Fast wavelets recorded through orbital skin-electrodes near the lateral canthus of the human eye during ERG-neutralization

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Summary. Fast wavelets were recorded through skin-electrodes near the lateral canthus of the human eye while the electroretinogram (ERG) was neutralized by the nasal deviation of the visual axis. A high possibility is noted that these wavelets are the action potential of the optic nerve, which has failed to be picked up clinically.

The electroretinogram (ERG) is routinely recorded through a pair of electrodes: an active electrode on the cornea and a reference electrode on the tissue bio-electrically near the sclera. However, the use of corneal electrode has several disadvantages, and the ERG-recordings by skin-electrodes have been investigated[1,2]. On the way of investigation of characteristics of the skin-electrode ERG, we have found that responses from the lateral canthus were neutralized in appearance when the gaze of subjects was deviated to the nasal side by about 35°[3-5]. This is considered to be the cancelling effect of the retinal action potentials within the electrically-shielded eyeball. We named this phenomenon 'ERG-neutralization'. We have further investigated the neutralized responses and found that a new component is involved in an early phase.

Methods. The position of active electrodes of this series of experiments are shown in the schema of figure 1. The electrode on the nasal canthus picked up prominent

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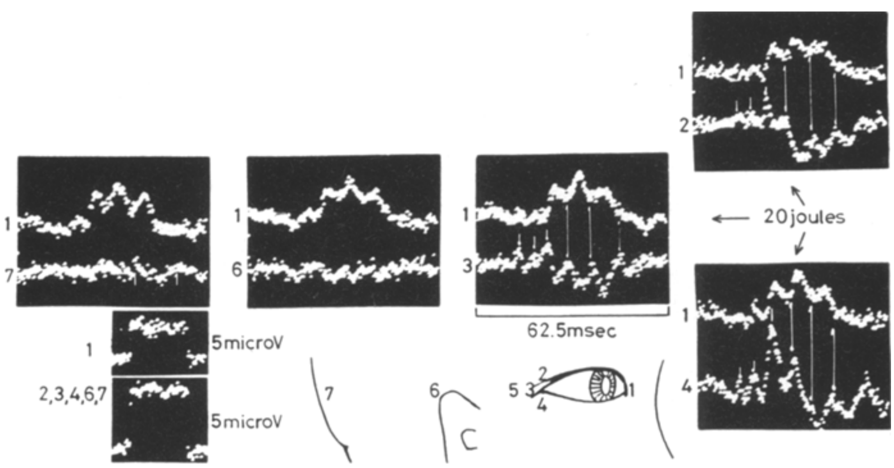

Fig. 1. A series of recordings showing action potentials recorded by skin-electrodes. The position of electrodes is temporarily numbered as the drawing schema. Indifferent electrodes were placed on the earlobes of both sides. Responses were amplified (100 Hz to 10 KHz) and were summed 30 times on an averaging computer. The positivity of active electrodes was recorded as an upward deflection. A diffuse white light of xenon flash discharge was used as stimulus. The discharged energy was 20 joules, and the distance between the light source and the eye was 40 cm. The frequency of the stimulus was set at 1/sec throughout experiments. The duration of stimulus was about 10 µsec. Two adult males, with no ocular abnormality except for myopia, were used as subjects for figures 1 and 2. The pupil of the stimulated eye was dilated submaximally by a mydriatica. The non-stimulated eye was shielded from the stimulus light by a black eye-patch. Before the beginning of experiments, the eye was dark-adapted for 30 min under intermittent stimuli of xenon light.

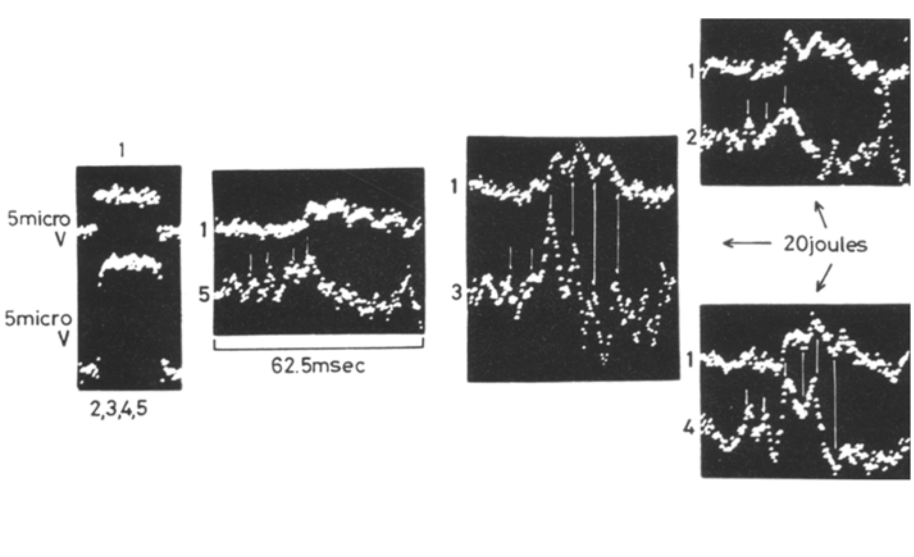

Fig. 2. Another series of recordings showing a limited distribution of potentials. The analysis time is 62.5 msec.

ERGs because of nasal deviation of the gaze, and the responses through this electrode (No. 1) were always recorded as control. The eye of subjects was deviated to the nasal side by 35° and was fixed by gazing at a visual target marked on the inner surface of an adapting dome.

Results and discussion. 2 series of recordings were typically shown in figures 1 and 2. Responses through the electrode 1 were normal ERGs (control). They consisted of a faint a-wave, a prominent b-wave and oscillatory potentials. A faint slow wave on the response through the electrode 6 was an appearance of the visually evoked cortical potential (VECP). It was noted that, on the recordings of 3, 4 (figure 1) and of 2, 3, 4, 5 (figure 2), several wavelets appeared. The implicit times of positive peaks were measured and were 13–15, 18–20, 24–26, 30–31, 37–38 and 44–46 msec in turn. Among them, the latter 3 (7–8 msec interval) were the rest of the oscillatory potentials superimposed on the remaining and slightly reversed b-wave of a low amplitude, because of an excess deviation of the visual axis to the nasal side. However, the initial 2 or 3 peaks on these recordings are difficult to identify as special parts of ERGs from the following reasons. We are inclined to consider that these wavelets on an early phase might be the potentials from the optic nerve. 1. No wavelets corresponding to these were observed on the early phase of upper traces. If these wavelets are parts of ERGs, they should appear more prominently on the recordings through the electrode 1. 2. These wavelets have not appeared on the recordings from the position 6 and 7. This suggested that the wavelets were different from VECP. The implicit times were too short to suggest that they are parts of VECP. 3. If these are potentials from extraocular muscles, they should appear also on the latter phase and appear on responses of the position 1, because the eye was deviated to the nasal side. In this case, the external rectal muscle is antagonizing and the internal rectal muscle is an acting one. The action potential of the antagonizing muscle is weaker than that of the acting muscle. Another reason to exclude the muscle potentials is that the action potentials of extraocular muscles are as fast as 300–800 Hz[6]. The action potential of periocular muscle is similar to that of skell muscle, and is 5–10 Hz[6]. This is quite different from the fast wavelets of this study. The action potentials of periocular muscles are responses which do not synchronize with photo-stimuli. 5. Another possibility is that these are responses from the visual tract of higher level, for example, the lateral geniculate body (LGB). But LGB is anatomically far from the lateral canthus of the eye, and responses of LGB consist of slow waves as VECP. The nasal deviation of the visual axis pushes the optic nerve near to the lateral canthus. This phenomenon has usually been observed by a computer-assisted tomography, and is convenient for the electrodes on the lateral canthus to pick up potentials from the optic nerve.

We are interested in these early, fast wavelets recorded from the lateral canthus during ERG-neutralization, and consider a high possibility that these are the optic nerve potentials. Until now all trials to record clinically action potentials of the optic nerve have failed, for example, inserting electrodes into the nasal and oral cavity. Hence, we suggest the importance of further investigation of these wavelets and a possibility of clinical use, although the signal/noise ratio is low and more advance in recording techniques is needed.

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Alternating activity between neurons of lateral geniculate nucleus and Superior colliculus in rabbit

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Summary. In rabbits, simultaneous recordings of unitary activity of lateral geniculate nucleus and superior colliculus revealed that some neurons of these structures presented fluctuations in their firing pattern which are opposite in phase.

Among mammals, two neural networks play a role in the processing of visual information: they are retino-tectal and retino-cortical[3–6]. The retino-tectal system is involved in oculo-motor functions[7,8] whereas the retino-geniculo-cortical pathway primarily serves perceptual functions[9]. The relationship between these 2 networks is not fully understood[10–12]. Thus, the aim of this study was to demonstrate by simultaneous recording from the *lateral geniculate nucleus* (L.G.N.) and the *Superior colliculus* (S.C.) that the occurrence of spike activity for some cells in one structure is time-locked to an absence of discharge at the other site; that is, some geniculate and collicular neurons present fluctuations in their neural activity which are opposite in phase.

Methods. The experiments were conducted on pentobarbital-anesthetized and paralyzed rabbits. 2 tungsten micro-electrodes were lowered into the L.G.N. and S.C. In the S.C., all cells described in this study were recorded from the superficial layers, i.e. zonale, superficial gray and optic as determined by the morphology of the field potential[13]; electrode site was verified by histological examination. Unit recordings were identified primarily on the basis of the waveform[14]. Cells were activated by full-field 'ON' and 'OFF' illumination (4 foot candle at the cornea) and electrical stimulation of the retina (transretinal stimulation), visual cortex and the optic nerve at its exit from the eye. In the L.G.N., response to optic nerve stimulation permitted differentiation between relay cells (P) and interneurons (I), which gave repetitive responses or a burst to a single afferent volley[15]. The method of mapping the receptive field of some of the cells has been described elsewhere[16].

Results. 36 pairs of simultaneously recorded units were investigated (36 collicular units and 31 from the L.G.N., since some geniculate neurons were coupled with more than one collicular cell). 16 pairs of cells exhibited a clearly opposite phase pattern of discharge. Examples of alternating activity between geniculate and collicular neurons is shown in Figure 1A for three different pairs. The cells of the first pair (tracing *1*, *2*, Figure 1) both responded by a brief burst to light 'ON' with identical latencies (see dot), indicating that the same retinal chan-