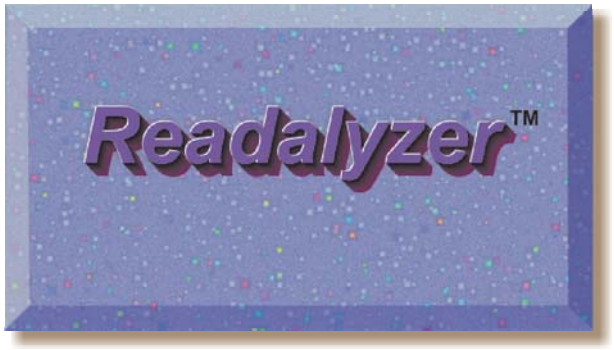

Getting Started

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In some cases you may get an absolute straight line with one of the eyes consistently. This most likely represents a problem with the goggles or the wires connecting the goggles to the interface box. Contact your supplier if this condition continues for diagnosis of the problem.

Getting Started

Eye Movement Recording Basics

Congratulations in getting started with eye movement recording. Using an infra-red eye movement recording device can be extremely helpful in:

- Objective documentation of the mechanical skills for reading
- Before and after data to show changes from treatment
- A method of showing the immediate impact of lenses on performance
- A helpful tool in showing patients and interested parties what the current status is of their visual scan skills for reading

Today's devices are very easy to use. However, ease of use does not guarantee that the results obtained will always be meaningful. A great deal of confusion seems to exist in the mental models held about eye movement recording. This guide should help you get started on the right foot. For those of you that are experienced users of eye movement recording equipment this guide may help clarify this often confusing field.

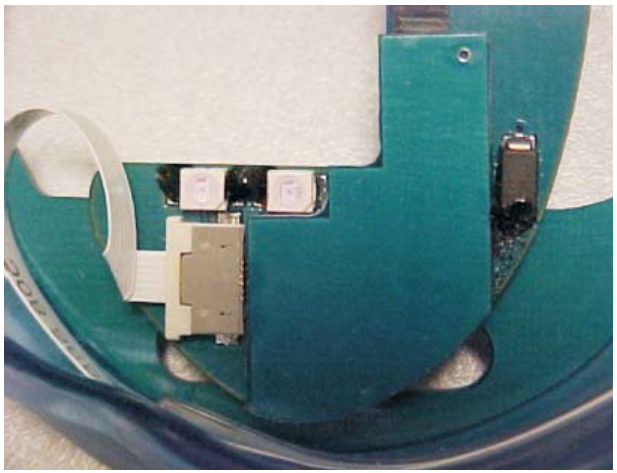
How do these devices work?

Infra-red eye movement recording devices work by projecting infrared light onto the eye and then recording the amount of light reflected back. Earlier devices such as the Eye Trac I and the Eye Trac II, or the Ophthalmograph, used point white light sources to illuminate the eye. The cornea of the subject reflected that light. The brightest of these reflections is the first Purkinje image. As the eye moved right to left or up and down the reflection of the point light source on the cornea moved. This reflection could be focusing on a moving film plane (Eye Trac I) or onto a ground glass screen with a light detector connected to a strip chart recorder (Eye Trac II). These early devices worked off corneal reflections.

Infra-red eye movement recording devices work off a reflection at the corneal scleral junction. The curvatures of the cornea (clear part of the eye) and the sclera (white part of the eye) are curved to very different degrees. The junction between the two reflects infra-red light as if it were a concave mirror. Generally, a minimum of two light sources for each eye and two measuring sensors at the outer edges of the goggles are present for each eye. Most of these devices sample the reflected light many times per second. Generally, the sampling rate from the "real world" is far more frequent than is actually reported on the screen or on the recording printouts.

Several real-world sample points are averaged to obtain a single reported point in the software displays. One of the reasons that this is done is to eliminate the influence of ambient lights. Early white light Purkinje devices required stationary heads with low level lighting in the entire room. Early infra-red devices required very low levels of ambient lighting. Ambient lighting, particularly light from fluorescent tubes, which flicker with the alternating current, caused these devices particular difficulty.

Current devices deal with this by rapidly switching on and off the infra-red illumination system. Every other raw data point is taken with the infra-red illumination system switched on. Sophisticated software, generally executed in the interface box and performed in the hardware, averages several of these points with and without the infra-red system on. This signal averaging methodology has all but eliminated ambient lighting problems. Thus, you can take excellent recordings in nearly all lighting conditions and be assured that you will get reliable recordings.



The infra-red emitters are the two small white squares just above the connector. This view is from the inside of the right side of the Readalyzer™ goggle looking outward.

this instance, if they could actually do all the movements at near saccadic velocities, which cannot be done with neck and torso muscles, then the resultant recording would be a straight line as the eyes would be held fast in the head. In a real-life situation there would be small jumps with corrections of head and eye positions to effectively hold the eyes steady in the head. In this instance, it would be very difficult for the computer to figure out where a fixation begins and ends since there would be only the slightest position shift from one fixation to another. Thus, the primary factor downgrading the reliability is "confusion" (in actual fact difficulty in the analysis algorithm to classify fixations or to find return sweeps) in the analysis program. So keep in mind if you see lots of movement and a low reliability factor, repeat the recording with a different passage and attempt to dampen the observed movements. If this creates a too unnatural a situation for the patient then this fact is clinically relevant. In fact, this may be more clinically relevant than any actual data that you might have attained through analysis with a low reliability quotient.

What are artifacts?

Artifacts are anything that looks to the analysis algorithm to not be "reading", meaning not fixations, regression, or return sweeps. An example are blinks. When looking at the "original" wave or recording (not the "model" recording as blinks are removed from this display) you may see the two waves momentarily shift quickly in opposite directions and then come back. This is the characteristic recording of a blink. The device loses its infra-red reflection from the cornea-scleral junction for the period that it is blocked by the lids. Other artifacts may result from anything that disrupts the clean view of the eye of either the infra-red emitters or the detectors. Causes of other artifacts involve physical manipulation of the goggles during the recording such as scratching the face or smiling and having the cheeks move and shift the goggles on the face.

What happens when one of the "waves" is straight but the other is moving?

Occasionally you may see the recording of one eye or the other "peg out". By this I mean go to either the left-most or right-most extreme position and record a straight line. Most often this represents a problem with the goggle positioning. Sometimes you will have it all aligned and just as the person goes to read they drastically alter their posture, such as moving very close or very far away or tilting their head to one side or turning their face to one side or another and leaving it in this extreme position. If you see this, correct the problem or the posture and do a repeat recording with a different story.

Why only show one eye?

On the Readalyzer™ printout and profile screen you will notice that there is a single column reporting the data for the person and not for the right eye and left eye separately. Once computer analysis of the eye movement recordings became possible some felt that many of the subtleties in the recordings could be teased out. One of these was to look at differences between the recordings of the two eyes. Thus, some earlier devices showed a column for the right eye and a separate column for the left eye yielding in some cases different numbers of fixations and regressions for each eye. Much significance was made about these differences by some.

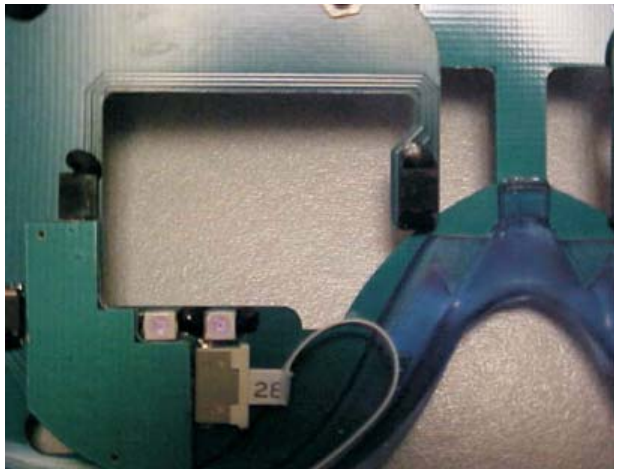
However, those placing significance to these variations simply don't understand the neurology of the human ocular motor system. For a person to be able to make a saccade with one eye and not with the other while engaged in the act of reading would take either enormous training or would be evidence of a very serious neurological problem.

Indeed there were differences in the actual recordings from these highly sensitive non-linear infra-red eye movement recording devices. However, the differences were not a result of asymmetries in the subjects' eye movements, but were asymmetries in the recordings introduced by the devices, the processors and the software.

Thus, numbers such as the cross-correlation are not felt to be indicators of ocular motor or neurological problems but are indicators of non-linearities in the recording most likely introduced by the above named factors as well as others. Often, one will see low cross-correlation numbers when the person moves their head a lot during the reading passage, if the person is a very immature reader, or if there is some lighting or eye glass anomaly hat may be fixed by taking another recording. I have occasionally found patients that jiggle a leg or twist side-to-side on their stool or chair during the recording and cause the analysis program some difficulties that are cleared up on a subsequent recording when the extraneous movement is dampened.

What does the reliability number mean?

In the release of the Readalyzer™ a reliability factor was added. This number can vary from 0.00 to 0.95 with 0.95 being the highest reliability. Things that will reduce the reliability involve many of the things already mentioned, such as lots of head movement. Imagine the patient who moves their head from side-to-side exactly the same amount in angular movement as is necessary to move across the entire body of the text. In

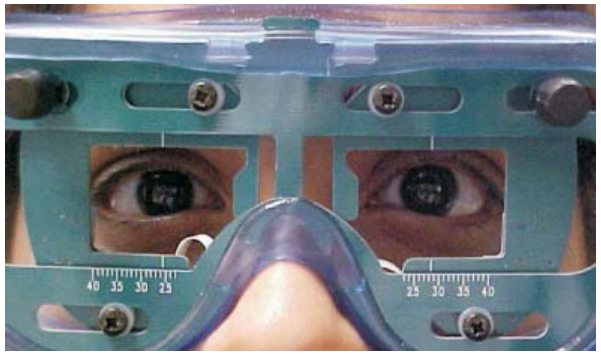


The infra-red receivers are the black square on the left and the vertically oriented rectangle on the right in the picture above. This picture shows the left eye from the inside of the Readalyzer™ goggles.

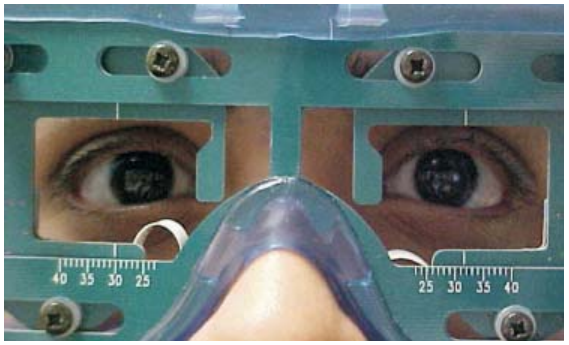
Placing the goggles

Begin a testing session by adjusting the goggles on your patient's head. Here's my method. I hold the goggles by the front and come towards the patient with them and as they come up to their eyes I ask them to hold them in place. As I come towards them I say, "I'll adjust the strap." While they hold the front on their face I adjust the strap around their head making sure it is not twisted and that it is not too low or too high across the back of their head. I will make any adjustment in the Velcro strap to make sure the goggles are not too tight or not too loose. Finally, I then have them look directly at me and I pull the goggles towards me slightly and then reseat the goggles on their face making sure that their eyes are centered in the openings of the goggles.

The final adjustment I make is to the horizontal placement of the individual front pieces of the goggles. By loosening the knob on the front of each goggle half you can slide that part right and left to adjust to the person's eye placement in their head. I do not measure my patient's inter-pupillary distance and dial that into the device. Due to asymmetries in some patients' noses, once the goggles are seated comfortably the goggle sections may need to be asymmetrically placed to work properly. I have found over the years that, in actual fact, I get more reliable recordings if the goggle halves are separated slightly more than would be to have the eyes exactly in the center. I prefer to line the vertical lines up with the outside edge of the patients' pupil.



Here the vertical lines would project close to the center of the subjects' pupils. Note that the right eye (left side of picture) is set at 26mm and the left eye (right side of picture) is set at 28mm.



Here the vertical markers have been spread outwards temporally to 30mm for the right eye and 32 mm for the left eye. This placement, in many patients, results in cleaner recordings.

Glasses or Contact Lenses

Modern infra-red eye movement recording devices generally work just fine in combination with patient's wearing their contact lenses or eye glasses. I have found a few metal frames that in some positions can cause recording problems. Generally, by reseating the goggles and changing the horizontal positioning of the goggle halves further out or closer in, I have been able to obtain reliable recordings.

What about bifocals, trifocal, or progressives?

In some instances, the area that a patient can see clearly at near is quite small and very low in their glasses. This may be too low to effectively allow them to see through the proper section of their glasses with the goggles on. You may elect in that situation, to use a trial frame with their near vision prescription under the goggles.

You may also notice that on the left side of the graph fixations under .20 seconds in duration are marked in red. Generally, comprehension cannot occur during these very short fixations. Most of these are used to reposition the fixation point to a "better" place for deriving of meaning. On the extreme right, fixations greater than 0.75 seconds are also marked in red. These most likely represent times when active parsing of text stops and the person is thinking about the story or discussing it with themselves internally.

The ideal scatter plot would have a small standard deviation around an average time close to 0.24 seconds. The taller each bar in the bar graph the more events (fixations) were of that duration.

Span of perception

Some of the early analysis methodology also calculated a "span of perception". The inference to be made was if there were more fixations per words read then the person must have "taken in" fewer characters per fixation. With fewer fixations per words read, then the inference was that their span of perception was wider.

Research into the span of perception shows this to be fairly stable amongst "readers" (those who have broken the code and can read). The span of perception is asymmetric and in those who read left to right read languages is only a few characters to the left of fixation (2-3) but quite a few more to the right of fixation (6-8) and that this is a factor of how a person has learned to use their physiology.

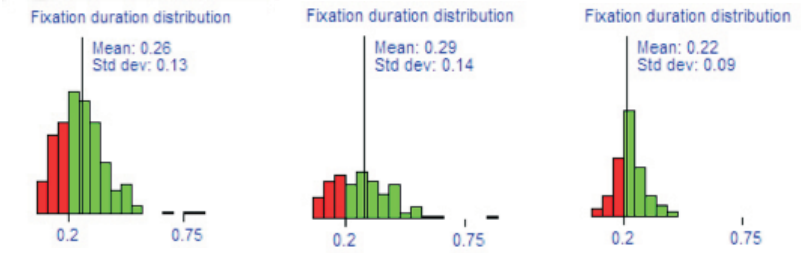
It can be observed that the number of fixations per words can vary a great deal as the difficulty levels of the reading passage are modified from the *free and easy* level right up through and beyond the *frustration* level of demand. The implication from reported variations in the span of perception was that the person actually changed their span. More likely is that the person uses a relatively fixed span of perception that is overlapped to a higher degree with more difficult texts and less so with easier texts.

Thus, in the Readalyzer™ the span of perception has been left out of the analysis profile. If you wish to determine the span of perception to compare to the old numbers you can simply divide 100 by the number of fixations.

As can be seen from this table there is very little variation in the average duration of fixation from grades 3 to 10. Although one could calculate this number there wasn't much clinical significance that could be placed on these numbers. In some cases where the average duration of fixation was very long, then it could be inferred that the person might be taking the time to verbally discuss the story to themselves or to even be "sounding out" some of the words.

Scatter plot of fixation durations

Since there is such variation in the duration of individual fixations it was felt that there might be a better way to display this data in a more clinically relevant manner. The Readalyzer™ includes a frequency distribution plot of the duration of fixation. The total number of events lasting similar amounts of time are counted and then shown on the following graph.



Above are three bar graphs for three different recordings. Each shows the mean and standard deviation. The graph on the extreme right has the fastest average time and the smallest standard deviation and is from a recording of an excellent adult reader. The recording on the left is from a poor adult reader. He has many total events (NOTE: the more events as a particular time, the taller the bar. A patient with many fixations and regressions will have more, taller bars than a reader with fewer overall events.) Also, be sure to see in the recording on the left, the few longer fixations well off to the right of graph. The middle recording is from an immature reader. The average is the highest and there is the most variation in the lengths of the fixations.

The first thing you may notice is the addition of a standard deviation. The smaller the standard deviation the less variability there is from fixation to fixation in terms of the length of the fixations. The bigger the standard deviation the larger the variations in durations of fixation from one fixation to another.

Picking the beginning level story

Testing at the right demand level is one of the most important aspects of deriving insights into the mechanics of reading used by the patient. This also seems to be one of the most confusing aspects of eye movement recording amongst those using these types of devices. Although some people seem to use the same scan pattern to parse whatever level text they are reading, most people alter their scan pattern significantly as they shift up and down the demand levels relative to their current reading abilities.

By scan pattern, I am referring to the manner that the person moves their eyes over the text over time. As the difficulty or demand level of the text changes there may be large changes in the number of fixations. Often we see with very easy stories, ones that would be considered at the patient's *free and easy* level (generally defined as two or more years below a person's instructional level), a reduction in the number of fixations as they take in key words and fill in the rest as they read silently to themselves, with what from their experience, should connect those key words together. At this level, with an experienced reader, we often see very few regressions. The *instructional* level is defined as the current demand level at which the person is learning new words, new usages of known words, or new sentence structures. The *frustration* level is a more difficult level of reading above the instructional level and is defined as the point where the demand of the text exceeds the capacity to derive meaning from the text in and physiologically one often sees the shift to flight (giving up trying to understand the meaning) rather than fight.

As the difficulty level increases and comes closer to their *instructional* level, the number of events (total number of fixations and regressions) increases. Now, in order to get comprehension, the person needs to pay more attention to more of the actual text, rather than filling it in from their general knowledge base of the spoken language. Specific pieces of data, such as dates or place names, may be stopped on longer or repeatedly as the person attempts to remember these pieces of information for the comprehension test. So, as the instructional level is found, there often is this increase in the total number of events and an even great increase in the number of regressions. Thus, the ratio of regressions to fixations increases as the demand of the reading level increases from the free and easy level to the instructional level.

If the reading demand is too difficult then there appear to be two different types of responses seen. The key factor is that comprehension dips below the acceptable minimum level of 70%. Some readers attempt to maintain their scan patterns that they use when they encounter text at their

instructional level. They plow through the text using their same scan pattern and simply come away without understanding the passage -but often thinking that they did. Others may attempt to orally (out loud, under their breath, or silently but internally speaking to themselves) read the passage, with conscious repeating of key parts to themselves. However, the passage is too difficult and they still, in spite of these sometimes Herculean efforts, come away with less than 70% comprehension. Others simply give up, move into flight and fly over the text, using their scan patterns similar to those used when reading at the *free and easy* level, but definitely not understanding. They might get lucky on a yes/no type of comprehension test. That is one reason why it is critical to ascertain if they are familiar with the content of a particular passage before beginning.

So how do we know what level to begin with?

Prior to doing a recording it is best to have an idea of what the patients' reading level is. Often, when parents are asked they either don't know or have a single number, such as fourth grade. Generally this isn't good enough. One of the issues is that it is difficult to sum up a person's reading ability with a single number. Does that number represent their oral reading: their ability to 'bark at print', to decipher the graphemes in front of them and to pronounce the proper associated phoneme/lexeme? Does that number represent the level at which they can read silently for understanding? From clinical experience I find that there is often nearly a one-year difference, and in some people an even greater difference, with the oral reading being more advanced than the level at which they can read silently with comprehension.

Lastly, does that number represent a summary of their mechanical skills of reading? Often I see a child who reads orally at the 6th grade level, whose silent reading with a minimum 70% comprehension score is at the 5th grade level, yet whose number of fixations and regressions and reading speed are at the second grade level. How can one number describe this child's reading level adequately? It can't! So again I ask the question, where do we start?

Prior to moving to the eye movement recording I will have the person do an oral reading survey. It is beyond the scope of this paper to discuss the pros or cons of any particular reading survey or to go over the other insights one can get into how a person reads from such a survey. I will only address how to derive the starting point for testing.

One section of the "Handbook of Diagnostic Tests" by Ray Lowry, distributed by OEPF, is on oral reading survey. This section includes two

Thus, to get the reading speed one simply measured the length of film or the paper from the recording device, beginning at the start of the second line and measuring to the end of the next to last line. This length was then converted to a reading speed, using a chart. The following are grade level norms for silent reading with comprehension speed.

EDL Reading Speed Grade Level Norms Grade Level	Reading Speed (words per minute)
1	80
2	115
3	138
4	158
5	173
6	185
Jr. High (8)	204
High School (10)	224
Adult	280

Several other "measures", which are not really measures at all but are simply transformations of the above data were made but has less significance. These included the average duration of fixation and the span of perception.

Average Duration of Fixation

The average duration of fixation was calculated by dividing the total time for reading the middle 7 lines on the grade 1-3 passages and dividing by the number of fixations or by dividing the number total time for reading the middle 10 lines on all other passages by the total number of fixations. Earlier recording devices showed some variation in the lengths of individual fixations but there was no simple way to quantify these variations so a simple calculated average was determined. The following are the old norms by grade level.

EDL Average Duration of Fixation Grade Level Norms Grade Level	Average Duration of Fixation (sec)
1	.33
2	.30
3	.28
4	.27
5	.27
6	.27
Jr. High (8)	.27
High School (10)	.26
Adult	.24

EDL Fixations Grade Level Norms Grade Level	Number of Fixations
1	224
2	174
3	155
4	139
5	129
6	120
Jr. High (8)	109
High School (10)	101
Adult	90

We then counted the number of regressions. Return sweeps are not included in the regression count. However, if the return sweep was not made as a single movement then the extra backward eye movements needed to get to the beginning of the new line were counted in the regression total. The following are the old norms for the number of regressions per 100 words read. Again note that the number of fixations above includes these regressions.

EDL Regressions Grade Level Norms Grade Level	Number of Regressions
1	52
2	40
3	35
4	31
5	28
6	25
Jr. High (8)	21
High School (10)	19
Adult	15

At this point when analyzing older recordings the final piece of data was the overall reading speed. In old film based systems the film moved through the device at a fixed rate of speed. The longer the film, the slower the reader and the shorter the film, the faster the reader. Some later devices used strip chart recorders, where the paper moved through the device at a fixed rate of speed. Again, the length of the paper was relative to the speed of reading.

Analysis was not done on the first or last lines of text, which in most of the testing paragraphs were partial lines. The first line of the passage was indented and the last line generally was not a complete line. On passages at the first through third grade demand the passages had 50 words on the middle 7 lines. On all other passages they were constructed to have 100 words on the middle 10 lines.

series of graded paragraphs. Each series has seven paragraphs that get longer and more difficult. Each series is a single extended story, one about a rat and a dog and the other about a girl and her cat. Included are step-by-step instructions for administering and grading the test.

Over the years I have modified the scoring on the test slightly. The modification I have made is the following. Strict marking of the test is that any error counts as an error. I have reclassified one type of error as a half point of an error. These are when the person makes an error when they first encounter a word but they self-correct the error before moving more than two words further on. These types of errors are often small-word substitutions or making contractions out of two words, in spite of my asking them to read exactly what is on the page. I find that these small-word substitutions, which often include words with the same beginning letter and general overall length and end up being the correct part of speech to complete the sentence, are signs of an inability to sustain visual attention and are not true indicators of a reading problem but are more signs of a visual problem affecting reading ability.

To begin eye movement recording I choose a story that is one year below the level derived from the oral reading survey. So, if the oral reading survey comes out to grade 4.3, then I begin with a third grade story. If the oral reading survey comes out to grade 6.4, then I begin with a fifth grade story.

Subject Familiarity

When selecting a reading passage it is important to pick a story about a topic or subject that the person is not familiar with. Thus, it is important that the tester be familiar with the stories and to then ask the patient ahead of time about subject familiarity. For example, one of the stories is about surfing. A person that knows the sport could get 80-90% on the comprehension test without ever reading the paragraph. Prior to using that paragraph I would ask the patient if they were a surfer or knew much about the sport. If they answered in the affirmative, then that story was not used. This is one reason why at the lower levels you have been supplied with at least 10 different stories at each level.

Oral vs. Silent Reading

This question comes up now and then: Isn't it better to have the person read out loud so you could tell if they know the words and if they are really reading the story? It all depends on what you are trying to find out by doing the eye movement recording. When the question is asked it is

usually coming from a model of understanding reading that says that oral reading is fundamentally the same process as reading silently, with the addition of the out-loud portion and that the addition of the out-loud part does not change the reading act. This may be so with some people and in particular with early readers who have not yet moved to reading for information but who are still in the learning to read phase.

If reading orally were just reading silently with one extra added part, then we would not expect to see much of a variation in scan types or reading speeds from one to the other. In addition, we would also expect that if there was always the capability of simply adding in the oral part, that reading speeds would top out at about the speed of speech. However, most people can read silently to themselves much more quickly than they can speak. (This is of course referring to accomplished readers.)

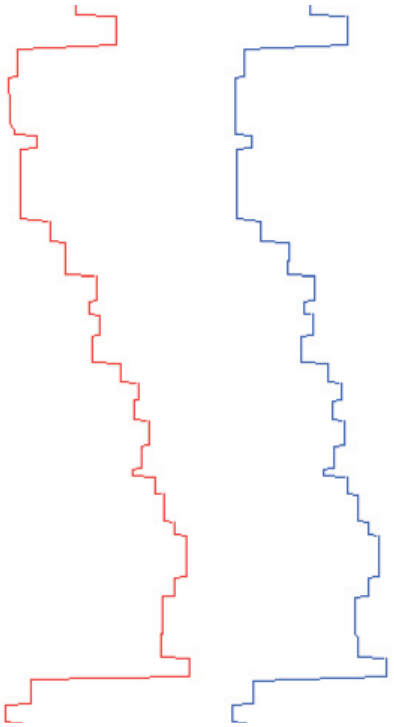
The reading survey discussed above is when I get the insights into their reading level and how easily they are decoding the words they read. What I am looking for by doing eye movement recording is to gain insight into their scan types and their mechanics of reading, without the addition of reading out loud.

While on the subject of reading aloud it turns out that there is a special case of this that we might call *oration*. Think of oration as a theatrical type of reading aloud. This is usually more of a performance than simply giving others an insight into one's reading skills. Unfortunately, how often do we suffer listening to people read aloud who have not acquired the skill of oration? To read aloud AND to captivate an audience requires a very different type of scan path. It requires the scan path generally seen in excellent musicians. Current visual input, in oration, should be well ahead (in time), of what the person is actually saying. The text on the page needs to parsed and analyzed prior to being spoken to allow for the maximally effective presentation of the words. A good orator, even when sight-reading a performance, looks well enough ahead to see how much breath to take, to decide where the emphasis should be in the sentence, to see if it is a declarative statement or a question so as to know how to shift the inflection of the voice towards the end, and to know when to speak up or slow down for maximal effect. These are just some of the aspects that make oration different than silent reading.

Off the screen or from the printed page?

Another question often asked is if it might be better to have the patient read the stories off of the computer screen. In fact, almost every person I test with these devices expects the story to come up on the computer screen.

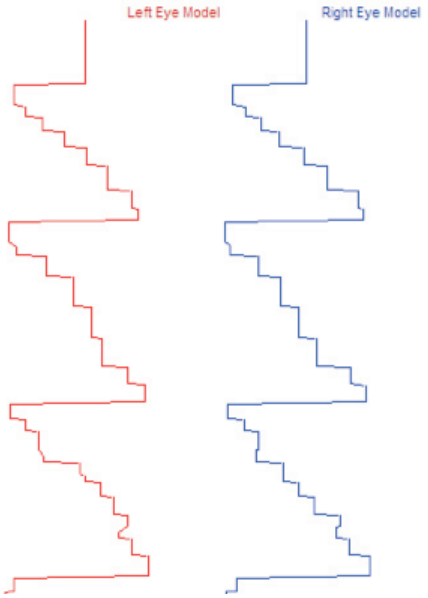
Above is a single trace (OD only) in the middle of a line. There are two regressions here. A regression is the small shift of the fixation point to the left in the middle of a line of text.



Above is a single line of text as read by an adult patient. There are only 10 words on this line and he made 24 separate fixations of which 9 are regressions!

Before the computer age we had to hand count the number of fixations. The total number of fixations includes all forward fixations and backward fixations (regressions) and should actually be called the total number of *events*. However, by convention this total number of all fixations, regardless of the direction of eye movement as the person came to that position, is reported as the total number of fixations. The original norms by Educational Development Laboratories done in the late 1950's and published in 1960, gave grade level norms for this total number of fixations per 100 words of text read.

When good readers read text written in a language that is read in a left to right, top-down pattern, one generally sees a stair-step type of pattern in the fixations as they move across the line of text



Above is a recording of a very good adult reader. Clearly visible are the large return sweeps with stair step fixations moving to the right. On the third line two very small regressions are visible.

At the end of the line the person makes a return sweep to get ready to begin the next line of text.

Above is a single return sweep. Here the two eyes move in tandem from the end of one line to the beginning of the next line.

Often while reading a line of text, a reader will go backwards to reread a portion of a line. This eye movement is called a regression. Most people are not consciously aware of the regressions they make. These are different from when a person decides, “Hmm, I don’t think I get this. I had better reread this last sentence or maybe even the whole last paragraph.” As we take in new text even excellent readers will make regressions in from 8-12% of their fixations.

My clinical experience as well as my reading of the literature shows an almost universal slower reading speed when reading directly from a video display terminal versus reading the same material on the printed page. Thus, unless you are performing a study specifically to find reading speeds from computer displays all reading tests should be done from the printed page using the books supplied with your testing device.

What about really poor readers?

Infra red eye movement recording is primarily done to gain insight into the mechanics and the scan patterns used by the subject. Unless a reader shows a basic level of decoding skill on the sample reading survey, taking the time to look at the mechanics is not advised. With very poor readers and particularly with immature readers who have yet to read primarily by moving their eyes rather than moving their head from side to side to move from fixation to fixation, the reliability of the recording is generally poor and the data is not very meaningful. Generally, unless the reader demonstrates a decoding ability to at least the third grade level I do not find that it adds to the clinical picture much to do infra-red eye movement recording.

You might then ask, “Why have the first and second grade stories?” These are primarily used with older children who can read but whose comprehension skills are below par. The situation is often encountered where a fourth grader is seen who can decode at the third grade level but who does not get the required 70% comprehension levels at this demand level. Thus, the second, and at times, even the first grade level stories are needed to establish good baseline data for before and after testing.

Instructions

Over the years I have used a number of variations for my instructional set. I suggest the following but in your own words.

What I want you to do is to read the story in front of you one time to yourself. You don't need to read it out loud, just to yourself. You should read it to understand because I will be asking you 10 yes/no questions and ou need to get at least 7 out of 10 correct. So just read the story one time to yourself, but read it to understand it. When you are all done just close your eyes or look up. Are you ready?

Wait for a positive response.

Look at the "O" here and I'll tell you when to begin.

You would be surprised how many people, in spite of me saying to read silently to themselves twice in the above set of instructions, still go ahead and begin reading out loud.

Comprehension the key

When you have completed the recording you need to ask the patient the comprehension questions. I read the questions from the computer screen to the patient and wait for their answer. Of course some of the patients read along with me and that is fine. Some even say "yes" or "no" before I have even finished reading the questions to them. It is a bit amusing to me that if I ask them if I should stop reading them out loud to them, not one patient in over 25 years has said yes!

One thing I have worked hard on and attempt to keep foremost in my mind is to not give the answer away to the person in how I ask the question. I generally read the question in a deadpan flat voice and I never make eye contact with the patient. I stare at the computer screen with one finger on the "Y" and another finger on the "N" button so that they do not read from my finger what the answer might be. I try to use the same inflection and speed of delivery for each question and I never tell them, until all complete, if an individual answer is right or wrong as we go through the 10 questions.

Throw out the first test sample

Work by a number of authors has shown that the first sample should be discarded. There are so many unknowns for the subject during the first

test sample run that it should be considered an orientation run only and the data from it should not be used for any significant purpose.

If a person gets 90 or 100% on the first sample then I will move to a more difficult passage on the second test sample. If they fail to get to the 70% level and if I feel that they were close and seemed to understand it but just got a question or two wrong, I will ask them if they would like to try a story at the same level or if we should try an easier story. By giving the patient a choice in the matter it seems to help them prepare better for the next trial.

I continue taking more samples until I find the highest demand level at which the person can get at least 70% correct on the comprehension test. If I go all the way down to the first grade level and they still do not get to this minimum level then I do not consider the eye movement analysis to be valid.

When performing analysis and reporting data to others I then use the data from the highest demand passage on which they got a minimum of 70% correct on the comprehension test.

What do all those numbers mean?

Over the years the analysis of the data obtained during eye movement recordings has gotten more and more sophisticated. However, there are only a few things that are absolutes and these should always demand the greatest attention with less emphasis put onto some of the more marginal data. The following will explain these differences.

There are several pieces of data that are keys in understanding the mechanics of reading. These include the number of fixation, the number of regressions, and overall reading speed. A fixation is a period of time when the eyes stop at a spot in the text to analyze that portion of the text, integrate it into what has come before, make an educated guess as to what to expect, to decide where to go next to continue deriving meaning, and to then execute the actual next eye movement. When looking at eye movement recordings fixations are characterized by a straight line in the eye movement path showing a steady fixation. The shorter the fixation, the shorter is that particular part of the recording. The longer the fixation in time, the longer is that particular part of the recording. Fixation lengths can vary considerably and this will be discussed later.

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