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VISUAL MOTOR COORDINATION AND READING:

A CORRELATIONAL ANALYSIS PART II

by
Marita C. Marcionese

A Thesis

Submitted in partial fulfillment of the requirements of the
Masters of Arts Degree
of
The Graduate School
at
Rowan University
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Approved by _____
Advisor
Date Approved May 3, 2005

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ABSTRACT

Marita C. Marcionese
VISUAL MOTOR COORDINATION AND READING:
A CORRELATIONAL ANALYSIS PART II
2005/05
Dr. Roberta Dihoff and Dr. John Klanderman
Masters of Arts in School Psychology

The purpose of this study was to determine if there was a correlation between reading rate and visual-motor coordination. This study was a replication of the researcher's prior study. The population of interest was the only differing aspect. This study used 32 high school 9th and 10th grade students from an all boy's college prep school. Reading rate was measured by two tests: the Nelson-Denny Reading Test and a 40-letter test. The game Perfection and a bead stringing task were the measures used to determine visual-motor coordination. Aggregated scores combined the z-scores to create a total score for reading and also visual-motor coordination. A Pearson's Correlation yielded significance that supports the hypothesis: There was a significant positive correlation between reading rate and visual-motor coordination in 9th and 10th grade high school students. Another significant finding was that the Nelson-Denny reading rate score was positively correlated with the aggregated score for visual-motor coordination.

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Introduction

NEED

Reading is a critical skill. In fact, some researchers have suggested that it contributes to success in every area of life throughout the entire lifespan (Brown, Fishco, & Hanna, 1993). As a result, numerous treatment programs for people with reading disabilities have been developed. In past years, one such treatment approach had focused on improving visual-motor coordination, with the assumption that this would improve reading ability. Empirical support for this approach has been equivocal with some studies supporting the relationship between visual-motor coordination and others, not.

Reading disabilities may not always be apparent from the surface level. A reader may possess average to excellent comprehension and vocabulary skills, but they can have a reading speed that is below average. In the case of our researcher this was true. Possessing above average grades and scores on scholastic aptitude tests she was dismissed when approaching teachers and counselors about difficulties in reading. Not until college was it established that she was reading at the rate of someone 4-5 grades below her. Subsequently, the researcher began to research the topic and observe her reading functions more closely. The researcher also found that she performed poorly on tasks that involved high levels of visual-motor coordination. Consequently, the research topic was established: Do reading rates and visual-motor coordination vary with one another?

The current researcher has already completed a research study that found a positive correlation between reading rate and visual-motor coordination within the undergraduate population. Subsequently, the current study reflects a continuation of the researcher's prior research changing only the population of interest. Freshman and sophomores in high school will become the participant group of this research. Stability in the older population could be attributed to the fact that learning is at or near its highest level while students in the intended population (9^{th} and 10^{th} graders) may be unstable because learning is still occurring. That is, the correlation that was recorded in the original study may or may not be apparent in the current study.

PURPOSE OF THE THESIS

The purpose of this thesis is to replicate the researcher's undergraduate research and determine if adolescent's reading rate and visual-motor coordination correlate. If a similar significance is found with this new population (9^{th} and 10^{th} graders) there may be a way to help strengthen a person's reading rate and coordination by developing a program that includes both factors. This could eventually enable us to become proactive and integrate strengthening programs within the student's curriculum.

HYPOTHESIS

It was hypothesized that there will be a significant positive correlation between reading rate and visual-motor coordination tasks in 9^{th} and 10^{th} grade students.

THEORY OR BACKGROUND

Two theories can help ground the present research. The first is a learning theory. This theory is known as the Information Processing Theory. The second is a perceptual-motor theory. Information processing is an extremely important element involved in both reading and visual-motor coordination. For example, in order to read there are certain steps involved in processing the information. These steps are found to be the same across different types of readers. The rate of processing is the aspect that may differ.

Information processing "is not the name of a single theory; it is a generic name applied to theoretical perspectives dealing with the sequence and execution of cognitive events" (Schunk, 2004, 136). This stage of processing model explains how information coming into a sensory register becomes a response. There are different levels of processing: attentional, visual, phonological, and semantic (Samuels, 1987). Attention describes the individual's level of arousal, alertness, vigilance, selectivity, and capacity when attending to a specific task. The visual aspect deals with the size of the word. This may vary between the smallest segment (a single letter), to a moderate segment (a letter cluster: i.e.- sh, ion, ing… etc.) to the largest segment (whole words). The third component phonological memory involves sounds/acoustics. During this level of processing sound is integrated with the word sizes. Thereby giving letters, letter clusters, and whole words appropriate sound units. Finally, the deepest level of processing occurs at the semantic level. At this level the visual units and phonological units are given meaning. Comprehension is the end result from this highest level of processing.

Some researchers attribute poor reading speed to poor automatic information processing (Samuels. 1987). Others feel that poor naming speed would consequently

lower reading speed (Denckla & Rudel, 1976). While there are also others who have researched a "global mechanism" that affects speed and is related to age and "the speed with which children and adolescents process information (Kail & Hall, 1994). Together these differing assumptions all are from the theory of information processing. While information processing is a widely accepted theory of learning, perceptual-motor theory was a short-lived theory of the past.

Perceptual-motor theory became very popular in the 1970's by a team of professors at Perdue University. Researchers such as Frostig, Kephart, and Barsch studied perceptual-motor abilities and developed programs to strengthen these skills. They also combined perceptual-motor learning and content areas such as reading in their strengthening techniques. In recent years this theory has become less highly regarded. It is still important to recognize it as historical support for the current study.

DEFINITIONS

This study has unique terminology that must be understood for the intended interpretation of this project.

40-letter test- ("letter test"; Joshi & Aaron, 2000) a list of 40 random letters was constructed. These letters were printed on a single 8 ½" x 11" standard white sheet of paper. Participants were asked to read the 40 letters as quickly and accurately as possible.

Bead rate- the number of beads (25) divided by the recorded time to create the final variable.

Bead stringing task- participants were given an unlimited amount of time to string 25 beads onto an 18 inch piece of string.

Nelson-Denny Reading Test- Form G was given to test reading, comprehension, and rate. This test includes two parts.

Perceptual-Motor Ability- This is the ability to perceive information and then react physically to the perceived stimulant. This must happen simultaneously.

Perfection- game by Milton Bradley. Standard rules for this game allow players to place shaped pegs in corresponding slots in any order. However, for this study, participants were asked to place the pegs in a certain order, from left to right and from top to bottom. The number of pegs correctly placed in a 60-second interval was recorded.

Perfection Ratio- consists of the number of correctly placed pegs per minute.

Reading- a skill that consists of the combined use of vocabulary, comprehension, and speed.

Reading Rate- the speed at which one reads. Measured specifically in this study by the Nelson Denny Reading Speed Test and the 40 letter test.

Visual-Motor Coordination- ie-- hand-eye coordination. Harmonious functioning of muscles and visually processed information in the execution of movements.

ASSUMPTIONS

1. It is assumed that the participants of this study will all come from similar backgrounds and have similar educational histories
2. It is also assumed that they will not have any practice with any of the data collection materials. That is, with the exception of the game Perfection. This will be controlled for in the demographic portion of the data collection.

3. All participants will be of normal learning ability and not represent any physical handicaps.

LIMITATIONS

1. This study may not be overgeneralized because the researcher used a private catholic school population.
2. The nature of the study was not causal. The hypothesized similarities between the two variables were simply being examined for correlational purposes. Even though there was and underlying factor that was alluded to (processing speed), this was not being suggested as a cause. Further research may be done to delve into this area.
3. Human error may be a slight limitation to this research (ie—time keeping and data collection)

SUMMARY

In the section to follow research was reviewed to provide support for this study. Particularly research on Visual-Motor Coordination and Reading Rate was provided. Both subjects were explored on their own and then together. Doing so the researcher was able to show the importance of both variables individually and then how equally important it is to integrate the two factors. In doing so this provided sufficient evidence to support this current research endeavor.

The study to follow determined if a significant correlation exists between the two variables (visual-motor coordination and reading rate). The researcher intends to established this through testing 9th and 10th grade students.

Chapter 2

Literature Review

INTRODUCTION

Historically, no researcher has ever completed a study that has looked for a correlation between reading rate and visual-motor coordination. Reading rate has only recently become a subject of interest. On the other hand, visual-motor coordination had a decade or so of popularity when it was researched in the area of perceptual-motor training. Therefore, this literature review is designed to analyze studies in three areas: (1) reading rate, (2) perceptual-motor abilities and training, and (3) visual-motor coordination and reading.

READING RATE

In order to understand the concept of reading's purpose in this study, you must start with understanding reading as a concept as a whole with very important individual parts. These parts are vocabulary, comprehension, and rate. Disabilities in any area can affect reading on a whole. The area that is most important to this review is reading rate.

Historically, there is a general lack of research in the area of reading rate. Although in recent years rate has had a little more interest. The research that has been done involves reading rate-- as a speed of naming effected by a global mechanism that increases with age (Kail & Hall, 1994), as a range of limits within the undergraduate student population (O'Reilly & Walker, 1990; Lewandowski et al, 2003; Rankin, 1993), as associated with information processing (Rankin, 1993; Palmer et al, 1985; Kail & Hall,

1994; Samuels, 1987; Breznitz & Berman, 2003), as an assessment tool for students overall reading performance (Rasinski, 2000; Kelly- Vance & Schreck, 2002), on a developmental scale (Breznitz, 1997), as it effects vocabulary (Whitt, 1993) and how it is influenced by automaticity (Teele, 2004, Samuels, 1987). In affect, researchers from the early 1990's to present day have slowly begun to recognize that the importance of reading rate weighs the same as its counterparts, comprehension and vocabulary. Subsequently, finding that rate can help detect deficits in both of those areas. In order to become more fully educated on these recent findings we must delve into the reading rate research at a deeper level.

"Speed Does Matter" as Rasinski (2000) found. He found that problem readers often manifest their reading deficiencies through slow, disfluent, labored, inexpressive reading. He also found that struggling readers in grade 2 had a reading rate that was 60% of their instructional level. Concluding that low reading rate becomes evidence for slow/poor processing of text. This study suggests that slow readers are most likely inefficient readers. They are lacking the automaticity in word recognition of skilled readers which inhibits the flow of reading and requires the reader to be more attentive and use more cognitive energy.

Samuels (1987) and Teele (2004) also suggested automaticity to be directly related to reading rate. Samuels (1987) explains the four main elements that are related to information processing and reading. Defined as the ability to decode and comprehend simultaneously, automaticity falls within the first element, attention. In his article he supports the finding that poor readers have to continuously divide their attention between decoding and comprehending. Unfortunately, these readers spend the bulk of their time

and attention on the decoding task. Samuels suggests in order to determine if a person lacks automaticity you must have them read orally. During their oral reading you are looking for expressionless readers. That is, reading that is dull, flat, and lacks appropriate expression. In Teele's (2004) book, *Overcoming the Barricades to Reading: A Multiple Intelligence Approach*, she also speaks about the notion of automaticity. "Automaticity is the ability to blend meaning, grammar, and sentence structure together so that reading words is an effortless, automatic procedure" (Teele, 2004, 80). She supports developing automatic word recognition abilities as a major goal in teaching reading. In doing so, the reader will be more constructive and critical in their ability. In short, she attributes automaticity in reading to word recognition which she directly relates to word identification. In order to recognize a word in text you must also be efficient in identifying a word when it stands alone.

Kail and Hall (1994) referred to the speed at which we identify words (and their breakdown) as naming speed. They found that rapid naming of digits (letters) is a predictor of word recognition which in turn is a predictor of comprehension.

Breznitz (1997) completed a longitudinal study that considered the relationship between reading rate, decoding, and comprehension during the acquisition stages of reading. He found reading rate in Grades 4 and 5 could determine overall reading performance for each student. He also suggests that reading rate can be thought of as either a dependent or independent variable. In other words, reading rate is respectfully either the outcome of effective decoding and comprehension or a direct contributor to the quality of decoding and comprehension. In prior research, Breznitz (1988, 1987a, 1992, 1997) had found that accelerating a persons reading rate improved working memory

functioning, reduce visual distractibility, and produced more effective, context based information processing. His longitudinal study revealed that accelerated reading rates are crucial to the development of reading skills and ability at every grade level. Specifically, reading rate initially becomes critical at the second-grade level. He suggests that reading rate may transition, due to stability, from a dependent to an independent variable. Finding that at the fourth-grade level reading skills are stronger and they are ready to allow rate to become independent.

Breznitz and Berman (2003) studied the underlying factors of word reading rate. In this study they used the term "acceleration phenomenon" to refer to finding that reading acceleration affects cognitive processes, such as attention, memory, and information processing, that are stronger in effective readers. He attributes word recognition and word reading to phonological and orthographic reading skills. Phonological skills essentially reflects a persons ability to process words both orally and written through the sound structure of language. While orthographic processing basically refers to the visual code or spelling of words. Effective processing of both abilities increases the strength of an individual's word recognition. Therefore, these skills directly affect processing speed which in turn affects reading rate.

There is also research available that supports reading rate as a distinct ability. Palmer et al (1985) constructed an experiment that investigated information processing correlates of reading. Specifically, the study considered reading speed and comprehension. Results supported reading comprehension as a correlate of information processing. Their findings also indicated that reading speed and comprehension were not direct correlates. This finding supports the rationale that reading speed and

comprehension should be considered distinct abilities. Vocabulary and reading rate were analyzed by Witt (1993). This researcher gave timed and untimed vocabulary tests to college students. The results that she found indicated that students scored higher when taking untimed vocabulary tests. This suggested that a student who scores poorly on a timed vocabulary test may exhibit higher scores when tested in an untimed environment. Untimed testing enables vocabulary and reading speed to become distinct abilities.

Several studies researched reading rate and college students (Lewandowski et al, 2003; O'Reilly & Walker, 1990; Rankin, 1993). Based on the criteria that more college students possess reading disabilities and require special services to accommodate their needs, Lewandowski et al (2003) decided to research reading rate in college students. In particular they searched for more accurate ranges of reading rates for this population. Prior to this study rates ranged from 200-400 words per minute (wpm). The new range that was found through their research was between the averages of 189-231 wpm.

O'Reilly and Walker (1990) reviewed literature on reading rate and college students. Their overall findings were:

> A rational program designed to detect specific problems with microprocessing implicated in ineffective reading and thereafter providing appropriate experiences for rectifying the underlying problems might better serve the needs of these readers (slow, disfluent readers with poor comprehension). If failures in automatization can be identified among these deficient subprocesses, then effective methods might be applied to expand the range and depth of the reader's conceptual structures. (O'Reilly& Walker, 1990, 8).

Rankin (1993) tested four groups of readers: high comprehension—high speed, high--comprehension—low speed, low comprehension—low speed, and low comprehension--high speed. Specifically, reading comprehension and speed were examined in regards to information processing. Results supported that speed is a variable

that affects performance. Findings supported a correlation between slow, good readers (low speed—high comprehension) and fast, poor readers (high speed—low comprehension). In other words, slow readers with high comprehension are more affective in word recognition and comprehension then those who are fast readers.

According to some researchers, a useful and easy way to increase the rate at which one reads is by increasing the amount of reading that they participate in (Rasinski, 2000; Teele, 2004; Kelly-Vance & Schreck, 2002). Rasinski (2000) specifically suggests that a low speed reader should participate in repeated readings and also read with a stronger reading partner. Repeated reading is an instructional technique that involves practicing scripts of poetry. Constantly rereading these materials allows the poor reader to become more familiar with the word recognition and allows for more ease in fluency. Performing these pieces also allows for the reader to learn to read and recite with appropriate expression. The second technique, paired reading, can be done with either parents or more fluent peers. This technique allows for constant support and immediate reinforcement.

Teele (2004) supports techniques that increase word recognition rate that will in turn increase reading rate. In search for automaticity among poor readers the following suggestions were made: give students the opportunity to read many enjoyable books, using flashcards with high frequency words, using a concentration game, or incorporating high frequency words into a game of hopscotch. These techniques are for younger populations. Early strengthening of word recognition can support higher reading rates throughout development.

Finally, Kelly-Vance and Schreck (2002) implemented a parent/school reading program in their study. With support from the school the aim of this research was to strengthen the students' reading rate through more parental reading at home. The benefit of the program was for all readers no matter what their ability. The researchers found support for their program with an increase in the students' reading rate and accuracy.

PERCEPTUAL-MOTOR ABILITIES AND TRAINING

The late 1960's brought about an influx of research on perceptual-motor abilities and training. A primary source of this research was based at Perdue University. Such researchers as Marianne Frostig, Newell Kephart, and Ray Barsch were involved in this movement. Remaining popular, this idea was strongly supported through to the late 1970's. In the 1980's, the popularity of perceptual-motor training began to taper off. In current research this notion is considered passé.

Although this concept is no longer current, it is important to discuss its history. For the backbone of this theory brings forth understanding for the research at hand. As stated, the 1970's brought forth a plethora of research in this area. Perceptual-motor training could have been thought of as a "fad" in the educational world. Research on the subject is primarily based on programs and their success, or lack there of.

Frostig (1970) developed a program based on movement. Her program not only included visual-motor coordination, but it also included how other aspects effect movement. The other aspects are as follows: speed (time from beginning to end; not reaction time), agility, strength, balance, and endurance. Frostig's program was developed to use a learning disabled child's strengths (i.e. – visual-perception, auditory, etc.) to teach the child a new subject matter. She backs her program with the notion that

control and coordination that is developed through movement education is transferred to the classroom.

Olson (1966) wanted to investigate the Frostig Developmental Test. Intentions of this study were to determine how readily this test would predict achievement test scores and reading abilities. The Frostig Developmental Test tested for five abilities: (1) visual-motor coordination, (2) figure-ground, (3) form constancy, (4) position in space, and (5) spatial relations. This researcher was trying to compare these abilities directly to various reading abilities including: paragraph comprehension and word recognition. Olson's (1966) findings were mixed. He found a significant correlation between figure-ground and vocabulary. But he found no support for figure-ground and word recognition.

Also using the Frostig Developmental Test, Rosen (1966) tested the significance of the Frostig program on first grade readers. The Frostig program was a program developed to strengthen the 5 abilities that are present in her test. The rationale for Rosen's (1966) study was based on the premise that there was research available that gave evidence for the effectiveness of the Frostig Developmental Test predicting reading readiness in Grades K and 1. Therefore, his research hypothesized that the Frostig perceptual program would affect first grade reading. Results were insignificant. The program did in fact strengthen the five abilities it was designed to support, but it did not subsequently strengthen reading abilities.

Stein (1970) explained perceptual-motor development using an information processing mode. Specifically, he stated that the process involves:

> (1) Receiving and transmitting input information via various internal and external sensory pathways—vision, touch, kinesthetic, smell, taste, hearing, proprioceptive, balance; (2) Collecting, indexing, storing, and making information available for future use; (3) Matching, and/or

> referring new information to information which has been previously collected, indexed, and stored; (4) Translating information into activity through movement; (5) Children learn through direct involvement as they participate in this process (Stein, 1970, 29).

His main point was that perceptual-motor development does not stand alone as its own entity. It is constructed by various aspects one such being this information processing model.

One research study designed by Anderson and Stern (1972) focused directly on Frostig's training program and corrective reading instruction. Testing was performed to analyze the effects of these programs on reading ability and visual-motor skills in students who had difficulty in both areas. Findings indicated a lack of significance for the ability of these programs to improve reading and visual-motor skills.

Two other studies reflected the same findings. McCann (1979) studied the effect of a perceptual-motor training program on reading comprehension in remedial readers. His findings showed a lack of significance of the program on reading comprehension scores. Battaglia (1973) also studied the effects of perceptual motor training. Her study was looking for sex differences. She used Getman's Developing Learning Readiness Program as a supplemental instructional tool in a classroom with neurologically impaired children. Comparing her male and female students she did not find a significant difference in ability. The lack of findings of both of these studies could be contributed to their relatively low sample sizes (McCann— N=21; Battaglia—N=10).

Broadhurst (1988) searched for a correlation between motor-free visual perception and perceptual-motor ability. Motor-free visual perception defined as "devoid of motor involvement and includes performance in spatial relationships, visual discrimination, figure-ground awareness, visual closure, and visual memory"

(Broadhurst, 1988, 6). Perceptual-motor skills were the combination of gross motor skills and fine motor skills. Significant correlations did not exist between the two variables.

Burke et al (1978) searched for the effects of three experimental perceptual-motor training programs on reading readiness. The three programs had different approaches to perceptual-motor training: (1) a language experience approach, (2) a basal approach, and (3) a visual, motor, and tactile approach. The results show strengths for each program in the terms of their approach style. In other words they strengthened the area that the program was designed to approach. Consequently, the most appropriate test will depend on the goal of one's use.

A significant difference in normal and brain injured children within two age groups in regards to reading and visual motor coordination was elicited in a study performed by Aviezer and Simpson (1980). This study was based on variability, the concept that describes "differences in levels of achievement of a child from one area of performance to another" (Aviezer & Simpson, 1980, 42).

VISUAL-MOTOR COORDINATION VS READING

Many of the studies on the relationship between visual-motor coordination and reading have focused on young children. For example, in his study of elementary-school aged children, Plack (1968) found a significant relationship between reading achievement, as measured by the Iowa Tests of Basic Skills, and two tests of perceptual motor ability: the throw-and-catch test and the zig-zag run test. Similarly, Eckert (1975) examined the relationship between first- and second-graders' scores on the Gates Primary Reading Test and six different measures of visual-motor coordination. For boys, reading abilities loaded on the same factor as a pursuit rotor task (in which the participant

removes a doll from a rotating platform) and a catch task (for which the participant catches a ball from different distances). For girls, only the pursuit-rotor task loaded with reading abilities. Eckert hypothesized that her findings reflected sex differences in motivation for the tasks.

More recently, Goldstein and Britt (1994) controlled for the effects of intelligence in their study of relationship between visual-motor coordination and academic skills, including reading abilities. Intelligence was measured using the Weschler Intelligence Scale for Children-Revised (WISC-R); visual-motor coordination, using the Test of Visual-Motor Skills, the Developmental Test of Visual-Motor Integration, and the Bender-Gestalt Test for Young Children; and reading, using the Woodcock-Johnson Psycho-Educational Battery. Initial findings indicated that scores on all three visual-motor measures were significantly related to reading scores. However, when verbal intelligence scores are partialed out, none of the visual-motor task scores predicted reading.

Other studies have also found no correlation between visual-motor and reading abilities. For example, Husak and Magil (1979) assessed the correlations between perceptual-motor ability and reading achievement in first through third grade children. Perceptual-motor ability was measured with a modified Minnesota Manual Dexterity Test and a tapping test and reading achievement was measured by using the Science Research Associates Assessment Survey. Subsequent data provided little evidence of a correlation between these two variables. Robinson and Schwartz (1973) also found little support of a correlation in their longitudinal study of reading abilities in high-risk children with visual-motor and/or visual perception handicaps. In this study, visual-motor coordination

was measured using the Bender Gestalt Test and reading, using the Schonell Word Recognition Scale. Results indicated no significant differences in reading abilities between the group of high-risk children and a control group. The authors hypothesized that any one deficiency alone (such as in visual-motor coordination) cannot explain reading difficulties; instead, these difficulties may be the result of multiple deficiencies.

The divergent findings from these studies may be a result of inconsistencies in how the variables are defined and measured. For example, visual-motor coordination has been measured with the throw and catch test and the zig-zag run test (Plack, 1968), the Test of Visual-Motor Skills, the Developmental Test of Visual-Motor Integration, and the Bender-Gestalt Test for Young Children (Goldstein & Britt, 1994), a modified Minnesota Manual Dexterity Test and a tapping test (Husak & Magil, 1979). Similarly, the term "reading" is vague. Most studies that include "reading" as a variable do not include measurements of rate, but instead include only reading comprehension and vocabulary. This may neglect one of the most important areas of reading (Carver, 1990).

CONCLUSION

The current study is looking to reevaluate the findings from the 1970's and the perceptual-motor training movement. In essence, the researcher is attempting to examine why it didn't work. Visual-motor perception was correlated against reading as a whole in those studies. Prior research ignored rate as a single entity. Since Marcionese (2002; unpublished) found a significance with undergraduates, the hopes of this study are that 9th and 10th graders also reflect a significant correlation between visual-motor coordination and reading rate. If this is found, visual-motor training may be given a second look in regards to improving reading rate. Thereby improving naming speed, word identification,

and word recognition rate.

Chapter 3

Method

SUBJECTS

Participants in this study were 33 high school students at a small, private, Catholic, college preparatory school. Two participants' data were incomplete and were not able to be used. Therefore, subsequent information and results reflects 32 participants. A power analysis indicated that this sample would be adequate to detect a large effect at the .05 level (Cohen, 1992). The entire population was made up of males. All participants were recruited from the school's freshman and sophomore english courses. Permission letters went home to parents prior to the start of the study. Participants' ages ranged from 14-17 years, with a mean age of 15.03 years (SD = .86).

MATERIALS

Demographics. A short questionnaire was designed for this study. On it, participants were asked to self-report demographic information, including their age, sex, race, and handicaps. Reading Tests. The Nelson-Denny Reading Test, Form G ("Nelson-Denny") was given to test reading, comprehension, and rate. This test includes two parts. The first was a 15-minute vocabulary section and the second was a 20-minute comprehension section. Reading rate was measured during the first minute of the comprehension section. The test takes an average of 40 minutes to complete, including instruction time. The Nelson-Denny has strong reliability and validity data. There is strong support for its reliability through alternate forms reliability and internal

consistency data. The test also shows its validity through its effective use with high school students, undergraduate and graduate students, and professionals.

This study also included a second measure of reading: the 40-letter test ("letter test"; Joshi & Aaron, 2000). For this test, a list of 40 random letters was constructed. These letters were printed on a single 81/2" x 11" standard white sheet of paper. Participants were asked to read the 40 letters as quickly and accurately as possible. Their responses were audiotaped and later, replayed. The time it took participants to read all letters and the number of errors they made were recorded from these audiotapes.

Visual-Motor Tasks. Visual-motor coordination was measured using two tasks. First, participants played the game Perfection, by Milton Bradley. Standard rules for this game allow players to place shaped pegs in corresponding slots in any order. However, for this study, participants were asked to place the pegs in a certain order, from left to right and from top to bottom. The number of pegs correctly placed in a 60-second interval was recorded.

The second measure of visual-motor coordination was a bead-stringing task. For this test, participants were given an unlimited amount of time to string 25 beads onto an 18-inch piece of string. Participants were instructed to use only their dominant-hand and also to only pick up one bead at a time.

PROCEDURE

This was an exact replication of the researcher's prior study (Marcionese, 2002, unpublished). In order for the results of this study to be compared with prior research the procedure was followed precisely.

Testing was conducted over a two-day period of time. The freshman were all tested on the first day and the sophomores on the second. Each individual testing session took approximately 10 minutes. To ensure that results were not influenced by testing fatigue, the administration of the three tests of similar time and ability (Perfection, the letter test, and the bead-stringing task) were counterbalanced. Because of its length and complexity, the Nelson-Denny was administered last. Administration of the Nelson Denny occurred during two separate sessions. The students' english periods were 50 minutes long. This allowed for both instruction and administration. The freshman English class consisted of 18 students who were given the Nelson Denny on the first day of testing. The Nelson Denny was given to the sophomores, 14 students, during the second day of testing.

MEASURES

Reading Tests. The Nelson-Denny was scored in accordance with the publisher's instructions. This yielded two variables: the Nelson-Denny score and the Nelson-Denny rate. The entire Nelson-Denny score reflects participants' vocabulary and comprehension. As previously described, the Nelson-Denny rate reflects the number of words read in the first minute of the comprehension section of the test.

The letter test data was collected from the audiotapes. First, the number of errors was noted and subtracted from the number of letters presented (40). Second, the amount of time it took to read the letters was measured. To ensure accuracy, two independent raters measured this data. If the raters' measurements differed by more than half a second, the data was timed again to determine the correct number. The final variable,

"letter ratio," was calculated by dividing the number of correct letters read by the time taken to read them.

To simplify the presentation of results, an aggregated reading score was derived from these two measures. This score was calculated by averaging the *z*-scores for the Nelson-Denny rate and the letter ratio. In this paper, "reading abilities" refers to this aggregated score.

Visual-Motor Tasks. Perfection was scored by recording the number of pegs that were in their corresponding slot after 60 seconds. Then, the number of errors was subtracted from this score. The number of pegs correctly placed was than divided by the number of seconds given to complete the task. In most cases, this was 60 seconds; however, a few participants completed the task earlier. Thus, the final Perfection score ("Perfection ratio") consisted of the number correctly placed pegs per minute.

The bead-stringing task was scored by recording the time that it took for participants to string 25 beads. The number of beads (25) was then divided by the recorded time to create the final variable, "bead rate."

Again, an aggregate score was calculated by finding and averaging the *z*-scores for the two visual-motor tasks. For the rest of this paper, "visual-motor abilities" refers to this aggregate score.

DESIGN

As stated previously, this research was correlational analysis. A Pearson Correlation was used to analyze the data collected. Raw ratio data, as well as

standardized z-score data, was analyzed using this method. Significances were looked for at both the .05 and .01 levels.

HYPOTHESIS

It was hypothesized that there will be a significant positive correlation between reading rate and visual-motor coordination tasks in high school students. The null hypothesis was that no correlation will exist between the two variables, which were alternate hypotheses.

Chapter 4

Results

Before examining the hypothesis, a number of preliminary analyses were conducted. First, the descriptive statistics for all variables can be found in Table 1.

Table 4.1

Descriptive Statistics for Visual Motor Coordination and Reading Scores (n=32)

	M	(SD)
Reading		
Nelson-Denny Rate	244.16	91.36
Letter Ratio	2.40	.49
Aggregated Reading Score	123.28	45.70
Visual-Motor Coordination		
Perfection Ratio	.22	.08
Bead Rate	.42	.07
Aggregated Visual-Motor Score	.32	.06

Second, inter-correlations were conducted on all visual-motor tasks and all reading tasks to determine if the tasks measured the same underlying variable. The results of these analyses can be found in Table 2. As indicated, the Nelson-Denny rate and letter ratio were not significantly correlated, $r_{(31)} = .07$, $p > .05$, indicating that these tests measure

different aspects of reading ability. Bead rate and Perfection ratio also were not significantly correlated, $r_{(31)}$ =.22, p<.05, suggesting that these constructs may not individually give meaning to visual-motor coordination.

Table 4.2

Correlational Analysis of Visual-Motor Coordination and Reading (n=32)

Ratios	1	2	3	4	5
1. Letter Ratio	--	.14	.35*	.07	-.21
2. Perfection Ratio		--	.22	.26	.07
3. Bead Rate			--	.31	.06
4. Nelson-Denny Rate				--	.16
5. Nelson-Denny					--

* p<.05

Finally, the hypothesis that visual-motor coordination and reading ability were significantly correlated was tested in correlational analyses. Results were significantly correlated in table Table 4.3. As indicated, neither set of individual measures had inter-correlations. However, the aggregated scores for both reading and visual-motor coordination were significantly correlated, $r_{(31)}$=.47,p<.007. Other significances were found among the z-scores. The z-score for Nelson-Denny rate was significant correlated with the aggregated score for visual-motor coordination. Also, the aggregated score for reading and the z-score for letter ratio were significantly correlated with the z-score for bead rate, $r_{(31)}$ = .45,p<.009 and $r_{(31)}$ = .35,p<.05, respectively.

Table 4.3

Correlational Analysis of Aggregated Scores of Visual-Motor Coordination and Reading with Z-scores of Nelson-Denny Rate, Bead Rate, and Letter Ratio (n=32)

	1	2	3	4	5
1. Aggregated Visual-Motor Score	--	.47**	.37*	.78**	.32
2. Aggregated Reading Score		--	.73**	.45**	.73**
3. Nelson-Denny Rate			--	.31	.07
4. Bead Rate				--	.35*
5. Letter Ratio					--

*$p<.05$
**$p<.01$

Chapter 5

Discussion

SUMMARY

The current study was a correlational analysis developed to determine if reading speed correlated with visual-motor coordination. The hypothesis stated that there will be a significant positive significance between reading rate and visual-motor coordination in 9th and 10th grade students. This study was a replication of the researcher's prior research. The differing component was the age of the population of interest. High school boys were the chosen population. Two measures were used to obtain scores for each construct. Reading was measured using the Nelson-Denny and a 40-letter test. While on the other hand, the game Perfection and a bead stringing task measured visual-motor coordination.

Results yielded from the original study showed significance between the two constructs. The findings in the current study proved to be the same, but at a higher level. Current results were whole construct correlations in comparison to the individual measure significances that were found previously.

DISCUSSION

Results supported the hypothesis that there was a significant positive correlation between speed of visual-motor coordination and speed of reading. However, this finding depends on how the variables are measured. Specifically, significant results were found when variables were combined and compared as aggregated scores. This finding directly

supports the hypothesis in question. Subsequently, this supports the idea that high or low levels of visual-motor coordination can help predict the rate at which one reads.

The other significant findings that were found should also be discussed. In Marcionese's (2002) study, Perfection ratio and letter ratio were found to be significantly correlated. This was suggested to mean they were measures using similar stimuli and tasks. Perfection measured participants' ability to identify and physically manipulate symbols whereas the letter test measured participants' ability to identify and read symbols (in this case letters). This study did not support this notion. Instead, the individual measures of letter ratio and bead rate correlated. This could also be a product of design. Each of these measures gave the participant and unlimited amount of time to complete the task. Taking away time as a confounding variable could have possibly given a truer measure of each construct. Bead rate was also significantly correlated with the aggregated reading score. This finding was not surprising, given that the aggregated score includes the letter ratio score.

When variables use different stimuli and tasks, they were not related. For example, the Nelson-Denny was not positively correlated with any measures of visual-motor ability. This may have been due to the complexity of its nature. The Nelson-Denny test was used because it is a standardized measure that provides a measure of reading rate; however, it is designed to also measure vocabulary and comprehension. Fortunately for the purposes of this study, the Nelson-Denny total score does not affect reading rate. The Nelson-Denny reading rate was significantly correlated to the aggregated score for visual-motor coordination. This finding truly helps further the support of the hypothesis. Basically, Nelson-Denny reading rate scores are widely used

and accepted as reliable and valid measures of reading speed. The 40-letter test, which was designed by Joshi & Aaron (2000), has not been used to the same extent and cannot provide the same reliability and validity data. Consequently, in this study it did not prove to be a strong measure of reading rate ability. A whole word approach provided sounder results then its counterpart symbolic representation. That being said we cannot discount the use of the 40-letter test. Multiple measures of both constructs were needed to help give weight to the study. Further research should attempt to add additional measures for each both the constructs of reading and visual-motor coordination. This should be done to take into consideration all aspects of both constructs.

The limitations of this study did not seem to effect the significance of the results. Nonetheless, it is important to understand that this data and the subsequent results were provided by an extremely limited population. These participants were all of the same sex. This does not allow for proper generalization of the results. Another confound provided by the population is their SES. These boys were upper-middle class in a highly competitive, college prep, private catholic boy's high school. Lack of response from other high schools forced the researcher to choose such a limited population. Future research should include a more diverse population.

SUGGESTIONS FOR FUTURE RESEARCH

Additional work is also needed about why visual-motor skills and reading skills are related. The reason that some individuals process information faster than others is itself unclear. There may be differences in strategy usage between individuals with strong reading and visual-motor skills and individuals who are slower on these tasks.

Another possible explanation for the relationship between visual-motor skills and reading abilities is that both tap the same general construct of speed of processing. Speed of processing is thought to be biologically based, perhaps on changes in myelination or neurotransmitters (Salthouse, 1995). As a result, many speed-of-processing tasks show developmental changes. One strength of the current study is that participants were all approximately the same age, eliminating the likelihood that results were due to developmental changes. Rather, the present study suggests that there are individual differences in individual differences in speed of processing that affect both reading abilities and visual-motor skills. This possibility is consistent with studies showing relationships between reading abilities and other speed of processing on other information-processing tasks, such as visual search (Palmer, MacLeod, Hunt, & Davidson, 1985), visual matching (Palmer et al., 1985) and word recognition (O'Reilly & Walker, 1990). In addition, speed of processing is thought to be a primary determinant of intelligence.

There has been a lack of research on the relationship between visual-motor skills and speed of processing. This study suggests that additional research on this topic is warranted. Such studies may not only provide basic research information about the nature of the human information-processing system, but may also have applied purposes. Specifically, it may provide important information in determining appropriate testing protocols for at-risk individuals and developing appropriate treatment and skill-strengthening programs. Ultimately, the researcher's goal is to continue with this research while adding the variable of speed of processing. If this research is also significant,

development of a program that will focus on speed of in order to increase ability in reading rate and visual-motor coordination processing is necessary.

CONCLUSION

1. There was statistical evidence that supports a positive correlation between reading rate and visual-motor coordination.
2. On a narrower scale, there was also support for significance between the strongest measure of reading rate, the Nelson-Denny rate score, and the aggregated score for visual-motor coordination. This strengthens the significance because of the reliability and validity of the test.
3. This study was a replication which once again brought forth significant results. A study needs to be developed for a younger population. Further research also must be completed to make this information more useful.

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