Towards a "Product Design BCI" based on Event-related Potentials: Preliminary Results and Lessons Learned

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The human visual system is a powerful tool for the recognition and discrimination of objects. Several studies have been conducted in order to determine the speed of visual processing during rapid serial visual presentation (RSVP). If placed in front of a monitor and focused on it, the human eye and visual cortex can thoroughly distinguish between rapidly flashing target and distractor images (Bigdely-Shamlo et al., 2008). This phenomenon has been already used to design computer vision systems for rapid image search (Gerson et al., 2006) and reactions to these images can be recorded with modern electroencephalography (EEG) methods. Furthermore results of recent studies showed that emotional target pictures show a greater detectability because of more distinct event-related potentials (ERPs) when presented during RSVP (Flaisch et al., 2008; Carretié et al., 2001; Olofsson et al., 2008). The question arises, whether such ERPs can also be used as a tool for product design by distinguishing between neutral objects and objects of someone's personal favour.

A preliminary study with 5 subjects has been conducted in order to examine possible distinct ERPs, wherein presumably "likeable" objects (causing favor of the subject) and "not-likable" objects (inflicting negative emotions) will be displayed in a RSVP paradigm. The classification accuracy between positive, neutral, and negative images was calculated in between 55.62% and 70.91% using stepwise linear discriminant analysis (SWLDA).

Based on these results a further EEG study was conducted presenting a series of different objects (images of cars and chairs) to a number of ten healthy participants. Right after the experiment the same participants were asked to perform a self-assessment test, where they had to rate the objects previously seen according to their attractiveness, comfortability, and innovativeness. To validate the paradigm and the processing routine, a so-called "oddball paradigm" was used, in which the subjects were asked to focus on one of the images (target). The results were quite promising, as the classification of the individual target condition reached accuracies between 82.48% and 98.55% for the individual subjects. The mean waveforms showed a clear difference between the target condition and all others. The method of classifying each class against the rest of the classes (One-vs-Rest) serves as a proper way of comparing a large number of classes (n = 80) with each other. There was no significant correlation between the results of the self-assessment test and the resulting classification accuracies for each condition. The difference between negative and positive pictures, as observed in the preliminary study, is not as clear when comparing attractive and unattractive images from the main study with each other. Only in 5 out of 10 subjects, this difference though is still observable. As in such a paradigm, focus of attention and concentration are the main effects providing good results, the paradigm for a "Product design-BCI" should also be implemented in consideration of the impact of visual attention achieving success.

Concluding, the results of this work are promising but there are several limitations, like timing parameters and analysing methods which should be improved for future studies. A successful implementation of a "Product Design BCI" would not only provide a new tool in arts and product design, but also in the design process in general.

REFERENCES

- Bigdely-Shamlo, N., Vankov, A., Ramirez, R.R., Makeig, S. 2008. "Brain activity-based image classification from rapid serial visual presentation". *IEEE Trans Neural Syst Rehabil Eng*, 16(5):432–41.
- Carretié, L., Martín-Loeches, M., Hinojosa, J.A., Mercado, F. 2001. "Emotion and attention interaction studied through event-related potentials". *J Cogn Neurosci*, 13(8):1109–1128.
- Flaisch, T., Junghöfer, M., Bradley, M.M., Schupp, H.T., Lang, P.J. 2008. "Rapid picture processing: Affective primes and targets". Psychophysiology, 45(1):1–10.
- Gerson, A.D., Parra, L.C., Sajda, P. 2006. "Cortically coupled computer vision for rapid image search". *IEEE Transactions on Neural and Rehabilitation Systems Engineering*, 14(2):174–179.
- Olofsson, J.K., Nordin, S., Sequeira, H., Polich, J. 2008. "Affective picture processing: an integrative review of ERP findings". *Biol Psychol*, 77(3):247–65.