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The measurement of tonic brain activity by means of magnetoencephalography

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Introduction

Event-related brain activity – electric potentials and biomagnetic fields – are measured as changes in activity relative to a baseline interval prior to the eliciting event. It is likely that the level of this baseline affects the particular activity evoked. A depolarization of apical dendritic networks shifts the surface potential towards negativity and adds up to cortical excitability. The response of a highly excitable neuronal network to a stimulus will differ in waveshape and amplitude from an event-related potential generated by the same neuronal network with little excitability. Therefore it is of interest to quantify baseline activity and to relate it to the event-related one. Strong artefacts render the measurement of the absolute electric DC potential useless. We have developed and evaluated a technique to quantify the baseline level by means of magnetic measurements.

A direct measurement of slow variations in the magnetic fields would be contaminated by external sources. Moving the magnetic source, i.e. the head, away from the magnetic sensors and back again will interrupt the detection of the tonic field of the brain, and thus convert it into a field varying as fast as the movement of the head. The amplitudes of these variations allow the quantification of the DC-field. Thereby it is necessary to leave external sources unchanged, i.e. to move the head and not the sensor.

Method

The head was adjusted on a platform which could be moved along the dewer axis so that the distance between the surface of the dewer and the head could be varied from 0.25–4.75 cm. The difference in magnetic fields between the two extreme head positions was measured at 30 locations centered around C4, using a Siemens KRENIKON®. The DC-field was measured during and after a 3 min hyperventilation period and compared to resting periods before and after hyperventilation.

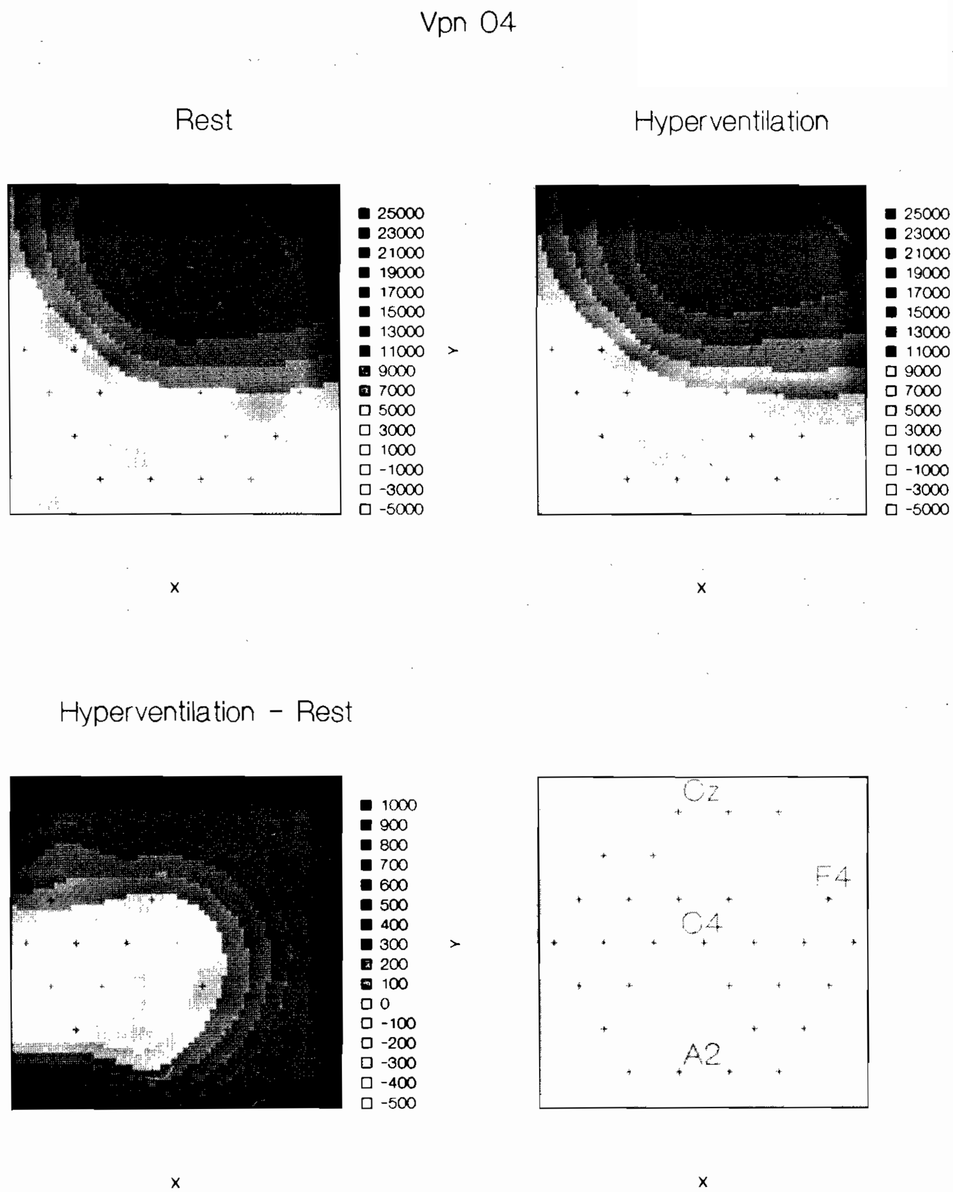

Fig. 1. Absolute biomagnetic fields for one subject during rest (upper left) and hyperventilation (upper right). Numbers indicate the field strength in fT. The positions of the sensors are marked by crosses. The average difference between measurements during hyperventilation and rest is illustrated on the lower left.

Results

A marked step in the range of several pT accompanies the movement of the head in either direction. The magnitude and polarity of this step depends on the location of the channel sensor. The magnitude of these steps were quantified as the difference of the magnetic field before and after the change in head position. A typical map of these differences which represent the tonic field is illustrated in Fig. 1. Under resting conditions, the magnetic fieldlines penetrated out of frontocentral regions and went back into temporal sites. Thus, the corresponding equivalent current dipole would point to a ventro-anterior direction, producing fields of up to 20 pT. It turned out to be more or less perpendicular to the much weaker equivalent dipole of the magnetically measured CNV. Hyperventilation altered the tonic field up to 1 pT in the six subjects investigated.

No comparable changes were detected, when a phantom head filled with saline solution was moved away from the sensors and back again.

Discussion

Results demonstrate the feasibility to quantify tonic electromagnetic activity of the brain. The relations between phasic biomagnetic fields, DC-changes during hyperventilation and tonic levels correspond with those measured electrically: the average DC changes during hyperventilation typically range from 50–70 μV [1], i.e. they are 5–10 times as large as evoked potential amplitudes; the same holds for the magnetic measurements. Electrically, the tonic, absolute DC fields are more difficult to determine; animal studies suggest levels in the range of mV, and thus magnitudes about 20 times larger than the hyperventilation induced potentials. The same relation seems to hold when measured by means of MEG. The present results suggest the existence of tonic tangential current dipoles in the region of the central sulcus. They could be explained, if we assume a relatively higher tonic excitability in sensory areas compared to other cortical regions. Excitability is known to be modulated through depolarization in apical dendritic trees [2] which, when only present in sensory areas, would produce such tangential dipoles. In the waking state external stimuli would be received by relatively higher excitable neuronal tissue. In sleep stages this excitability may be lowered, as suggested by animal studies [3]. In motor and action related cortex phasic changes may predominate the regulation of cortical excitability. Only when needed, excitability is enhanced for seconds, represented in a CNV.

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References

1. Rockstroh B (1992) In: McCallum WC and Cuury HS (eds) Slow Potential Changes in the Human Brain, Plenum Publishing Corp, New York, in press.
2. Elbert T and Curry HS (1992) In: McCallum WC and Curry HS (eds) Slow Potential Changes in the Human Brain, Plenum Publishing Corp, New York, in press.
3. Land V (1968) In: Stellar E and Sprague J (eds) Progress in Physiological Psychology, Academic Press, New York, pp 1–77.