

# Home-Based Rehabilitation System Using Portable Brain-Computer Interface and Functional Electrical Stimulation

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**Introduction:** Brain Computer Interface (BCI) controlled Functional Electrical Stimulation (FES) has been proposed in literature for rehabilitation of spinal cord injury (SCI) and stroke patients [1, 2]. It is believed that faster rehabilitation can be achieved by combining the activation of the motor pathways through motor imagery (MI) and sensory pathways using FES [3]. Currently, suggested solutions typically rely on costly equipment, limiting their application to a hospital environment. The period of potential rehabilitation for patients is longer than the average time spent at the hospital post-injury; therefore patients would benefit from extended home-based therapy with an inexpensive, user-friendly device. Here we propose a portable BCI system consisting of a wireless multi-channel headset (EPOC, Emotiv, USA) and a tablet (ASUS Win 8.1), combined with multi-channel FES (Rehastim, Hasomed, Germany).

**Material, Methods and Results:** Eight able bodied participants took part in this study (age=31.7±5.05) (5M, 3F). Custom-made software was developed in Visual C++ to synchronize the EPOC with FES using a tablet computer. The FES was applied to the participants’ right hand flexor muscles. Electroencephalography (EEG) was recorded bipolarly from FC3-CP3 location (sampling frequency 128 Hz). The relative power of the sensory motor rhythm (SMR, 8-12 Hz), calculated online by band pass filtering the signal, squaring, smoothing and averaging over 0.5 s window, was used as a parameter to provide a visual feedback to the users. A time-controlled switch algorithm [1] was used for BCI-FES system with the time set to 1s and SMR threshold set individually. To control the FES using BCI, subjects were instructed to imagine moving their right hand, following a visual feedback in the form of a scale (Fig. 1). If the threshold was achieved within 10s and sustained for 1s, the FES was activated and caused muscle contraction resulting in wrist flexion, otherwise the trial was considered unsuccessful. Each participant attempted 2 sessions of 30 trials each. All the participants were able to use the system with an average success rate of 77.1% in session 1 and 87.5% in session 2 (Table 1), which shows fast improvement of BCI performances in participants due to the training. Fig. 2 shows the power spectral density (PSD) as the alpha band at rest and during imagined movement (MI) for a representative subject.

Table 1. Success rate

Subjects	1	2	3	4	5	6	7	8	Avg.
Session 1 Success rate (%)	77	67	93	80	80	67	70	83	<b>77.1</b>
Session 2 Success rate (%)	93	87	100	83	80	77	87	93	<b>87.5</b>

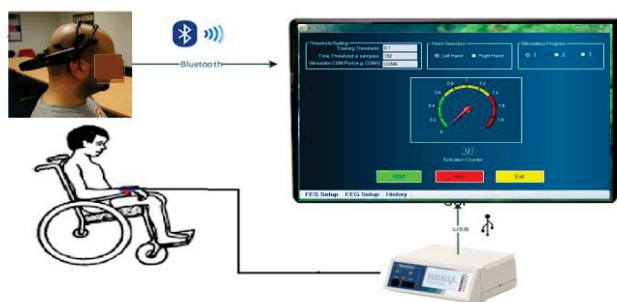


Fig. 1 BCI-FES System

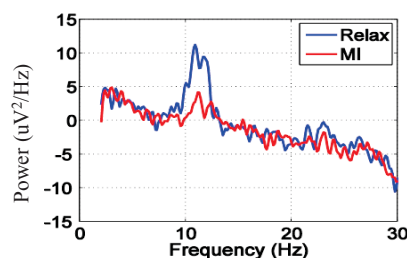


Fig. 2 PSD for alpha band at rest and during MI State

**Discussion and Conclusion:** This study demonstrates the technical feasibility of a portable, inexpensive and user friendly BCI-FES system. Experiments with patients in their home environment are planned in the near future to establish long-term reliability and user friendliness of the system.

**Acknowledgements:** This work has been supported by the (HCED) scholarship in Iraq and by the EPSRC IAA grant.

## References

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