SENSORIMOTOR CORTICAL ACTIVITY OF TETRAPLEGICS DURING ATTEMPTED FINGER MOVEMENTS

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SUMMARY: We studied the sensorimotor cortical neuromagnetic activity in three tetraplegics during attempted movements of 1) the right 2) the left and 3) both index fingers. Left and right sensorimotor cortices produced constant 20-Hz activity that was suppressed bilaterally during attempted movements. Unlike after real movements in healthy subjects, this suppression was not followed by a rebound of the synchronous activity. Contralateral motor fields to attempted movements were recorded in one subject.

INTRODUCTION

In healthy subjects, movements of body parts evoke contralaterally-dominant motor electric potentials and neuromagnetic fields in the sensorimotor cortex [1]. The pre-movement fields begin already 0.5 s prior to the movement onset and are followed by three phasic movement evoked fields (MEFs) [2,3]. The sensorimotor cortex also generates 10- and 20-Hz rhythmic activity (mu-rhythm) that is suppressed before and during movements [4,5]. When the movement ends, the power of the mu-rhythm is enhanced ('rebound').

A potential user group of Brain-Computer Interfaces (BCIs) are tetraplegic persons. Interestingly, even though these patients cannot move there extremities, their sensorimotor cortices are activated during attempted movements. An fMRI study of five tetraplegic patients showed sensorimotor activation during attempted hand and foot movements [6]. Such activation to attempted big-toe movements was also found in nine paraplegic patients [7]. The activation patterns resembled those of the healthy control group.

Our aim is to further characterize cortical activation of tetraplegic persons. For this aim, we used whole-head neuromagnetic recordings.

MATERALS AND METHODS

Subjects: Three, right-handed, male, tetraplegics. S1 injured four months earlier, aged 24. S2 injured two years earlier, aged 24. S3 injured five years earlier, aged 31. All patients were classified ASIA A with complete tetraplegia.

Recordings: Recordings were made in a magnetically shielded room using a 306-ch whole-head magnetoencephalography (MEG) device. This device measures neuromagnetic signals from 102 locations with triple sensor units. Each unit consists of one magnetometer and two orthogonal planar gradiometers.

Procedure: One of four visual stimuli (duration 0.5 s, ISI 3 s) instructed the subject to attempt to lift the left (←) index finger, the right (→) index finger, both (↔) fingers, or not (□) to attempt finger movements. The subjects were instructed to attempt a quick movement after the stimulus disappeared. Two 16-minute sessions with 80 repetitions of each task were recorded.

Data-analysis: Time-Frequency Representations (TFRs) and motor fields to the attempted movements were calculated (from one second before stimulus onset to three seconds after it). Due to technical problems, evoked fields could be measured only from one subject.

RESULTS

Fig. 1 shows TFRs from two locations (means of the two orthogonal gradiometers) over the left and right sensorimotor cortices of the three subjects when they were relaxed and did not attempt to move their fingers. 20-Hz MEG activity was recorded bilaterally in all subjects. S1 and S2 showed also bilateral 10-Hz activity.

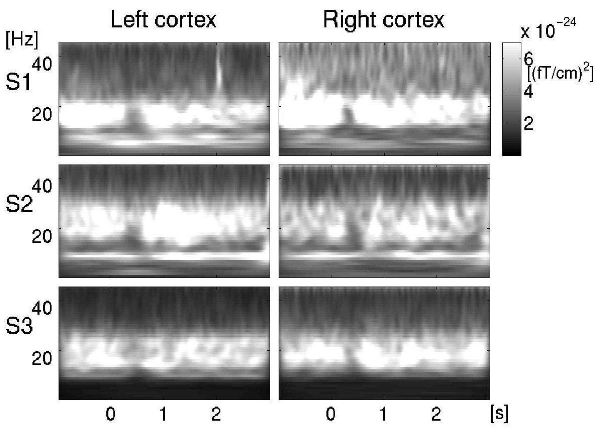

Figure 1: TFRs (80 repetitions) of the three subjects when they were relaxed and did not attempt to move their fingers. Time point 0 indicates the onset of the visual stimulus.

Fig. 2 shows how the 20-Hz activity was suppressed during attempted movements in S3. Suppression started already before the attempted movement. It was seen in all three conditions and lasted for almost two seconds. Very similar pattern was seen in the data of the two other subjects. The 10-Hz activity seen in S1 and S2 was also suppressed during the attempted movements.

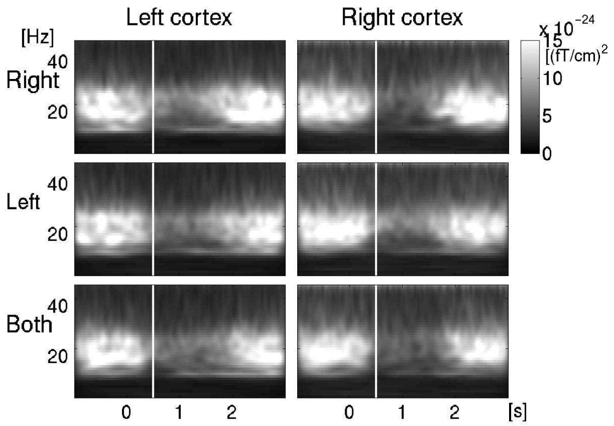

Figure 2: TFRs (80 trials) of S3 during different attempted finger movements (onset at white line). The bilateral suppression of the 20-Hz activity begins already before the movement onset.

Fig. 3 depicts the evoked motor fields of S3 from gradiometers over the left and right sensorimotor cortices. The response, beginning already before the onset of the movement attempt, was contralaterally dominant. Attempt to move both fingers simultaneously caused bilateral activation.

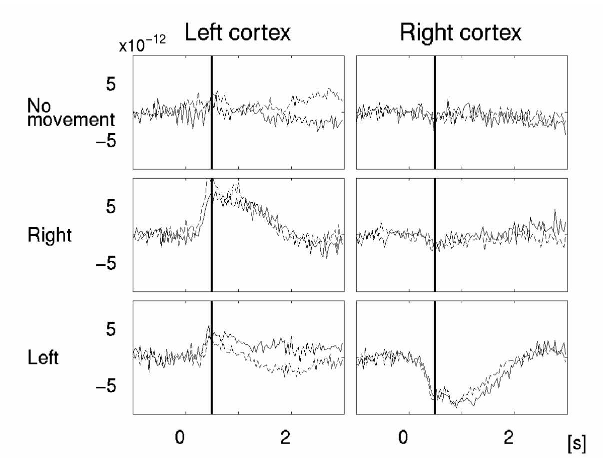

Figure 3: Evoked motor fields of S3 when no movement was attempted and during the attempt to move the right and left fingers (onset at black line). The two different sessions are overlaid. Signals are shown from two gradiometers located over the left and right sensorimotor cortices. 80 trials averaged in each of the sessions, pass band 0.1-200 Hz.

DISCUSSION

Our preliminary data show that neuromagnetic 10- and 20-Hz rhythmic activity can be recorded over the sensorimotor cortex of paralyzed patients. This activity was suppressed during attempted finger movements. The suppression resembles that found in healthy subjects, reported in other studies. However, the suppression of the mu-rhythm seems to be more widely distributed than in healthy subjects. In addition, the suppression of the 20-Hz activity was not followed by the strong rebound typically found in healthy subjects.

The motor evoked fields of S3 were quite different from those in healthy subjects. The pre-movement activation was fast compared with the slow activation in healthy subjects. The phasic evoked fields were not recorded at all.

Because of the lack of the strongly lateralized 20-Hz rebound found in healthy subjects, the separation of cortical activities during the attempted left and right movement is not easy. However, the side of the attempted movement can be easily seen in the motor evoked fields of S3.

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