SSVEP-based navigation using stimuli that are tightly integrated within a virtual feedback scenario

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BACKGROUND AND OBJECTIVE

EEG-based brain-computer interface (BCI) systems that operate based on the dynamics of the sensorimotor rythms (event-related desynchronization; ERD) have proven effective to allow navigation through a virtual apartment [2]. This contribution presents a BCI that relies on steady-state visual evoked potentials (SSVEPs) to navigate through the same virtual apartment (see [1] for additional details). The visual stimuli required for this type of BCI are tightly integrated within the virtual feedback scenario, making this system very intuitive and flexible to use.

METHODS

Seven healthy subjects participated in this study. One bipolar derivation over electrode position O1 (according to International 10-20 system) was used for the measurements. We presented three visual target stimuli, which corresponded to the three virtual actions also available in [2]: Turn left, turn right, and walk forward. The feedback environment is based upon the mixed reality framework Studierstube [3]. The two tasks were to navigate along (i) a shorter and (ii) a longer path through the apartment within a given time limit.

RESULTS

Six out of seven subjects were able to finish the first navigation task; five out of seven subjects completed both navigation tasks within the given time limits. The overall average positive predictive value (PPV => TP/(TP+FP), mean ± SD) in the SSVEP condition for all subjects was 91.7±9.9%.

DISCUSSION AND CONCLUSIONS

The SSVEP-based BCI, like the ERD BCI presented in [2], enabled the subjects to navigate through the virtual apartment scenario. However, the SSVEP approach shows advantages over the ERD approach: This SSVEP BCI requires (i) minimal training, (ii) only one bipolar derivation, and (iii) allows for faster more accurate control. ERD BCIs on the other hand do not require external stimuli to elicit the necessary EEG activity. Future work should further explore the merits of both approaches, as well as possible benefits of combining ERD and SSVEP systems in a "hybrid" BCI. Apart from that, further pilot-studies already showed that SSVEP-based BCIs can also be operated using visual stimuli implemented in highly immersive augmented reality scenarios.

SUPPORT

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References:
[1] Faller, J., Müller-Putz, G., Schmalstieg, D. and Pfurtscheller, G. (in Press). An application framework for controlling an avatar in a desktop based virtual environment via a software SSVEP brain-computer interface. Presence: Teleoperators and Virtual Environments, MIT Press
[2] Leeb, R., Lee, F., Keinrath, C., Scherer, R., Bischof, H., Pfurtscheller, G. (2007) Brain-computer communication: motivation, aim and impact of exploreing a virtual apartment. IEEE Transactions on Neural Systems and Rehabilitation Engineering; 15(4):473-482
[3] Schmalstieg, D., Fuhrmann, A., Hesina, G., Szalavári, Z., Encarnação, L. M., Gervautz, M. and Purgathofer, W. (2002) The studierstube augmented reality project. Presence: Teleoperated Virtual Environment; 11(1):33-54

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Asynchronous BCI, SSVEP, ERD, Studierstube, virtual reality