A Proposed Addition to the Standard Protocol for the Visagraph II™ Eye Movement Recording System

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Abstract

The Visagraph II™ Eye Movement Recording System is an instrument that assesses reading eye movement efficiency and related parameters objectively. It also incorporates automated data analysis. In the standard protocol, the patient reads selections only at the level of their current school grade, or at the level that has been determined by a standardized reading test. In either case, deficient reading eye movements may be the consequence of a language-based reading disability, an oculomotor-based reading inefficiency, or both. We propose an addition to the standard protocol: the patient's eye movements are recorded a second time with text that is significantly below the grade level of the initial reading. The goal is to determine which factor is primarily contributing to the patient's reading problem, oculomotor or language. This concept is discussed in the context of two representative cases.

Key Words

fixation, grade level efficiency, oculomotor inefficiency, reading eye movements, reading disability, reading rate, regressions, relative efficiency, Visagraph II™ Eye Movement Recording System, vision therapy

INTRODUCTION

Optometrists are frequently requested to assess individuals with reported reading difficulties. Accompanying symptoms can include: loss of place when reading, skipping of words, headaches, and moderately or severely reduced reading speed.[1] There are only a few standardized optometric tests, such as the Developmental Eye Movement Test,[2] that can be used to assess versional eye movement scanning ability. Inferences are then made regarding how the test results relate to the reading symptoms. However, a more direct approach is the Visagraph II™ Eye Movement Recording System[a] (Visagraph). This is a commercially-available testing system that objectively records reading eye movement with computer automation. It compares the results to a large standardized population over a range of established parameters.[3,4] Hence, it directly measures and assesses eye movements during actual reading, as well as the comprehension level.

Reading problems may be related to two primary factors; these are oculomotor and language. Solan was the first to propose separating these two factors.[5] He identified a group of readers who performed at grade level on standardized reading tests. However, their symptoms suggested an oculomotor inefficiency, such as loss of place and skipping of words when reading. Moreover, this group functioned at a reduced level of reading efficiency. This occurred when their eye movements were objectively assessed while reading text both at, and significantly below, their grade level. Solan proposed vision therapy (VT) with an emphasis on improvements in eye movements for these individuals.

Hence, there is a clinical dilemma with patients who present to optometrists with a reading problem. Specifically, there is a need to determine whether the reading problem is primarily language-based or oculomotor-based.

Applying Solan's earlier work,[5] we propose an addition to the standard Visagraph clinical protocol. Two categories of patients with reading problems will be defined and discussed in the context of case reports where the following protocol was used.

Protocol

Objective eye movements are recorded using the Visagraph Eye Movement Recording System,[6,a] that is based on the infrared limbal reflection technique.[7] The reading eye movement parameters are: fixations/100 words, regressions/100 words, span of recognition, duration of fixation, reading rate, and grade level efficiency. These parameters are automatically computer-analyzed and graphically displayed for comparison to Taylor's established norms.[8]

In the standard protocol, two or more paragraphs are read. They are either one level below the patient's current school grade, since there is a known reading problem, or at their most recent reading grade level as determined by a standardized test. The first paragraph constitutes a practice trial. The second recording is included in the analysis, if at least 70% comprehension is achieved. When comprehension is less than 70%, testing with another paragraph at the same grade level is used, until at least 70% or greater comprehension criterion is achieved**.** If 70% comprehension cannot be achieved after the third trial, the level of the text is arbitrarily dropped one grade level and another recording is attempted. This process is repeated until

the 70% comprehension standard is met. This basic protocol has been previously described.[8]

In our addition to the basic protocol the patient reads a third paragraph; it is up to five grade levels below the level used for the second paragraph. However, since the first-grade level texts are the lowest available in the Visagraph's testing protocol,[4] first grade level texts are used for all patients below seventh grade. Further, all high school students read a fifth-grade level paragraph. The purpose of reading text at a markedly reduced grade level is to ascertain the patient's reading eye movement proficiency per se. We propose that reading comprehension and fluency are then likely to have minimal impact on the reading eye movements.

Computerized Data Interpretation

A computerized summary of all oculomotor aspects that are measured by the second and third paragraph presentations are printed. See Figures 1-4. Each aspect is graphically presented in terms of grade normed data. Particularly noteworthy is the Grade Level Efficiency (GLE) as noted by the star in each figure's graph. It is created by first deriving a Relative Efficiency Score that is based on the following assumptions:[4]

1. Fixations, regressions, and reading rate are the most important components of reading eye movements.
2. Patients who make more regressions are generally less effective readers. Thus, regressions should be allotted additional weight in the overall calculation.

The equation for relative efficiency is: Relative Efficiency = Rate (wpm)/ Fixations per 100 words + Regressions per 100 words.

Relative Efficiency has been grade normed and is referred to as the Grade Level Efficiency (GLE). The GLE is a measure of relative reading eye movement efficiency.[4] It provides an objective grade level numerical indication of the patient's reading performance. The comparison of the patient's GLE on the second (grade level) paragraph to the patient's GLE on the third (five grades below) paragraph is then made within the context of the basic optometric evaluation.

We propose that this results in two basic categories of patients:

Category I

This refers to a patient whose GLE on text, either one level below their current school grade, or at a level determined by a standardized reading test (second paragraph), is at least two grades below their current school grade level. Further, they do not improve their GLEs at least three grade levels, when tested with the reduced grade level text used in paragraph three. This suggests an oculomotor efficiency based reading problem.

Category II

This refers to a patient whose GLE on text either one level below their current grade, or at a level determined by a standardized reading test (second paragraph) is at least two grades below their current school grade level. However, these patients do improve their GLEs at least three grade levels, when tested with the reduced grade level text used in paragraph three. This suggests a language based reading problem.

Category I Case Report-Patient C.S.

C.S. was a 19-year-old male referred to the office by a local optometrist. The patient manifested several symptoms during reading: headaches after 15 minutes, intermittent blur and/or double vision, frequent loss of place, and an extended period of time to complete academic assignments. These were long-standing problems that had worsened over the past 1.5 years. There was no history or evidence of ocular, medical, or neurologic disease, and he was not taking any medications. According to his parents, C.S. learned to read at an early age and was an avid reader until third grade. Afterwards, he gradually exhibited less interest in reading and studying. This trend intensified in high school. C.S. reported that he no longer read for pleasure and was "just about passing" his classes. His clinical findings are presented in Table 1. The Visagraph results are presented in Figures 1 and 2.

Discussion of Patient C.S.

The diagnosis of an oculomotor-based, reading eye movement inefficiency was made on the basis of a GLE of 2.8 on paragraph 2, that did not improve at least three grade levels when 5th grade text was read (paragraph 3). See Figures 1 and 2. Additionally, a language-based reading disability was ruled out, as he was performing adequately in high school, and furthermore, he had been an avid reader until 4th grade.

Analysis of the optometric tests led to the diagnoses of accommodative and convergence dysfunctions. See Table 1. These conditions could well account for CS's vision symptoms and complaints. Furthermore, these conditions could also account for his inability to read for extended periods, as well as his decreased interest in reading. When a patient has difficulty achieving clear, single, and comfortable binocular vision, excessive attention and effort must be diverted to the visual task itself rather than being allocated primarily for efficient reading and understanding of the material.[9]

It is possible that the reading difficulty was also partially due to an underlying versional eye movement dysfunction, i.e., oculomotor dysfunction. This condition is defined by OMD (ICD-9-CM 378.9) and refers to deficits in at least one of three types of versional eye movements (pursuit, saccade and fixation).[1] This may present clinically as frequent loss of fixation when the patient is asked to maintain gaze on a stationary target, inaccurate saccades, jerky (low-gain) pursuit, and/or the inability to sequence saccadic eye movements with verbal directions. C.S.'s eye movements themselves appeared to exhibit normal physiologic attributes (e.g., normal saccadic latency and velocity based on gross visual observation).[7] However, the overall oculomotor efficiency, as indicated by the GLE was reduced per the Visagraphic findings. This might have been due to cognitive or attentional factors,[10] or some yet unknown reason.

While the precise etiology of the underlying reading eye movement inefficiency is unclear, the prognosis for improvement of the accommodative/binocular dysfunctions, as well as OMD, with VT is excellent.[11-13] Our experience has been that the GLE post-VT improves markedly when this Category I clinical oculomotor pattern is present.

Category II Case Report-Patient J.D.

J.D. was a 10-year-old, visually asymptomatic female in the 5th grade. Her parents sought an optometric evaluation based on information found on the Internet suggesting that VT may help in certain cases of reading difficulties. J.D. had recently been diagnosed by her school district's child-study team as dyslexic. She was receiving resource room help in reading and mathematics. This involved leaving her regular classroom for three sessions per week of reading and two sessions per week of mathematics. She had not been left back in school, but was below grade level for reading and mathematics accord-

Table 1. Optometric Findings For Patient C.S.

Test	Exam Result	Normal Range	Clinical Interpretation
Best corrected visual acuity	OD 20/20 OS 20/20	OD 20/20 OS 20/20	Normal
Refractive status	OD –5.25D-0.75Dx010 OS –6.00D-1.00Dx165	N/A	Myopic astigmatism
Distance phoria	Orthophoria	0-2 pd exophoria	Normal
Near phoria	5pd exophoria	0-6 pd exophoria	Normal
Nearpoint of convergence	8 inches	3 inches	Convergence insufficiency
Near convergence range	10pd	18-24 pd	Convergence insufficiency
Near convergence recovery	4pd	7-15pd	Convergence insufficiency
Near divergence range	22pd	18-24pd	Normal
Near divergence recovery	13pd	10-16pd	Normal
40cm plus to blur (NRA)	+2.00D	+1.75 to +2.25D	Normal
40cm minus to blur (PRA)	-1.75D	-1.75 to –3.00D	Normal
Accommodative amplitude	OD 5.50D, OS 4.50D	12.00D	Accommodative insufficiency
Accommodative facility	OD 13, OS 12 cpm	Above 12 cpm	Normal
Vergence facility	13 cpm	Above 15 cpm	Fusional instability
Stereoacuity	20 sec arc	20 sec arc	Normal
Visagraph	Grade level efficiency: 2.8 (at text grade level 10) 3.7 (at text grade level 5)	12.0 or greater grade level efficiency	Reading eye movement inefficiency

Symbols: pd= prism diopters, cpm= cycles per minute

Figure 1. Second paragraph for Patient C.S.

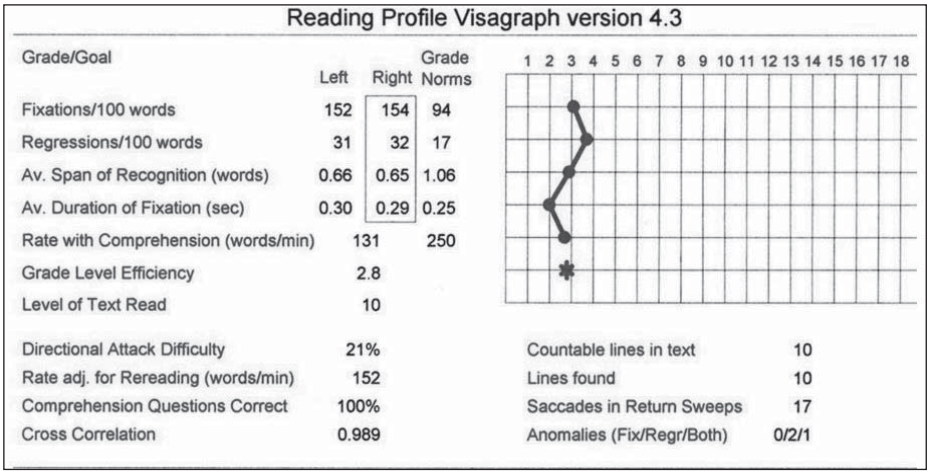
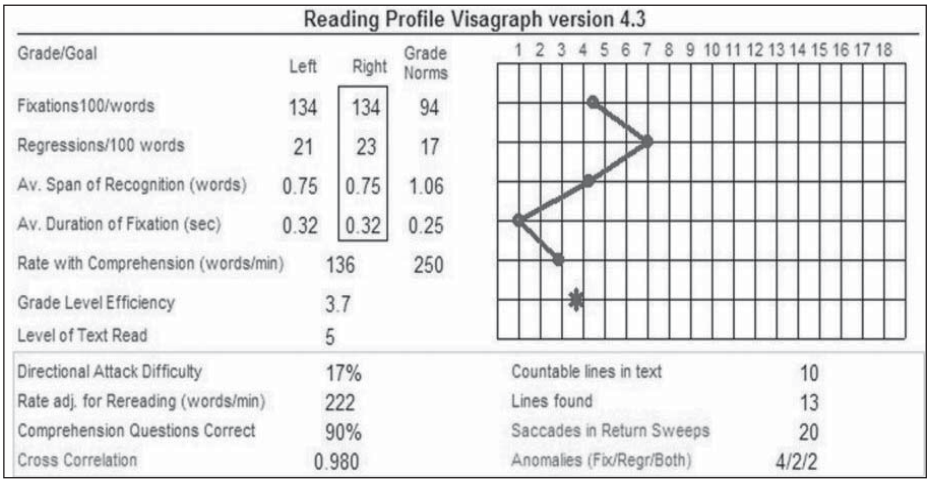


Figure 2. Third Paragraph for Patient C.S.



ing to her mother. She reread assignments when she did not understand them the first time. Her ocular, medical, and neurologic disease history was unremarkable, and she was not taking any medications. However, her father also reported having reading difficulties in grade school, although he did not recall them as being as severe.

Her clinical findings are presented in Table 2. The Visagraph results are presented in Figures 3 and 4.

Discussion of patient J.D.

J.D. had a history of reading disability and was recently diagnosed as being dyslexic. However, the results of the child study team that made this diagnosis were not available at the time of the optometric evaluation. The optometric findings were essentially normal, except for reduced grade-level efficiency on the Visagraph. See Table 2. J.D. was tested on paragraph two with text one level below her current fifth grade school placement. She achieved 100% comprehension at this level, which indicated that it was valid for purposes of analysis.[4] Nevertheless, it was evident that this level of text was quite challenging for her as indicated by the time it took to complete, and that her GLE was only 1.8. See Figure 3. However, when tested with the first grade paragraph, her GLE markedly increased to 5.3, an increase of over three grade levels. See Figure 4. Thus, based upon her other optometric findings and the increase in GLE, there was a strong indication that her reading difficulty was based in language, or possibly other factors. Consequently, further optometric intervention was not recommended.

Conclusion

We have proposed an addition to the standard clinical protocol of the Visagraph that can be used for the optometric diagnosis and management of patients who present with reading problems. Two common clinical categories of reading difficulty have been presented that are frequently encountered in optometric practice. By appropriate variations in text difficulty of the Visagraph paragraph selections,

the clinician can gain valuable information that aids in the diagnosis and prognosis of reading eye movement inefficiencies. These data are considered within the context of the basic optometric evaluation, particularly the patient's accommodative and binocular status.

The proposed revision of clinical protocol and the two representative case examples may help the clinician attain a more accurate diagnosis, and furthermore predict the likelihood of success with VT.

A number of questions remain:

1. What is the appropriate reduction in text difficulty to determine best that language or other factors, as opposed to basic visual factors, are or are not the basis of one's reading problem? Five grade levels (or less) were used here, depending on current school grade level.
2. What improvement of GLE at the lower text level is significant and suggestive that a language-based reading disability per se is not present, but rather that an oculomotor-based reading inefficiency exists and is at least a factor for the reading problem? Based on our clinical experience, at least three levels of improvement on the GLE have been clinically significant. It is also possible that a patient could have both language-based and oculomotor-based components to their reading problem. In these instances, future investigation should be directed at developing a method to determine the relative significance of each to the individual's reading problem.
3. Is reading eye movement inefficiency more likely due to an underlying accommodative/binocular dysfunction or to a pure versional oculomotor-based dysfunction, or both?

The authors have no financial or other interest in the Visagraph II™.

Table 2. Optometric Findings for Patient J.D.

Test	Exam Result	Normal Range	Clinical Interpretation
Best corrected visual acuity	OD 20/20 OS 20/20	OD 20/20 OS 20/20	Normal
Refractive status	OD –1.25D OS –1.00D	N/A	Myopia
Distance phoria	Orthophoria	0-2 pd exophoria	Normal
Near phoria	2pd exophoria	0-6 pd exophoria	Normal
Nearpoint of convergence	2 inches	3 inches	Normal
Near convergence range	18pd	18-24 pd	Normal
Near convergence recovery	10pd	7-15pd	Normal
Near divergence range	20pd	18-24pd	Normal
Near divergence recovery	10pd	10-16pd	Normal
40cm plus to blur (NRA)	+2.50D	+1.75 to +2.25D	Normal
40cm minus to blur (PRA)	-1.75D	-1.75 to –3.00D	Normal
Accommodative amplitude	OD 11.50D OS 12.00D	12.00D	Normal
Accommodative facility	OD 12, OS 12 cpm	Above 12cpm	Normal
Stereoacuity	20 sec arc	20 sec arc	Normal
Visagraph	Grade level efficiency: 1.8 (at text grade level 4) 5.3 (at text grade level 1)	5.0 or greater grade level efficiency	Suspected language based reading disability

Symbols: pd= prism diopters, cpm= cycles per minute

Figure 3. Second Paragraph for Patient J.D.

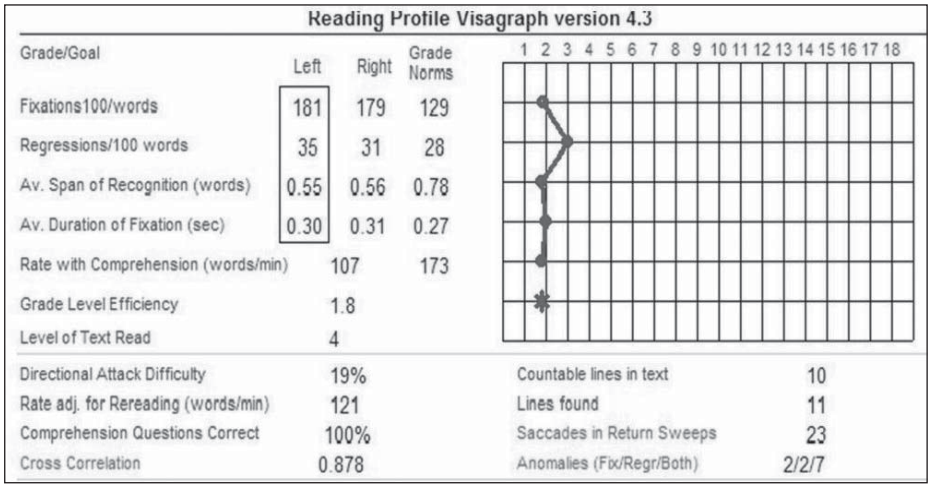
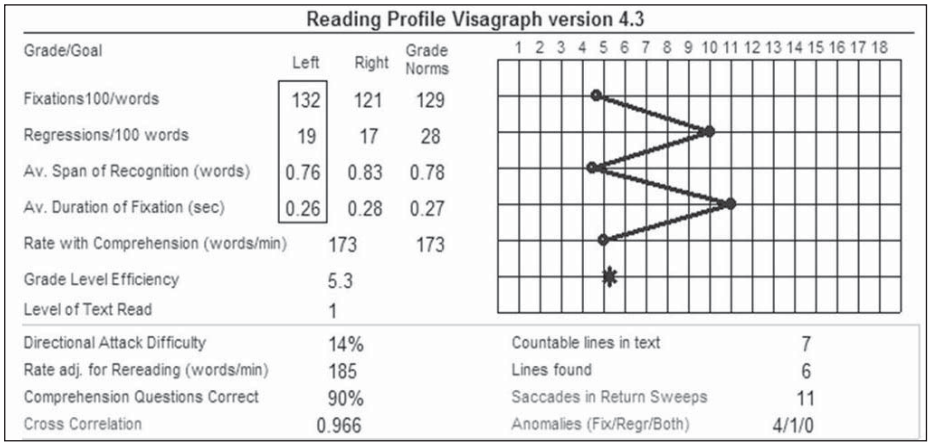


Figure 4. Third Paragraph for Patient J.D.



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EDITORIAL continued

extremely fortunate that OEP assigned Mrs. Sally Corngold as managing editor. This position entails the final phase of the publishing process that involves authors, copy editors and the printing and mailing processes. She and I were on the same wavelength from the first day. I have benefited greatly from her expertise, superb dedication to the *Journal*, and her valued friendship.

My wife Gloria has been an important, but invisible part of the *Journal's* family. I thank her for the support, understanding and encouragement that she has given me as the *Journal's* editor-in chief, and her partnership in my many optometric career changes.

Please note that the title of this editorial is "Some Parting Thoughts." These are not final thoughts because old professors and editors never die or fade away; they just attain the title of *emeritus*, and go on to other things.