buktenica, 1997) was done by three occupational therapists experienced in pediatric assessment. These tools were administered according to standardized protocol as described in the test manuals.

All of the test administrators were blind as to participants' group placement (proficient or nonproficient reader groups). The tests were administered in a counterbalanced order to control for the effects of participant fatigue. The participants' classroom teachers were asked to complete the Academic Performance Questionnaire as well as the Revised Conners Parent and Teacher Rating Scale (Goyette et al., 1978). The researchers chose this version of the Conners as a result of its relative brevity in order to assure optimal response compliance.

### Data Analysis

Descriptive statistics, including frequencies, group means, and standard deviations, were used to describe the demographic profile of the sample's participants, including their gender, country of origin, father's and mother's years of education, and socioeconomic status. Chi-square analysis was performed to compare between study groups with respect to these variables.

In the first phase of statistical analysis, the performance of proficient readers was compared to that of nonproficient readers in the following areas: (1) vision (scores on the MCT screening including Total Vision, Visual Efficiency, and Visual Health), (2) visual-information processing (scores on the VMI and MVPT), and (3) academic performance (scores on the Academic Performance Questionnaire). For this purpose *t*-test analyses were used.

In the second phase of data analysis, the sample cohort was divided into two groups according to whether members passed the MCT vision screening (i.e., no visual deficits found at all) or failed the MCT vision screening (one or more visual deficits found). *T*-test analyses were then used to compare the group with visual deficits to those without visual deficits in their mean academic performance and vision information processing scores (i.e., VMI and MVPT) (see study design, Table 1).

**Table 1. Study Design**

Groups	Group Comparison Variables		
	Vision <sup>2</sup>	Academic Performance <sup>3</sup>	Visual-Information Processing <sup>4</sup>
1. Proficient Readers ( <i>n</i> = 46) vs. Nonproficient Readers ( <i>n</i> = 25)	X		X
2. Passed MCT <sup>1</sup> Screening ( <i>n</i> = 23) vs. Failed MCT Screening ( <i>n</i> = 47)		X	X

MCT<sup>1</sup> = Modified Clinical Technique.

Vision<sup>2</sup> refers to all MCT vision screening scores (Total Vision, Visual Efficiency, and Visual Health).

Academic Performance<sup>3</sup> refers to scores on Academic Performance Questionnaire.

Visual-Information Processing<sup>4</sup> refers to scores on the VMI (The Developmental Test of Visual-Motor Integration), and the MVPT-R (The Motor-Free Visual-Perception Test)-Revised.

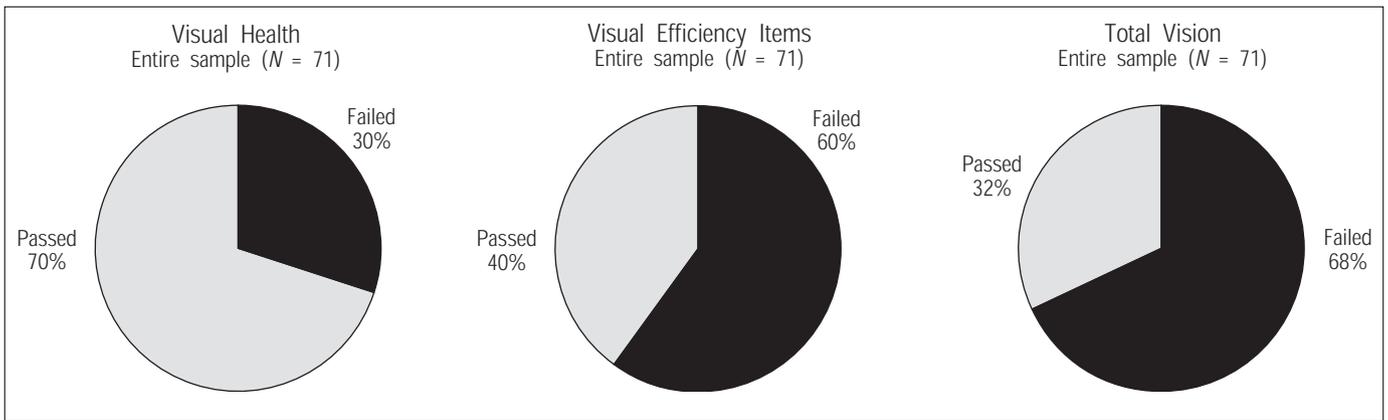
Finally, the relative overall occurrence of visual deficits among study participants was calculated. The percentage of all participants who failed one or more of the MCT vision screening items was calculated and reported as failed Total Vision. Then, the percentage of participants who failed items within the categories of Visual Efficiency and Vision Health were calculated and referred to as failing in those categories.

### Results

Participants' scores on the vision-screening test were examined to reveal the occurrence of visual anomalies among the study cohort. It was found that 68% of the children in the total sample failed the MCT screening category of Total Vision. Furthermore, results revealed that 60% of the participants failed the MCT category of Visual Efficiency, and 36% of the children failed the MCT category of Visual Health (see Figure 1).

Results of chi-square analysis indicated that significantly more boys failed Total Vision and Visual Efficiency than did girls ( $\chi^2 [1, N = 71] = 7.12, p = .008$ ;  $\chi^2 [1, N = 71] = 5.14, p = .023$ , respectively). However, no significant differences were found between children who passed and those who failed the MCT visual screening with respect to their socioeconomic status, parents' education, or countries of origin.

A second purpose of this study was to compare the visual skills of children with and without mild reading and academic difficulties. First, we examined whether the group division into proficient and nonproficient readers according to the Altalef Reading Screening Test (Altalef, 1994) and the Tikva Reading Evaluation (Altalef, 1982) was also reflective of their respective academic performance abilities. To do this, the multiple analysis of variance (MANOVA)



**Figure 1. Results of Modified Clinical Technique (MCT) (N = 71).**

was used to compare the groups' scores on the Academic Performance Questionnaire. Results of this analysis indicated that reading proficiency was also reflective of group differences with respect to scores in academic performance,  $F(1, 69) = 9.37, p = .000$ , in the following academic areas: spelling, composition, math, reading, and general academic ability. In addition, to control for the effects of attentional factors on academic performance, the multiple analysis of covariance (MANCOVA) was performed, designating the scores on the Conners Questionnaire as a covariate. Results indicated that these group differences existed irrespective of the participants' scores on the Conners,  $F(1, 62) = 4.5, p = .002$ .

Next, to compare the Visual Efficiency scores between the proficient and nonproficient reading groups, a  $t$  test was performed. Results indicated that nonproficient readers had significantly poorer Visual Efficiency abilities than proficient readers did ( $t = 2.14, df = 68, p = .036$ ). In contrast, there were no significant differences between these groups with respect to MCT items reflective of Visual Health ( $t = 0.72, df = 68, p = .49$ ).

These findings were strengthened by the comparison of the study groups with respect to the referrals made by the optometrists supervising the vision screening of the participants, for further evaluation and follow-up management. It was found that 28% of the nonproficient readers were so referred as opposed to only 4% of the proficient readers. When this data was statistically analyzed through chi-square testing, the results indicated that the differences between the groups were significant,  $\chi^2(1, N = 71) = 8.78, p = .012$ .

An additional  $t$  test, performed to examine whether the reading groups differed with respect to visual-information processing scores (i.e., the VMI and the MVPT), did not yield any significant differences between them ( $t = 0.75, df = 68, p = .46$  and  $t = 0.54, df = 68, p = .59$ , respectively).

Secondary statistical analysis was then performed to strengthen the researchers' contention that children with visual deficits would perform significantly worse than chil-

dren without deficits with respect to overall academic performance and visual-information processing. A  $t$  test was used to compare the mean academic performance of participants who passed the MCT (Total Vision) and those who failed the MCT (Total Vision). Results indicated that participants who passed the MCT (no visual deficits) had significantly better mean academic scores than those who failed the MCT (had visual deficits) ( $t = 2.11, df = 66, p = .04$ ). Next, participants with visual deficits were compared to those without visual deficits with respect to visual-information processing scores. Results of  $t$ -test analysis indicated that children who passed the MCT vision screening performed significantly better on the MVPT than children who failed the MCT ( $t = 1.98, df = 69, p = .05$ ). In comparison,  $t$ -test results indicated that no significant differences were found between children who passed the MCT and those who failed the MCT with respect to their scores on the VMI ( $t = 1.23, df = 69, p = .23$ ).

## Discussion

This study afforded an opportunity to collect data regarding the occurrence of visual anomalies in a sample of seventh-grade schoolchildren. This type of information is not frequently reported in the literature, in which most prevalence studies report on frequencies of visual deficits among vision clinic outpatients (Lara, Cacho, Garcia, & Megias, 2001; Scheiman et al., 1996), children with disabilities (Johnson et al., 1996; Johnson, Blair, & Zaba, 2000; Koslowe, 1995), or from other populations at risk (Festinger, & Duckman, 2000; Mozlin, 2001). Results of the visual screening of the participants in the current study revealed that over half of the children failed the MCT vision screening, with a similar percentage failing in the Visual Efficiency items of the screening. Even among the proficient readers, a high percentage revealed visual deficits (see Figure 1).

A review of the relevant literature revealed that in a study performed by Hammond and Schmidt (1986), in which 483 typical schoolchildren 5–13 years of age were screened with the MCT, over 50% of their subjects failed the MCT and 45% failed in Visual Efficiency items. In addition, Koslowe (1991) screened a sample of 34 third-grade schoolchildren using the MCT, and reported that 41% failed the binocular portion, consisting of the items categorized as Visual Efficiency items in the current study. These robust findings, in addition to those reported for the participants in the current study, suggest that visual deficits may be fairly common among schoolchildren. It is important to note that although the socioeconomic background of the community tested might sometimes lead to less than average health and vision care (Johnson et al., 1996; Krumholtz, 2001; Zaba, 2001), it is doubtful to have played a role in this study sample since our demographic data indicated that participants were from middle- to upper-middle-class households, and considering that our participants have free access to governmentally subsidized health care.

Given the fact that vision is considered by some to be a primary tool through which learning takes place (Richards, 1984; Zaba, 2001), such information is vital to occupational therapists and educators whose responsibilities involve the understanding, identification, and management of factors that may affect children's ability to perform in school. This is particularly true of visual deficits, since a tremendous amount of stress is placed on the visual system for over 70% of a typical school day (Ritty et al., 1993).

This study also reports that over one third of the participants failed in Visual Health items of the visual screening. This finding is telling, since one would expect seventh-grade children to have undergone basic visual exams in which these types of vision problems should be identifiable. The fact that so many children with uncorrected vision problems were found in the current study is an issue of concern, since the ability to accurately and automatically take in visual input may influence the development of efficient visual-information acquisition and/or perceptual processing (American Academy of Optometry and American Optometric Association, 1999; Peachey, 1991; Schmidt, 1990). In fact, in a recently published article, Castanes (2003) reports that up to 80% of preschoolers do not receive an eye exam and that many "back to school" physical exams fail to test for common vision disorders. Thus, the findings of the current study are in line with the suggestion of researchers that traditional models of vision screening through routine pediatric exams and school nurse vision screenings may not be meeting the needs of all children as well as they should (Castanes; Krumholtz, 1996; Mozlin, 2001; Schmidt, 1990).

With respect to possible associations between visual status and the demographic variables of this study, the results of chi-square analysis revealed that significantly more boys than girls among the participants were found to have visual deficits, including specifically Visual Efficiency deficits. No studies were found in the literature from which to extrapolate a direct interpretation of this finding, suggesting this to be an issue to be explored in future research. However, these findings are in line with those individuals who suggest that a higher prevalence of boys are found to be diagnosed with a variety of developmental disabilities than girls (Cermak, Gubbay, & Larkin, 2002).

Another major finding was the significant differences found between the proficient and nonproficient reader groups in their respective scores on MCT Visual Efficiency items. The functional significance of this finding was revealed by the results of MANOVA analysis, in which it was found that proficient readers performed significantly better academically than nonproficient readers. In fact, proficient readers performed significantly better in academic performance than did nonproficient readers, even when scores on the Conners rating scale were included as covariates in a MANCOVA procedure, indicating that attention was not a confounding variable. Thus, the study's findings that nonproficient readers have significantly more visual deficits than proficient readers, seems to have implications with respect to general academic functioning, a most important occupational component of the school-age child's daily life.

The literature on the subject of reading and vision is replete with controversy. However, the results of this study are consistent with those of other investigators who found that children with reading problems have a higher prevalence of deficient visual efficiency skills, such as oculomotor (Brodney et al., 2001; Eden et al., 1994; Kulp & Schmidt, 1996; Maples & Ficklin, 1990), accommodative (Evans, Drasdo, & Richards, 1996; Scheiman, 1997), and binocular visual skills (Koslowe, 1995; Krumholtz, 2001), than do children who are proficient readers. It should be noted that most of the studies cited above involved the investigation of children who have a history of diagnosed learning problems, including dyslexia, whereas this study was performed with a sample of children who did not receive supportive services, including remedial education, occupational, physical, or speech therapy. Thus, if learning difficulties existed among the current study participants, they were probably relatively mild. The fact that visual anomalies were related to reading ability as well as general academic performance in this study strengthens the importance of examining the visual function and efficiency of school-age children who demonstrate difficulty in performing educational tasks (Fahle & Luberichs, 1995).

Another finding of this study was that *t*-test analysis did not reveal significant difference in the visual-information processing test scores between proficient readers and non-proficient readers. A possible explanation for these findings involves the developmental aspects of the variables being examined. Since the task demands of reading proficiency vary as a child progresses through school, the relationship between “vision” and “reading” changes as well (Schneck & Lemer, 1993). Several investigators who believe that visual-information processing plays a role in reading achievement, have stated that its role is more significant among younger children in the early school grades (Kavale, 1982). In fact, when Solan and Mozlin (1986) examined the perceptual-motor skills of typical schoolchildren in kindergarten–second grade, they found that over 50% of the variations in learning readiness in kindergarten and reading vocabulary in grade one could be explained by differences in the perceptual abilities of the children. By the end of second grade, however, the correlation between perceptual-task scores and reading vocabulary was much reduced and accounted for only 25% of the variance. The authors suggest that once children have completed second grade, language and other higher level cognitive skills begin to be more significant factors in learning to read. The findings of the current study are in line with this view.

The next focus of this research was to compare the children who passed the MCT vision screening (indicating they had no visual deficits) to those who failed the MCT vision screening (indicating they had visual deficits) with respect to mean academic performance and visual-information processing scores. *T*-test analysis revealed that children who passed the vision screening performed significantly better in mean academic performance than those who failed the vision screening. This finding strengthens the suggestion that when basic visual skills do not function optimally, it may have implications not only for reading ability, but for overall academic functioning as well.

Additionally, the current study’s findings revealed that children who failed the MCT vision screening performed significantly worse than did those children who passed the MCT on the MVPT–R test of visual perception. In contrast, the data indicated that no significant differences existed between these children with respect to VMI scores. The literature regarding the relationship between basic visual skills and visual-information processing is sparse and has yielded mixed results. Hoffman (1982) attempted to show that a connection between these abilities exists by providing vision therapy to children with accommodative difficulties and comparing their performance on visual-motor and visual-perceptual skills before and after this intervention. The subjects were divided into three age groups: 5–7.11 years,

8–10.11 years, and 11–13.11 years. Results indicated that the subjects in the 5–7.11 year age group demonstrated significant improvement in visual-perceptual and visual-motor integration test scores. Hoffman suggests that visual inefficiency may affect the perceptual development of children in this age group. However, those results differ from those of Brodney and colleagues (2001), who found that although a course of vision therapy improved the visual efficiency skills of the 30 children (first–fifth graders) in their study sample, there were no significant improvements on either the visual perception test or the VMI as a result of the therapy. The authors suggested that, had the vision therapy been continued for a longer period of time, the visual-information processing skills might have begun to show improvement. In yet another related study, Jongmans and colleagues (1996) found that in 6-year-old children who had been born prematurely, a significant association existed between results of binocular vision assessments and performance on the VMI. However, as their study included participants at risk for subtle neurological deficits, it is difficult to compare those results with those obtained in the current study, in which typical children were investigated. With respect to the current study, it is possible that the presence or absence of visual deficits did not result in significantly different scores on the VMI may reflect the age of the subjects investigated, as was suggested by Hoffman (1982). However, it is clear that this is an area in which more research needs to be conducted in order to improve our understanding the nature of the relationship between these variables.

Finally, an interesting finding was that although significant differences were found in the MVPT–R scores between children who passed the MCT screening (no visual deficits) and those who failed the MCT (had visual deficits), no such differences were found for VMI scores between these participants. The explanation for these results may lie in the design of these respective instruments. Specifically, the MVPT–R requires the individual to visually scan a variety of figures of varying complexities arranged in a horizontal row across each test plate. In contrast, the VMI allows for the individual examination of only one visual form at a time, which is presented within a box with a clear black outline. It is possible to speculate that, in part, the specific findings of the current study reflect the need to visually discriminate and scan back and forth between the multiple figures on the test plates of the MVPT, whereas these visual skills are not emphasized as much in the performance of the VMI. In fact, this suggestion is supported by Locher and Worms (1981), in which they found qualitative differences in the visual scanning patterns of children with certain types of perceptual impairments in their performance on the MVPT–R. Caution must be exercised in

generalizing the results of the study since the participants represent a convenience sample of seventh-grade students from a single middle school. This type of subject selection, combined with the relatively limited number of participants, means that the findings derived are not necessarily representative of the total population. A larger sample, in which participants are selected according to randomized sampling procedures, would increase our ability of researchers to extrapolate from the findings. Furthermore, as a result of the possibility of incurring type I or II errors when utilizing *t*-test analyses in group comparisons, the results of our study should be interpreted cautiously.

It is also recognized that factors other than those accounted for in this research can impact on children's academic achievement. These may include IQ, emotional status, the specific values regarding education imbued upon children in their home environment, and motivation. Thus, these factors may have played a role in enabling some children to overcome the effects of subtle visual deficits in their academic performance, or as limiting factors that aggravated the effects of such deficits. Nonetheless, the results of this study suggest that at least for some seventh-grade students who do not suffer from significant learning or medical impairment, visual-efficiency dysfunctions should be considered as a factor that contributes to below than expected academic performance.

Also, it should be noted that the MCT was administered to the participants as soon as the school day began. Since several studies have indicated that fatigue can result in symptoms derived from the breakdown of visual abilities and visually related stress (Birnbaum, 1993; Krumholtz, 1996, 2001; Mozlin, 2001), it is possible that, had the assessment been done later in the school day, more significant visual efficiency findings would have been discovered. This may suggest that the results of the screening were relatively conservative. Future research could take this factor into consideration by assessing for visual function after students have had to spend time completing reading and other academic tasks that place stress on the visual system. Such symptoms include headaches, eyestrain, occasional double vision, and avoidance of prolonged reading or writing tasks (Scheiman, 1997; Simons, 1993).

## Conclusions and Implications

This study's findings suggest that screening for visual efficiency status may be warranted, at least with respect to children with unexplained difficulty in coping with the reading demands placed on them for school learning. Indeed, this suggestion is supported by the finding that in this study, children who passed the MCT vision screening achieved

significantly better mean academic performance than did those children who failed the MCT.

Although a screening performed by the occupational therapist is not a substitute for a comprehensive examination by a vision professional, it can help establish the need for such an examination and also help the therapist to plan his or her therapy program taking vision into consideration. Furthermore, if and when visual deficits have been properly diagnosed, the therapist could develop supportive, compensatory, and/or instructional strategies to help improve the child's performance within his visual capacities (Scheiman, 1997; Schneck, 2001).

Another finding of this study was that children who passed the MCT vision screening achieved significantly better scores on the MVPT-R test of visual perception. This suggests that, for children with poor MVPT-R test scores, clinicians should consider that visual efficiency skills may have influenced the scores. It may be prudent for them to consider referring such children to a vision care specialist for assessment before proceeding with therapy to enhance visual-perception performance. This suggestion is especially relevant given the relatively high percentage of participants in this study who were found to have visual deficits. It is hoped that the results of this study will provide a basis for further research on this topic and, in addition, serve to facilitate the clinical reasoning process of pediatric clinicians who service school-age children.▲

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