Brain Computer Interface through Vision System Pathways

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A brain computer interface (BCI) is a real-time communication system designed to allow users to voluntarily send messages or commands without sending them through the brain's normal output pathways [1]. A BCI device allows people to communicate without movement. People can send information simply by thinking. Everybody can imagine how useful would be a system that could know accurately what we desire to do just by reading our scalp potentials. BCI users must produce distinct EEG signatures when engaged in discrete mental tasks originated by visual stimuli. P300 test could be the trigger of these tasks. In a P300 test we don't analyze the free running electroencephalogram (recorded EEG) but the event related potentials (ERP) which are voltage fluctuations in the EEG induced within the brain that are time locked to sensory, motor, or cognitive events [2]. The ERPs consist of a sequence of positive and negative voltage fluctuations. These components reflect various sensory, cognitive (e.g., stimulus evaluation) and motor processes that are classified on the basis of their scalp distribution and response to experimental variables [2]. The P300 component is a positive bump in the ERP that typically starts around 300 ms after an event and reflects a cognitive process about the deviant event (an event highlighted from the background events). Mismatch Negativity (MMN) component is a negative bump in the ERP that starts before 250 ms after the event presentation and reflects the response to the difference between successive stimuli [3].

Since there are few factors that lead some BCI users to better performing stimuli detection than others this study[4a] focused on which are the real effects of age on target P300 as an ERP and on subject's behaviour (performance in response to target) during these tasks. The age is thought to increase P300 latency and to reduce P300 amplitude [4b] as well as behavioural response impairment. This study intends to acknowledge these hypotheses to target P300 in visual modality and introduce some variability in stimuli-type.

Usually the P300 is elicited during an Oddball Task. This component can be seen after the occurrence of any stimulus but it's highlighted in the presence of a low frequent stimulus (target) that demands subject attention. Each subject was instructed about 'standard' and 'target' stimuli (response to target by clicking on the left mouse button). This test has 2 sorts of stimuli: human faces and geometrical shapes. In the first, the standard stimulus is a man face and the target is a woman face. In the second, the standard is a simpler geometrical shape and the target is a shape more complex than standard.

The recording sites according the 10-20 international system are: VEOG, HEOG, F7, F3, Fz, F4, F8, FC1, FC2, T7, Cz, T8, Tp9, Tp10, P7, Pz, P8, O1, Oz and O2 referenced to A (linked earlobes).

As all the twelve subjects are between 19-70 and we want to evaluate age effects, they were equally distributed in three age classes (4 subjects per class) but the results presented compare the youngest against the oldest class.

In the youngest class, the target P300 component shows a distribution parietal-oriented and in the oldest class, the target P300 component has also a distribution parietal-oriented but with large components at central and frontal sites. Additionally the target P300 amplitude is typically largest over the Pz site. According literature, the target P300 has a posterior distribution as confirmed by these results [5].

Oldest subjects (>51 years) show smaller P300 amplitudes, bigger P300 latencies than younger in faces stimuli and smaller in shapes stimuli.

In literature, the frontal P300 components reflect a stimulus memory template creation/management [2]. The target stimulus is previously known by the subject, then it's not supposed to need a template creation/management but a constantly categorization. The posterior P300 components reflect stimulus categorization, as referred in [2]. Therefore the target P300 is typically larger over parietal sites.

The large frontal components of the oldest class may represent an additional need of stimuli memory template creation/management due to a lack of habituation which is well known as an amplitude decrease of controls (subjects with no impairments) to frontal P300 components with experience [6]. This extra need can suggest progressive frontal cognitive functions impairment with age and elderly lack of habituation.

On the contrary, the results don't support the P300 latency increase with age, since younger P300 components should have lower latencies than older ones.

Moreover, the youngest have MMN components with less amplitude and latency than the oldest ones. Since the youngest class has smaller MMN amplitudes and bigger target P300 amplitudes than the oldest one for both stimuli types, this study supports the target P300 amplitude age effects hypothesis. Given that amplitude provides an index of the extent of neural activity [2], the target P300 amplitude decrease for older can be related to neural activity reduction with age and MNN amplitude increase may be related to the successive stimuli differences sensitiveness increase, as Gaeta and Friedman concluded [7].

A typing system for impaired people has been developed as BCI based on P300. A virtual keyboard is displayed on a screen and the symbols on the keyboard are flashed randomly. Each flash is synchronized with EEG data which able us to determine the user selected symbol through the detection of the P300 ERP 300 ms after flashes.

A cursor control system has been developed as another BCI using vision system pathways. The vertical electroculogram (VEOG) and horizontal electroculogram (VHOG) channels are used as eye movement monitoring channels and draw the cursor trajectory on screen.

This work is supported by Foundation for Science and Technology (SFRH/BD/21529/2005)

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