Spontaneous Activity of Thalamic Neurones during Wakefulness and Sleep in Monkeys

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Spontaneous thalamic unit activity in the monkey, as in the cat, varies in dependence of the state of vigilance [Benoit and Châtaignier, 1972]
The aim of this work was to look for a way to systemize the observed modifications. The following conditions were imposed:
1. To observe the same neurones in the three principal states: waking (W), slow-wave sleep (SWS) and desynchronized sleep (DS);
2. To recognize the neurones recorded. The neurones of the ventrobasal complex (VB) and of the lateral geniculate body (LGB) have been identified by their response to well-defined physiological stimuli.
The spontaneous activity of 317 thalamic neurones have been recorded in 3 Macaca speciosa under chronic experimental conditions using glasscoated platinum micro-electrodes in accordance with the usual techniques. The W, SWS and DS states have been defined using the normal criteria. The LGB neurones have been recorded after dark adaptation.

Results

A detailed analysis was done on 108 neurones; 48 neurones were
observed in the three states (W, SWS and DS) of which 30 had been identified as neurones of the YB and LGB; 5 others were thought to belong to the thalamic reticular nucleus (RT) (based on their type of discharge and the recording position). 60 other neurones were recorded only in two vigilant states (W, SWS), 17 of which were not identified. Only discharge patterns during stable periods of wakefulness and sleep were analyzed.

During State W

The spontaneous activity patterns of the VB and LGB neurones during W are of up to three distinct types:

Type I. The mean firing rate exceeds 16 spikes/sec and can be as high as 77 spikes/sec. The interspike interval histogram (IIH) is grouped; the calculation of the lower quartiles (LQ), higher quartiles (HQ) and the median (M) yields the following values: LQ <35 msec, M < 50 msec, HQ < 80 msec. The joint interval histogram (JIH) [Rodieck et al., 1962] is grouped on the bisector or near the axis intersection. The intervals of comparable duration followed one another.

Type II. The mean firing rate ranges between 5 and 15 spikes/sec (inclusive). The interspike interval histogram is asymmetrical: 5 msec < LQ < 70 msec; 30 msec < M < 135 msec; 100 msec < HQ < 250 msec. The JIH is dispersed showing successions of comparable intervals more often included between 30 and 100 msec, and the association of intervals of very different lengths.

Type III. The mean firing rate is less than 5 spikes/sec. The IIH is very asymmetrical: QI < 70 msec, M > 100 msec, QS > 250 msec. The JIH values are aligned along the axes showing the predominance of the interval associations of very different durations.

The neurones of RT show a type III pattern with a firing rate smaller than 5 spikes/sec during W and higher in SWS and DS. The type of discharge in SWS is different from that of the neurones of VB and LGB and resembles the one described in the cat [Mukhametov et al., 1970], Table I shows the distribution of the neurones according to type of discharge pattern.

Table I. Distribution of the 108 analyzed neurones

<table>
<thead>
<tr>
<th>Type of Discharge</th>
<th>Number of Neurones</th>
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<tbody>
<tr>
<td>W</td>
<td>VB, LGB</td>
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<tr>
<td>SWS</td>
<td>RT</td>
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<tr>
<td>DS</td>
<td></td>
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Table 11. Mean firing rate (spikes/sec) in W, SWS and DS calculated for the 35 units (VB, LGB and RT) according to the type they belong to in W (N = number of units)
During sleep, the discharge patterns change in the sense of standardizing of the spontaneous activity of the different neurones. The mean discharge rates are shown in table II.

During State SWS

The modifications of IIH and JIH are difficult to systemize and depend on the discharge frequency. Nevertheless, for the majority of the neurones there is a marked asymmetry of the IIH with an LQ lower than 70 msec and a strong dispersion of the medians (10-200 msec) and of the HQ (50 msec to 1 sec and more). Clustered firing is reduced or absent in the neurones of medium or high discharge frequency.

During State DS

The change in discharge depends on the type of neurone in W. The discharge diminishes in the W type I neurones; the IIH is asymmetric; the values are grouped along the axes on the JIH as they are during state SWS. The discharge hardly varies in W type II neurones; an acceleration in the bursts of rapid firing is the phenomenon most frequently seen.

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The neurones of W type III strongly accelerate their discharge, the IIH reveals grouping and is slightly asymmetrical, thus sometimes resembling those obtained on awakening in group I.

For all the JIH of all neurones the difference between W and DS is clearly demonstrated by the values of the medians. In fact, in DS all the values are lower than 90 msec, whereas on awakening they are highly dispersed. The asymmetry in DS of the majority of the JIH is demonstrated by the dispersion of values of the HQ which nevertheless stays lower than that observed in W for type III neurones.

These data show that the greatest number of neurones during state DS have an irregular discharge with bursts of extremely rapid firing and some periods of inactivity between them, while in W the high frequency neurones (type I) have a regular discharge.

From these results certain points seem to emerge. In the waking state, the organization of the spontaneous activity and the firing rate allows a clear differentiation of three groups of neurones. Their distinct role in the sensory transmission must be considered. In fact, our results are similar to those obtained in LGB by Sakakura [1968], who described in the cat two
types of neurones (P and I) according to their response modality to electrical stimulation of the optic tract. The type of spontaneous activity of their P cells is comparable to the activity of our type I and the one of their I cells to our types II and III. During sleep, the ‘standardization’ of the spontaneous discharge in these groups is noticeable.

The changes occurring with the onset of SWS and DS depend in effect on the type of activity during waking and can be explained, in part, by disinhibiting mechanisms for some and by defacilitating mechanisms for other neurones as Evarts [1964] has proposed. While the spontaneous neuronal activity increases most often in passing from SWS to DS it appears that during DS state the discharge is always organized differently as compared to W.

Since variations observed in SWS and DS are to some degree similar, it is not unlikely that common mechanisms are active in the two types of sleep.

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Hippocampal EEG Changes and the Motivational-Emotional Aspects of the Paradoxical Phase of Sleep

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EEG recordings in the cat made during the paradoxical phase (PP) of sleep in the presence of continuously desynchronized neocortical activity revealed three significantly different hippocampal electrical patterns: (1) desynchronization (fig. la); (2) 0-dominance (fig. lb), and (3) 8-dominance (fig. lc) [7].

During 0-periods there occurred an increase in heart rate and respiration, while during 8-periods a decrease of these effects was recorded (fig. 2).

Earlier experiments of Grastyân and his associates [2, 4] suggested that emotional-motivational mechanisms would be active during PP. Since during the PP inhibition of muscular tone and of spinal reflexes makes it impossible to observe actual behavioral changes, correlation of electrohippocampal and vegetative patterns observed in PP and during characteristic motivational states of the awake animal seemed to be the only available way of testing the above suggestion.

In a recent study of Grastyân et al. [3], a strict correlation was revealed between the spatial direction of subcortical stimulation-elicited