

NOVEL P300 BCI INTERFACES TO DIRECTLY SELECT PHYSICAL AND VIRTUAL OBJECTS

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INTRODUCTION

- ❖ We discuss two novel P300 BCIs that highlight virtual or real objects directly.
- ❖ Previous P300-based BCIs have typically used a grid-based spelling or selection task with characters or symbols displayed on a monitor.
- ❖ For example, even when navigating through a virtual environment, the P300 grid has been displayed on a separate screen [1] which means that users have to turn their heads away from the virtual space whenever they wish to interact with it.
- ❖ We present two of our own systems that allow users to directly interact with the target objects.
- ❖ The first system integrates the P300 BCI into a fully immersive virtual environment, allowing 3D virtual objects to be selected directly.
- ❖ The second system takes this one step further and demonstrates how physical objects themselves can be used as P300 targets.
- ❖ These studies demonstrate the wealth of possible applications and future directions of P300 BCIs.

SYSTEM 1

- ❖ We demonstrated that it is possible to directly select virtual objects from a fully immersive virtual environment by using 3D objects as targets (Michael and Donnerer, 2010) [2].
- ❖ Users were presented with scenes containing differently-sized virtual objects placed irregularly (Figure 1).

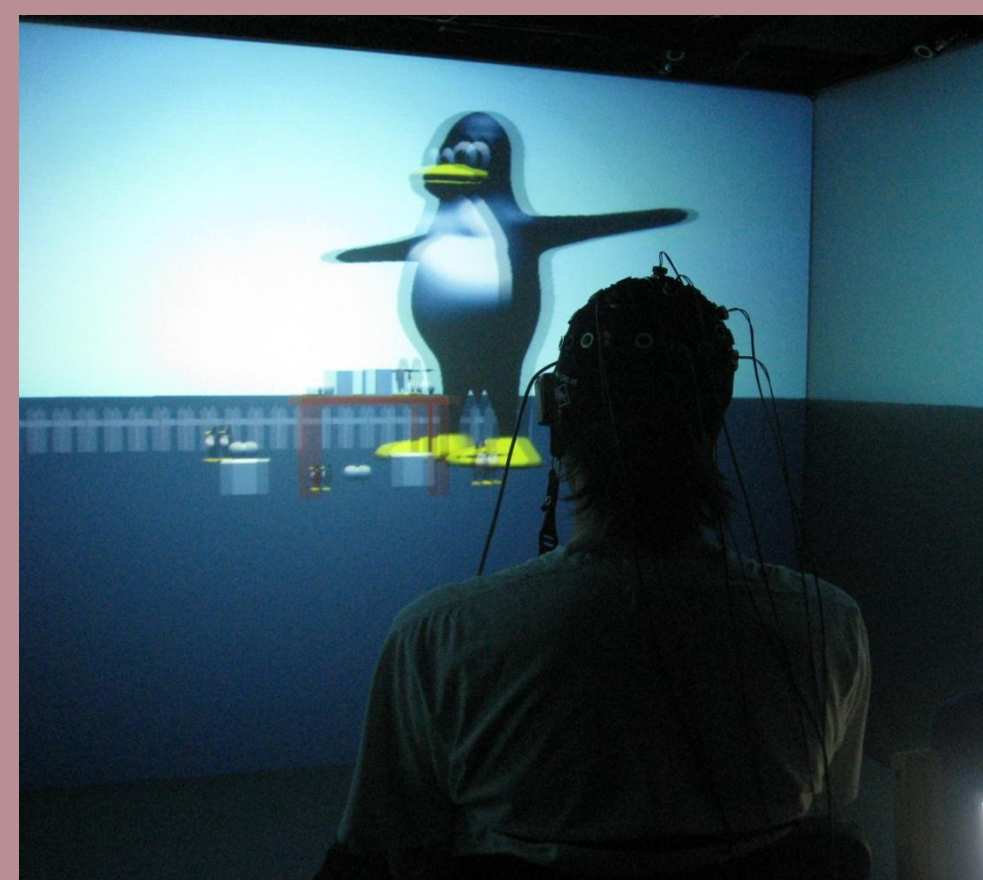


Figure 1: A participant interacting with a scene containing various virtual objects. The table (in red) is currently being flashed.

- ❖ Instead of selecting a character or image from a regular grid, users were able to select the object itself using keeping a running mental count whenever their target object flashed.

- ❖ Another paradigm was investigated where, instead of flashing the individual objects, a virtual grid was overlaid onto the scene. Individual tiles within the grid were flashed (Figure 2).

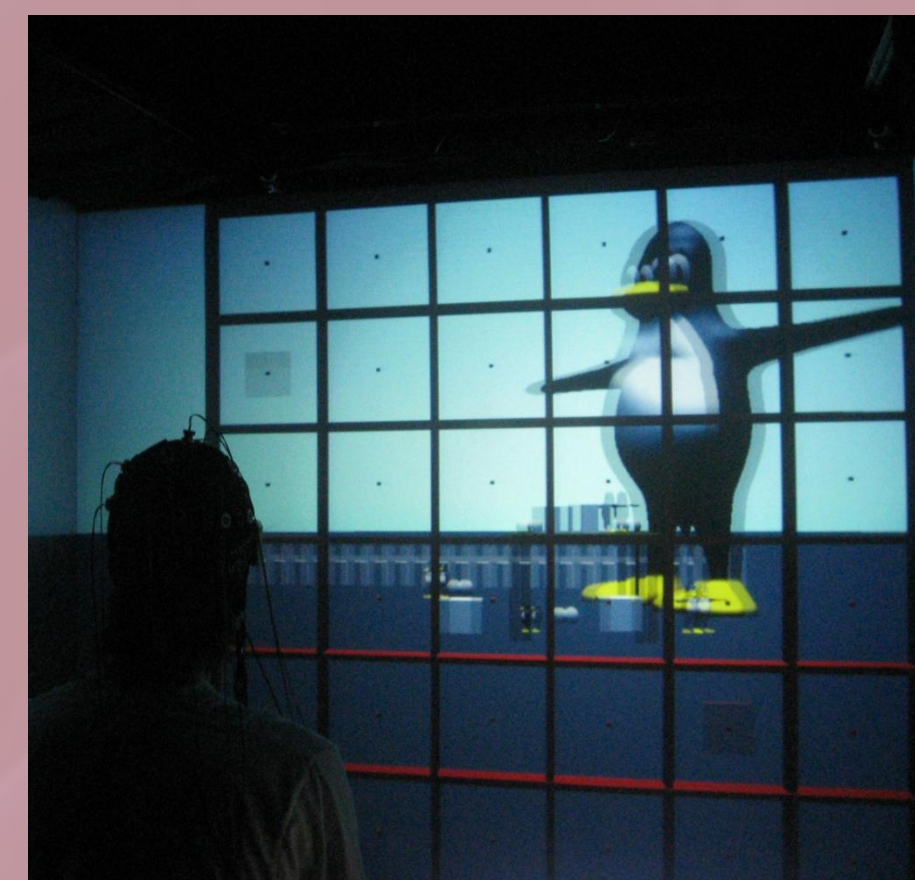


Figure 2: A participant interacting with a scene overlaid with a virtual grid. A row of tiles (in red) being flashed.

- ❖ Results showed that users being able to select objects directly 50% of the time and were able to select objects using the flashing tiles around 66% of the time.

SYSTEM 2

- ❖ Our next step following these promising results was to select real objects directly using a P300-based BCI.
- ❖ Therefore, we replaced the normal grid of characters with physical objects (Yuksel et al., 2010) [3].
- ❖ We created a system whereby objects could be placed on a multi-touch surface which recognized object outlines by a simple computer vision system. Image processing algorithms generated areas of light around the objects that could then be flashed.
- ❖ Users were then able to select any object on the table directly by keeping a running mental count of the number of the times the area underneath the object flashed (Figure 3).
- ❖ We compared the accuracy of our multi-touch system (MTS) to the standard speller system (SSS). We asked participants to select four 3-letter words from the SSS and four sets of 3 objects from the MTS.
- ❖ Our participants had a mean accuracy rate of 96.2% using the SSS and 98.7% using the MTS.
- ❖ We were also able to compare the overall success rates to another recent study by Edlinger et al. (2009) [4] (Table 1) who also used the same EEG parameters as us except they used 15 flashes per character whilst we used 8.



Figure 3: A participant interacting with the multi-touch table P300-based BCI. Six objects have been placed on the table. Top: The spoon is flashed by surrounding it with light. Centre: A non-object flash. Bottom: The area around the CD is being flashed.

Classification Accuracy (%)	Edlinger et al. (2009) % of Sessions	Standard P300 Speller % of Sessions	Multi-touch BCI % of Sessions
100	55.3	70.0	90.0
80-100	76.3	95.0	100.0
60-79	10.6	5.0	0
40-59	7.9	0	0
20-39	2.6	0	0
0-19	2.6	0	0
Average Accuracy of all Subjects	82	96	99

Table 1: Comparison of classification accuracies of the P300 BCI in Edlinger et al. (2009) [5], the standard industry P300 speller and the novel multi-touch table P300-based speller in [4].

CONCLUSIONS

- ❖ The two studies demonstrate that P300-based spellers can be used in real and virtual world settings. Our main contribution is the first demonstration of a P300 BCI that does not use the standard speller or graphical icon interface.
- ❖ There are several direct applications for this new paradigm such as allowing persons with severe motor disabilities to interact with real objects rather than a screen.
- ❖ For example, real environments could be overlaid with augmented reality so that the physical objects could act as their own interfaces. In a smart home, a projector or array of lights could highlight objects to be used with the BCI.
- ❖ Alternatively, the physical objects themselves could emit light rather than using a projector, e.g., with LED lights integrated into the object. The active lighting can then be co-ordinated wirelessly to synchronize the flashes.
- ❖ A more advanced option could be to wear a head-mounted or pendant-like mobile device with a camera and a small projector that augments the physical world and allows the user to interact with the world through BCI. This is not a far-fetched fantasy as a very similar device has already been created by Mistry et al. (2009)[5].
- ❖ The device in [5] is based on hand gesture recognition. We suggest instead that the P300 BCI can be used as the interface: Object recognition algorithms could highlight potential objects in the scene from which to select, and additional virtual objects could be added to the scene to provide sufficient objects to trigger the P300 response.
- ❖ The studies and examples presented here open the space of opportunities for BCIs.

REFERENCES

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