VISAGRAPH Baseline Analysis & Procedural Guidelines

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Abstract

The Visagraph II system has gained popularity as a standardized, objective, and automated method to assess specifics of reading eye movements and, by inference, global reading ability (i.e., reading rate and grade level equivalent) in both adults and children. However, procedural guidelines for the proper determination of a valid and stable baseline for comparative purposes have yet to be established. Thirty visually-normal adult subjects without self-reported reading or related disabilities read five standardized high school/college level 10 Visagraph paragraphs in consecutive trials within a single session. Habitual refractive correction for near was worn during all testing. Detailed instructions and procedures were provided to each subject. Eye movements were objectively recorded, computer analyzed, and compared with Taylor's normative database to establish grade level equivalent and reading rate. Trend analysis of these two parameters revealed five patterns; namely, those who: (1) remained constant throughout the five trials (63%), (2) shifted abruptly upward after either one or two trial paragraphs to a new level and then remained constant (6.5%), (3) shifted abruptly downward after either one or two trial paragraphs to a new level and then remained constant (6.5%), (4) progressively decreased and plateaued after three trials (17%), or (5) progressively increased and plateaued after three trials (7%). The results suggest that with full instructions and procedural guidelines, at least three practice paragraphs should be administered prior to formal testing to assure a valid and stable baseline determination in adults.

Keywords

eye movements, practice effects, reading, reading rate, Visagraph

Introduction

The Visagraph II reading eye movement system (Instructional/Communications Technology, Inc., Huntington Station, New York) has been available for over a decade. There has been a recent increased use by optometrists and reading remediation centers for diagnostic and therapeutic purposes in both adults and children. It provides a standardized, objective, and automated method to assess specifics of reading eye movements, as well as overall global reading ability. However, methodologies and criteria vary considerably among individual optometric practitioners and others who use this system, as no universally accepted standard protocol has been established. Of particular importance is the establishment of a stable and valid baseline, since this is the reference point for all subsequent comparisons (i.e., to assess therapeutic effects, fatigue effects, neurological/ocular disease progression effects, etc.).

However, there is relatively little information in the literature relating to the topic of stable and valid baseline establishment.[1] Only the Taylor,[2,3] Griffin and Grisham,[4] and Yolton[5,6] groups have suggested at least one practice trial before actual reading baseline measurements are obtained. Such a vague instruction, however, is of limited practical value. Furthermore, procedural guidelines vary considerably.[1-6] Hence, the purpose of the present investigation was to develop and test standard procedures and criteria for determination of a stable and valid baseline reading rate and grade level equivalent in a normal adult population.

Methods:

I. Subjects:

Thirty visually-normal adults ranging in age from 20 to 59 years, with a mean age of 28 years, served as subjects. This included 10 males and 20 females. All had binocular visual acuity of 20/20 or better at distance and near with their current optical corrections. Habitual refractive prescription for near was worn during all testing. None had self-reported reading disabilities, or neurological/ocular/binocular problems, that could interfere with reading performance. At the time of testing, none was taking any drugs or medications that could affect alertness, attention, or oculomotor control. All were fluent in the English language.

II. Apparatus:

Objective eye movements were obtained using the Visagraph II eye movement system, which is based on the infrared limbal reflection technique,[1] in conjunction with the associated automated computer analysis programs.[1,5] These programs employ Taylor's well-established normative values for comparative purposes in the global analysis and grading of reading ability based solely on one's eye movements and comprehension.[2,3] Five of the 10 standardized high school/college adult level 10 paragraphs were selected for the test trials based on having the least degree of topical familiarity. These included the following paragraphs: #87-Admunson, #90-John Roebling, #91-Dorothea Dix, #92-Clarence Darrow, and #95-Sir Ernest Shackleton.

III. Procedures:

The eye movement goggles were placed on the subject and adjusted per the instruction manual for the near interpupillary distance. The head was then placed in a chinrest with an attached forehead stabilizer. The test paragraphs were placed 16 inches from the apex of the cornea on a reading stand raised slightly above eye level to avoid signal interference from the upper eyelids as they lowered downward during reading. The reading stand and test materials were centered along the subject's midline.

Subjects were seated adjacent to the Visagraph computerized eye movement system, and the following standard instructional set was read verbatim to each individual:

1. You will be given five paragraphs to read with approximately 1-minute rest periods interspersed; all instructions are the same for each paragraph.
2. Look at the dot at the top of the page.
3. Begin reading when the blank cover page is removed from the front of the test paragraph, and you hear a beep from the computer.
4. Read the paragraph once silently.
5. Do not re-read.
6. Read for comprehension, because ten detailed "yes/no forced-choice" questions will immediately follow (i.e., dates, objects, colors, etc.). Read normally like you would a textbook.
7. When you are finished reading, close your eyes and say "done".
8. Keep your head steady and against the forehead rest at all times.

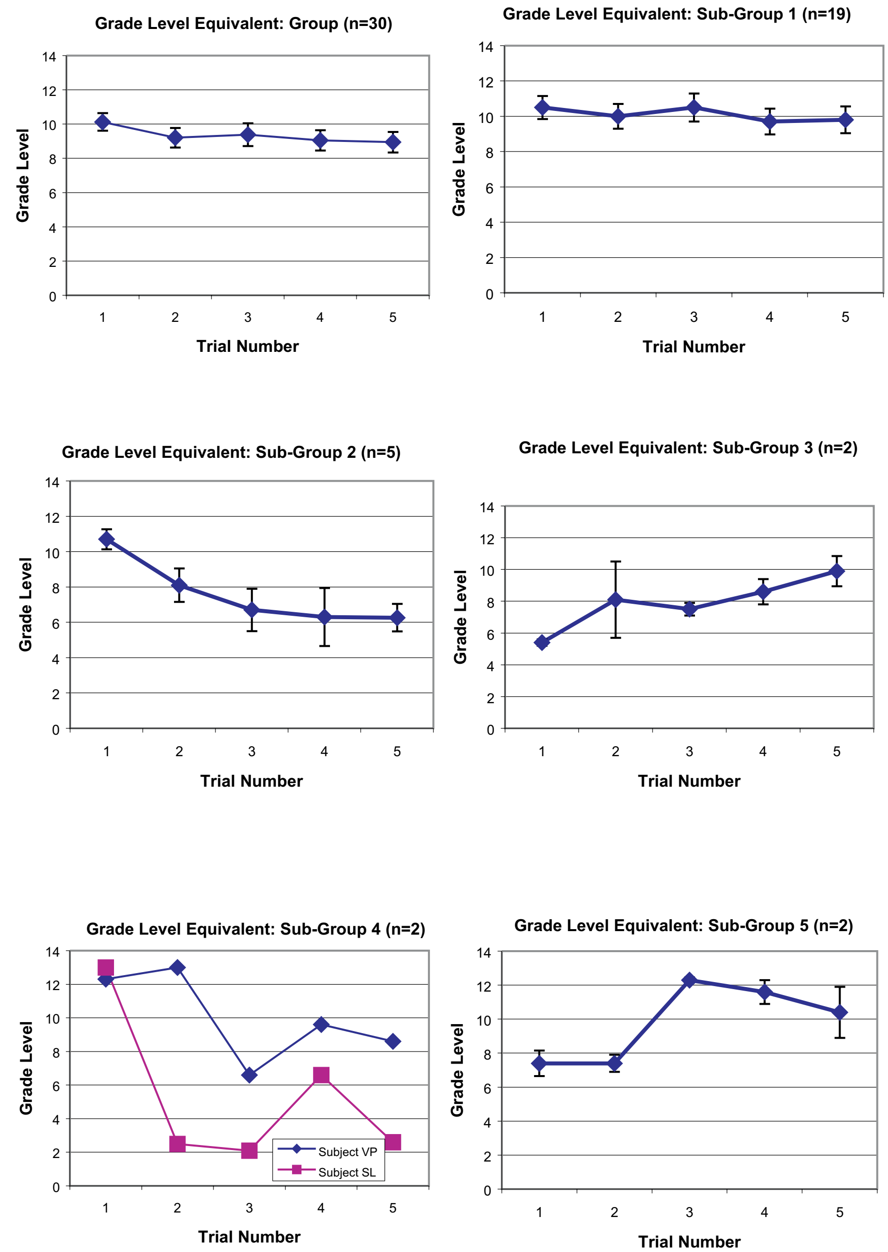

Figure 1. Group and sub-group grade level equivalent as a function of trial number. Plotted is the mean ± 1 SEM.

When needed, the following feedback was provided to the subjects:

1. If the comprehension fell below the minimally acceptable level of 70%,[3] which was rare, the subject was reminded that it is important to read for comprehension, as the test questions are detailed. However, the trial was not discarded.
2. If the eye movement traces were markedly unequal in amplitude or contained considerable artifacts, the records were discarded, the trial redone with a different paragraph, and the subject was reminded to keep the head steady in the headrest.
3. If excessive blinking obscured much of the eye movement traces, the trial was redone with another paragraph, and the subject was asked to keep the eyes open widely and to try to reduce their blink rate.

After completion of the reading of each paragraph, the subject's head was removed from the headrest but with the goggles remaining in place. They then read the 10 "yes/no" comprehension questions silently and directly from the computer screen, which now faced them, with the experimenter denoting their answers. The response to the last question was not entered, until the screen was turned away from the subjects to avoid having them see and potentially be influenced by their scores.

The eye movement recordings were analyzed by the Visagraph's computer program, which uses Taylor's normative values for comparison.[2,3] Several standard parameters were measured and plotted on the Taylor chart profile;[1,2] however, in the present experiment, only grade level equivalent and reading rate were considered in the analysis, as they provide a meaningful global assessment of reading ability. These two parameter values were then graphed as a function of trial number using an Excel program on a separate PC.

Results:

I. Group:

The group data (n=30) exhibited stable responses across the five consecutive test trials. The mean grade level equivalent was 9th grade, with a standard error of the mean (SEM) of ± 0.6 grade levels (Figure 1). A similar trend was found with respect to reading rate, which had a mean of 225 words/minute with an SEM of ± 10 words/minute (Figure 2).

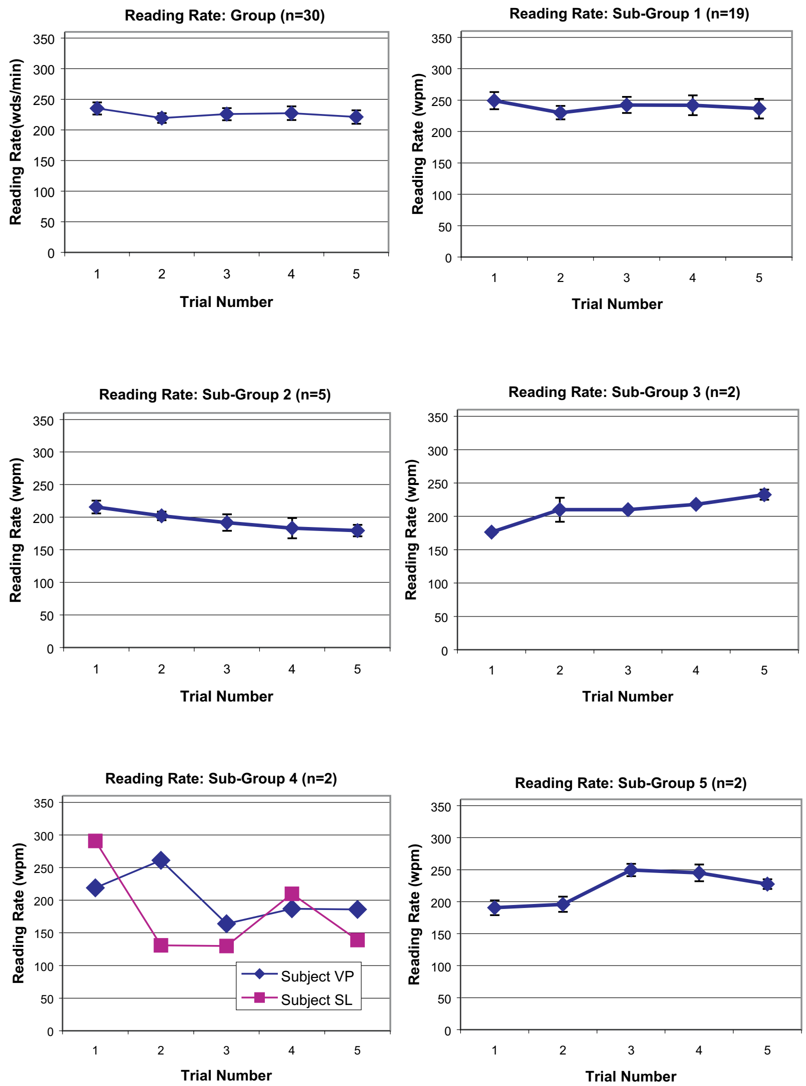

Figure 2. Group and sub-group reading rate as a function of trial number. Plotted is the mean ± 1 SEM.

II. Sub-groups:

The group data were subdivided into five sub-groups based upon their trial-by-trial variability and compared with the group data using a criterion of values exceeding ± 2 SEMs (i.e., greater than ± 1.2 grade level equivalents or ± 20 words per minute reading rate above or below the group data). If the individual trial responses did not exceed the above criteria, the subject was placed into sub-group 1; however, if it exceeded either of these values, the subject was placed into one of the other sub-groups depending upon the overall response profile (Figures 1 and 2) as described below:

1. Sub-group 1 (n=19; 63%): The majority of subjects exhibited a stable and consistent response pattern, similar to that of the group data. Mean grade level equivalent was 10, with an SEM of ± 0.7. The same trend was evident with respect to reading rate, which had a mean of 240 words/minute and an SEM of ± 14 words/minute.
2. Sub-group 2 (n=5; 17%): These subjects showed a decreasing exponential response pattern, with a plateau occurring at the 3rd trial. The mean grade level equivalent decreased from 11 to 6. A similar pattern was found for mean reading rate, with it decreasing from 220 to 180 words/minute before stabilizing.
3. Sub-group 3 (n=2; 6.5%): In contrast to sub-group 2, these subjects exhibited a progressively increasing exponential trend. Mean grade level equivalent increased from 5.5 to 10. Mean reading rate paralleled the above, with it increasing from 175 to 230 words/minute before stablizing.
4. Sub-group 4 (n=2; 6.5%): Since each of the two subjects shifted abruptly on a different test trial, the individual subject data were not combined. This sub-group exhibited a discrete shift downward after either the first or second trial, and then stabilized. For example, grade level equivalent of subject SL decreased from 13 to 4, and reading rate decreased from 290 to 170, both after the 1st trial.
5. Sub-group 5 (n=2; 7%): This sub-group did the opposite of sub-group 4, as it increased abruptly after the 2nd trial, and then stabilized. Mean grade level equivalent shifted from 7.5 to 10.5, with mean reading

rate increasing from 190 to 230 words/minute.

III. Reliability:

Four subjects were re-tested approximately 4 weeks later using similar level but different story content Visagraph II paragraphs. Three of the subjects maintained their initial baseline levels. This is presented for two of them (M.E. and M.K.) in Figure 3. However, one subject (B.H.) did not, but rather increased at the 2nd session to a slightly higher level than predicted based on normal test-retest variability (Figure 3).

Discussion

The present findings provide an explicit set of procedural guidelines to obtain reliable, valid, and stable baseline reading levels using the Visagraph II system. Both proper set-up of the goggles and text materials, as well as a full, clear, and consistent instructional set, are crucial to obtain high quality eye movement recordings that can be properly interpreted, analyzed, and summarized by the provided software. This last point is extremely important. There is the misperception by some that the input data does not have to be obtained with any special care, as the analysis is computer automated. Just the opposite is true. Since the data do not go through any artifact prescreening process either by an additional automated software program or human editing, the data acquisition must be conducted with extra care. Misalignment of the infrared photodetectors, excessive blinking, lid intrusion into the photodetectors' field-of-view, head movements, etc., are but a few possible artifacts that may readily occur and produce less than optimal recordings for subsequent computer automated analysis. Thus, the quality of the output, i.e., Taylor table analysis, is no better than the quality of the input.

Our findings demonstrate the importance of sub-group analysis. If only the group data were compiled, the conclusion would be different. It shows a remarkably stable baseline across trials, thus suggesting that no practice trials would be necessary prior to formal baseline establishment. However, based on the sub-group analysis, the conclusion is much different and more accurate. Approximately one-third of the subjects required more than one practice trial to achieve a stable baseline, and, in fact, up to three to do so.

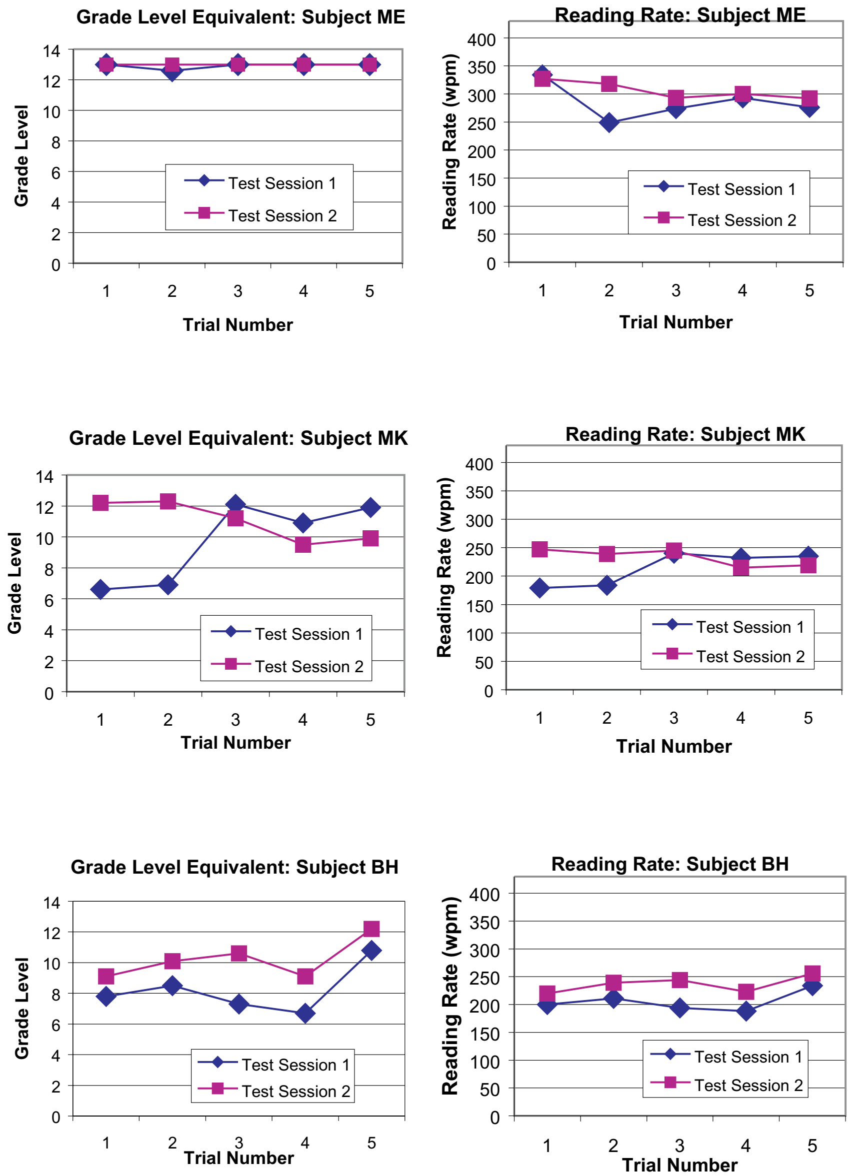

Figure 3. Repeatability of grade level equivalent and reading rate as a function of trial number and test session for individual subjects.

Thus, our suggested conservative guideline is to use three practice paragraphs in cooperative adults. In uncooperative adults or those manifesting a considerable degree of hyperactivity and resultant body movement, more than three paragraphs may be required, and perhaps even more than one baseline test session.

The next step that should be pursued is repeating the present study, but now with subjects covering the entire range of test materials (i.e., grade 3 to high school/college level). It is in this population, in particular the youngest ones, that the potential benefits of proper reading-related diagnosis and therapeutic outcomes may be most important. And, it is in this youngest population that the greatest degree of motor learning reflecting oculomotor neural plasticity[7] may occur. This may involve learning of an optimal oculomotor control strategy when oculomotor developmental immaturity may be present,[8] or relearning one caused by a faultily developed oculomotor control strategy.[8] In young children, it may not only require more practice paragraphs for a baseline plateau to occur, but perhaps even more than one baseline test session, to assure a consistent, stable, and repeatable baseline, as increased variability is a hallmark sign in children's oculomotor performance.[9]

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