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Relationships Among Orthographic Measures and Reading Achievement

Margaret Scruggs Wood
University of Tennessee, Knoxville

To the Graduate Council:

I am submitting herewith a thesis written by Margaret Scruggs Wood entitled "Relationships Among Orthographic Measures and Reading Achievement." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Teacher Education.

Sherry Mee Bell, Major Professor

We have read this thesis and recommend its acceptance:

R. Steve McCallum, Michael Hannum

Accepted for the Council:
Dixie L. Thompson

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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Dean of Graduate Studies

RELATIONSHIPS AMONG ORTHOGRAPHIC MEASURES AND READING ACHIEVEMENT

A Thesis
Presented for the
Master of Science
Degree

The University of Tennessee, Knoxville

Margaret Scruggs Wood
August 2004

Abstract

As participants in an after school tutoring program, 29 second through fifth graders were administered subtests designed to measure visual processing and memory skills: *Orthography, Visual Discrimination, Sound Symbol Learning, Letter Memory: Visual,* and *Rapid Symbol Naming* from the *Test of Dyslexia* (McCallum & Bell, 2001); and *Picture Recognition* and *Visual-Auditory Learning* from the *Woodcock-Johnson III-Cognitive Battery* (WJIII; Woodcock, McGrew & Mather, 2001). Subtest scores were obtained from administration of achievement measures: *Letter-Word Calling, Fluency, Passage Comprehension,* and *Spelling (Test of Dyslexia); Letter-Word Identification, Reading Fluency, Comprehension,* and *Spelling* (*WJIII-Achievement Battery);* and the *Test of Silent Word Reading Fluency* (Mather, Hamill, Allen, & Roberts, 2004). Zero-order correlational analyses were employed to demonstrate the relationships among the orthographic and achievement variables. *Orthography, Letter Memory: Visual,* and *Rapid Symbol Naming* from the *Test of Dyslexia* had mildly positive correlational relationships with achievement measures. In addition, stepwise multiple regressions were conducted to measure the extent to which the orthographic variables predict criterion achievement variables. *TOD Rapid Symbol Naming* was found to have predictive capabilities to all four achievement constructs: Sight word identification, fluency, comprehension, and spelling. *WJIII Reading Fluency* had three predictors: *Orthography, Letter Memory: Visual,* and *Rapid Symbol Naming* from the *Test of Dyslexia.*

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CHAPTER I

Introduction

Although the relationship between reading and the underlying cognitive mechanisms remains somewhat elusive, some relationships appear well documented. For example, phonological awareness measures correlate with reading acquisition ability. According to Stanovich (1986) “evidence is mounting that the primary specific mechanism that enables early reading success is phonological awareness” (p.153). In her study of 630 preliterate children tested on phonological and phonemic tasks in their first week of school and mid year, Christiansen (2000) found that phonemic measures of initial sound identification and rhyme were significantly predictive of end-of-year reading scores. Bell, McCallum, and Cox (2003) found that auditory measures (including phonological awareness and auditory memory) strongly predicted four reading and reading-related skills: letter-word calling, reading comprehension, spelling, and decoding. In addition, the significance of phonological skills in reading was documented by Adams in her 1990 review of reading research; “deep and thorough knowledge of letters, spelling patterns, and words, and of the phonological translations of all three, are of inescapable importance to both skillful reading and its acquisition" (Adams, 1990, p. 416).

According to Roberts and Mather (1997), even though the importance of phonological skills and underlying auditory abilities appear to be well accepted by researchers, the contribution of orthographic and underlying visual processing abilities is less certain. “Despite neurological support for the existence of subtypes of dyslexia, the significance of orthographic processing as a causal factor has been neglected in the literature, in research, and in the most current dyslexia definitions" (Roberts & Mather, 1997, p. 237). They further assert that a reason for the limited acceptance of orthographic coding as a correlate of reading disability is the lack of appropriate diagnostic instrumentation to assess and identify orthographic processing difficulties. Even the most recent definition of dyslexia approved by the International Dyslexia Association (IDA) Board of Directors (2002) and the National Institute of Child Health and Human Development (NICHD) overlooks orthographic difficulties.

> Dyslexia is a specific learning disability that is neurological in origin. It is characterized by difficulties with accurate and/or fluent word recognition and by poor spelling and decoding abilities. These difficulties typically result from a deficit in the phonological component of language that is often unexpected in relation to other cognitive abilities and the provision of effective classroom instruction. Secondary consequences may include problems in reading comprehension and reduced reading experience that can impede growth of vocabulary and background knowledge (IDA, 2002).

However, "as pointed out by Stanovich, phonological awareness or sensitivity is a necessary, but not sufficient, condition for efficient reading acquisition" (Badian, 200[illegible], p. 183). What additional skills are needed to sufficiently predict efficient reading? More research needs to focus on "the contribution of various subtypes of visual processing [illegible] memory to the prediction of various reading and spelling skills" (Bell et al., 2003, p [illegible]). While noting that their visual processing/speed subtest scores loaded partially with auditory processing skills, Bell et al. (2003) acknowledged that reading may be subtly impacted by visual processing/orthography. They further suggested: "Future research should continue to explore the role of visual processing in orthography and reading disabilities and to link findings on the cognitive underpinnings of reading to findings from the emerging body of brain research" (p. 515). Similarly, Manis and Bailey (2003) noted …"some dyslexics have a basic phonological deficit that results in a deviant developmental pathway, but others can be characterized as having across the board delays in learning to read words that do not stem entirely from phonological deficits, but perhaps from core orthographic encoding deficits" (p. 1).

Booth and Burman (2001) referred to two subtypes of dyslexics—"surface dyslexics, who have relative orthographic deficits, and phonologic dyslexics, who have relative phonologic deficits" (p. 207). The derivation of the term *orthography* assists in the clarification of its application in the context of reading-related skills. The Greek root *ortho-* is defined as straight, at right angles, or correct, while the root *graph* means "a writing, recording, or process of representation" (Funk & Wagnall, 1973). Booth and Burman use the term *orthography* to refer to the correct written representation of a language. "Orthographic dyslexia," also known as "surface dyslexia," was defined by Roberts and Mather (1997):

> Orthographic dyslexia refers to a problem with the acquisition of decoding (reading) or encoding (spelling) skills that is caused by difficulty with rapid and accurate formation of word images in memory… Individuals with orthographic dyslexia often have difficulty recalling sight words and, subsequently, are slow to develop fluency and automaticity. One common characteristic of individuals with

> orthographic dyslexia is that they have difficulty storing mental representations of phonetically irregular words or gestalts. As a result, they rely primarily on phonic principles for reading and produce misspellings that have good phonetic resemblance to target words (pp. 239-240).

Orthographic *skills* are those which enable an individual to correctly spell words which have patterns that are not encodable using his or her current phonetic knowledge but are reliant on the visual memory of non-phonetic letter patterns and spellings (such as "could", "tongue", or "rough"). According to Badian, only a minimal amount of research exists that examines the predictive role of early orthographic skills on later reading; she has asserted that early orthographic processing should not be neglected in predictive research (2000, 2001). In a longitudinal study of 96 participants, Badian (2001) demonstrated a significant relationship between early orthographic matching skill weaknesses in first graders and poor comprehension skills in seventh graders: "For seventh grade reading comprehension, a cutoff raw score of <3 on orthographic matching classified 60 percent of poor and 80 percent of good readers correctly" (p. 194). As a group, seventh grade poor comprehenders scored well on first grade phonological skills. The group of first graders with lower orthographic matching scores was significantly higher on the first grade test of phonological skills. However, there was not a strong correlation between the orthographic matching scores and first and third grade reading scores. The group scoring lower on orthographic matching was higher in preschool verbal IQ ($M = 104.2$, SD 10.6) than the group with average orthographic matching scores ($M = 91.3$, SD 9.8). Badian's findings suggest that further research on the influence of orthography is needed. Despite modest reliabilities on several subtests used in their study of 39 participants on the orthographic influence of reading acquisition, Cunningham, Perry, and Stanovich (2001) found that the orthographic composite remained a potent predictor of word recognition ability. They concluded

> ...the linkage between orthographic processing ability and word recognition skill seems not to be the result of spurious linkages between orthographic processing skill and phonological abilities. Individual processing differences in orthographic processing skill do not seem to be totally parasitic on the operation of phonological processes (p. 564).

There is behavioral evidence that deficits in rapid visual processing are related more to orthographic ability while a deficit in rapid auditory processing is related to phonologic ability (Booth, Perfetti, MacWhinney & Hunt, 2000). Compton (2002) proposed that "a different balance of phonological and orthographic skills (i.e., an asymmetry) characterizes children with [Reading Disabilities] RD when compared with children without reading disabilities" (p. 502). Although he referred to research presented by several authors that suggested that there was a relationship between identifying pseudowords and phonemic awareness deficits, Compton agreed with Metsala (1999) that results from the pseudoword reading match should be replicated and compared to other tasks measuring orthographic abilities (p. 156).

In addition to the behavioral research, accumulating data on the role of visual processing in reading are being generated through brain imaging studies. Booth and Burman (2001) reviewed recent neurocognitive research related to reading; they cited a

2000 Pugh et al study which showed that a functional disconnection in dyslexics exists between the left angular gyrus, fusiform gyrus, and inferior frontal gyrus which is limited to visual tasks that require orthographic-to-phonologic conversion. Further, Booth and Burman (2001) described a functional Magnetic Resonance Imaging (f-MRI) study which examined the differences between unimpaired children (9 to 12 year-olds) and adults (22-31 year olds) while performing word judgment tasks in both the visual and auditory modalities. "Each judgment task tapped into one of four levels of linguistic processing: phonologic, orthographic, semantic, and syntactic" (Booth & Burman, 2001, p. 206). They concluded that the visual system for processing rapidly changing information in dyslexics may be abnormal. Booth and Burman (2001) further asserted that a failure in the development of accurate, stable systems in the fusiform gyrus for orthographic representations or in the mapping between that system and the superior temporal gyrus for phonologic representations through integration in the tempo-parietal system could be responsible for the deficits causing dyslexia. However, according to Eden and Moats (2002), "the exact mechanisms by which the brain recovers phonemes and associates them with visually presented orthography remain elusive" (p. 1082).

Further investigation is needed both to determine central nervous system substructure underlying reading dysfunction and to investigate the functional relationships among various visual processing (orthographic) variables and measures of achievement in reading. Although the literature supports some influence of visual processing on reading achievement, the extent is unclear. The first purpose of this study was to examine the relationships between specific measures of visual processing and measures of reading achievement using zero-order correlational analyses. Based on previous research, measures of visual processing/orthographic abilities are expected to correlate modestly in a positive direction with measures of reading achievement including measures of sight word recognition, fluency, comprehension, and spelling. Further, and more specifically, the second purpose of this study was to examine the relative power of several visually-based measures to *predict* scores of reading achievement component tests including sight word recognition, fluency, comprehension, and spelling, using a multiple regression format.

CHAPTER II

Method

Participants and Setting

Participants in this study were approximately 29 students in grades two through five in a rural-suburban elementary school in East Tennessee. Fifty-six percent of the families in the school's population are eligible for free or reduced-price lunch based on federal guidelines. At the onset of testing, these students had received regular classroom instruction and had not been diagnosed with a learning disability; therefore, they were not eligible to receive special education services. These students had been chosen by the school's principal to participate in after-school supplementary instruction in math, reading, or both based on below average standardized *Comprehensive Test of Basic Skills* (*CTBS/4; CTB/McGraw-Hill, 1997*) scores. The investigators had no initial knowledge of individual students' standardized scores. Some students were below average in reading and some were not.

Instruments

Specific subtests from the *Test of Dyslexia (TOD)*, an experimental test currently undergoing field testing (McCallum & Bell, 2001), the *Woodcock Johnson III- Cognitive and Achievement Batteries (WJIII)* (Woodcock, McGrew & Mather, 2001),and the *Test of Silent Word Reading Fluency (TOSWRF)* (Hamill, Allen, & Roberts, 2004) were the instruments in this study. The TOD is currently under development. See Bell, McCallum and Cox (2003) for a description of psychometric data from an administration to 105 elementary school students. *TOD* subtest reliabilities are generally above .80 and evidence of construct and concurrent validity is presented. The *WJIII Cognitive and Achievement Batteries* are widely used individually administered instruments. Median reliabilities of subtests used in this study were .80 or higher and authors report evidence of various types of validity. The *TOSWRF* is a three minute test of reading fluency which can be group or individually administered. The authors report test-retest reliability for Form A to be .92 (corrected) and .68 (uncorrected) and cite evidence of concurrent, construct and predictive validity. Descriptions of orthographic processing and achievement subtests used in this study are in Table 1. The visually based subtests used as predictors from the *TOD* were *Orthography, Visual Discrimination, Sound Symbol Learning, Letter Memory: Visual,* and *Rapid Symbol Naming*. The visually based subtests from *WJIII* were *Picture Recognition* and *Visual-Auditory Learning*. Achievement subtests included *Letter-Word Calling, Fluency, Passage Comprehension,* and *Spelling,* from *TOD; Letter-Word Identification, Reading Fluency, Comprehension,* and *Spelling* from *WJIII;* and the *Test of Silent Word Reading Fluency.*

Procedure

A school psychologist and professor of special education, an experienced educational diagnostician, and school psychology doctoral students administered the designated subtests from the *Test of Dyslexia,* the *Woodcock Johnson III- Cognitive* and *Achievement Batteries,* and the *Test of Silent Word Reading Fluency* to the participants. Some tests were given in a group setting, with others requiring one-to-one administration. Group testing required participants to be pulled from class, but most individual testing was completed during the after-school curriculum enhancement program. Individual

Table 1

Description of Orthographic Processing and Achievement Subtests

Subtest	Description	
TOD-Orthography	Processing:	^{T} Participant chooses correctly spelled word from choice of four as fast as possible.
TOD-Sound Symbol Naming	Processing:	Participant "reads" words made from pseudofonts that examiner pairs with sounds.
TOD-Letter Memory: Visual	Processing:	Participant chooses one matching letter string of four choices after viewing stimulus for five secs.
TOD- Rapid Symbol Naming	Processing:	^{T} Participant calls out randomly presented letters (A,B,C) and numbers (1,2,3) as fast as possible.
TOD-Visual Discrimination	Processing:	^{T} Participant chooses one unique letter string from a group of four as fast as possible.
WJ-Visual-Auditory Learning	Processing:	Participant "reads" sentences made of symbols that examiner pairs with whole words.
WJ-Picture Recognition	Processing:	Participant chooses exact match or matches after viewing stimulus picture for five seconds.
TOD- Letter Word Calling	Achievement:	Participant reads letters and words of increasing difficulty.
TOD- Fluency	Achievement:	^{T} Participant reads passages orally, examiner records # of words read correctly and time taken.
TOD- Comprehension	Achievement:	Participant orally reads passages and orally responds to examiner's questions.
TOD- Spelling	Achievement:	Participant writes letters and words with regular and irregular spellings of increasing difficulty.
WJ-Letter Word Identification	Achievement:	Participant reads letters and words of increasing difficulty.
WJ-Reading Fluency	Achievement:	^{T} Participant silently reads simple sentences and marks true or false for three minutes.
WJ-Comprehension	Achievement:	Participant silently reads a sentence and states the missing word orally.
WJ-Spelling	Achievement:	Participant writes letters and spells words of increasing difficulty.
TOSWRF	Achievement:	^{T} Participant splits a page-long series of connected word chains into real words for three minutes.

Note. TOD = *Test of Dyslexia* (McCallum & Bell, 2001).

WJ = *Woodcock Johnson III Cognitive and Achievement Batteries* (Woodcock, McGrew & Mather, 2001).

TOSWRF = *Test of Silent Word Reading Fluency* (Mather, Hamill, Allen, & Roberts, 2004)

^{T} = Timed Task.

administration time varied according to schedules of participants and testers, rarely exceeding one hour of continuous testing. Subtest scores from the *Test of Dyslexia* were calculated based on raw scores, or raw score/completion time ratios on timed tasks. Standard scores were available for the *WJIII* subtests and the *Test of Silent Word Reading Fluency.*

CHAPTER III

Results

Descriptive statistics for the sample of 29 participants are presented in Table 2 (p.13). The means on measures yielding standard scores (i.e., *WJIII* and *TOSWRF)* ranged from .91.00 to 105.38 and the standard deviations ranged from 6.70 to 11.25.

In order to examine the relationships among various processing/orthographic abilities and reading achievement variables, Pearson product moment correlation coefficients were calculated and are presented in Table 3. Because mild positive relationships were predicted, one-tailed tests of correlations were generated. Thirty-one of the 120 coefficients yielded relationships significant at the $p < .01$ level. Additionally, ten were significant at the $p < .05$ level. Of the seven visually based subtests used as independent variables, the *TOD Rapid Symbol Naming* subtest related most consistently with achievement scores; coefficients were at the $p < .01$ level with five of the ten achievement test measures: *WJIII Letter-Word Identification* (.51), *TOD Comprehension* (.51), *WJIII Passage Comprehension* (.52), *TOD Spelling* (.75) and *WJIII Spelling* (.47). The *TOD Orthography* subtest yielded strong correlation coefficients ($p < .01$) with three of the reading achievement tests: *WJIII Reading Fluency* (.61), *TOD Spelling* (.57), and *WJIII Spelling* (.48). *TOD Letter Memory: Visual* correlated significantly with *TOD Comprehension* (.43. $p < .01$), and correlated with *TOD Spelling* (.41. $p < .05$). *TOD Visual Discrimination* also correlated with *TOD Spelling* (.45. $p < .01$). *TOD Sound Symbol Naming*, *WJIII Picture Recognition*, and *WJIII Visual-Auditory Learning* subtests yielded nonsignificant correlation coefficients with the reading achievement subtests.

Table 2

Descriptive Statistics of the *TOD, WJIII,* and *TOSWRF*

Subtest	N	Mean	Standard Deviation
T-Orthography	29	.25	.09
T-Sound Symbol Naming	29	7.93	4.0
T-Letter Memory: Visual	29	16.83	3.01
T-Rapid Symbol Naming	29	1.69	.36
T-Visual Discrimination	28	.14	.04
WJ-Visual-Auditory Learning	29	99.38	11.25
WJ-Picture Recognition	29	105.38	6.70
T-Letter Word Calling	27	47.85	34.70
T-Fluency	29	.13	.09
T-Passage Comprehension	29	29.59	10.74
T-Spelling	29	19.69	6.78
WJ-Letter Word Identification	29	93.79	8.24
WJ-Reading Fluency	28	91.75	10.34
WJ-Comprehension	29	96.93	7.60
WJ-Spelling	28	91.00	9.55
TOSWRF	27	95.30	10.91

Note. T = *Test of Dyslexia* (McCallum, Bell, & Cox, 2001).

WJ = *Woodcock Johnson III* (Woodcock, McGrew, & Mather, 2001).

TOSWRF = *Test of Silent Word Reading Fluency* (Mather, Hammill, Allen, Roberts, 2004).

Table 3

Intercorrelations between *TOD* and *WJIII* Achievement and Visual Processing Measures

	Subtest Name	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	T-Letter Word Calling	—															
2	WJ-Letter Word ID	.08	—														
3	T-Fluency	-.05	.06	—													
4	WJ-Reading Fluency	-.05	.37*	.17	—												
5	TOSWRF	.09	.49**	-.06	.61**	—											
6	T-Passage Comprehension	.13	.47**	-.59**	.05	.32	—										
7	WJ- Comprehension	.15	.71**	.18	.57**	.53**	.44**	—									
8	T-Spelling	.33*	.57**	.13	.31	.37*	.50**	.49**	—								
9	WJ-Spelling	.03	.76**	.30	.54**	.54**	.18	.61**	.68**	—							
10	T-Orthography	.33*	.30	.34*	.61**	.40*	.20	.39*	.57**	.48**	—						
11	T-Visual Discrimination	.27	.02	.05	.20	.04	.33*	.15	.45**	-.01	.54**	—					
12	T-Sound-Symbol Naming	-.05	-.05	.02	.17	.16	.17	.17	.26	-.02	-.07	.01	—				
13	T-Letter Memory: Visual	-.00	.19	.06	-.09	-.17	.43**	.17	.41*	.16	.35*	.26	.06	—			
14	T-Rapid Symbol Naming	.19	.51**	.18	.43*	.30	.51**	.52**	.75**	.47**	.60**	.46**	.20	.63**	—		
15	WJ-Picture Recognition	.11	-.25	.04	.05	-.08	-.10	.05	-.05	-.11	.07	.16	.03	-.12	-.08	—	
16	WJ-Visual-Auditory Learning	-.09	.21	.10	.01	.13	.08	.31	.15	.20	-.16	-.44**	.36*	.14	.17	-.08	—

Note: N=29; T = *Test of Dyslexia* (McCallum & Bell, 2001). TOSWRF = *Test of Silent Word Reading Fluency* (Mather, Hamill, Allen, & Roberts, 2004).

WJ = *Woodcock Johnson III: Cognitive and Achievement Batteries* (WJIII; Woodcock, McGrew & Mather, 2001).

*$p < 0.05$ (1-tailed), ** $p < 0.01$ (1-tailed).

A second objective of this study was to determine if any of the visual processing measures significantly predict reading achievement. To examine the relative contributions, nine stepwise multiple regression analyses were performed using the reading achievement subtests as the dependent variables. For each multiple regression analyses, the independent variables were the visual processing/orthographic subtests from the *Test of Dyslexia*: *Orthography, Visual Discrimination, Sound Symbol Naming, Letter Memory: Visual,* and *Rapid Symbol Naming*; and the two from the *WJIII: Picture Recognition* and *Visual-Auditory Learning*. The dependent variables were various reading achievement measures, grouped by construct: sight word recognition—*TOD Letter-Word Calling* and *WJIII Letter-Word Identification*; fluency—*TOD Fluency*, *WJIII Reading Fluency*, and *Test of Silent Word Reading Fluency*; comprehension—*TOD Passage Comprehension* and *WJIII Comprehension*; and spelling—*TOD* and *WJIII Spelling* subtests. Stepwise regression analysis criterion required a probability of $F \leq .05$ in order for an independent variable to enter the equation. Of the nine multiple regressions, only one yielded an equation with more than one significant predictor. Six of the regressions yielded equations with one significant predictor, and two yielded equations with no significant predictors. Although none of the visual measures significantly predicted *TOD Letter-Word Calling*, *TOD Rapid Symbol Naming* predicted *WJIII Letter-Word Identification* scores (R^2 adj. = .23; $p < .006$). Similarly, none of the independent variables significantly predicted *TOD Fluency*, but three variables significantly predicted *WJIII Reading Fluency*: *Orthography, Letter Memory: Visual,* and *Rapid Symbol Naming* (see Table 4). Only the *TOD Orthography* measure predicted the *Test of Silent Word*

Table 4

Prediction of *WJIII Reading Fluency* from *TOD* and *WJIII* Visual Processing measures

Subtest/Model	β	R	R^2	R^2adj.	ΔR^2	F	p
TOD Orthography	.61	.61[a]	.38	.35	.38	15.15	.001
TOD Letter Memory: Visual	-.34	.69[b]	.48	.44	.10	11.12	.039
TOD Rapid Symbol Naming	.46	.76[c]	.57	.52	.09	10.34	.035

Note. N = 29. TOD = *Test of Dyslexia* (McCallum & Bell, 2001). adj. = adjusted.

Reading Fluency, (R^2 adj. = .12; $p < .044$). Only one variable, *TOD Rapid Symbol Naming,* predicted achievement on *TOD Passage Comprehension* (R^2 adj.= .23; $p < .006$) and *WJIII Comprehension* (R^2 adj. = .24; $p < .005$). Also, *TOD Rapid Symbol Naming* significantly predicted both of the spelling measures, *TOD Spelling* (R^2 adj. = .54; $p <$ .000) and *WJIII Spelling* (R^2 adj. = .19; $p < .012$). Generally, results of stepwise multiple regression analyses suggest that the visual processing measures used in this study have, at best, modest ability to predict reading achievement.

CHAPTER IV

Discussion

Consistent with findings from previous research (Booth et al., 2001; Compton, 2002; Cunningham, Perry, & Stanovich, 2001; Denckla & Cutting, 1999; Manis & Bailey, 2003; Roberts & Mather, 1997; Wolf, 1999) , these results indicate that measures of visual processing/speed are significantly related to reading and spelling. Two visual processing/speed subtests from the *TOD, Rapid Symbol Naming* and *Orthography,* yielded significant correlations with at least one measure of each of the four reading achievement constructs measured in this study: sight word recognition, fluency, comprehension, and spelling. Two more visual processing/speed measures, *TOD Visual Discrimination* and *TOD Letter Memory: Visual* correlated significantly with two of the four criterion constructs, comprehension and spelling, as measured by the *TOD* but not with the *WJIII* measures of the same constructs. Like *TOD Rapid Symbol Naming* and *Orthography, TOD Visual Discrimination* is speeded; that is, student performance is timed. *TOD Letter Memory: Visual* involves timed exposure of test stimuli but student performance is not timed. Three other measures of visual processing, *WJ Picture Recognition, WJ Visual-Auditory Learning,* and *TOD Sound Symbol Naming,* did not produce significant correlations with any of the criterion measures of reading achievement. Though length of time students are exposed to stimuli on these tasks is controlled, student performance is not timed. The only visual subtests that correlated with reading measures strongly measured visual processing combined with speed. These findings are consistent with brain research by Booth and Burman (2001) demonstrating the role of the brain's visual system for processing rapidly changing information in reading abilities.

The results of the stepwise multiple regression analyses suggest that visual processing/speed tasks have relatively weak ability to predict reading performance generally. Sight word recognition was measured by the *TOD Letter Word Calling* and the *WJIII Letter Word Identification* subtests. Although no significant predictors were found for the *TOD* word recognition test, the *TOD Rapid Symbol Naming* test accounted for 23% of the variance in the *WJIII Letter Word Identification* subtest. However, fluency as measured by the *WJIII Reading Fluency* test was predicted significantly (52% of the variance) by three of the visual measures: *Orthography, Letter Memory: Visual,* and *Rapid Symbol Naming (TOD).* The *Test of Silent Word Reading Fluency* was also predicted by the *TOD Orthography* measure, accounting for 12% of the variance. Interestingly, both tests measure fluency silently, the *WJIII* via sentences and the *TOSWRF* via single words. However, the *TOD Fluency* measure, which employs oral passage reading and is calculated based on words read correctly divided by time, was not significantly predicted by any of the visual subtests. The comprehension construct as measured by *TOD Passage Comprehension* and *WJIII Comprehension* were both predicted by *TOD Rapid Symbol Naming,* accounting for 23% and 24% of the variance respectively. Spelling was measured by *TOD* and *WJIII Spelling* subtests. *TOD Rapid Symbol Naming* accounted for 54% of the variance in the *TOD Spelling* subtest. In contrast, *TOD Orthography* accounted for 19% of the variance in *WJIII Spelling*. These findings indicate that neither the *Visual-Auditory Learning* nor the *Picture Recognition* measures from the *WJIII* significantly predict reading achievement as operationalized in this study. These findings are consistent with Mather (1999), who indicated that visually based subtests from the *Woodcock-Johnson Revised* are not related to achievement.

The measure of rapid naming used in the study, *TOD Rapid Symbol Naming*, was the independent variable most consistently related to criterion measures. *TOD Rapid Symbol Naming* correlated significantly with at least one of the subtests from each of the reading achievement constructs examined: sight word recognition, fluency, comprehension, and spelling (see Table 3). *TOD Rapid Symbol Naming* and *TOD Spelling* yielded the strongest relationship between a measure of visual processing and reading achievement in the study (.75, $p < .01$). *TOD Rapid Symbol Naming* was significantly related to more of the measures in the correlational and stepwise regression analyses than any other. Because this subtest requires the examinee to name the letters A, B, and C and the numbers 1, 2, and 3 in the random order seen on the stimulus page while being timed, it would intuitively appear to measure visual processing speed separately from memory or auditory ability. However, results of a factor analyses conducted by Bell et al. (2003) indicated that *Rapid Symbol Naming* loaded significantly with three factors: auditory processing, visual processing/speed, and memory factors. The authors acknowledged that "…each of the factors contributed uniquely and significantly to the variance associated with each of the academic skills" (p. 511). Wolf (1999) noted that naming speed measures are strongly predictive of reading disability, especially in languages that are not phonologically complex. Her findings were in contrast to assumptions by many behavioral and neurological researchers that naming speed is a phonological processing task. Instead, Wolf characterized naming speed as a "complex ensemble of multiple processes that included, but was not limited to, phonological processes"(p.10). When exploring the relationships between phonological processing, orthographic processing, and print exposure as predictors of word recognition, Stanovich (2001) found that the orthographic composite accounted for 16.3% of the additional variance after the percentage attributable to phonological processing had been removed. He summarized that his data provides "at least a tentative indication that phonological and orthographic processing skills are separable components of variance in word recognition during the beginning stages of reading acquisition" (p. 565). The findings in this study offer support to Stanovich's claim that visual processing, particularly speeded measures of visual processing, do account for some of the variance in different aspects of reading achievement, predominantly spelling and fluency. These findings are consistent with brain research (Denckla & Cutting, 1999; Eden & Moats, 2002; Turtletaub et al., 2003; Wolf ,1999.) suggesting the importance of speed of visual processing in performing reading tasks.

Implications

According to empirical evidence, phonological abilities remain an important predictor of reading achievement. However, this research and other studies indicate that visual processing/speed skills account for a significant and separate variance in reading achievement. Adams (1990) analyzed the types of orthographic skills in detail that are required for automatic word recognition and discussed their impact on fluency and comprehension. Several researchers have shown the importance of visual processing and visual memory skills to spelling ability (Bell, McCallum, & Cox, 2003; Adams, 1990; Roberts & Mather, 1997). In the study relating orthographic processing to word recognition skills, Stanovich (2001) used an extensive set of instruments to assess various aspects of visual processing in reading. This study added fluency, comprehension, and spelling to the reading achievement variables investigated.

Bell, McCallum, and Cox (2003) discussed which abilities and skills should be measured to determine if a student exhibits a pattern of dyslexia. Results from this study further refine our knowledge regarding which orthographic variables might be useful to include in such a battery. In addition to an ecologically valid measure of rapid naming, speeded measures of orthographic skill and visual memory using real letters appear to have utility in predicting reading and spelling achievement. Wolf (1999) found in a longitudinal five-year study that "children with dyslexia began their school years with both a general naming speed problem and a particular difficulty with speed for letter naming" (p. 7), and that the differences remained through grade four, especially for the more automized categories, letters and numbers. The *TOD* is designed to be ecologically valid. That is, letters and words are used rather than symbols. This may be a factor in explaining why the *WJIII* visually based subtests do not appear to have utility for diagnosing dyslexia, though further research with a larger sample would be needed to confirm this conclusion. The *TOD* measures of rapid naming, visual memory, and (timed) orthography appear to have utility for predicting reading achievement, but they are currently under development. Practitioners interested in obtaining a thorough assessment will need to include similar measures from various commercially available instruments. For teachers, results suggest the need to explicitly address both auditory and visual aspects of words in instruction and remediation. Results support that visual processing/speed plays a small but important role in reading achievement and, consequently, in dyslexia.

Limitations and Further Research

The sample size of this study is small, and from only one area of the country, consequently, the findings cannot be presumed to generalize to the United States population. Nonetheless, results are valuable for researchers and practitioners because they substantiate the unique relationship of rapid naming and visual processing with reading achievement constructs. Similar studies with a larger, more diverse, population are needed to substantiate the results of this study. Also, the relationship of these constructs should be explored in persons identified as having dyslexia and/or learning disabilities in basic reading skills. Further refinement of the *TOD*, particularly its measure of fluency and word recognition is recommended.

LIST OF REFERENCES

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Adams, Marilyn J., (1990). *Beginning to read: Thinking and learning about print.* Cambridge, MA: MIT Press.

Badian, Nathalie A. (2000). Introduction. *Prediction and prevention of reading failure.* Baltimore: York Press.

Badian, Nathalie A. (2001). Phonological and orthographic processing: Their roles in reading prediction. *Annals of Dyslexia, 51,* 179-202.

Bell, S.M., McCallum, R.S., and Cox, E.A. (2003). Toward a research-based assessment of dyslexia: Using cognitive measures to identify reading disabilities. *Journal of Learning Disabilities, 36,* 505-16.

Booth, J.R. and Burman, D.D. (2001). Development and disorders of neurocognitive systems for oral language and reading. *Learning Disability Quarterly, 24:3*, 205-15.

Booth, J.R., Perfetti, C.A., MacWhinney, B., & Hunt, S.B. (2000). The association of rapid temporal perception with orthographic and phonological processing in reading impaired children and adults. *Scientific Studies of Reading. 4,* 101-132.

CTB/McGraw-Hill. (1996). *Comprehensive test of basic skills.* Monterey, CA: Author.

Christiansen, C.A. (2000). Preschool Phonemic Awareness and Success in Reading. In N.A. Badian (Ed.) *Prediction and Prevention of Reading Failure* (p. 153). Baltimore: York Press.

Compton, D.L. (2002). The relationships among phonological processing, orthographic processing, and lexical development in children with reading disabilities. *Journal* *of Special Education, 35:4,* 201-210.

Cunningham, A.F., Perry, K.E., and Stanovich, K.E. (2001). Converging evidence for the concept of orthographic processing. *Reading and Writing: An Interdisciplinary Journal, 14,* 549-68.

Denckla, M.B. & Cutting, L.E. (1999). History and Significance of Rapid Automatized Naming. *Annals of Dyslexia, 49.*p. 29-42.

Eden, G. F. and Moats, L. (2002). The role of neuroscience in the remediation of students with dyslexia. *Nature Neuroscience Supplement.* Received March 12, 2004, from Nature Publishing Group: www.nature.com/natureneurosciencedoi:10.1038/nn946 . 1080-84.

International Dyslexia Association (2003). Definition of dyslexia. Retrieved April 10, 2004, from http://www.interdys.org

Manis, F., and Bailey, C. (2003). Develomental profiles for phonological and surface dyslexia in grades 3-5. Presentation at 5th British Dyslexia Association International Conference. Psychology Dept. Univ. of Southern California, USA.

Mather, N. (1999). *Interpretation of the WJ-R cognitive and achievement batteries.* Workshop presented at the Knox County Schools, Knoxville, TN.

Mather, N., Hammill, D.D., Allen, E.A., Roberts, R. (2004). *Test of silent word reading fluency.* PRO-ED, Inc.: Austin.

McCallum, R.S., & Bell, S.M. (2001). *Test of dyslexia.* Unpublished manuscript, University of Tennessee, Knoxville.

Roberts, R., & Mather, N. (1997). Orthographic dyslexia: The neglected subtype.

Learning Disabilities Research & Practice, 12(4), 236-250.

Stanovich, K.E. (1986). Matthew effects in reading: Some consequences of individual differences in the acquisition of literacy. *Reading Research Quarterly*, *21*, 360-406.

Turtletaub, P.E., Gareau, L., Flowers, D.L., Seffiro, T.A., Eden, G.F. (2003) Development of neural mechanisms for reading. Received on March 4, 2004, *Nature Neuroscience: Advance Online Publication*. www.nature.com/natureneurosciencedoi:10.1038/nn1065 1-7.

Wolf, M. (1999). What time may tell: Towards a new conceptualization of developmental dyslexia. *Annals of Dyslexia, 49*.p. 3-28.

Woodcock, R.W., McGrew, K.S., & Mather, N. (2001). *Woodcock-Johnson Tests of Cognitive Abilities and Tests of Achievement* (3rd ed.). Chicago, IL: Riverside.

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