LATERAL GENICULATE UNIT ACTIVITY IN FREELY MOVING RATS.
II. RELATION TO CONDITIONING AND MOTIVATION

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Abstract. Unit activity of the lateral geniculate body was recorded on successive days using implanted semimicroelectrodes. Unit responses to light stimuli recorded in water deprived and satiated animals were compared. They differed in dependence on whether the light stimulus is a conditioned one (leading to a behavioral response) or is acting merely as a physical event without relevance to the animal’s adaptive behavior. This was confirmed using the following experimental procedures: (i) recording from one cell population on several successive days under equal conditions, (ii) elaborating a conditioned reflex during recording, and (iii) comparing unit responses to light stimuli in relation to the rat’s behavioral responses (correct, not correct) during the first training days.

Reliability and reproducibility of results are factors often stressed in studies on unit activity. Taking into account the variability of unit activity in neuronal networks, difficulties may arise when one tries to extrapolate results obtained from single cells to groups of cells. The method of chronically implanted semimicroelectrodes is suitable for repeated recordings of units under the same conditions.

Results obtained previously (1, 4) show that there is a statistically significant tendency for LGB unit responses to light, recorded in water deprived light trained animals, to be different from responses recorded
after satiation. We therefore decided to study whether the same response relations occur when the activity of one cell is recorded for several days under thirst and satiation. We were furthermore interested in knowing whether similar changes can be observed during the elaboration of a conditioned reflex to light.

Unit activity of the LGB was recorded via implanted NiCr-wire (50 μm) electrodes in male adult albino rats under water deprivation and after satiation. The methods are described in detail elsewhere (1, 4). Records were taken from rats which were previously trained either to keep still in order to receive water (WT) or to obtain light stimulation with water reward after a correct behavior (LT), or from naive animals during the light training procedure (LTr).

Unit responses to light (15 ms flashes of a light emitting diode 7 mcd, 560 nm) were compiled and represented graphically in peristimulus histograms (PSH) or in cumulative histograms (CH) according to the experimental conditions. Statistical analysis of unit response to light and comparison of PSH and CH derived from the activity of the cell was carried out with a χ²-test (4).

Occasionally potentials of two or three units were recorded simultaneously, as described by Disterhoft (5). For the sake of simplicity the term “unit” will be used. We can assume however, that in structures with columnar organization, neurons in the vicinity of the electrode tip functionally belong to the same neuronal population. In 15 animals (7 WT, 8 LT) unit activity was recorded for 2 to 6 successive days. As regards the number and sequence of phases of unit responses (excitation or suppression of activity (4)), recorded in the satiated animal for several days, no differences were found in 9 animals (Fig. 1a, S), in 6 rats the number of late phases varied from day to day (Fig. 1b, S). When the response pairs, thirsty — satiated (Dw or Drew/S), were compared in 14 out of 15 units the response were similar (Fig. 1a, b).

LGB unit activity of 16 rats was recorded during the elaboration of a conditioned reflex to light. In 11 (group LTr) rats the discharges could be considered as being recorded from identical cell populations (Fig. 2, original spike trains, session 2–8). Concerning the response type, 3 units were stable throughout all sessions (5 to 10 days). In 6 out of the remaining 8 units late response phases disappeared before the 5th session and sometimes reappeared up to the 8th session (Fig. 2, LTr 296). Additionally during this period we found a decrease of the response latency (number of bins between stimulus and first significant deviation) by about 5 ms (one bin) in 5 units. In 3 of them the latency returned to the initial value during the experimental period. In the course
Fig. 1A (WT 351), 1B (LT 318), PSH of the activity of 2 LGB units recorded on several successive days in rats trained to react to light (LT) or to the water tube moved into the box (WT). D, deprived, receiving no water; Dw, deprived, light given stochastically between drinking; D_{rew}, deprived, reaction to the light stimulus is rewarded by water; S, satiated. Bin width 5 ms, arrows, beginning and termination of the light stimulus, number of single responses \( n = 10 \). The marked channels differ significantly (\( P \leqslant 0.05 \)) from the background activity (average of the first 15 bins) in their number of impulses.
of the sessions the rats developed an attentive behavior and began to react more correctly.

When visually evoked unitary responses recorded in an animal moving towards the water tube (D_{rew+}) were compared to those which occurred when the thirsty rat was behaviorally unresponsive (D_{rew-}) we found similar results (Fig. 2, LTr 299). Out of 15 recording sessions with 9 rats a stable response pattern was observed in 3 cases. In 12 records the PSH showed significant differences consisting mainly in a smaller number of phases when the reaction was correct (Fig. 2).

In 4 experiments with light trained animals we were able to monitor

![Fig. 2. PSH of the activity of 2 LGB units recorded in rats during conditioning to light stimulation. s, 1–8: number of training session. Other denotations are the same as in Fig. 1. LTr 299: bin width 5 ms, n = 8, LTr 296; bin width 10 ms, n = 6; at right, photographs of original spike trains, dots: discriminated impulses. — no reaction to light, + reaction to light, both signs combined: the behavioral reaction of the first sign prevails.](image-url)
unit activity during extinction. When the reward probability decreased, a significant suppression of primary responses was observed, especially when the rat reacted to light (Fig. 3, $D_{w+}$).

We may assume from our experiments that visually evoked LGB unit responses can differ from one another under various experimental situations, specially depending on whether the light stimulus is a conditioned one (leading to a behavioral reaction) or merely acts as a physical event without relevance to the animal's adaptive behavior. Ramos et al. (7) suppose that differences of LGB neuron responses during discrimination tasks are brought about by memory processes. As has been shown by mapping studies (5, 6) changes of neuronal activity during conditioning which possibly could be ascribed to the learning process, never occur in the sensory nuclei first, but in brain sites associated with

Fig. 3. Single responses and cumulative histogram of an LGB unit in a light-trained animal; extinction trials ($D_w$) at two days. Despite of correct ($D_{w+}$) or not correct ($D_{w-}$) behavior to the light stimulus no reinforcement by water reward is given. Numbers at the right side: the number of light responses during the experiment.
the reward systems, as well as in the motor system, which can modula-
te the transmission of signals in the visual system (2, 8, 9). The transfer
eratio of LGB neurons is related to the state of arousal too, as was point-
ed out by Coenen and Vendrik (3). Considering the conditions under
which the experiments were performed our results could be interpreted
in terms of dependence on the actual attentive or arousal state in
connection with the elaborated conditioned reflex, rather than as a neu-
ronal correlate of memory processes.

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