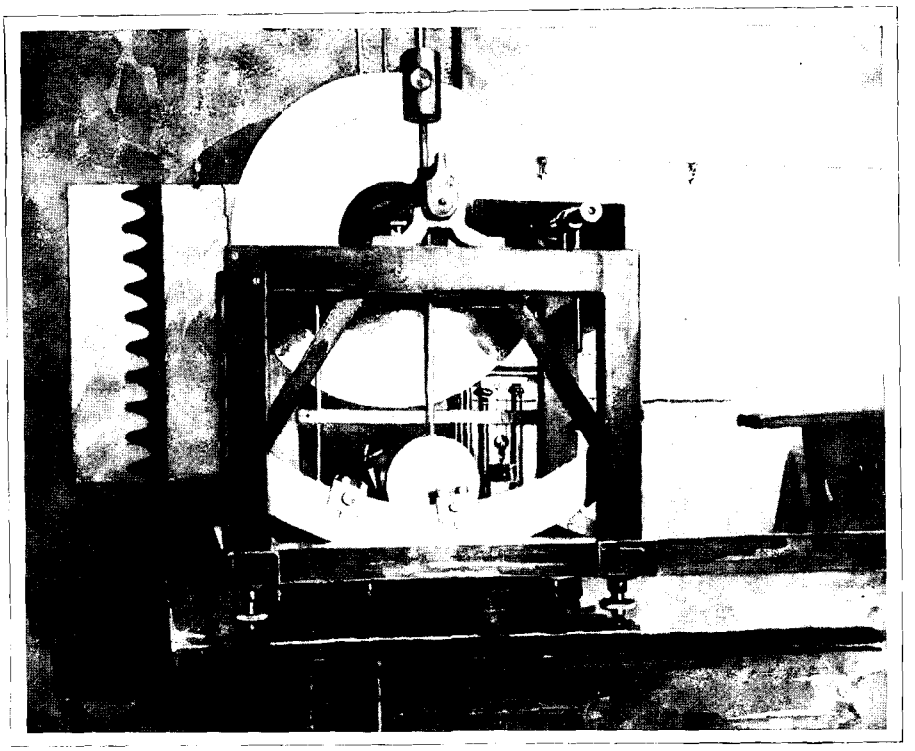

FIG. I. – APPARATUS FOR MEASURING THE REACTION-TIME OF THE EYE, USED AT THE PSYCHOLOGICAL LABORATORY, WESLEYAN UNIVERSITY

The Act of Vision

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A COMPREHENSIVE answer to the question how we see would be a long one. Much of it, however, may be presupposed by those who speak to the well-informed magazine-reader, while some of it would be too technical to be of any general interest. It is not our purpose to rewrite any of the chapters on vision which may be found in the text-books. We shall presuppose what they contain; and shall confine our attention to some recently established facts, which, in these days of rapid transit and weakened eye muscles, no one can afford to neglect.

It is a well-known fact that, whenever we wish to see anything clearly, we turn our eyes towards it until its image falls on the visual centre of the retina. We can, indeed, see more or less vaguely on either side of this centre, out to the extreme limits of the field of view; but the field of clearest vision is practically a point, viz., that point at which we are looking. If the object moves, our eyes naturally follow it. If our interest changes its direction, our eyes involuntarily move until the new point of interest is fixated. When we examine an object of any appreciable size, we may feel our eyes follow the contour lines, while we apprehend one after another the minuter characteristics of the object, as the point of clearest vision

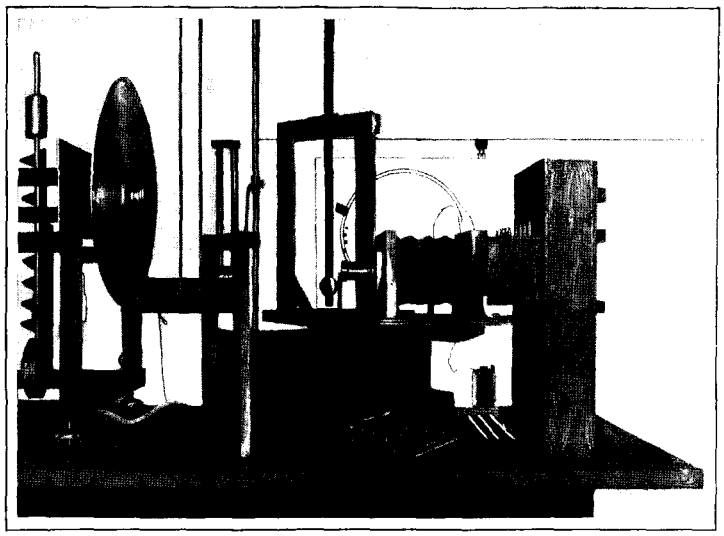

FIG. II.—APPARATUS FOR RECORDING THE MOVEMENTS OF THE EYES, USED AT THE PSYCHOLOGICAL LABORATORY, WESLEYAN UNIVERSITY

The essentials of the apparatus are a photographic camera and a head-rest. The camera is focussed on the eye of the subject in such a way that the image of the eye passes through a narrow horizontal slit to a movable photographic plate. The plate falls regularly downward during exposure, and thus receives a continuous series of impressions, which are in vertical lines while the eye is still, and in oblique lines when the eye moves.

moves back and forth. All normal vision is thus seen to involve eye-movements, and it is practically impossible to make a reasonable guess what vision would be like if our eyes were absolutely fixed. The importance of the eye-movements has been recognized more or less clearly since the time of Aristotle. But they are exceedingly delicate phenomena, and difficult to observe introspectively. Moreover, it is obviously rather dangerous to harness the eyes to physiological registering apparatus. So it is, after all, scarcely surprising that we have really known almost nothing about the eye-movements until recently, and that their relation to vision has been consistently misinterpreted both by science and by commonsense.

Which of us has not envied the intellectual genius who is from time to time reported able to take in two or three lines of print at a time, during a single sweep of the eyes across the page? It may be some satisfaction to plodding mediocrity to know that, however fast the man of genius may have read, neither he nor any one else has ever taken in so much as a single word during a sweep of the eyes. A little over a year ago it was demonstrated that, while the eyes are moving, as we look from one point to another in an ordinarily complex field of view, we can distinguish none of the impressions the eyes receive. This means that every one is practically blind to all that occurs about him for no inconsiderable fraction of the time when he believes that he sees best. Few statements would seem more absurdly improbable to the uninitiated than this. Indeed, it would be hard to find any one, however well informed in matters concerning the eye, who would believe the law without seeing the evidence. The reasons for this general incredulity are identical with the reasons why the law remained so long undiscovered, viz., we are never directly conscious of these moments of practical blindness, and we can learn almost nothing about our eye-movements by self-observation.

To restate the formal proof of the law here would be out of place. Since, however, most of my readers are sure to be more or less incredulous, I must repeat at least a part of the evidence.

All of us see a reflection of our eyes in a mirror many times a day, but no one of us ever saw his own eyes move. It is worth investigating, if you have never noticed the fact, because there is no other simple experiment that is so satisfactory a test of the law. It will not do to watch another's eyes. We can easily see them move, and can even determine by their movements where they are looking. Moreover, it is possible to see our heads move, and so to produce the illusion that we see our eyes during a movement of the point of regard. It may even be possible for some persons to catch sight of the beginning or end of the movement of one eye by means of the other after the latter has come to rest; since it has recently been demonstrated that often our two eyes neither start to move nor stop exactly together. But if the head is at rest and one eye covered, the other eye as it moves about will appear now in one position and again in another, but it can never see itself in motion. There is only one explanation of these facts. Since we can see the movements of another's eyes, our inability to see the movements of our own eyes in a mirror cannot lie in any difficulty of perceiving the eye-movements themselves, but only in practical blindness during the eye-movements. The experiment is singularly precise. Indeed, the writer, during several years of experimentation, has never succeeded in producing any other phenomenon which begins and ends exactly with the eye-movements.

A rather more convincing experiment depends on the smallness of the field of clear vision. If the reader will fixate a letter at the left of this page, the letters and words at the centre of the page will appear as indistinct patches of gray. The same will be true if one fixates a letter at the right of the page. If one looks rapidly from the extreme left to the extreme right, the centre will at no time be seen more distinctly than it was seen from either of the extreme positions. Now, in glancing from left to right, the point of clear vision must have passed across the centre of the page. If the words in the path of the point of regard were not seen clearly, there is only one explanation, and that is that the eye could not see while it was moving. Whoever tries this experiment will find no error in the above description so long as he looks from one point to the other as rapidly as possible; but it may seem to more than one that, if he only looks a little more slowly, the intermediate words may be seen with perfect distinctness. The apparent ability to move the eyes slowly is an illusion. In every case an assistant, looking at the eyes, would have been able to observe that the attempted slow movement was really broken by one or more full stops. Some persons may be able to detect these stops without an assistant, but it is an exceedingly difficult thing to do. Even after many years' experience the writer never dares trust his own introspection in this matter.

The last experiment, besides proving our law, indicates that the velocity of the eye-movements is very imperfectly under the control of the will. Direct experimentation with delicate apparatus confirms this indication. The average duration of an eye-movement by which the point of regard sweeps from one side of this page to the other, at normal reading distance, is about one-twentieth of a second. This will vary with the individual, with the different eyes of the same individual, and with the same eye at different degrees of fatigue. But it is practically uninfluenced by the strongest exertion of the will. It may seem strange that we cannot move our eyes slowly if we choose, but on closer inspection this inability is seen to be a wise provision of nature.

We could gain nothing by voluntary control of the eye-movements. And if we occasionally succeeded in moving them slowly, the results would be altogether unpleasant and misleading. At about one-quarter of the ordinary velocity the whole field of vision would fuse into a uniform gray during every eye-movement. A gray veil would seem to shut out everything from view about four times a second as we read this page. If one winks as fast as possible for about a minute, one gets about the same unpleasant sensations. If the eyes should move still more slowly, the whole field of vision would seem to rush past one at every eye-movement; and we would continually be misled by these illusions of motion.

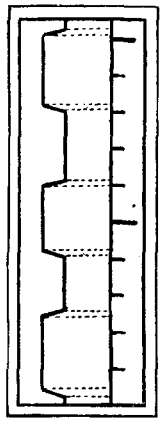

Fig. III.

Fig. III.—The broken line at the left of the figure is reproduced from a photographic record of the movements of a point of light on the eyeball, when the subject tried to move his eyes as rapidly as possible back and forth between two points. The duration of the actual eye-movement is represented by the vertical height of the oblique lines; the moments of rest by the length of the vertical lines. The duration of the eye-movements is less than one-tenth of the total time. Yet it seemed to the subject as if his eyes moved continuously. Each division of the scale at the right of the figure corresponds to one-fifth of a second.

If one takes pains to watch the eyes of a person reading, it will be noticed that each sweep of the eyes across the page to the right is broken by a number of pauses, which may be counted with a little practice. The frequency of these pauses is a fairly good measure of the difficulty of reading. They are fewer if the subject matter read is easy, and the type is large and clear. They are more numerous when one reads a foreign language or a difficult scientific essay. They are much less numerous for rapid readers, but they are never entirely absent.

The general law that we are practically blind during a fraction of a second at each eye-movement has a number of unsuspected consequences. Many a sleight-of-hand trick, apparently depending only on rapidity of movement, really depends for its success on these moments of blindness, when the spectator's eyes attempt to follow a rapid movement of the operator's hand, or unconsciously move in obedience to some other suggestion. More serious are such moments of blindness to the boxer or the fencer. Empirical expediency long ago developed the maxim that both should fixate the eyes of the opponent. This is not merely to avoid giving cues of intended movement, but also to avoid the disastrously numerous moments of blindness which would result if one attempted to follow the motions of the opponent's hands.

If, in a moving street car, one watches the eyes of some person who is interested in the outside objects, one will notice an apparently incessant movement of the eyes. Some are slow as the eyes follow a point of interest. Others are rapid and jerky, as some new point of interest claims the attention. The rapid jerks have all the characteristics of the eye-movements which we have just discussed. They are moments of practical blindness, and serve only to bring a new point of interest into the field of clearest vision. The slow movements are of a totally different type, both in origin and in function. They cannot be produced voluntarily, but they involuntarily follow every continuous movement of the object of regard. They serve the purpose of the previously discussed moments of rest, viz., they keep the point of interest in the field of clearest vision. This new type of movement is peculiar in several respects. It is not a simple reaction to an interesting stimulus, but it is a habitual movement, and may persist after its occasion has ceased, thus giving rise to curious illusions of motion. If one looks at the scenery for a few minutes, from the window of a rapidly moving car, and then suddenly looks at the floor of the car, the whole car will seem to be moving rapidly away from one. This was formerly explained by the law of contrast, but an assistant will notice that the eyes have involuntarily continued to move, just as they did while looking out of the window; so that the image of the car floor moves across the retina just as it would if the floor were really moving ahead while the eyes were still. It will be remembered that we predicted this il-

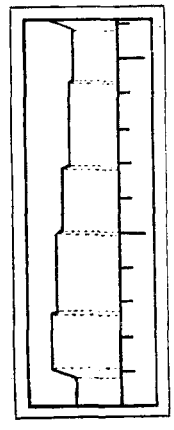

Fig. IV.

Fig. IV.—From a record of the eye-movements of an average reader, reading one line of an easy scientific essay; obtained by the author and Mr. T. J. Cline. The vertical lines show the number and duration of the fixation pauses, *i. e.*, of the moments when the eye is motionless, and receiving impressions from the text. The vertical height of the oblique lines is a measure of the duration of eye-movements during reading. It will be seen that the eye muscles are at rest more than nine-tenths of the time as we read.

lusion in case the eye should move slowly. Similar illusions accompany the phenomena of dizziness.

If one compares the record of work done when the eye follows a moving object, as represented by the oblique lines of Fig. V., with the record of work done by the eye in reading, as represented by the oblique lines of Fig. IV., it will at once be evident why looking from car windows is so unusually fatiguing. Incessant activity such as this would exhaust the strongest muscles. It is ruinous to the delicate muscles of the eyes. Street cars with seats along the sides, so that the attention is constantly directed towards outside objects directly opposite, are menaces to the public health. They will be prohibited some time by public opinion, if not by law. The sooner the better! Meanwhile, if we value our eyes and our general vitality, we will keep our attention inside moving cars, except so far as we can look well towards the front or the rear. The fatigue of travel will be much lessened for those who will observe this simple rule. It will do more than lessen eye-weariness, since the nervous centres for the co-ordination of the eye-movements are situated in close proximity to the centres for the most important reflex and automatic functions, and even moderate fatigue of the former centres is known to have more or less marked influence on the latter.

A comparison of Figs. IV. and V. would seem to indicate that it would be less fatiguing to read on the cars than to watch the scenery. As far as the movements of the eyeball are concerned, this is undoubtedly true. But the question is complicated by the constant jar of rapid travel, and the consequent blurring effect, which causes serious muscular strains within the eyeball, like those produced by looking at badly focussed stereopticon views. These are probably due to the vain and persistent attempts to correct the blur by changes in the convexity of the eye lens. The nature of the circumstances has precluded experimentation, but all the data obtained by the writer, both direct and indirect, seem to indicate that if the car rides smoothly, reading is incomparably

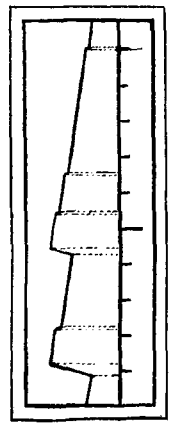

Fig. V.

Fig. V.—Record of an eye following uniformly moving objects; obtained by the author and Mr. J. J. Cogan. It will be noticed that there are no vertical lines. The exclusively oblique lines indicate that in following moving objects there are no moments of rest, but the eyes are in constant motion, more or less rapid, according as the obliquity of the lines in the record approaches the horizontal.

preferable to looking at the scenery, provided the print is large and clear. The travelling public, at least, evidently has some reason to be grateful to those newspapers which print the more important news in heavy type. It should be remembered that in reading a foreign language the attention to details must be closer, so that the evil effects of blurring will be more keenly felt. If the car jolts badly, the eyes had better be kept closed, especially if one needs one's vitality at the journey's end.

To watch the scenery with a minimum of fatigue, pains must be taken to look through a window well ahead. It is even better, if one can control the eye muscles sufficiently, to fixate some point on the window-glass one or two seats ahead. The eyes will in this way be kept motionless, while the general features of the landscape may be seen quite plainly.

Thessaly

BY ROBERT GILBERT WELSH

SPRING perpetual is in thee,
Thessaly!
Here our Northern boughs are bare,
Ravished by the rougher air;
Nymph and faun are fled away;
Procne left us yesterday.
Would that I might follow there,
And, like her, with folded wing,
By the Aegean, blue and fair,
Greet the spring,—
Would that I were now in thee,
Thessaly! Thessaly!

Jason's *Argo* sailed from thee,
Thessaly!
But were I upon thy shore,
Golden fleece could nevermore
Tempt me seaward,—I would stray,
Like Apollo, all the day,
Careless of Admetus' flocks,
Happy with my dark-haired friend
Hyacinthus, on the rocks.
We should blend
Songs that breathed of love and thee,
Thessaly! Thessaly!

All my dreaming is of thee,
Thessaly!
With an aimless step, and slow,
O'er our Northern hills I go,
Where the snowy uplands speak
Of Olympos' snowy peak,
Where the lowland slopes declare
Tempe far away,—this road
Southward lures to places where
Zeus abode.
Shall I never come to thee,
Thessaly! Thessaly!