Abstract

One of the most important aspects in designing a Brain-Computer Interface (BCI) system is the feature extraction. Event-Related (De)Synchronization (ERD/ERS) phenomena are widely used features in this respect. However, before extracting the features it is necessary to verify if the data present well defined ERD/ERS patterns. In this paper we used a time-frequency (TF) analysis to recognize and identify event-related patterns. One healthy, female subject was submitted to a BCI offline experiment. The results of the TF analysis of the data reveals the presence of ERD/ERS patterns as reported in the literature.

1 Introduction

In general a non-invasive BCI system consists essentially of five elements (e.g. [1], [7], [8] and [9]). Succinctly, is acquired using a non-invasive imaging technique, like electroencephalography (EEG), and the most valuable features to be applied, are extracted.

Event-related Potentials (ERPs) are time-locked potentials that change after a particular event whether external or internal: a sensory stimulus, a mental event, or even the omission of a stimulus within a series of repetitive stimuli. In many cases of BCI applications changes in ongoing EEG signals are used. On the one hand, a decrease of EEG power in a given frequency band is assumed to result from a decrease of synchrony of neurons and is called Event-related Desynchronization (ERD). This is commonly seen in the alpha frequency band corresponding to a state where the corresponding cortical areas are actively involved in attentional processes and/or motor preparation. On the other hand, an increase of power in a given frequency band, that is assumed to reflect an increase in neuronal synchrony, corresponds to a state where inhibition of the cortical network prevails, and is called Event-Related Synchronization (ERS).

These ERD/ERS phenomena in the alpha oscillations are typically recorded over the somatosensory cortical areas (mu rhythm) and have to be well defined. In this paper we used a time-frequency (TF) analysis (see [2]) as a tool to identify event-related EEG patterns in an offline motor movement based BCI experiment.

2 Method

A scalp EEG was recorded from a healthy female subject (21 years old). The experiment lasted for about on hour including the placement of the EEG cap, that displays the electrodes on the 10-20 international placement system. The subject was seated comfortably in front of a computer screen and was asked to refrain from making movements during the sessions and to concentrate on the computer screen. One session composed of 40 cued trials was recorded. In 20 trials the subject was asked to imagine a left hand movement, and in other 20 to imagine a right hand movement. Each trial started by asking the subject to fixate a cross in the center of the screen to indicate which hand to imagine or move. During the baseline, two figures (one for each hand) were added. Each figure contains three plots with the averaged power (across frequency and trials), the difference between power in channel C3 and C4, and the standard deviation of the averaged power. All three plots are in function of time (0−9 s).

In order to see the evolution of the power in time and the averaged power during the baseline, two figures (one for each hand) were added. Each figure contains three plots with the averaged power (across frequency and trials), the difference between power in channel C3 and C4, and the standard deviation of the averaged power. All three plots are in function of time (0−9 s).

3 Results

Left Hand: Figures 3 and 4 show a desynchronization in the channels C3 and C4, specially for the lower frequencies (11-14 Hz). Figure 5 show the averaged power (‘AVG’; normalized by the mean power of the baseline period), in the time window 0-9 s, as well as its standard deviation.
Looking to the upper and lower frequencies, it is not possible to clearly identify the ERD on channel C4 and ERS on channel C3, being evident an ipsilateral desynchronization. In Figure 5, the high average and standard deviation values during the baseline is noticeable, followed by a significant decrease after the cue is presented (4 s).

Right hand: Comparing the channels C3 (Figure 6) and C4 (Figure 7) a higher desynchronization on C3 than on C4 is apparent, apparent for both the upper and lower frequencies of the mu rhythm. Considering the averaged power and its standard deviation (Figure 8), for lower frequencies the average power in channel C3 is considerably lower than in channel C4, though the same pattern can also be observed for upper frequencies. Despite the high variability during the baseline, the power stabilized after the cue onset, as well as its standard deviation.

4 Discussion

The recorded session seems to have congruent results with the literature [4]. Comparing Figures 3 and 4 not only a desynchronization is visible in the channel C4 but also an ipsilateral desynchronization. For the right hand movement, a desynchronization of the left side of the motor cortex compared do the right side would be expected, which is observable from Figures 6 and 7. These last corroborate the phenomena of desynchronization of contralateral motor cortex. It is also interesting to look to the upper and lower frequencies of the mu band. For the right hand movement, in Figure 8 the ERD is more visible for upper frequencies than for lower frequencies, which is supported by the results described in [6]. Here, Pfurtscheller et al. observe that the lower frequency components report non-specific ERD patterns, whereas the upper frequencies show a more specific pattern.

5 Conclusion

In order to verify if the data contains ERD/ERS patterns, a TF analysis was performed. This study explains how to use TF information of upper and lower frequency components of the mu rhythm to identify the ERD/ERS phenomena. For hand motor tasks the power over channels C3 and C4 are analysed and the results seem to agree with the ones found in the literature. Hence, the data can be considered for subsequent analyses, namely to apply feature extraction methods of ERD/ERS.

References


