Shahid et al. BMC Neuroscience 2010, 11(Suppl 1):P127
http://www.biomedcentral.com/1471-2202/11/S1/P127

BMC Neuroscience

POSTER PRESENTATION Open Access

Mu and beta rhythm modulations in motor imagery related post-stroke EEG: a study under BCI framework for post-stroke rehabilitation

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From Nineteenth Annual Computational Neuroscience Meeting: CNS*2010
San Antonio, TX, USA. 24-30 July 2010

Motor impairment after stroke is a leading cause of disability. Fortunately there is sufficient evidence that undertaking motor imagery (MI) in conjunction with physical practice of rehabilitation tasks leads to enhanced functional recovery of paralyzed limbs among stroke sufferers. This requires ensuring patient engagement through neuro-feedback which can be provided by an MI based brain-computer interface (BCI). A BCI uses EEG from motor cortex and finds MI related modulation of sensorimotor rhythms, as it is known that left or right hand MI by a healthy subject results in a desynchronization (ERD) of mu (8-13Hz) in contralateral EEG along with synchronization (ERS) of beta rhythm (18-24Hz) in ipsilateral EEG [1]. This study examines if the MI related EEG from hemiplegic patients has similar mu and beta oscillation patterns and its effectiveness in BCI development.

Under the supervision of rehabilitation experts 3 left and 2 right hemiplegic stroke patients (59 ± 12y) underwent up to 12 EEG recording sessions (each session has 120 trials of 7 seconds (including 3s rest)). The subjects were performing MI while playing a ball-basket game as part of the neuro-feedback. During trials, two bi-polar channels C3 and C4 and left/right imagination labels were recorded for processing. The EEG power in the impaired hemisphere was found much lower than that of the healthy side. Off-line analysis using widely-used power spectral density (PSD) features and a linear discriminant analysis (LDA) classifier resulted in poor MI classification accuracy (CA) for impaired limb. We therefore, use bispectrum-based (BSP) feature extraction technique along with LDA classifier. BSP computes the sum of absolute log-bispectrum of band-passed EEG, which finds non-Gaussian and nonlinear properties of

Table 1 Two class MI classification accuracy for stroke subjects with different frequency bands

Subject	Age (year), Gender, Motor Impairment Side, Time since stroke (month)	Mu band only (8-14 Hz)		beta band only (14-30 Hz)		Mu & beta band (8-30 Hz)	
		Max. Acc % O (L R) ¥	TB† (s)	Max. Acc % O (L R) ¥	TB† (s)	Max. Acc % O (L R) ¥	TB† (s)
P1	55y, M, L, 48m	67 (68 66)	5 – 6	72 (73 72)	5 – 6	73 (72 73)	6 – 7
P2	47y, F, L, 41m	68 (68 67)	6 – 7	67 (67 66)	5 – 6	70 (70 70)	6 – 7
P3	57y, M, L, 15m	62 (64 62)	6 – 7	64 (64 62)	6 – 7	66 (67 65)	6 – 7
P4	63y, M, R, 20m	65 (65 65)	5 – 6	67 (68 66)	5 – 6	67 (66 68)	5 – 6
P5	71y, M, R, 16m	64 (63 64)	5 – 6	67 (69 66)	6 – 7	69 (69 68)	5 – 6

¥Mean of maximum accuracies obtained in different sessions. O = Overall, L = Left and R = Right imagery accuracy.
†TB=Time band within which the max number of highest accuracies occur.

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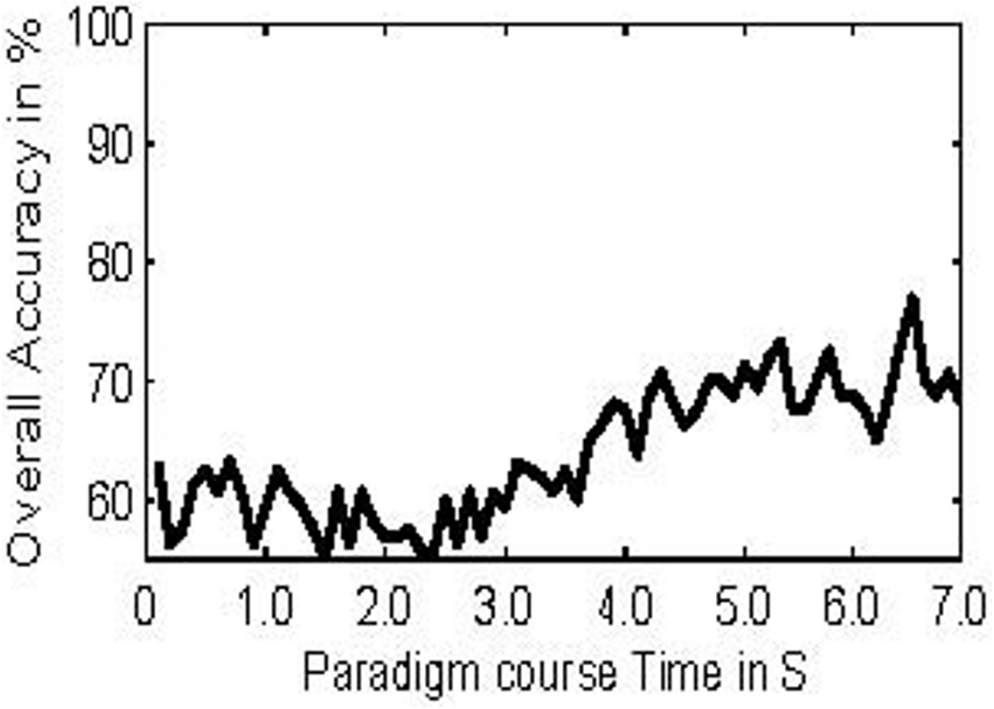

Figure 1 CA during the time course of paradigm (P1)

the signal providing bispectral energy. Two BSP features from each channel of EEG were extracted. A 5-fold cross validation technique followed by optimization was applied to find the best classifier for the subject-specific BCI system. Feature CA obtained in the optimization phase (Table 1) is computed from the inter-session mean of maximum CA. The CA was grouped in terms of selected frequency band (used in BSP). Fig. 1 displays an example of accuracy distribution (observed for the subject P1) during the time course of the paradigm.

Conclusions

In spite of unequal power distribution, a separable MI bispectral features could be found resulting into nearly equal (69%) left and right MI accuracy using the BSP features in all sessions (120 trials). This happens due to inherent properties of BSP and not usual with power spectrum based BCI. Also the higher CA comes if both mu and beta bands of EEG is considered. This indicates that the post-stroke subject's MI related EEG contains modulated mu and beta rhythms. Compared to the rest state, CA increases during MI time course (Fig. 1). But, the post-stroke subjects perform delayed (6-7s) MI, peaking closer to the end of the trial. Hence it is concluded that the BSP based BCI can be effective for stroke rehabilitation.

Published: 20 July 2010

Reference

1. Pfurtscheller G, Neuper C, Flotzinger D, Pregenzer M: **EEG-based discrimination between imagination of right and left hand movement.** *Electroencephalogr Clin Neurophysiol* 1997, **103**:642-651.

doi:10.1186/1471-2202-11-S1-P127
Cite this article as: Shahid *et al.*: Mu and beta rhythm modulations in motor imagery related post-stroke EEG: a study under BCI framework for post-stroke rehabilitation. *BMC Neuroscience* 2010 **11**(Suppl 1):P127.