Ehlers 1936

Acta Ophthalmologica 14, 56-63

lesen, die auswendig gelernt werden sollen, z. B. Psalmen — Religion — Geschichte und dergl. Dagegen soll das Kind täglich ein grösseres Stück aus einem Buch laut lesen, am besten aus einem leicht zu begreifenden Roman, während der Erwachsene dabei sitzt und alle Fehler berichtigt. Man soll das Kind nicht denselben Abschnitt mehrmals lesen lassen — weil es ihn dann auswendig lernt; so werden beispielsweise oft die dänischen Aufgaben dieser Kinder erledigt —, sondern man soll sie immer im Buche weiter lesen lassen. Kann man es aber später dazu bringen, dass das Kind Lust bekommt, Unterhaltungsbücher zu lesen, so ist dies eine grosse Hilfe. Schliesslich soll der Schule über das Gebrechen des Kindes Mitteilung gemacht werden, sodass hierauf gebührende Rücksicht genommen wird, sowohl beim Unterricht als auch bei der Beurteilung des Standes der Schulkenntnisse des Kindes, namentlich betreffs der Rechtschreibung, mit der es immer hapern wird.

Rönne (Kopenhagen).

THE MOVEMENTS OF THE EYES DURING READING

BY

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By looking closely at the eyes of a reading person it becomes evident that they do not move gradually along the lines, but in small nystagmiform dextrad jerks in order, when the line is finished, to move back to the left side (of the reader) and commence the next line in the same way. There is much reason for presuming that the eyes during reading merely see during the quiet stationary intervals between the jerks and not whilst the eyes perform the rapid jerking movements. This theory is for instance corroborated by the circumstance that the top line of a page can be read without the background of the room, which is visible above the book, showing the slightest sign of specious sinistrad movement, which naturally should be the case if the eyes could see all the time during their dextrad movements along the lines. Therefore, the movements of the eyes during reading should probably be identified with the rapid phase of nystagmus, but in this connection this question shall not be discussed in detail.

The perpetual jerk-like movements of the eyes during ordinary steady reading do not occur more rapidly than that a somewhat experienced person can count them. In reading with one eye only and placing a stethoscope on the other, closed, eye with a uniformly slight pressure, the eye movements can be auscultated also. Both by direct counting and by auscultation, the number of eye movements during a certain period of reading can be determined with great accuracy. I have repeatedly tried to read with one eye, whilst one of my colleagues auscultated and another kept direct account of the number of movements performed by my reading eye. The detected figures were as a rule the same. During my subsequent experiments I therefore considered the information derived from simple counting of the eye movements sufficient. I am quite aware of the existence of cleverly devised nystagmographs for recording the movements of the eyes, but for the very simple examinations, of which I shall give an account in the following, I have found the direct counting of the eye movements accurate enough.

In order to study the movements of the eyes independently of the movements required for the change of line, I cut out some columns of a newspaper article and glued the lines in succession on a long strip of paper so as to form one line of five meters' length, which could be rolled up. During the reading of this long line, it was guided past the reader's eyes with the hands. The reading was performed at a distance of 30 cm. and, in order to insure a constant reading distance during the experiments, the reader was requested to place a wooden stick of 30 cm.'s length between his teeth. The line was then guided past the end of the stick and the number of movements performed by the eyeballs during reading were counted at the same time.

The natural thought that the eyes during reading move from one word to the other, that the nystagmiform movements appear when the eyes look from one word to the next, prove to be erroneous. A simple counting will readily show that there is no relation between the number of words in a line and the number of movements, which the eyes perform whilst reading the line. Most frequently the number of movements

carried out by the eyes will be considerably inferior to the number of words read. Moreover, the experiments will soon show that the number of eye movements required for reading a certain text is individually somewhat varying, evidently being somewhat smaller in the trained reader than in the non-trained.

According to this one might feel inclined to conclude that only part of the words are actually seen during reading, whereas the others are omitted and added by a kind of psychic completion without actually having been seen. This idea, however, is quite wrong.

As was mentioned already, the eyes probably see in the interims between the eye movements only. Therefore, if we endeavour to detect the factors, which are decisive for the eye movements during reading, it is natural to commence by ascertaining what the eye sees when it stops at a certain place of the line between the movements.

It is a wellknown fact that the sense of the eye for form is most developed in the center of the visual field. We recognise the form of an object best at the very moment of fixation. That which lies in the vicinity of the object is also distinctly seen, but the farther away from the center of the visual field the object is situated, the less distinct does its form become. This shows that only a certain region of the visual field can directly be utilised in reading. Only that region of the visual field, where the sense of form is sufficient for the recognition of the type of letters concerned, acquires importance. Only that part of a line, which falls within that region of the visual field whose sense of form is sufficient, has a possibility of being seen when the eyes are kept quiet. The remaining parts of the line require one or several movements of the eyeball in order to be seen.

By fixing one letter of a line and taking care not to move the eye, one is able to distinguish a certain number of letters on either side of the fixed one. As it is difficult to avoid moving the eyes, the test requires a little patience. However, it is facilitated by covering the types on either side of the fixed letter with scraps of paper. By successively uncovering more and more of the types on either side of the fixed letter, it is

feasible to ascertain very accurately how long a piece of a line can be overlooked at a time without being obliged to remove one's glance. Now if the length of this piece of line is measured and the number thus obtained is divided by the number representing the length of the previously mentioned long line (5 meters), the quotient represents the number of movements, which the eyes theoretically must perform if all the letters of the line shall be seen without the glance omitting any of them.

The experiments have shown that the theoretically calculated number of absolutely necessary eye movements nearly always is the same as that which the eyes actually perform. By way of example it may be mentioned that, in our examination, 210 eye movements were recorded during the reading of a continuous line of 5000 mm.'s length. The length of the piece of line, which the same test person could oversee at one fixed glance and at the same distance, amounted to 24 mm. The quotient derived from the division of the total length of line of 5000 mm. by this number is just 210, i. e. the exact number of eye movements, which was recorded by direct counting. The examination of another test person yielded 344 eye movements during reading. The length of line, which could at one time be seen by this person, was 15 mm. Accordingly, the theoretically calculated number of necessary eye movements is 333. Compared with the actually detected number of 344, the concordance in this instance must likewise be called very good.

Thus, these very simple examinations show that the eyes during reading move exactly the number of times absolutely required for the recognition of all the letters of the text. With regard to their movements, the eyes work with the greatest economy, and superfluous eye movements in the majority of cases amount to but a few per cent. and may be 0. The eye movements are numerous enough to warrant that all the letters of the text fall within the region og the visual field, where the sense of form is sufficiently developed for this recognition. Both the dextrolateral and the sinistrolateral parts of the visual field are utilised during reading. The hypothesis of a psychic complementary process and of systematic omission of words is unnecessary.

In the hitherto reported experiments I worked with a long continuous line in order to avoid the dependence of the change of lines in the elementary experiments. The experiments, which will be reported in the following, concern reading of text printed in lines below one another.

By recording the small, jerk-like eye movements of a person who reads 5 meters of line of a newspaper article, and by letting aside the great sinistrad eye movements performed at the change of line, it becomes evident that a great many more eye movements are performed than if the same person read the same article in one continuous line of 5 meters' length. The newspaper article employed for these experiments was printed in columns of 60 millimeters' width. The increase in the number of eye movements, which is provoked by the text being printed in 84 short lines instead of forming one long line, is unmistakable, but it is difficult to treat from a purely numerical point of view, because the counting itself is much more difficult. The explanation of the increase of eye movements in reading shorter lines, probably is that the length of a line does not form a multiple of the length of line, which the eye can observe at a time, and that a part of the region of the visual field hence must remain unemployed at the end of such lines. If this explanation holds good, it should be possible, in case the width of a newspaper line were changed, to economise the eye movements, namely by arranging the width of the column so that it forms a multiple of the length of line, which can be seen at one fixed glance. However, as this is individually very different, the problem will scarcely acquire any practical importance.

If the points of view with regard to the eye movements during reading, which I have advanced above, are correct and universally accepted, it must be justifiable to expect that the visual possibilities are best taken advantage of, if the types stand very close together and that the reading of such types requires fewer eye movements than if there were more space between the types.

The following experiments tend to show that this is correct. On a type-writer I wrote long strips of lines with texts about the same subject written by the same author. Whilst

some of the strips were typed in the ordinary manner, others were typed with interspaced letters. By way of example I mention that the reading of 2.3 meters of ordinarily typed line required 52 eye movements and 32 seconds. The reading of a corresponding number of interspaced letters required 88 eye movements and 56 seconds. By typing the text with interspaced letters, which is usually done in order to draw the reader's special attention to it, this end is not only attained by the typographical change, but the reader is actually compelled to perform a greater amount of reading-work and, besides, to devote more time to it. By placing the types as close together as possible, the eyes are spared unnecessary movements. Moreover, high and slender types appear to be preferable. These latter conclusions, however, are valid only within certain limits, owing to some factors which I shall finally account for.

It was previously mentioned that, by fixing a letter in a line, it is possible to determine how long a piece of the line one is able to see without moving one's glance. It is evident that the piece of line thus seen, must lie within the region of the visual field, where the sense of form suffices for distinguishing the type of letter in question. However, it is not beforehand sure that the whole width of the region of the visual field, whose sense of form suffices for the distinction of the type, can be ascertained. This will best be illustrated by the following experiment. By fixing a small pencil mark in the center of a sheet of white paper and placing some small scraps of paper, each provided with a single printed letter (cut out of a newspaper), on the sheet, it will be possible, by means of removing the scraps, to ascertain at how great a lateral distance from the fixation mark, the types can be seen and read. In this manner it is possible to determine the utmost limits of the region of the visual field, within which the sense of form is sufficient for the distinction of isolated letters. This region will probably prove somewhat wider than the piece of line, which can be seen at a time when the characters of a line are in close type (provided the reading distance and the size of types are the same). This tends to show that the eyes during reading do not always work with maximal utilisa-

tion of the visual possibilities. It seems as if our psychic capacity opposite a certain number of letters can reach its maximum before the purely visual possibilities are fully utilised. On the other hand, if the characters are less close together or interspaced, it may happen that the visual possibilities put a limit and that it is not the psychic capacity that is decisive for the length of line which a person at a given position of glance can read and, concequently, for the number of eye movements, which the reader must perform during reading.

This discussion with regard to the psychic and visual capacity opposite the types, likewise tends to explain why the piece of line, which can be seeen at one fixed glance, varies individually and independently of the knowledge of reading.

As the form of types of ordinary books usually is so close that it is the reader's psychic more than visual capacity that puts a limit to the number of letters, which the eye can perceive without moving, it is easily understood that the size of the characters and the reading distance usually acquire but little influence on the number of eye movements necessary for reading a given amount of words. That changes of the visual angle, at which the characters are seen, is without any essential importance for the number of letters recognised by the reader at a fixed glance — an observation which has previously been recorded by *Lamare* — any one can convince himself of by holding a book at different distances from the eye. For the magnitude of the excursions, which the eyes have to perform during reading, and for the rapidity with which a person can read, the visual angle at which the characters are perceived, is of essential importance. For, the recognition of characters seen at a great visual angle claims much less time than the recognition of characters seen at a small visual angle. By way of example I shall mention that i have experimentally found out that, if the visual angle is diminished, the rate of reading a letter can vary between $^1/_{10}$ and $^1/_{100}$ second. It would, however, be beyond the scope of this report, if I attempted giving a detailed account of these experiments.

The aim of my study was to show how relatively simple are the experiments, which render it possible to penetrade into

the physiology of reading, of which so little is known as yet, and besides, to report some of the results I have derived from this study.

Aussprache:

Granit (Helsingfors): Soweit der Vortragende seine Resultate dahin gedeutet hat, dass sie die Annahme einer psychischen Ergänzung als eines mitwirkenden Faktors bei der Bestimmung des Gesichtswinkelgebietes, in welchem bei zentraler Fixation ein Stück Text gelesen wird, ausschlössen oder nicht notwendig machten, muss man zu Zweifeln geneigt sein. In Anbetracht der raschen Verschlechterung der Sehschärfe, die seitlich vom zentralen Fixationspunkte eintritt, ist es wahrscheinlich, dass normalerweise die Grenze des auf einmal Aufzufassenden durch solche psychische Ergänzung bestimmt wird. Die Phänomene sind allbekannt, z. B. die Ausfüllung des blinden Flecks, die Ausfüllung gegen die blinde Seite bei Hemianopsie und andere Umstände, welche die sogen. Gestaltpsychologie, für die solche Phänomene von besonderem Interesse sind, an den Tag gelegt hat. Es handelt sich um völlig normale Erscheinungen, obgleich sie, experimentaltechnisch betrachtet, am leichtesten isoliert werden können, wo ein lichtempfindlicheres und für Sehschärfe besser ausgerüstetes Gebiet an ein relativ blinderes Gebiet grenzt. Dies ist jedoch auch bei fovealer Fixation der Fall, wobei das Gebiet für maximale Sehschärfe schon 85 Gesichtswinkelminuten peripher an ein Gebiet mit 50 Prozent herabgesetzter Sehschärfe grenzt (Weymouth et al., Amer. Journ. of Ophthalm., 1928, 2, 947).

Berg (Uppsala).

Granström (Stockholm).

Ehlers (Kopenhagen).

VI.

RESULTATE DER SCHIELAMBLYOPIEBEHANDLUNG. (Nachuntersuchung).

VON

T. FRIEBERG

(Malmö).

Seitdem *Javal* im Jahre 1896 hervorhob, dass die Schielamblyopie durch methodische Übungen des schwachen Auges gebessert werden könnte, haben sich die meisten Ophthalmo-