SILENT WORD READING FLUENCY & TEMPORAL VISION PROCESSING

Differences Between Good And Poor Readers

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Abstract

This investigation examined the relationships between indicators of temporal visual processing ability, visual attention, reading comprehension, and a test of reading fluency. Seventh-grade students (N=37) were divided into "good" and "poor" readers based on a standardized comprehension test. All subjects were subsequently tested for fluency (TOSWRF), visual attention (CAS), reading eye movements (Visagraph), rapid automated naming (RAN) and coherent motion sensitivity (CM). All measures were significantly different between good and poor readers, with the exception of three RAN subscales. Spearman correlations between fluency and vision-related variables were significant, except for one RAN subscale, CM, and the number of regressions while reading. Predictions of students' original reading group (good or poor) were significant with relatively high sensitivity and specificity for all vision measures except for RAN subscales and CM. While the current trend in the literature is to emphasize phonological awareness (PA), the current results support the notion that visual attention and visual temporal processing deficits may also contribute to reading problems in children.

Key Words

coherent motion, rapid automatized naming (RAN), reading disability, reading fluency, saccadic eye movements, standardized reading test, visual attention

INTRODUCTION

Currently within the area of reading disability, the majority of educational research on the causes and treatments of poor reading has stressed the phonological deficit hypothesis: Among children with difficulties in learning to read, the fundamental problem is poor phonological awareness (PA).[1] Although this line of research has lead to important insights and productive treatments, additional factors may need to be considered in order to fully understand reading problems. For instance, fluency, one of the most critical areas of reading identified by the National Reading Panel,[2] is mostly unaffected by remediation strategies aimed at improving PA.[3] Indeed, other important factors such as visual processing skills may play a role in poor reading performance, particularly impaired fluency. Although it is well established that visual processing skills are related to reading comprehension,[4] currently there is a dearth of information linking reading fluency to comprehension and visual processing skills.

For the purpose of this study and at its most basic level, reading fluency embraces reading rate and accuracy. *That is*, fluency stresses the ability to silently decode a given visual stimulus rapidly and accurately. Reading fluency also implies grouping words in phrases meaningfully; therefore, it is sometimes called prosodic reading.[5] In this regard, we propose that reading fluency can also involve temporal visual processing skills such as oculomotor efficiency, rapid automatized naming (RAN), coherent motion detection, and visual attention.

The current study is intended to examine the following questions:

1. Do good and poor readers differ in measures of temporal visual processing?
2. In a class that includes above and below average readers, to what extent are the temporal visual processing skills, RAN, visual attention, reading eye-movements, and visual motion sensitivity related to reading fluency?
3. Can measures of temporal visual processing predict which students are good or poor readers?

RELATED RESEARCH

Reading fluency

Reading fluency may be thought of as a measure of the child's cumulative reading skills at a particular educational level. In practice, levels of fluency often are based on word identification skills standardized for the child's age and grade placement. Wolf[6] proposed that rapid word naming speed (serial naming) deficits and phonological core deficits are not necessarily mutually exclusive: There exists a population of children whose treatment regimen may require a dual emphasis on phonological processing and naming speed. The research of Bowers and Swanson[7] supported the view that naming speed deficits were primarily related to orthographic aspects of a reading disability, whereas PA was associated with deficits in word attack skills. Although the former requires spatial processing, temporal processing predominates in the latter. In reading, auditory and visual skills are not mutually exclusive functions.[8,9] Solan et al.[10] reported that during grade one, the common variance between auditory and visual processing increases from 12% to 58%. The intersensory research of Birch and

Belmont strongly supports the notion that auditory-visual integration differentiates good and poor readers.[11] Finally; Wolf and her associates proposed that classifying individuals according to the nature of their deficit is often helpful in planning educational intervention. For example, the RAN task demands an array of learning processes that includes attention, perceptual, conceptual, memory, lexical, and articulatory skills.[12, 13]

Wolf[6] concluded from her research that four diagnostic subtypes were evident within the participants she studied: (1) an average reading group that included normal PA, naming speed skills, and reading skills; (2) a rate group with naming speed deficits, normal phonology, and impaired comprehension; (3) a phonology group of individuals with PA deficit, intact naming speed, and impaired comprehension; and (4) a double-deficit group comprising individuals with naming speed and phonological-awareness deficits that resulted in significant comprehension deficits. As expected, the double deficit group included the poorest readers.

More than three decades have elapsed since Denckla and Rudel proposed and initially standardized the relationship of RAN pictured objects, colors, letters and numbers for normal children.[14] Subsequently, they demonstrated that performance on RAN tests differentiated dyslexic children not only from normal controls, but also from non-dyslexic, otherwise learning-disabled children.[15] Although the components of the RAN series of tests are indeed elementary, the child's ability to respond smoothly and rapidly appears to be an important predictor of reading fluency that, in turn, contributes to comprehension. Intact temporal visual processing appears to serve as a foundation for both, rapid naming and phonological processing. Finally, performance on the RAN task not only suggests a measure of oculomotor skills but also auditory-visual integration (see below).

The magnocellular (M-cell) visual pathway

The magnocellular (M-cell) visual pathway is a motion-detecting area in the brain that is sensitive to visual temporal processing such as the rapid saccadic fixation patterns repeated in the RAN. Thus, it is appropriate to consider the ramifications of defects in the M-cell visual system as a potential impediment to rapid naming and reading fluency. A number of research studies involving functional Magnetic Resonance Imaging (fMRI) have concluded that visual disorders may be just as much a component of reading disability (RD) as language disorder problems.[16] These studies have provided psychophysical and anatomic evidence of an anomaly of the M-cell visual subsystem in RD subjects. In all of their subjects with RD, lateral motion on the retina failed to produce task related activation in the area V5/MT of the M-cell visual subsystem that was observed in controls.[17] Furthermore, Solan, et al. provided clinical experimental evidence in a controlled study that temporal visual processing therapy is an effective procedure to improve silent reading comprehension.[18]

Meta-analyses on factors in reading

Recent research has focused on identifying the critical relationships between deficits in reading comprehension level and other reading related skills. In a comprehensive meta-analysis that involved 49 independent population samples (2,257 correlations), Swanson, Trainin, Necoechea, & Hamill made some interesting observations.[19] Even after correcting for variations in socioeconomic status (SES), ethnicity, and age, many of their correlations that related to PA, RAN, and comprehension were in the low range (mean $r = 0.38$). In general, the average correlations, albeit significant ($p < 0.01$), remained in the same range between kindergarten and grade 6: $r = 0.38$ to r = 0.40. That is, each individual test accounted for about 15% of the variance. Age did not play a significant role in moderating the correlations between PA and RAN. The researchers did not find support for the notion that RAN shares important variance with phonological skills. Thus, it appears that much work remains to be done to identify the other factors that contribute to the variance in reading ability.

In a related meta-analysis, Scarborough integrated the results of 61 research studies to determine that, on average, phonological awareness at kindergarten predicted 21% of the variance in later reading ability scores.[20] While this marks early PA as one of the better correlates of reading ability, the vision-related variables of letter identification and concepts of print similarly predicted 27% and 21% of the variance in later reading ability, respectively. In addition to intact visual functioning, these variables reflect appropriate exposure to, and acquired knowledge of letterforms. Because meta-analytic evidence represents a summary of a large number of peer reviewed data sets, this type of evidence is particularly important in highlighting the multifactorial nature of reading ability and should serve to prompt researchers to search broadly for adequate explanations of RD.

Thus, in an effort to explore the relationships between fluency and all of the potentially important factors reviewed above, the current investigation assessed visual attention, reading eye movements, rapid automated naming, and coherent motion sensitivity in a sample of 7th graders who demonstrated either good or poor reading on standardized tests. It was hypothesized that: 1) Good and poor readers differ in measures of temporal visual processing; 2)Temporal visual processing skills, RAN, visual attention, reading eye-movements, and visual motion sensitivity are related to reading fluency; 3) Measures of temporal visual processing will predict which students are good or poor readers.

METHODS

Subjects

The participants initially were selected from a pool of all grade 7 students at a public middle school in New York City. The authors identified 25 of these students as good readers and twenty-five as poor readers on the basis of routine standardized test scores that had been administered by the classroom teachers the previous spring. The school serves a mixed middle class population consisting of European-Americans, Asian Americans, Hispanic, and African-American children. Fifty-seven percent of the student population qualified for free or reduced cost lunches. All participants were English speaking and attended standard academic classes.

At the start of the academic year, the principal investigator administered the Gates-MacGinitie Reading Comprehension subtests[21] to 37 children (M age= 12.84 years) of the original pool of 50, who volunteered for further testing. Standardized directions were observed precisely. Each participant completed a multiple choice test that included main ideas, reasoning, vocabulary in context, and drawing conclusions. Obtained raw scores were converted to percentiles and grade equivalent scores. The results identified 17 good readers (ND) (*M* percentile = 90.7; *M* Grade Equivalent = 12.3) and twenty disabled readers (RD) (*M* percentile = 26.3; *M* Grade Equivalent = 5.0). Differences between the two groups in reading comprehension were statistically significant for each measurement ($p < 0.01$).

Letters of informed consent that required a parent and participant to agree to the research program were obtained from each family. The research program was approved by the State University of New York, State College of Optometry's Institutional Review Board (IRB). The investigators completed the CITI human research ethics program.

Procedures

The authors performed all tests. At the time they were unaware of the reading status of subjects. Additionally, the tests responses were objective. The following areas were assessed for each subject:

Coherent motion threshold

The researchers used the procedures from Solan et al.[18] to determine CM threshold. Prior research has confirmed that this putative measure of magnocellular integrity distinguishes between above and below average readers by comparing their sensitivity to lateral motion.[22, 23] The participants are differentiated by comparing their ability to distinguish the perception of minimal lateral motion from completely random motion when two rectangles, each with 150 dots, are viewed side-by-side on a computer screen (Figure 1). The random dot kinematogram (RDK) stimulus provides an M-cell sensitivity measure with a high degree of accuracy.

Saccadic eye movements

In order to quantify the participants eye movements, the Visagraph[a] was employed using the procedures detailed in Solan et al. [24] The Visagraph is an infrared recording device that accurately records the eye movements of an individual who is reading a selection for comprehension normally (Figure 2). Normal reading is a dynamic vision processing task that requires a succession of saccadic eye movements from one fixation to the next. (Since the responses to the questions are "yes/no", 8 out of 10 correct answers were required to pass.) Research has indicated

Table 1. Central Tendencies

Comprehension Level and Fluency	Poor		Good		
Measure	Median	Range	Median	Range	Sig
Comprehension Gates-MacGinitie Grade Eq	4.7	5.2	12.5	3.5	<.001
Fluency TOSWRF Grade Eq	6.0	4.8	10.9	7.0	<.001
Rapid Automatized Naming	Poor		Good		
Measure	Median	Range	Median	Range	Sig
RAN Objects Grade Eq	9.7	8.7	12.7	7.7	.001
RAN Colors Grade Eq	10.0	10.3	12.7	9.3	.111
RAN Numbers Grade Eq	12.7	11.0	12.7	5.5	.157
RAN Letters Grade Eq	12.7	10.7	12.7	5.7	.033
RAN2 Grade Eq	8.0	9.7	12.7	6.5	.001
RAN3 Grade Eq	12.7	10.3	12.7	7.0	.146
Visual Attention	Poor		Good		
Measure	Median	Range	Median	Range	Sig
CAS Expressive SS	10.0	14.0	15.5	9.0	< .001
CAS Number Detection SS	9.0	8.0	12.0	8.0	.003
CAS Recep Attention SS	9.0	7.0	11.5	9.0	.016
CAS Sum SS	30.0	18.0	37.5	22.0	< .001
Reading Eye-Movements and Motion Sensitivity	Poor		Good		
Measure	Median	Range	Median	Range	Sig
Rate	132.0	149.0	208.5	169.0	< .001
Fixations	132.0	144.0	103.5	65.0	.001
Regression	24.0	56.0	16.0	25.0	.012
Span	0.8	0.6	1.0	0.6	.002
Duration	0.3	0.3	0.3	0.1	.006
Coherent Motion Mean	7.1	10.8	5.2	11.9	.004

Note: All p values were produced using non-parametric Mann-Whitney U tests. SS = Scaled Score.

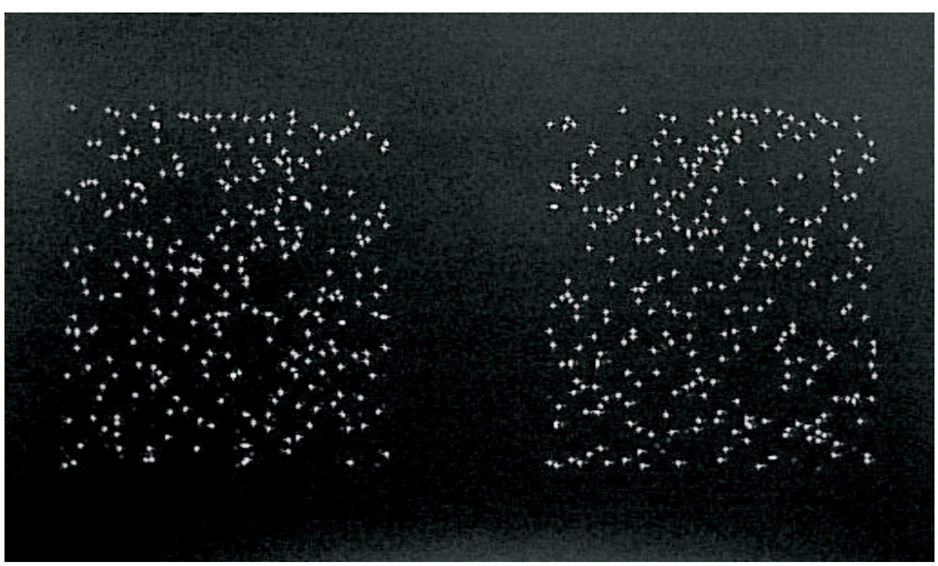

Figure 1. Random Dot Kinematogram (RDK)

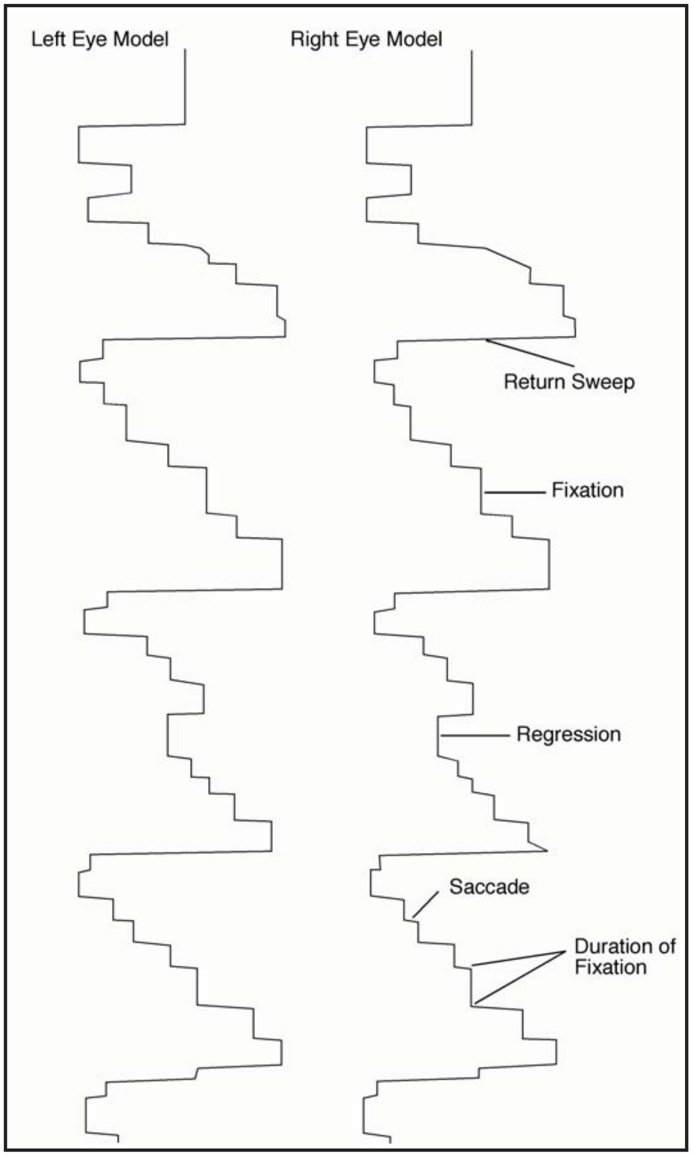

Figure 2. Eye Movement Recordings


seeheinmygogetdoupgreentwodress/
newflewletflytaketreebuyguessput/
overwhystaypeoplebagtryduckourall/
auntlunchsuncrycouldfiveprizehurry/
nightbygivecountcentpopkeptreal/
oakbuildemptyfullsentdeepablenut/
restwaghurtquietfoodkeyrivercomb/
freepoundaimnetrichserveagepurple/
dreweaglebullarrivepolestemfault/
yetsceneoilclubgiraffeagreepolar/

Figure 3. Test of Silent Word Reading Fluency (TOSWRF)

Visagraph recordings of RD individuals reveal a surfeit of fixations and regressions and a reduced rate of reading (Table 1) that contribute to impaired reading fluency, even when the participant is reading at his/her independent reading level.[24, 25]

Visual attention

The goal of attention is to facilitate attending to sources of relevant information and, simultaneously, to produce a decrement in responding to sources of irrelevant information. We propose that visual attention is the catalyst that links perception with cognition. Whereas perception makes visual information available, cognition uses the visual information. The question is, where do perception and cognition meet in a particular individual? Or more precisely, when does perception cease and cognitive processing begin?[26]

The assessment of visual attention consisted of three subtests that comprise the attention scales in the Cognitive Assessment System (CAS).[27] In addition to valuable developmental information, the CAS provides a measure of the student's potential to shift attention (focus). That is, the tests assess how well the child responds to relevant stimuli while being challenged with irrelevant stimuli. The Expressive Attention subtest, the only verbal response test, uses variations in color as distractors and is similar to the Stroop Test.[28] For example, the word GREEN is printed in blue, and the child is expected respond "Blue." The Number Detection subtest, the first of two timed pencil and paper tests, also measures the ability to shift attention and resist distraction. The child is required to underline certain numbers that appear in regular typeface and others that appear in outline typeface. Similarly, the Receptive Attention subtest matches letters according to physical similarity (t and t) and lexical similarity (t and T). The test scores are based on number of correct answers subtracted by the number of wrong answers, and the time required to complete the test. Therefore, the attention quotient represents the total effects of accuracy and automaticity, i.e., correctness and speed. Combined standard scores of the three subtests are available for statistical purposes.

Reading fluency

The instrument used in the present research was the Test of Silent Word Reading Fluency (TOSWRF).[b] The outcome, therefore, measures speed of word identification in silent reading, but not comprehension. In practice, reading fluency is a measure of the ability to read connected text rapidly, meaningfully, and effortlessly, without exceptional conscious attention to the mechanics of reading such as decoding. Others have compromised with a narrower definition that limits fluency to rate and accuracy in oral reading.[29] The TOSWRF (see Figure 3) stresses the ability to recognize words as lexical units.

The test utilizes 32 lines of unspaced words that become progressively more difficult. Maximum time permitted for the test was 3 minutes. Standardized for ages 6 years, 6 months to 17 years, 11 months, raw scores may be converted to standard scores, percentile ranks, and age and grade equivalents. The TOSWRF was administered individually in this study. The test administrator explained the procedures to each student as in the following example:

inyesgomesee

The instructor advised the student to place a line exactly between the n and y, where one word ends and the next word begins: in/yes/... When completed it should appear as:

in/yes/go/me/see

In summary, the test stresses (1) the ability to recognize words as orthographic units and (2) the speed with which sight words are processed. It is easy to administer in a short time. In addition, the test is well standardized, and it has high test-retest reliability. On the other hand, that word meaning and comprehension are lacking and phonemic decoding difficulties are not appraised represent shortcomings of the test.

Rapid automatized naming

Denckla and Rudel[14, 15] developed the concept of Rapid Automatized Naming (RAN) as a valuable tool in understanding the nature of reading problems in the primary grades. These tests of visual and verbal processing measure serial naming speed of letters, numbers, objects and colors in sequence. They are dynamic tests that require the integration of visual attention, verbal, and oculomotor skills. In addition to involving both temporal and orthographic processing, a high level of arousal must be maintained in order to match eye movements automatically with the visual symbols to be identified and articulated.

We utilized the Rapid Automatized Naming/ Rapid Automatized Stimulus Test (RAN/RAS).[30, c] The authors of the RAN tests propose that rapid naming speed is a predictor of reading fluency, a basic requisite for reading comprehension. The RAN/RAS comprise six subtests:

Test 1. RAN Objects: Consists of 5 stimuli (hand, book, dog, star, and chair) that are especially related to childhood, are easily pronounced, and have single-syllable word structure (Figure 4).

Test 2. RAN Colors: Consists of 5 colors (red, yellow, blue, green, black) that appeared in the original research. Stimulus items in each row appear twice per row with no blatant repetitions on a given line (red, red).

Test 3. RAN Numbers: Consists of 5 numbers (2, 4, 6, 7, 9) that appeared in the original research. Stimulus items appear twice per row with no blatant repetitions on a given line (e.g., 2 2, 4 4).

Test 4. RAN Letters: Consists of high-frequency lower case letters (a, d, o, p, s) used in the original research. Stimulus items appear twice per row with no blatant repetitions on a given line (e.g., a a, d d).

Figure 4. Rapid Automatized Naming (RAN)

Tests 5 and 6: RAS 2-Set and 3-Set: Consists of a subset of the stimulus items on the Objects, Colors, Numbers and Letters Tests. A set sequence or stimulus pattern is used throughout each of the tests. In Test 5, stimuli are an alternating pattern of letters and numbers. Test 6 consists of an alternating sequence of letters, numbers and colors.

Raw scores were converted to standard scores, age scores, grade scores and percentiles.

Wolf and Denckla recommend that RAN/RAS Tests should be administered yearly to each kindergarten, first and second grade child, and subsequently if the child's progress is questionable.[30] The tests are useful reading predictors and assessment tools. Since they often identify children who may develop subsequent reading disabilities (RD), the tests are helpful in pinpointing the children who require extra attention.

RESULTS

Non-parametric or "distribution-free" tests were used for all of the analyses in this study for a number of reasons. The majority of variables were found to be not normally distributed according to a Kolmogorov-Smirnov test performed on each score. In cases where small sample sizes are found, as in the present study, violations of the normality assumption can lead to invalid statistical outcomes if parametric tests such as the Pearson's r or t-test are employed.

Preliminary statistics for central tendencies (see Table 1) using Mann-Whitney Tests indicated that the median scores of good and poor reading groups differed significantly on the Gates MacGinitie Reading Comprehension Test (7.8 yrs., $p < .001$) and the TOSWRF Test (4.9 yrs., $p <. 001$). The Rapid Automatized Naming Tests (RAN) results for the good readers were uniformly superior; and poor readers' scores were acceptable for Grade 7 students. On the four CAS Attention Tests, median scores for good readers were significantly better than poor. All subtests of the Visagraph were recorded while reading 100 word selections at each participant's independent reading level (80% comprehension). The average median subtest scores for the good readers were significantly better than poor readers ($p < 0.01$). Finally, the coherent motion (CM) measure of M-cell sensitivity using the RDK stimulus favored the better readers who detected lateral motion with significantly fewer dots ($p < 0.01$). Although not statistically significant ($p = 0.09$), the regression analysis indicated that CM correctly classified 73% of the participants as being either good or poor readers (Table 6).

To determine the relationship between Silent Reading Fluency (TOSWRF) and the primary dependent measures in the study, the scores for each participant (good and poor readers) were entered into a Spearman Rho correlation equation (see Table 2). These analyses revealed significant correlations of fluency (TOSWRF Grade Eq.), with reading comprehension level (Gates Grade Eq.), all Rapid Automatized Naming (RAN Grade Eq.) subtests except for Numbers, all visual attention subtests (CAS Grade Eq.), and all Visagraph eye-movements subscales except regressions. However, TOSWRF did not correlate significantly with Coherent Motion.

The pattern differed when only poor readers were included in the analysis. Obtained correlations for poor readers only are displayed in Table 3: Among poor readers, TOSWRF did not significantly correlate with Gates-MacGinitie Comprehension. Nevertheless, it did correlate significantly with RAN Letters, RAN2, and Visagraph duration and rate in the non-attention subtests. Even with this reduced sample size, the CAS remains significantly associated with fluency in all but the expressive attention subscale.

Yet, a different pattern emerged for good readers in isolation. The obtained correlations for good readers only are displayed in Table 4. TOSWRF and Gates-MacGinitie Comprehension approached significance ($p < 0.075$). In this group, fluency correlates significantly with Expressive Attention, Receptive Attention, and Number Detection subtests as well as the overall sum of CAS scaled score measures. In addition, the RAN subtests of Objects, Colors, and RAN3 correlated significantly with fluency. Unlike poor readers, none of the Visagraph eye movement variables are significantly correlated with Fluency.

Table 2. Correlations Between Fluency (TOSWRF) and Other Measures

All Participants Measure	Rho	Sig
Gates MacGinitie Comprehension		
Gates Gr. Eq.	.781	<.001
Rapid Automatized Naming		
RAN Objects Gr. Eq.	.565	.001
RAN Colors Gr. Eq.	.492	.015
RAN Numbers Gr. Eq.	.374	.575
RAN Letters Gr. Eq.	.513	.001
RAN 2 Gr. Eq.	.624	.003
RAN 3 Gr. Eq.	.468	.019
Cognitive Assessment System		
CAS Expressive SS	.716	<.001
CAS Number Det. SS	.707	<.001
CAS Receptive Att. SS	.739	<.001
CAS Sum SS	.864	<.001
Reading Eye Movements		
Fixations	-.585	<.001
Regression	-.348	.075
Span	.547	.001
Duration	-.502	.004
Rate	.735	<.001
Coherent Motion Threshold	-.270	.098

Gr.Eq. =Grade Equivalent
SS = Scaled Score

Table 3. Correlations Between Fluency (TOSWRF) and Other Measures

All Participants Measure	Rho	Sig
Gates MacGinitie Comprehension		
Gates Gr. Eq.	.303	.194
Rapid Automatized Naming		
RAN Objects Gr. Eq.	.143	.560
RAN Colors Gr. Eq.	.238	.326
RAN Numbers Gr. Eq.	.272	.260
RAN Letters Gr. Eq.	.575	.010
RAN 2 Gr. Eq.	.480	.038
RAN 3 Gr. Eq.	.411	.081
Cognitive Assessment System		
CAS Expressive SS	.214	.366
CAS Number Det. SS	.550	.012
CAS Receptive Att. SS	.632	.003
CAS Sum SS	.782	<.001
Reading Eye Movements		
Fixations	-.242	.304
Regression	.056	.815
Span	.210	.373
Duration	-.451	.046
Rate	.534	.015
Coherent Motion Threshold	.155	.485

Gr.Eq. =Grade Equivalent
SS = Scaled Score

Table 4. *Correlations Between Fluency (TOSWRF) and Other Measures*

All Participants Measure	Rho	Sig
Gates MacGinitie Comprehension		
Gates Gr. Eq.	.456	.075
Rapid Automatized Naming		
RAN Objects Gr. Eq.	.502	.040
RAN Colors Gr. Eq.	.751	.001
RAN Numbers Gr. Eq.	.404	.108
RAN Letters Gr. Eq.	.205	.431
RAN 2 Gr. Eq.	.351	.167
RAN 3 Gr. Eq.	.613	.091
Cognitive Assessment System		
CAS Expressive SS	.650	.005
CAS Number Det. SS	.698	.002
CAS Receptive Att. SS	.852	<.001
CAS Sum SS	.810	<.001
Reading Eye Movements		
Fixations	-.278	.281
Regression	-.200	.442
Span	.299	.244
Duration	-.052	.842
Rate	.263	.307
Coherent Motion Threshold	.064	.807

Gr.Eq. =Grade Equivalent
SS = Scaled Score

Table 5. *Mann-Whitney U Tests for Effect of Reading Ability on Primary Dependent Measures*

All Participants Measure	Rho	Sig
Silent Word Reading Fluency		
TOSWRF	-4.579	<.001
Rapid Automatized Naming		
RAN Objects Gr. Eq.	-3.208	.001
RAN Colors Gr. Eq.	-1.594	.111
RAN Numbers Gr. Eq.	-1.415	.157
RAN Letters Gr. Eq.	-2.134	.033
RAN 2 Gr. Eq.	-3.258	.001
RAN 3 Gr. Eq.	-1.454	.146
Cognitive Assessment Sys		
CAS Expressive SS	-4.158	<.001
CAS Number Det. SS	-2.978	.003
CAS Receptive Att. SS	-2.407	.016
CAS Sum SS	-3.864	<.001
Reading Eye Movements		
Fixations	-3.414	.001
Regression	-2.518	.012
Span	-3.156	.002
Duration	-2.741	.006
Rate	-4.070	<.001
Coherent Motion Threshold	-2.850	.004

Gr.Eq. =Grade Equivalent
SS = Scaled Score

Inferential hypothesis testing (reading level)

Mann-Whitney U analyses (Table 5) were performed to determine the effect of reading level (poor or good) on the primary dependent variables. Significant results indicated that poor and good readers differed on several of the variables of interest. Namely, TOSWRF, all CAS, all Visagraph, Coherent Motion, and three of the RAN subtest scores were significantly different between the two groups. RAN Colors, Numbers, and RAN3 tests were not significantly different.

Logistic regression analyses

The final statistical analysis performed was a series of logistic regressions on the primary dependent measures in order to determine their ability to classify participants as good or poor reader.[29] The results of these analyses are summarized in Table 6 where it can be seen that Visagraph subtests, the TOSWRF, CAS subtests, and the CAS summed score all predicted correct reading group at better than chance levels. Interestingly, among the RAN series of tests, only the RAN Objects subtest showed a classification rate that was significantly greater than chance, while the rest were non-significant. Coherent motion was not significant ($p = .093$), but the results yielded some practical utility with an overall classification accuracy of 73%. TOSWRF Grade Equivalent is the single best classifier. With all participants, good and poor readers, accuracy is 86.5%; with poor readers, sensitivity, the ability to classify subjects according to disorder of interest, reached 95%.

Discussion

The participants provided a significant difference in Grade Equivalent levels on the Gates-MacGinitie and the TOSWRF between good and poor readers (Table 1, $p < 0.001$). However, it was equally important to examine the interrelationship between the two variables. The correlation of reading comprehension and fluency, for all participants, ($r = 0.781$, $p < 0.01$), represents a percent of variance equal to 61%

Table 6. Results of Logistic Regression of Reading Group (Poor Vs Good) by Primary Dependent Variables

Measure	OCA (%)	Sensitivity	Specificity	p =
Fixations	73.0	70.0	76.5	0.007
Regression	67.6	70.0	64.7	0.020
Span	73.0	80.0	64.7	0.006
Duration	67.6	75.0	58.8	0.017
Rate	78.4	85.0	70.6	0.002
Combined Visagraph Variables	83.8	80.0	88.2	0.001
TOS Grade Eq	86.5	95.0	76.5	0.011
CM	73.0	70.0	76.5	0.093
CAS Expressive SS	81.1	90.0	70.6	0.001
CAS Number Detection SS	70.3	75.0	64.7	0.006
CAS Receptive Attention SS	62.2	65.0	58.0	0.017
CAS Sum SS	83.8	90.0	76.5	0.005
RAN Objects Grade Eq	69.4	63.2	76.5	0.020
RAN Colors Grade Eq	63.9	63.2	64.7	0.135
RAN Numbers Grade Eq	47.2	31.6	88.2	0.552
RAN Letters Grade Eq	63.9	36.8	94.1	0.123
RAN2 Grade Eq	75.0	68.4	88.3	0.229
RAN3 Grade Eq	58.3	42.1	76.5	0.160

Note: OCA = Overall Classification Accuracy. All Classification Values are percentages of cases classified correctly. SS = Scaled Score.

(Table 2). That 61% of the variations in reading comprehension can be explained by variations in reading fluency is impressive. When the interrelationship between comprehension and fluency is coupled with the logistic regression analysis data (Table 6), the 95% sensitivity level for classifying poor readers using the TOSWRF alone suggests the potential for a neurocognitive linkage.

The RAN subtests correlated moderately and significantly with fluency for all readers, except for the numbers test, a finding best explained by the ceiling effect seen in the median scores. This subtest may well be too easy to be diagnostically useful with a 7th grade population. On the whole, however, rapid naming proved a consistent correlate to fluency as assessed by the TOSWRF. When good and poor readers are considered separately, different patterns of correlations emerge that warrant further discussion. For the good readers, RAN Objects, Colors, and RAN 3-set were significantly related to fluency, while only RAN Letters and RAN 2-set were correlated for the poor readers. RAN numbers was not significantly related to fluency for either group, a result that suggests the need for further investigation of that subtest's diagnostic utility. Neither group by itself demonstrated a significant correlation between Gates-MacGinitie Reading Level and fluency, a finding most easily explained by the reduction in sample size that occurred when dividing the groups and the inherently bimodal nature of the sample distribution.

Despite the reduction in sample size and greater variability in the scores of the poor reader group, the CAS was a strong correlate of fluency for the RD participants. The fact that all four CAS subtest scores also correlated positively with fluency for good readers supports the critical role of visual attention for fluency development at all levels of ability. The CAS subscale of Expressive Attention, which is a Stroop task, was the only CAS component not significantly associated with poor readers' scores, suggesting that perhaps a component of RD involves difficulty deploying the type of selective attention found uniquely in the Stroop task. This is not surprising given the well-documented co-morbidity of RD and ADHD.[31] However, relatively little work has been done to document and treat the exact subtype of attentional failure associated with RD. Further studies should be undertaken on large samples of RD individuals.

Perhaps the most interesting finding is that for good readers, all of the functional vision measures obtained from the Visagraph were unrelated to TOSWRF scores. In contrast, for poor readers, duration and rate were significantly related to TOSWRF scores. When considered in conjunction with the overall classification accuracy (OCA) of 83.8% in Table 6, this finding lends further support to the premise that eye movements are important for the assessment of RD students. Apparently, functional vision difficulties play a role in poor reading fluency

Wolf, in her conceptualization of the subtypes of reading disability, stressed the *double deficit hypothesis*, phonological and slow naming speed deficits.[6] Although serial naming speed was named as an extraordinary predictor of RD, she did not examine the possibility that the condition could be influenced by visual and/or auditory disabilities. The potential for multifactorial deficits beyond the double deficit hypothesis requires further consideration. Poor phonological awareness (PA) is represented conspicuously in her double-deficit hypothesis; nevertheless it fails to account for the children with adequate decoding and naming skills, but poor comprehension, a viable option. Furthermore, the question of mutual independence of the two deficits still exists. Their hypothesized independence should be resolved in light of the implications for prediction, diagnosis, and intervention.[32]

The children, who lack the prosody necessary for fluent reading, may concurrently be experiencing a temporal vision processing disorder. Is it probable that limited development of fluency in reading would be attributed solely to a breakdown in one specific component (e.g., phonological processing or naming speed) except, perhaps, in the most extreme cases? More likely, the reader would be experiencing the linguistic manifestations of a broader set of temporal limitations with ramifications for word attack, word identification, and comprehension. For example, naming speed has been conceptualized as a complex ensemble of attention, perceptual, conceptual, memory, phonological, semantic, and motoric processing that has precise rapid timing requirements within and across all components.[13]

Wolf[6] rightly asks the question: "Or is naming speed the linguistic tip of a systemic iceberg of temporal problems?" The outcomes of our prior investigations have provided statistical evidence that deficits in temporal vision processing skills are associated with magnocellular (M-cell) deficits in RD children. Moreover, the conditions were ameliorated with vision processing therapy that resulted in significant improvements in visual attention and reading comprehension.[18, 24]

The current investigation did not involve either vision or reading therapy, but future studies may wish to consider the potential effects of a vision therapy program that included enhancement of temporal as well as orthographic processing on good and poor readers. The treatment effect on each group would improve our understanding of the malleability of the vision processing subsystem, in general, and reading fluency, in particular. In the current study, it was noted that correlations involving all participants were quite different from those that included solely good or poor readers. The effect of visual temporal therapy on RAN findings is of special interest since the test engages visual–verbal interaction. Furthermore, as our prior research concentrated primarily on rendering temporal vision therapy solely to RD participants, no effort was made to compare the differential effects between good and poor readers.[18]

Additional avenues of inquiry are open as well. Although the basic composition of reading fluency initially may have appeared simplistic, a review of available research supports the notion that the antecedents of prosodic reading are indeed multifactorial. For example, a careful examination of Table 2 reveals that five of the six RAN tests, the four CAS attention tests, and four of the five eye-movement tests are significantly correlated with fluency. Another research question that requires further clarification is whether M-cell threshold is modifiable. The CAS visual attention battery correlates significantly with coherent motion ($r = 0.41$; $p < 0.01$).[33] CM threshold may be measured using motion sensitivity before and following vision therapy under carefully controlled conditions. Because the CM threshold is a putative measure of visual magnocellular functioning, a magnocellular deficit implies poor motion sensitivity. Therefore, improvements in CM threshold would:

(1) imply that vision therapy actually would be working to enhance magnocellular functioning;

(2) indicate the development of compensatory strategies associated with better cognitive processing and improved selective attention.

Furthermore, converging methodologies from the cognitive neurosciences could be employed to continue to explore the brain correlates of normal and disordered attention and fluency related subskills. For instance, while Eden, et al[17] and other investigators have illuminated the neural substrates of motion processing as it relates to RD, very little has been done thus far to examine the effects of remediation at the level of neural systems. Therefore, participants in future research should: (1) be selectively trained, using only empirically validated visual attention procedures with adequate control groups and (2) include individuals at multiple reading and disability levels whenever possible.

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EDITORIAL continued

seconds and the person is lucid, a yellow ribbon is given. The blanch test for perfusion is accomplished by putting pressure on a finger nail or palm of the hand, and then releasing the pressure. The color of the nail or hand should normally return to a reddish hue within two seconds. If the victim shows no respiration, a black and white ribbon is placed on the body. If the victim can walk, a green ribbon is given. Speed is essential because we are trying to do the most good for the most people in the shortest amount of time.

Medical Operations II covers treatment. We were instructed to select an area that is expandable and easily reached by ambulance. Subsequent topics were basic methods of transporting victims to the treatment area and head to toe assessments. We were taught to treat shock, stop the bleeding, and splint broken bones. An underlying concept in this phase of training was team work.

Search and Rescue was the subject for the fifth week. We learned how to assess a situation: Do we have enough people for the job? What are the dangers to the CERT team? A determination of the type of structure that is involved is made by careful external examination that includes the extent of damage, and the location of entrances and exits. A key aspect of Search and Rescue is how to ascertain the location of people who are in need of help. The action plan involves reporting all information to the team leader in order take actions that are based in proper search techniques, debris removal and victim extrication.

Disaster Psychology was the subject of our sixth class. Team members were warned not to over identify with survivors; empathetic engagement is an occupational hazard for rescuers. We were taught to be alert for symptoms of stress in ourselves, team members, and victims. We learned appropriate measures when signs of stress were evident.

The next class was a simulated disaster drill. Each team member was called to a staging area where we informed the incident commander of damage we observed on the way to the area. We then decided the particular damaged building that required our immediate attention because people were trapped there. The CERT members were divided into teams for search and rescue, fire suppression, triage and treatment. Treatment areas were determined and the team went into action.

I was assigned to search and rescue and triage. When we entered the building there were victims lying on the floor with burns, bruises, broken bones, and some with fake blood. I triaged five victims (four red and one yellow) in what felt like two minutes. The treatment team came in and transported the victims to the treatment area and started dressing, bandaging and splinting. There were twenty-two victims we had to find, triage, transport and treat. It was an exciting exercise that tested all that we had learned.

Terrorism was the subject of the final class. Topics included: weapons terrorists use, clues to identify when the attack occurred or may be imminent, CERT protocols for terrorist incidents, and protective action following an event.

At the end of the class, we received a certificate, helmet, goggles, gloves, shirt, flashlights, dressings and bandages in a CERT bag. Two city commissioners gave short speeches and congratulated the class for volunteering to participate in the program. There were eight people in my class: three men and five women, ages from sixteen to seventy-three. We were informed that, depending one's interest, additional training in first aid, CPR, fire suppression and search and rescue procedures are offered.

The overwhelming feeling of my class was that we were now well trained to productively support local law enforcement, fire and rescue, emergency medical services, and be effective participants in the four stages of emergency management: prevention, mitigation, response and recovery. We have the potential be important helpers and healers in these very turbulent times.

My experience has indicated that optometrists are especially well prepared to be productive members of CERT because of our education, training and experience as primary care health care providers. I strongly encourage you to join CERT; doing this will demonstrate a very tangible sincere and laudable interest, concern and dedication to your community and the nation. You can obtain more information about CERT in your locality at http://www.citizencorps.gov.

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Editors note: Dr. Miele is a past president of the Optometric Extension Program Foundation.