

## GRAZ BCI: FIRST RESULTS OF DIFFERENT TYPES OF VIRTUAL KEYBOARDS

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It is possible that completely paralyzed patients get the possibility to communicate with their environment by the use of a 'Virtual Keyboard' (VK). A 'Virtual Keyboard' is a letter spelling device operated by the Graz-BCI, based on the spontaneous EEG. The EEG is modulated by imaginations of hand or foot movements. Two types of VKs are presented, which have been tested in 3 able-bodied subjects.

To select a certain letter, using the standard VK, 5 steps of selection and two further levels of confirmation ('ok') and correction ('back/del') are provided. In a dichotomous structure with 5 levels 32 characters can be selected. Six steps are necessary to select a single letter. With this type of a VK and the standard BCI timing [Pfurtscheller 2000] a spelling rate of 1.25 letters per minute can be achieved (classification accuracy of 100 % assumed). The VK can be operated in two modes: a 'free spelling' mode and a 'copy spelling' mode for training. There is also a switch for 'error-ignoring' training.

A study on 3 able-bodied subjects was performed. The results (Table 1) show the number of written letters, performed trials and resulting accuracy [Obermaier 2002].

Table 1: Results of 3 subjects writing with the Virtual keyboard

Subject	Letters	Trials	Accuracy
i6	44	388	0.85
k3	46	340	1.02
m6	44	494	0.67

The newly developed VK is based on T9 technology of a cell phone including a dictionary. There are 8 keys, whereby each contains 4 letters (first one: 'A','B','C','D', last but one: 'Y','Z' and the last one: only a '.'). Each key is represented by a number, thus each word in a wordlist is coded, e.g. the word KAUFEN (buy) would be represented by 316224. In the wordlist 145 words, commonly used for a basic communication, are saved. Using the VK-T8 4 steps are necessary to select a letter.

In order to find the theoretical average spelling rate, which can be achieved by the BCI-VK8, 40 randomly selected words were simulated, assuming 100% correct decisions. The theoretical average spelling rate for the BCI-VK8 is 2.73 characters/min +/- 0.94, based on a trial length of 7.5 seconds.

In a first study 3 subjects wrote with the VK-T8. Two of them (S1, S2) were trained using the standard VK before. S3 never did so. Results are shown in Table 2.

Table 2: Required number of decisions and corresponding spelling rate \_ in characters per minute. Trial length was 7.5 seconds. Values for the standard VK are given for comparison. The best (theoretical) values for 100% correct decisions are given as well as the results achieved by subjects S1, S2, and S3, respectively.

	old VK dec	best dec/_	S1dec/_	S2dec/_	S3 dec/_
BRAUCHEN (to need)	48	16/4.00	16/4.00	31/2.06	49/1.31
SCHMERZEN (pain)	54	17/4.24	22/3.27	17/4.24	29/2.48
BITTE (please)	30	14/2.86	14/2.86	14/2.86	14/2.86
HUNGRIG (hungry)	42	16/3.50	21/2.67	16/3.50	30/1.87
HELFEN (to help)	36	16/3.00	16/3.00	45/1.06	19/2.53

Fewer decisions had to be made with the help of a wordlist behind the VK-T8. The spelling rate varied from 1.06 to 4.24 letters/min. It should be taken into account that the spelling rates from the VK-T8 depend on the wordlist. The present results are based on a list with 145 entries.

A problem using the VK, controlled by BCI, is the contiguity of decisions per letter and the classification accuracy reached by the BCI. Some examples are given in Table 3.

Table 3: Probability for correct letter selection with different classification accuracies.

	accuracy				
dec./letter	0.80	0.90	0.95	0.99	
6	0.26	0.53	0.74	0.94	standard VK
5	0.33	0.59	0.77	0.95	
4	0.41	0.66	0.81	0.96	VK-T8
3	0.51	0.73	0.86	0.97	
<b>Probability for a correct letter</b>					

Using the standard VK (6 decisions/letter) with an accuracy of 90 % the probability to type a correct character is 53%, whereas using the VK-T8 it is 66%. The probability increases by decreasing the number of decisions per letter or by increasing the BCI's accuracy. Thus, further investigations on developing intelligent Virtual Keyboards and improving the classification accuracy of the BCI system to reach optimal performance have to be done.

References:

[Pfurtscheller 2000] Pfurtscheller G, Neuper C, Guger C, Harkam W, Ramoser H, Schlogl A, Obermaier B, Pgegenzer M.: Current trends in Graz Brain-Computer Interface (BCI) research. IEEE Trans Rehabil Eng. 2000 Jun;8(2):216-9.

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