BrainBasher: a BCI Game

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Abstract. Brain-computer interaction (BCI) is starting to focus on healthy subjects. This research addresses the affects of using this novel input modality to control a simple game, and also looks into the beneficial effects of bringing game elements into BCI experiments. A BCI simple game has been developed and evaluated with fifteen subjects using the Game Experience Questionnaire (GEQ) developed at the Eindhoven Game Experience Lab. Three variations of the game were evaluated for comparison: the original game with BCI input, one with keyboard input, and one with a more clinical look leaving out all extraneous information. The keyboard-controlled game was considered easy and boring, whereas using BCI for input resulted in a more challenging, immersive and richer experience. The design and additional information presented by the game also resulted in higher immersion compared to the clinical design.

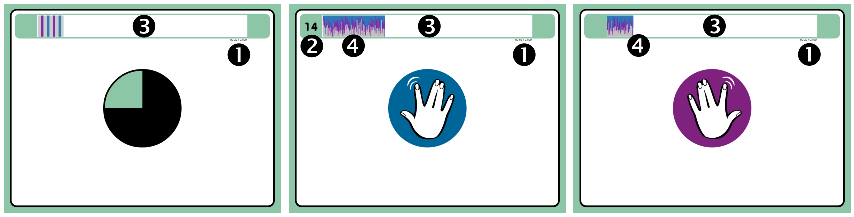
1 Introduction

For a long time BCI research has been dedicated to the medical domain, with the aim to develop new means of interacting with the outside world for paralyzed patients, and neurofeedback therapies [1, 2]. The focus now seems to be shifting toward healthy users [3, 4]. Brain activity could be used as an additional modality for control, for evaluation of either the user or the application, or to build adaptive user interfaces [3]. Games are usually early adopters of new paradigms, fed by the gamers' quest for novelty and challenges [4].

Furthermore, the game approach to experiments might aid science. It can be expected that test subjects for BCI experiments will be able to stay motivated and focused for longer periods if tests can be presented in a game format [5, 6]. However, researchers fear making the feedback more complex which could distract the test subject from the basic experiment and ambiguate the results [7, 8]. This has kept researchers from addressing the value of game elements.

2 BrainBasher

The Game First the subject will undergo a *training* in which stimuli (in the form of symbols denoting brain actions) and breaks are alternated. During the stimulus the subject performs the indicated action: imaginary movement of the left or right index finger. The user was instructed to stay relaxed and not to



(a) Training mode, showing break
(b) Game mode, showing right hand symbol
(c) Free play mode, showing left hand symbol

Fig. 1. The three application modi. Extraneous information: (1) total and passed time for the current session, (2) the current score, (3) a progress bar, and (4) the confidence levels for the brain actions (in the progress bar).

move, except for during breaks, to prevent noise in the EEG. During the actual *game*, the user performs the suggested action. When the system recognizes the action, it increases the score and moves on to the next stimulus. In *free play*, the application shows the actions recognized by the system. The subject can try different variations of input and learn how the system reacts to those.

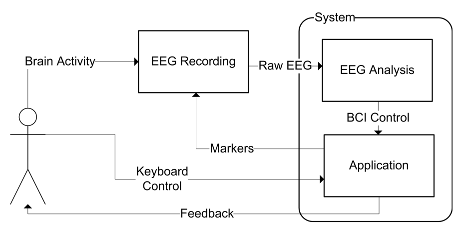


Fig. 2. BrainBasher System View

The Underlying System A schematic view of the system is shown in Figure 2. The user interacts with the system by executing brain actions, and by keyboard. Brain activity is acquired with a BioSemi EEG setup using 32 electrodes, at a 256Hz sample frequency. During analysis, the common reference is removed and the data is bandpassed to 8–30Hz. The common spatial patterns (CSP) method is used to extract features which are then classified with linear discriminant analysis (LDA). At the end of the cycle, BrainBasher returns feedback to the user in the form of symbols, score, the progress bar, and confidence values.

3 Methods

The game was evaluated with fifteen subjects, all right-handed, of which eight were male and seven female.

The goal was to look at the influence of game elements in BCI and the influence of BCI in games. For this, three versions of the game were played: (1) the original BCI-controlled version, (2) one controlled by keyboard, and (3) a cross version reduced to look like a clinical experiment.

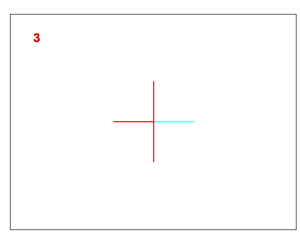
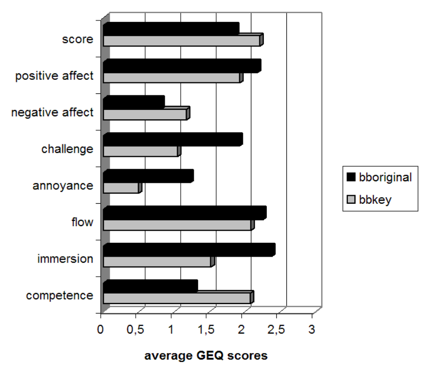


Fig. 3. Cross version

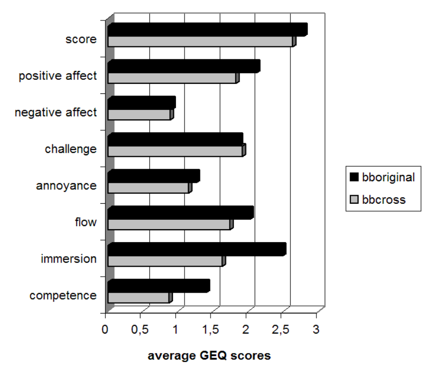
These versions are hereafter referred to as Original, Keyboard, and Cross. The version order was Keyboard first, and then Original and Cross in random order. After each version, the GEQ was filled in and the game scores were noted. The GEQ has been developed to determine the self-reported game experience of the user [9].

4 Results

BCI Input Compared to Keyboard Subjects felt significantly more competent ($p = 0.038$) at the keyboard-controlled game. Although they were more annoyed ($p = 0.048$) with Original, they noted also many positive experiences: it was considered less boring ($p = 0.043$), more challenging ($p = 0.003$), a richer experience ($p = 0.000$) and more immersive ($p = 0.006$) than just bashing keys.



(a) GEQ scores for Original and Keyboard



(b) GEQ scores for Original and Cross, with similar game scores

Fig. 4. Game Experience Questionnaire results. The scores for Original and Cross are 1:10; the scores for Keyboard 1:100.

Game Compared to Experiment The scores obtained for Original are higher than the scores for Cross. Higher scores result in a more positive experience as the subject feels more competent. To eliminate this influence, sessions with Original have been paired up with Cross sessions in which similar scores have been obtained. Over this new data set with a similar score average, again the GEQ component values were determined. The results are shown in Figure 4(b).

Original has a more enjoyable design ($p = 0.018$), and achieves a higher sense of immersion ($p = 0.017$) than Cross. Furthermore, a trend towards higher concentration ($p = 0.096$) and a richer experience ($p = 0.075$) for Original compared to Cross can be observed.

5 Conclusions

As can be expected for such a simple game, the keyboard version was considered easy, and quite boring. BCI input resulted in a more challenging, more immersive, and richer experience. It made it harder to play as well. The more engaging design and the extra stimuli presented to the subjects in the original version resulted in more immersion compared to the cross game. Subjects also enjoyed the design more. Subjects reported to tune out irrelevant stimuli (like the score and progress bar) when the brain action required their full attention.

BCI as input modality can certainly add to the game experience, and vice versa: the effects game elements can have on subject motivation during clinical experiments should not be ignored.

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