Brainwave Typing: Comparative Study of P300 and Motor Imagery for Typing Using Dry-Electrode EEG Devices

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Abstract. This paper presents the findings of an exploratory study comparing two of Brain-Computer Interface approaches, P300 and Motor Imagery, with EEG signals acquired using the Emotiv Neuroheadset. It was conducted to determine the most suitable approach for typing applications based on BCI. Results show that while selection accuracy is similar for both, with mean of 50%, the speed varies greatly, with the former approach being approximately 2 times more efficient in typing. Implications presented in this document are useful for BCI researchers who seek to build brain-controlled Augmentative and Alternative Communication technologies.

Keywords: BCI, Brain Computer Interface, P300, Motor Imagery, Brain Machine Interface, BMI, Augmentative and Alternative Communication, AAC, EEG.

1 Introduction

Brain-Computer Interface has engendered much research in recent years, with focus on providing people with severe motor disabilities, such as amyotrophic lateral sclerosis or spinal cord injury, with an alternative means of control [1]. This research, however, is mostly based on Gel-based signal acquisition devices that are too expensive for the average user. This experiment explores EEG BCI with consumer-market headset, the Emotiv EEG headset [2]. It is part of on-going research aimed to build a BCI typing applications for Arabic-speaking users. Non-invasive electroencephalography (EEG), where EEG signals are recorded from the surface of the scalp, is one of the popular ways to implement BCI. In fact, it has already been used to develop communication systems, where users can spell words via brain activity, and control systems, where they can drive a simulated wheelchair, for example [3].

There are two main approaches for EEG-BCI. First, Evoked Potential; methods of this kind depend on EEG components (features) evoked and time-locked to a specific

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sensory stimuli, which are also called cue-guided [4]. The most widely used example of this approach is P300 method [5]. Second, Motor Imagery; Methods of this kind use features that are processed in the frequency domain instead of the time domain, as it depends on recording rhythmic activities over the sensorimotor cortex [5]. In this type, instead of needing an external stimulus to generate a command, a user can voluntarily issue a command by controlling his brain activity, by imagining moving a virtual object in a certain direction, for example [4].

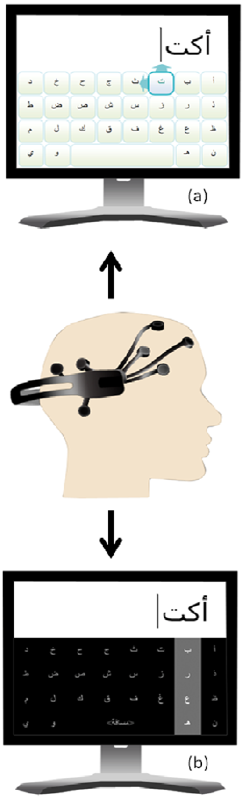
Visual representation of the physical and virtual interface for mind-typing.	**Descriptive representation of the functionality of navigation and selection in the typing program.**
	Mind-typing with Motor Imagery: Navigation on the virtual keypad is conducted with imagery movements in the horizontal and vertical directions. Navigating in the top-down direction rotates vertically when then top of the column of virtual keys is reached. Navigating in the right-left direction rotates horizontally when the left-most virtual key on a row is reached.
	Electrical activity of the brain is recorded by 14-channels on the surface of the scalp.
	Mind-typing with Evoked-Responses: The rows and columns in the matrix display Arabic alphabet and numbers. These flash successively and randomly at a rapid rate, and users select a character by directing and sustaining their attention on the Arabic character when it flashes. The row or column that contains this character evoke a P300 response, whereas all others do not. The system determines the desired row and column which exhibited the highest P300 amplitude to select the desired character for the typing task.

Fig. 1. Conceptual design of a typing application with the two approaches: (a) With Motor Imagery, keyboard is navigated in two directions, plus selection. (b) A traditional P300 matrix with Arabic letters.