

# Article ▶ Duration of Fixation in Patients with Acquired Brain Injury: Retrospective Analysis

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## ABSTRACT

**Background:** The use of objective eye movement measuring devices, such as the Visagraph or ReadAlyzer, has gained popularity in patients with acquired brain injury (ABI) in order to address their common complaints of reading difficulty. Based on our clinical experience, we have found a specific recording pattern in these patients, where the duration of fixation is increased proportionally greater than other test findings.

**Methods:** A retrospective research study was conducted to determine the characteristics of Visagraph/ReadAlyzer results in 36 patients with ABI.

**Results:** Our results show that out of 36 patients, 75% showed a pattern where the duration of fixation was increased, and a reduction of at least two grade levels as compared to the second-lowest component of the recording was present.

**Conclusion:** It is common to see increased duration of fixation in patients with a history of ABI. This may indicate a reduction in information processing. Tachistoscopic activities, as a part of a vision rehabilitation program, will be beneficial for these patients in order to improve their reading ability further.

**Keywords:** acquired brain injury (ABI), cerebrovascular attack (CVA), duration of fixation, ReadAlyzer, traumatic brain injury (TBI), Visagraph, vision rehabilitation

## Introduction

Computerized eye movement recording systems, such as the Visagraph (Compevo AB, Stockholm) and the ReadAlyzer (Compevo AB, Stockholm), are widely used to assess objectively the eye movements used in reading. Since the systems analyze and show different components of reading, including the number of fixations and regressions, fixation duration, span of recognition, reading comprehension, and reading rate with comprehension,<sup>1-3</sup> they are useful in analyzing with which specific reading skills an individual is having difficulty, and they allow clinicians to customize therapy.

It has been determined by numerous studies that patients with acquired brain injury (ABI), including traumatic brain injury (TBI) and cerebrovascular attack (CVA), often experience oculomotor dysfunction.<sup>4,5</sup> As these patients commonly complain about reading difficulty post-trauma, the Visagraph or ReadAlyzer can be used as a useful clinical tool in this population.

Interestingly, it is our observation that many of the patients with a history of ABI show a specific pattern on the Visagraph/ReadAlyzer recording. That is, in addition to any other eye movement difficulty, they often show a distinctive increase in the duration of fixation. To determine further the occurrence of this pattern, a retrospective analysis was conducted at the Pacific University College of Optometry.

## Method

We reviewed all of the Visagraph II and ReadAlyzer recordings saved in our recording system from December 2009

to October 2013. We also found several paper records prior to December 2009 and included them in our analysis. The patient data from the recording systems was then cross-referenced with the electronic medical record system of the Pacific Eye Clinic in order to identify the patients with a history of TBI or CVA. Once these patients were identified, their medical histories, optometric examinations, and Visagraph/ReadAlyzer recordings were reviewed.

The adult patients were tested on a level 10 reading text with their best near correction and were instructed to read silently, as they would do normally. After obtaining the first recording, they were retested with another reading text at the same level for test consistency and to ensure that the reading comprehension was at least 70%.<sup>5,6</sup> Usually, at least 2 valid test recordings we made following the trial run. The resultant graphs, reflecting the grade norm value, were evaluated.

## Results

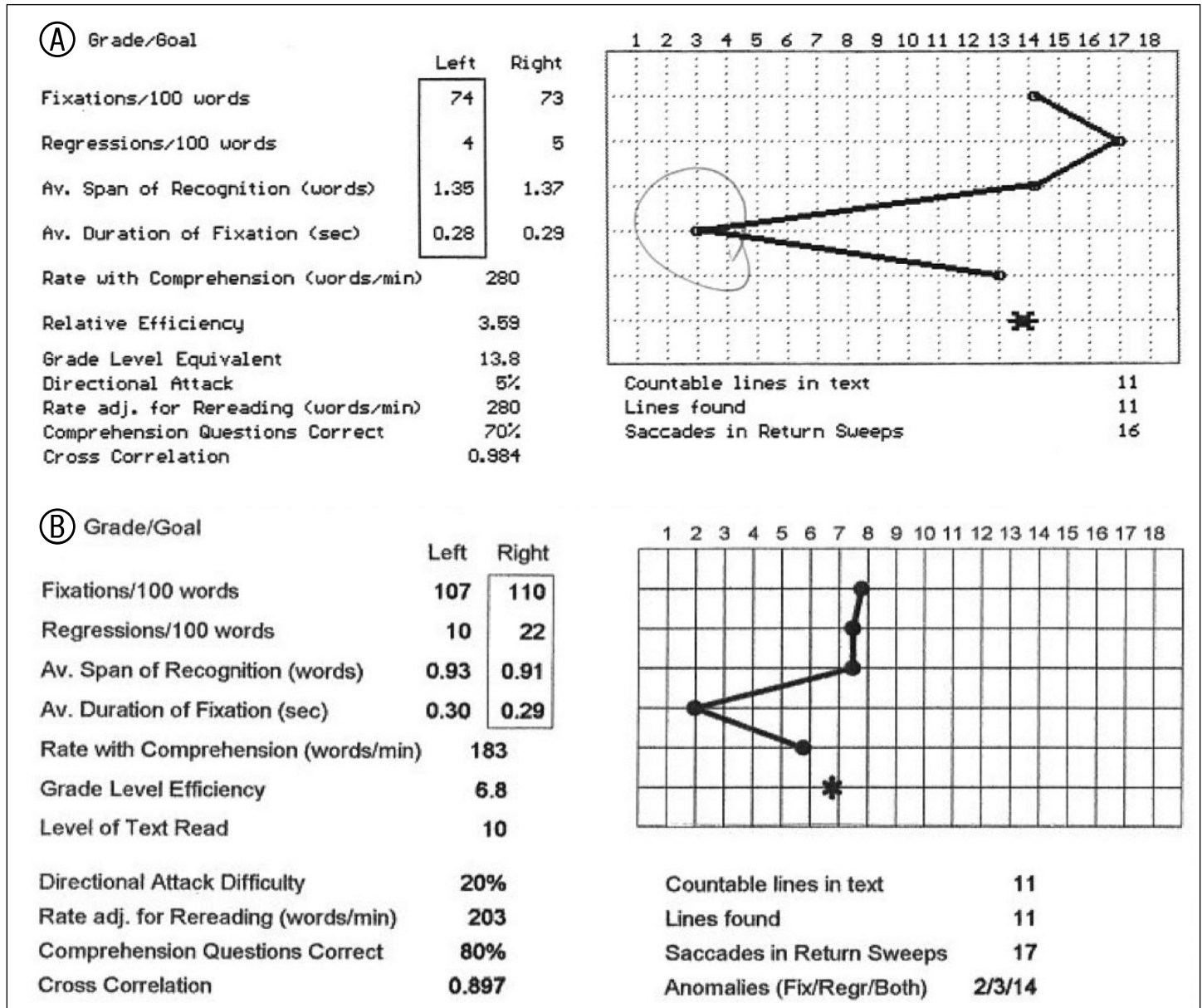
A total of 36 patients were included in this retrospective analysis. Seventeen patients (47.2%) had history of motor vehicle accident (MVA) and 16 (44.4%) had other types of TBI, including blunt trauma to the head and falling incidents (Table 1). Three patients (8.3%) had a history of CVA. The age range was 18 to 91 years, with a mean age of 48 years and a median age of 45 years. The length of time since the accident ranged from 1 month to 10 years (Table 2). Out of 36 total patients, 27 patients (75%) showed a pattern on the Visagraph/ReadAlyzer recording where the duration of fixation was increased<sup>3</sup> (i.e., increased time spent during each fixation)

**Table 1: Type of Acquired Brain Injury (ABI) of the Patients Included in the Study**

Type of ABI	Number of subjects (%)
TBI: Motor Vehicle Accident	17 (47.2%)
TBI: Others (hit, fall, etc.)	16 (44.4%)
CVA	3 (8.3%)
Total	36 (100%)

**Table 2: Demographic Characteristics of Patients Included in the Study**

Age Range (years)	18-91
Mean	48
Median	45
Gender	
Male	16 (44.4%)
Female	20 (55.6%)
Duration since the injury	1 month-10 years
Mean	1.7 years



**Figures 1a & 1b.** Sample Visagraph readings of patients with a history of ABI showing a pattern of increased average duration of fixation.

compared to the measurement of other components. A typical graph of such a pattern is shown in Figure 1.

## Discussion

A number of studies have determined that patients with a history of brain injury experience various oculomotor dysfunctions.<sup>4,5</sup> From these studies and our experience, reduced reading ability is one of the most common complaints with which these patients present.<sup>6-8</sup> Eye movement recording systems, such as the Visagraph or the ReadAlyzer, offer a method to distinguish oculomotor-based problems from accommodation or vergence problems, which are also common post-head trauma.

## Understanding Visagraph II/ReadAlyzer Measurements

To understand the relationship between the patient's symptoms and eye movement recordings, it is critical to understand each component of the measurement. The components assessed include number of fixations, number of regressions, duration of fixation, and overall reading rate; they are compared to the Taylor's grade norm in order to determine the individual's equivalent grade level.<sup>1,2</sup> In addition, reading comprehension is obtained based on the reader's ability to answer ten questions relevant to the text that they read.<sup>1,2</sup> There has been a suggestion to repeat the recording at the same or reduced reading level when the comprehension is below 70% as the readers are presumably scanning rather than reading.<sup>1,9</sup> The number of fixations is the total number of "events" or "stops" in eye movement.<sup>1-3,10</sup> Poor readers tend to make more fixations to read and to interpret the text.<sup>1-3,10</sup> A regression is a backward eye movement that occurs in order to re-read a portion of the line, and it is a process of normal reading.<sup>1-3,10</sup> Poor readers often show an increased number of regressions.<sup>1,7</sup> The span of recognition is also an important concept in reading. It is the part of a word or line that the reader is able to perceive and to interpret during a single fixation.<sup>6,11</sup> Finally, the time required for the interpretation of the text covered by the span of recognition is called the duration of fixation.<sup>2,3,10</sup> During this time, the eyes remain fixated, and the readers need to comprehend and appropriately make associations and responses to the context of the text.<sup>2</sup> Each parameter evaluated needs to be interpreted carefully as it is informative in understanding the patient's reading ability.

## Interpretation of Recording Pattern with Increased Duration of Fixation

Some have suggested that the duration of fixation measurement of the Visagraph/ReadAlyzer is relatively unreliable as there is limited variation of the measurement based on Taylor's norm (grade 1=0.33 seconds; college level=0.24 seconds).<sup>2,3</sup> However, in order to minimize the inter-test variability, the program discards the values from the beginning and the end of the recording and only includes the values obtained from the middle lines of the reading passage.<sup>1,3</sup>

In addition, when the same pattern of increased duration of fixation is evident on two repeated recordings, we believe that it has diagnostic significance. One of the possible causes of such a finding in patients with ABI is a disturbance to the neurological sequence that is involved in generating the pulse-step neural signal that results in horizontal saccades. During reading, the primary high-level control structures, such as the frontal eye fields and the superior colliculus, send the signals to the pause neural cells.<sup>12</sup> Their inhibitory effect allows the excitatory burst cells to fire in order to generate the pulse-step saccadic signal that eventually gets transmitted to the appropriate extraocular muscles and initiates horizontal saccadic movement.<sup>12</sup> The increased duration of fixation may occur if there is a disruption in this process that causes any delay in generating the saccadic movement between each fixation.

A visual information processing deficit is another possible cause that results in increased fixation duration. It can suggest that the reader cannot "take in" the words in a sufficient amount of time, which is caused by one's slowness in processing words.<sup>2,10</sup> The time spent at each fixation may increase further when these patients are mentally sounding out some words in order to assist with their visual retention.<sup>1</sup> In fact, many patients with a history of ABI also concurrently show deficits in visual information processing skills in addition to reading difficulty. Based on this finding and a successful visual perceptual treatment strategy in these patients, which is elaborated in the next section of this article, the latter is a more suggestive contributor than the neurological saccadic process disturbance.

## Treatment Strategy for Increased Duration of Fixation

Many studies show the effectiveness of pure oculomotor training, including fixation, basic saccades, pursuits, and simulated reading, in subjective and objective improvement of oculomotor dysfunction in patients with ABI.<sup>6-8,11</sup> However, none of these studies accounted for duration of fixation and its measurement, interpretation, or training strategies. Although all of the oculomotor training indirectly targets visual attention,<sup>6,11</sup> a specific training mechanism for rapid perception using tachistoscopic activities needs to be incorporated effectively to reduce the length of fixation.<sup>6</sup> Tachistoscopic activity requires the individual to recall the visual information, such as letters or words, that is "flashed" for a short period of time. As one improves with the task, the exposure time is decreased in order to increase the challenge. This activity is appropriate and relevant for improving this visual perception-based finding, as it requires the individual to perceive and to retain visual information for immediate recall.<sup>2,10,13</sup> This specific type of training encourages a higher level of attention and helps to develop word recognition.<sup>2,10,13</sup> With computerized technologies available, training programs are readily accessible through programs such as Vision Builder, Visual Information Processing Skills (VIPS), and Perceptual Home Vision Therapy System (PTS). Decreasing the duration

of fixation using tachistoscopic training can improve the span of recognition, which further enhances reading efficiency, as fewer fixations are required.<sup>2,10,13</sup> In other words, by enhancing the ability to perceive, to interpret, and to retain the text read at each fixation, the overall reading ability can be improved.<sup>2,10,13</sup> A number of cases were reported where tachistoscopic training alone achieved significant improvement not only in duration of fixation and span of recognition, but also in reading rate and reading level.<sup>2</sup>

### Suggestions for Further Studies

Despite the strong evident pattern of increased duration of fixation in ABI patients, our analysis has some limitations that warrant further research. Due to its retrospective nature, information about the specific location in the brain that was affected by TBI or CVA was not readily available. Therefore, it was not possible to determine any association between such findings on the Visagraph/ReadAlyzer and the particular area of the brain involved. In the future, any correlation between increased duration of fixation and specific locations of damaged brain structure should be further studied by including the neuroimaging technology to assist with the proper rehabilitation training in patient populations with ABI.

### Conclusion

Based on our retrospective analysis of Visagraph/ReadAlyzer eye movement recordings, 75% of patients with TBI and CVA who were tested with the devices showed a disproportionate decrease in grade-level equivalence for duration of fixation relative to the other aspects measured. We believe that tachistoscopic activity would be a beneficial part of their vision rehabilitation program. The relationship between the increase in duration of fixation and cortical insult should be further examined by correlating with neuro-imaging studies in future investigation.

### References

1. Compevo AB. ReadAlyzer: Getting Started. Compevo AB. Stockholm, Sweden.
2. Taylor EA. The Fundamental Reading Skill, as Related to Eye-Movement Photography and Visual Anomalies, 2nd ed. Springfield, IL: Charles C. Thomas, 1966:30-52.
3. Taylor EA. Visagraph: Eye-movement Recording System. New York, NY: Taylor Associates, Inc., 1995.
4. Bulson R, Jun W, Hayes J. Visual symptomatology and referral patterns for operation Iraqi Freedom and Operation Enduring Freedom veterans with traumatic brain injury. *J Rehabil Res Devel* 2012;49:1075-82.
5. Ciuffreda KJ, Kapoor N, Rutner D, Suchoff IB, et al. Occurrence of oculomotor dysfunctions in acquired brain injury: A retrospective analysis. *Optometry* 2007;78:55-61.
6. Thiagarajan P, Ciuffreda KJ, Capo-Aponte JE, Ludlam DP, Kapoor N. Oculomotor neurorehabilitation for reading in mild traumatic brain injury (mTBI): An integrative approach. *Neuro Rehabil* 2014;34:129-46.
7. Ciuffreda KJ, Han Y, Kapoor N, Ficarra AP. Oculomotor rehabilitation for reading in acquired brain injury. *Neuro Rehabil* 2006;21:9-21.
8. Han Y, Ciuffreda KJ, Kapoor N. Reading-related oculomotor testing and training protocols for acquired brain injury. *Brain Research Protocols* 2004;14:10-2.
9. Kapoor N, Ciuffreda KJ, Han Y. Oculomotor rehabilitation in acquired brain injury: A case series. *Arch Phys Med Rehabil* 2004;85:1667-78. Taylor SE. Fluency in silent reading. New York, NY: Taylor Associates, Inc., 2006.
10. Tannen BM, Ciuffreda KJ. A proposed addition to the standard protocol for the Visagraph II eye movement recording system. *J Behav Optom* 2007;18:143-7.
11. Ciuffreda KJ, Tannen B. Eye Movement Basic for The Clinician. St. Louis, MO: Mosby-Year Book, Inc., 1994:36-71, 161-83.
12. Godnig EC. The tachistoscope, its history and uses. *J Behav Optom* 2003;14:39-42.

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