

Towards a user-friendly BCI for elderly people

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Abstract

In this paper we compare the ease of use, comfort, efficiency and accuracy of two different graphical user interface (GUI) designs for a SSVEP-based BCI application. Main focus is on a user-friendly and intuitive layout design having in mind users of advanced age. The new 3-steps GUI with fewer selection options addresses those factors. Our results show that the majority of subjects favored the 3-steps GUI despite slightly deteriorated information transfer rate.

1 Introduction

The effects of ageing present physical handicaps that all-too-often prevent older people from maintaining relationships and actively participating in social life, even when they can live safely and independently in their own homes. Modern communication technologies could help elderly people with physical impairments if they provided special interfaces that worked independently of the person's limitations. For those people there is a way to express their needs, wishes and feelings by using a Brain-Computer Interface (BCI). This technology translates brain signals, usually acquired non-invasively using electroencephalogram (EEG), in computer commands without using the brain's normal output pathways of peripheral nerves and muscles [3].

The use of BCI as a spelling interface has been one of the main focuses in many BCI studies. One of the BCI paradigms used for realization of a spelling interface is the SSVEP BCI which measures the brain responses to a visual stimulation at specific constant frequencies [3]. High system speed is an essential goal in BCI studies. However, especially regarding elderly users, the layout of the graphical user interface plays a key role in ensuring user friendliness and effective control, therefore, the arrangement of the visual stimuli and the desired targets are important. For older people readability and simplicity are crucial, therefore we decreased the number of simultaneously displayed targets to reduce cognitive load and misselections.

2 Methods and Materials

2.1 Subjects

Seven subjects participated in the study, with a mean age of 23.6 ± 3.06 years (range 21 – 30). Two subjects were female. All subjects were students or employees of the Rhine-Waal University of Applied Sciences. The EEG recording took place in a standard laboratory room with low background noise and luminance. None of the subjects had neurological or visual disorders. Spectacles were worn when appropriate. All persons who volunteered to participate in the study became research subjects after reading the subject information sheet and signing a consent form. Subjects did not receive any financial reward for participating in this study.

2.2 Hardware

The subjects were seated in front of a LCD screen (BenQ XL2420T, resolution: 1920×1080 pixels, vertical refresh rate: 120 Hz) at a distance of about 60 cm. The used computer system operated on Microsoft Windows 7 Enterprise and was based on an Intel processor (Intel Core i7, 3.40 GHz). Standard Ag/AgCl electrodes were used to acquire the signals from the surface of the scalp. The ground electrode was placed over AF_Z , the reference electrode over C_Z , and the eight signal electrodes were placed at predefined locations on the EEG-cap marked with $P_Z, PO_3, PO_4, O_1, O_2, O_Z, O_9$ and O_{10} according to the international system of EEG electrode placement. Standard abrasive electrolytic electrode gel was applied between the electrodes and the scalp to bring impedances below $5 k\Omega$. An EEG amplifier g.USBamp (Guger Technologies, Graz, Austria) was utilized. The sampling frequency was set to 128 Hz. During the EEG signal acquisition, an analog band pass filter between 2 and 30 Hz and a notch filter around 50 Hz were applied directly in the amplifier.

2.3 Software, Experimental setup

Each subject used two different user interface layouts subsequently. The order of the presented GUI's as well as the spelling tasks were randomized for each subject in order to minimize the risk of adaption. The *2-steps GUI* resembles to an earlier developed GUI layout [2]. In the *2-steps GUI* seven commands were represented on the computer screen by flickering boxes of default sizes (125 x 125 pixels). The size of the boxes varied during the experiment as described in [1]. Initially the subject faced seven boxes containing "A-F", "G-L", "M-R", "S-X", "Y-_" and "Del" in a first window (see Figure 1(a)). After initial selection, the GUI changed to the second window with six individual letters of the initially selected group, so this layout allowed the user to select every letter with only two commands.

In order to improve user friendliness and to decrease the number of frequencies, in the here presented *3-steps GUI* the number of boxes was reduced to four. This also allows us to choose the frequency set more freely. The box for the written word and the word to spell was moved to the centre of the screen. The sizes and appearances of the boxes were the same as in the *2-steps GUI*, however, the number of steps needed to select a letter had increased to three and the position of the boxes changed in every step to increase the user-friendliness. In the first window there were three boxes in the upper part of the screen, arranged horizontally with all the letters divided into three groups "A-I", "J-R" and "S-_", respectively. The additional 4th box, containing the command "Del" (delete the last spelled character) was located on the right side of the screen. In the second window the position of three boxes changed from upper horizontal to left-hand vertical according to the first selection made in the initial window, e.g. "A B C", "D E F", "G H I" or "J K L", "M N O", "P Q R" or "S T U", "V W X", "Y Z _". After selecting a desired box in the second window the user faced a third window. Here each box contained a single letter and their positions changed once more from left vertical to horizontal bottom position. In both the second and the third window the far right box ("Del" in window 1) would contain the command "back", giving the user the option to switch to the previous window. The first window as well as an overview of the three steps necessary to choose a single letter are shown in Figure 1(b) and 1(c).

In both GUIs every command classification was also followed by an audio feedback with the name of the selected command or the letter spelled in order to reduce the information load of the visual channel. For SSVEP signal classification we used a minimum energy combination method. The SSVEP classification was performed on-line every 13 samples (ca. 100ms) on the basis of the adaptive time segment length of the acquired EEG data. More details about the

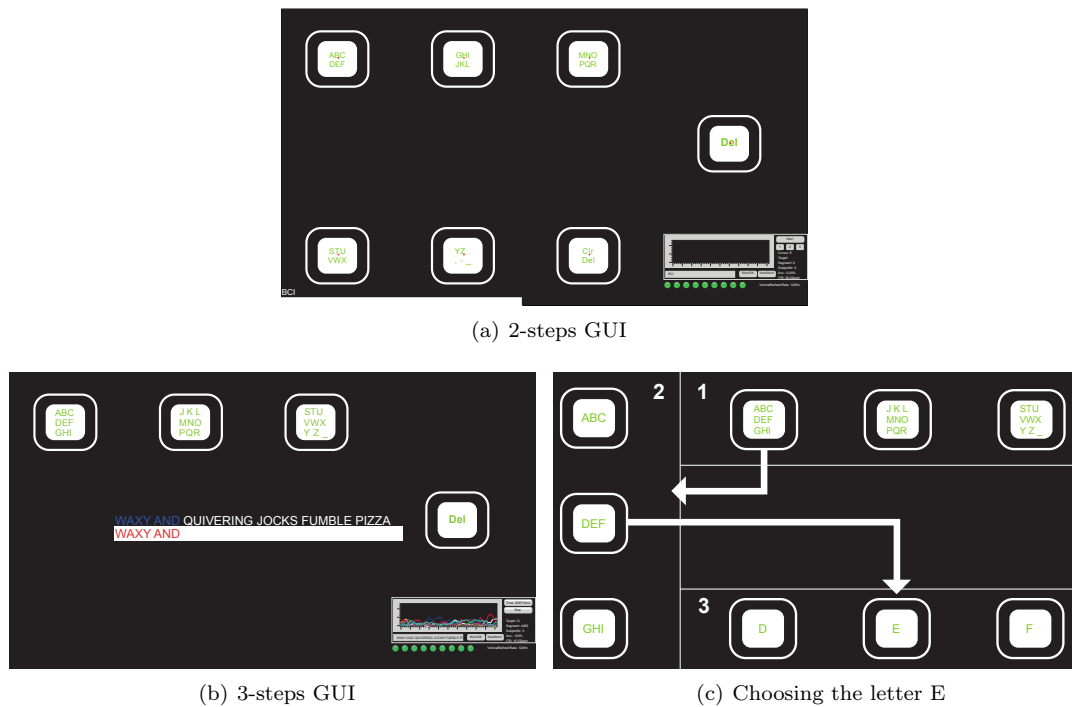


Figure 1: GUI's used in study

used SSVEP detection method can be found in [1].

2.4 Procedure

After completing the consent form, each subject completed a brief questionnaire and was prepared for the EEG recording. Subjects participated in a familiarization run spelling words “BCI”, “BRAIN”, and the word of choice (e.g. the own first name) and the experimenters used the collected data to manually adjust the individual parameters. Next, each subject used both GUI's to spell the phrase “WAXY AND QUIVERING JOCKS FUMBLE PIZZA” (commonly used pangram, a sentence using every letter of the alphabet at least once). Each spelling phase ended automatically when the presented word was spelled correctly. The experiment was stopped manually in case a subject could not execute a desired classification within a certain time frame, the subject wished to end the experiment or unintentional repeated misclassifications occurred. Spelling errors were corrected via the implemented Del button. Information needed for the analysis of the test was stored anonymously during the experiment. After finishing the spelling, subjects were asked to rate how well the BCI-System worked for them.

3 Results

BCI performance for each subject was evaluated by calculating the commonly used information transfer rate in bit/min, employing the formula as discussed e.g. in [4]. In the here presented GUI's, the overall number of possible choices was equal to seven and four for the *2-steps GUI*

and the *3-steps GUI*, respectively. The accuracy was calculated based on the number of correct command classifications divided by the total number of classified commands. The overall BCI performance is given in Table 1. All subjects were able to complete the pangram. Since for one subject the data were not stored due to a computer error, this table presents the data from only six subjects.

Subject	2-steps GUI			3-steps GUI			Subjective impression	
	Time sec	Acc %	ITR bpm	Time sec	Acc %	ITR bpm	2-steps GUI	3-steps GUI
1	894.66	95.06	13.02	1686.55	92.09	7.28	2	4
2	430.42	81.51	27.19	845.61	85.89	13.71	3	4
3	702.71	72.00	23.59	599.93	85.55	20.27	4	4
4	557.38	70.00	23.53	455.61	76.23	24.34	3	3
5	325.51	92.39	37.69	516.85	88.74	22.97	2	4
6	623.09	69.48	23.20	460.08	95.94	27.08	2	4
Mean	588.96	80.07	24.70	760.77	87.41	19.27	1- worked not at all	
SD	201.54	11.47	7.95	476.06	6.74	7.43	5- worked very well	

Table 1: Results for each subject and layout. Mean values are at the bottom of the table.

4 Discussion

Four out of six subjects reached higher ITR with the *2-steps GUI*, also the spelling time was faster for three subjects with this layout. However, the majority of subjects (five out of six) stated that they prefer the *3-steps GUI* over the *2-steps GUI* (right sight of Table 1). Also, some subjects stated that they found the overall design of the *3-steps GUI* more intuitive. All in all, the here presented *3-steps GUI* did not surpass the *2-steps GUI* in terms of spelling time and ITR. But because of other factors, such as user comfort, user-friendly design and better accuracies the *3-steps GUI* could be a valuable option especially for elderly users. Main advantage of the *3-steps GUI* is that only 4 boxes are displayed, which decreases the misselections and seems to be less stressful for the users.

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