INVOLUNTARY EYE MOVEMENTS AND BLINKING

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According to the disadaptation hypothesis, involuntary saccadic eye movements are necessary to prevent the formation of an empty field. On the other hand, blinking also creates the conditions for disadaptation. Interaction between saccades and blinking movements during point fixation ($\alpha - 2^1$) was accordingly investigated in adults. Involuntary eye movements and blinking were recorded by means of a photoelectronic apparatus. The results of these investigations showed that blinking can affect the appearance of the next saccade. Examination of many records showed the appearance of saccades after a short interval (20-150 msec), which is not in accordance with the disadaptation role of saccades, for at the time of appearance of the saccade there was no need for disadaptation since it was already present in response to the previous blinking.

According to the disadaptation hypothesis, involuntary saccadic movements prevent the formation of an empty field by changing the receptive fields [2, 4, 6]. Blinking also creates the conditions for disadaptation of the retinal receptors. It is therefore interesting to examine the interaction between saccades and blinking.

This investigation showed that blinking can affect the appearance of the next saccade of the eye.

EXPERIMENTAL METHOD

Adults with a visual acuity of unity were tested. The eye movements were recorded by means of a photoelectronic apparatus developed at the All-Union Scientific-Research Institute of Medical Instrumentation [1].

Horizontal eye movements were recorded with an accuracy of up to 2 minutes of angle, during fixation of a stationary illuminated point ($\alpha - 2^1$). The tests were carried out in a dark room.

Recordings were made with the VÉKS-4 apparatus on photographic paper at a speed of 25 mm/sec. The duration of recording was 1-1.5 min.

EXPERIMENTAL RESULTS

By using the photoelectronic no-contact apparatus, saccades and blinking movements could be recorded simultaneously, whereas most investigations of involuntary eye movements have been carried out with Yarbus's suction caps [5] and blinking was not recorded.

In the analysis of the records of involuntary eye movements and blinking, attention was concentrated on the short intervals between a blinking movement and the next saccade (B-S). The record illustrated in Fig. 1 is an example. In that case a saccade appeared 120 msec after the first blinking movements, and the interval after the second blinking was shorter still (70 msec). Sometimes a saccade appeared immediately after the eyelids were opened, in which case the interval was not more than 30 msec. Similar short intervals also were found between the saccade and the next blinking movement (S-B). Despite the

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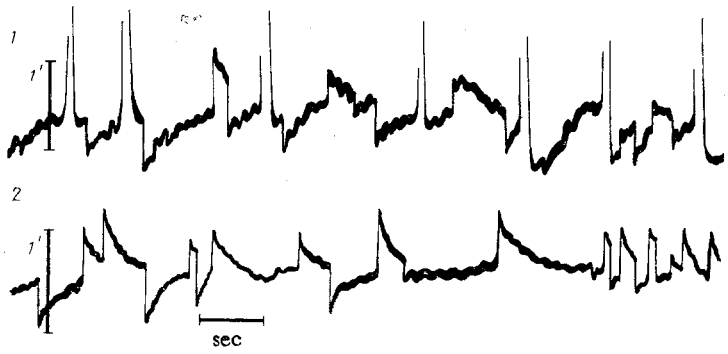

Fig. 1. Records of involuntary eye movements and blinking (1) and of involuntary eye movements without blinking (2). A sudden upward overshoot of the beam corresponds to blinking. Upward deviation of the beam represents an eye movement to the right, downward to the left. Calibration at beginning of record $\alpha = 1°$.

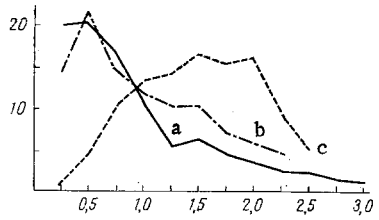

Fig. 2. Histograms of distribution of intervals between saccades (a), between blinking and saccade (b), and also between two saccades separated by blinking (c). Abscissa, time (in sec); ordinate, relative percentage.

numerous blinking movements (7) in the course of 11 sec, there were 16 saccades on this particular record; the mean interval was thus 0.7 sec. This is, of course, less than the normal mean interval of 1 sec.

Concentrating on the short intervals, an effort was made to elucidate the general character of distribution of the intervals by analysis of 120 intervals in 22 experiments (15 subjects). The distribution of intervals between blinking and the next saccade (B-S) was similar in character to the distribution of the time intervals between saccades (S-S) during point fixation (Fig. 2).

The histogram of distribution of intervals between saccades separated by blinking (S-B-S) was totally different in character and the curve rose to a maximum in the region of long intervals.

DISCUSSION

The disadaptation role of saccades is compatible with the existence of on- and off-receptors in the retina. During blinking the visible image is interrupted for a time, and this also creates the conditions for disadaptation of the retinal receptors. From the point of view of the disadaptation role of saccades and blinking it is easy to explain the similarity of the distribution of time intervals between blinking and the next saccade and the distribution of intervals between saccades. In that case it might be supposed that saccades and blinking movements are directly related to the same process and that, consequently, they can replace each other. The sharp increase in duration of intervals between saccades separated by blinking is also understandable from this point of view.

However, despite this clear explanation of the coincidence between the two intervals (B-S and S-S), the analysis of individual records makes it doubtful that the saccade can be replaced by blinking. It is hardly a question of replacement when a saccade appears a very short time (20-150 msec) after blinking, when in fact there is no need for disadaptation because it is already present as a result of the blinking that has just ended. Blinking itself likewise can arise a very short time after a saccade. The number of blinking movements in turn does not affect the mean intersaccadic interval.

It can be concluded from the facts described above that blinking and saccades are two independent processes, each with its own particular purpose.

Blinking can often delay the appearance of the next saccade, so that interaction between them can be considered to exist although it is not due to disadaptation.

The fact that saccades can follow a short time after blinking casts doubts in general on their disadaptation role. To this it must be added that the disadaptation role of the saccade also conflicts with the increase in the number of saccades during fixation of a blind point when, conversely, an increase in their

number would be expected. Additional illumination of the eye during point fixation likewise does not cause the appearance of additional saccades. Finally, the presence of saccades in blind persons, even after a long period of blindness [3], and the presence of saccades in darkness at night cannot be explained in terms of the disadaptation role of saccades.

Blinking can thus affect the appearance of the next involuntary saccade, but a saccade can be observed a very short time (20-150 msec) after blinking. The presence of these intervals cannot be reconciled with the view of the disadaptation role of saccades in the visual process.

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