Intuitive BCI
as an additional game input modality

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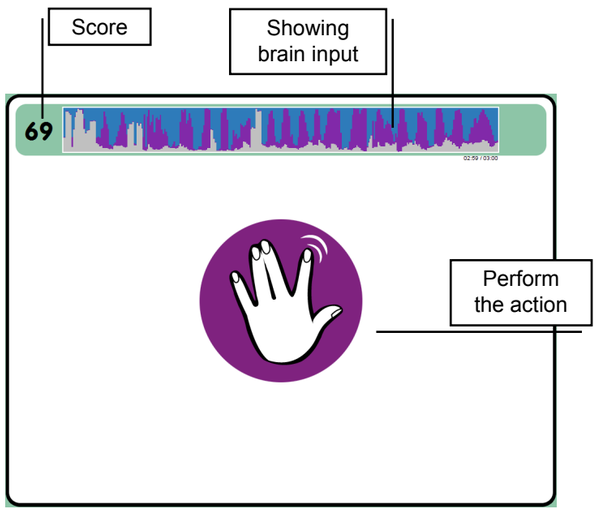
Previous Work: BrainBasher

As a master thesis final project, research has been conducted to look into the effects of using this novel input modality of brain-computer interaction (BCI) to control a game. It also looks into the potentially beneficial effects of bringing game elements into BCI experiments.

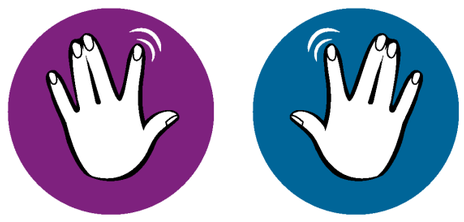
BrainBasher

To do this, a simple game has been developed called *BrainBasher*, which you control with your brain. The goal is to perform specific brain actions as quickly as possible. For each correct and detected action you score a point.



game session

Game control was achieved by two mental tasks: *left hand movement imagery* (imagine moving the left index finger up and down) versus *right hand movement imagery*.

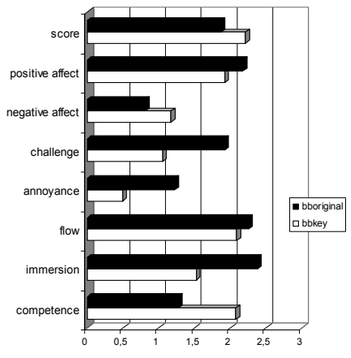


Methods

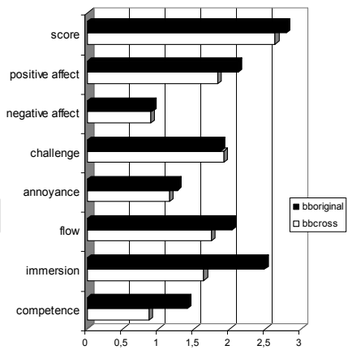
BrainBasher was evaluated with fifteen subjects using the Game Experience Questionnaire (GEQ) from the Eindhoven Game Experience Lab. Three variations of the game were evaluated for comparison: the original game with BCI input, one with keyboard input, and one with a more clinical look leaving out all extraneous information.

Results

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.



average GEQ scores for Original (BCI game) vs Keyboard



average GEQ for Original (game) vs Cross (clinical), scores normalized

Conclusions

BCI as input modality can certainly add to the game experience, and vice versa: the effects game elements (like an explicit goal, scoring, feedback) can have on subject motivation during clinical experiments should not be ignored.

Publication

Oude Bos, D. and Reuderink, B. BrainBasher: a BCI Game, In: *Extended Abstracts of the International Conference on Fun and Games 2008*, 20 October 2008, Demo Paper.

BCI + Games

The Human Media Interaction (HMI) group at the University of Twente has fairly recently (in 2007) started conducting research in the area of brain-computer interaction (BCI). The focus of our group is applying BCI for use by the general population, in games in particular.

Although BCI research has long been dedicated to the medical domain, there is a lot of potential for use with healthy subjects. Besides direct control, the mental state of the user can be used to adjust the application. New methods of input can be developed for a more direct and natural way of interaction.

Challenges

To enable use of BCI by the general population, BCI needs to be taken out of the highly-controlled laboratory environments and into the real world. Testing BCI games in more realistic environments will highlight many unresolved issues.

Intuitive Interaction The mapping of a BCI paradigm to a particular task should be intuitive and natural to the user, as this will increase (or maintain) the immersion. This intuitive quality also makes it easier to learn and remember the mental tasks available within the application.

Fusion and Artifacts In a real-world situation, people will talk and move during game-play. This results in artifacts in the recorded brain activity. One can decide to remove the artifacts, or use them as an additional source of information. Apart from combining with other modalities, there is also the question of what BCI paradigms may be used simultaneously.

Transfer Rate The information transfer rate attainable with EEG is not comparable to classical input methods. Our aim is then not to replace those existing methods, but to improve the interaction experience. Still, it is important to use fast processing methods in order to give feedback quickly, for more natural interaction.

Accuracy It is not (yet?) possible to have a perfect detection of mental actions or states. This is has to be taken into account when defining uses of BCI in applications. Even worse for the goal of providing BCI for the general population is that some users will not be able to use particular BCI paradigms.

Training In most BCI systems, both the user and the system learn to achieve an optimal performance. Usually a training period is required to provide initial detection. This training period should be short, and preferably part of the game itself.

Brain-Activity Measurement EEG setups in research are cumbersome in the amount of time it takes to mount, how it restricts movement, and the maintenance it requires. There are commercial headsets which are a lot more usable.

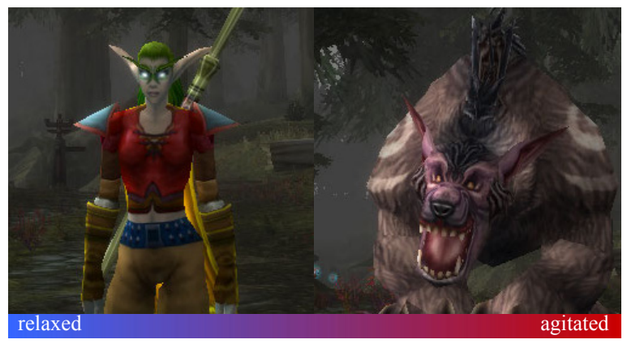
Future Work

This research will focus mainly on *intuitive interaction*, *fusion* with classical input modalities (mouse and keyboard) and using multiple BCI paradigms simultaneously, plus the influence of all of these elements on the *user experience* within the uncontrolled environment of a popular game.

> *"Any sufficiently advanced technology is indistinguishable from magic"*
>
> *Arthur C. Clarke*

Some ideas of using BCI in World of Warcraft:

Shapeshifting Based on the level or relaxation or agitation, the user can move from one mode of gameplay (spell-casting) to another (direct combat). While using conventional means would break immersion, this could actually be a more 'realistic' approach (from the point of view of the game world).



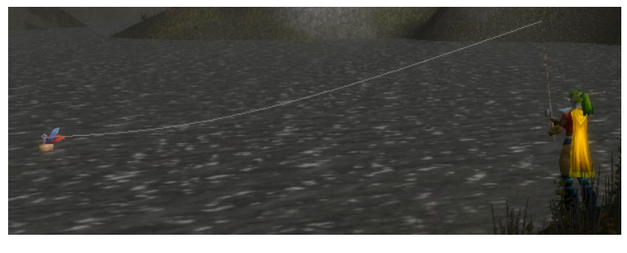
Emotes One of our master students (Lennart Boot) has looked into detection of facial expressions from the EEG. Smile, frown, and neutral are easy to detect. Mapped onto emotes, this could be a natural display of the user's emotion.

Background Music The affective state of the user could influence the background music to increase immersion.

Spell Casting A higher level of concentration could result in more effective (higher level) spells being used. Spell selection requires new BCI paradigms for natural interaction.

Hand-to-hand Combat Actual or imaginary movements could be mapped onto special moves that can be performed in hand-to-hand combat. A master student (Bram van de Laar) is comparing actual and imaginary movement.

Fishing In the game it is possible to fish. The user looks at the bobber and when it bounces with a splash sound, reels in the catch. As this is a rare and task-relevant event, it could be opportunity of looking into single-trial P300 detection.



Further Reading

A. Lécuyer, F. Lotte, R. Reilly, R. Leeb, M. Hirose, M. Slater, "*Brain-Computer Interfaces, Virtual Reality, and Videogames*", IEEE Computer, Vol 41, Num 10, pp. 66-72, 2008

A. Nijholt, D. Tan, G. Pfurtscheller, C. Brunner, J. del R. Millan, et al., *Brain-Computer Interfacing for Intelligent Systems.* IEEE Intelligent Systems, 23 (3). pp. 72-79. 2008. ISSN 1541-1672