148/08 - "Design and Testing of a Wearable Device for Neurofeedback of Physiological Correlates to States of Consciousness"
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Objectives: Conventional neurofeedback usually focuses on the self-regulation of a specific brain parameter which is fed back on a computer screen in order to counter-regulate a symptomatic brain correlate. In contrast the neurofeedback device developed in this project will provide simultaneous feedback of a variety of physiological signal sources such as EEG or ECG. Various subcomponents of a measured signal can be transferred to sounds of specific instruments with the aim to maintain the information content. The user will be able to perceive the inner body processes as a visual and sound experience.

Methods: Two prototypes of a small, wearable feedback device have been developed that allow for real-time data processing, sonification and control of light sources. The first prototype was equipped with 2 analog-to-digital converters for direct read in of pulse and respiration data. A 32 bit microprocessor was used for data processing. Processed data were sent to a MIDI sound chip and to a light controller. The second prototype was equipped with a Bluetooth transceiver that could directly interface a small, wearable EEG amplifier measuring EEG and pulse simultaneously.
The algorithms for sonification have also been implemented in a PC-based program for improved performance reasons. The systems were able to control studio lighting systems and external speakers. Consequently, a whole feedback environment was created that allowed a person to experience the inner processes in the outer world. This feedback environment was termed 'Sensorium'.

Results: In a pilot study, 20 participants (10 experienced meditators and 10 non-meditators) have been exposed in a meditative session to their ongoing brain and heart signals inside the Sensorium. ECG (pulse), slow cortical potentials, and different EEG frequencies were fed back in real-time. All participants were impressed and gave positive feedback. Almost all of them reported an increase in contentment, relaxation, happiness, and inner harmony which was assessed in a questionnaire . They also reported a widening of their body consciousness.

Discussion: This novel neurofeedback-device presents a variety of body signals and rhythms in sound and light to the user providing a unique sensory experience of non-perceptible inner processes leading to various positive states of consciousness.
Conclusions: In future, therapeutic paradigms will be developed and the treatment effects on people with psychological or psychosomatic diseases will be evaluated.

Publications:
Abstracts and conference talks:
T. Hinterberger, "Mind-Body Interaction using Real-Time Sonification of Neurophysiological Signals" 15. Herbstakademie "Embodied Cognition and Embodied Communication", Bern, Switzerland, Oct. 7-9, 2009.
T. Hinterberger, "Neurofeedback, Brain-Computer Communication, and Neurosonification – Approaches and Novel Applications" CallT Conference in Bad Tölz, Germany, Sept. 2010.
Journal articles:
Hinterberger, T., (2011), "The Sensorium: A Multimodal Neurofeedback Environment", Special Issue on Advances in Human-Computer Interaction, doi:10.1155/2011/724204.

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