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Decoding auditory attention using behind the ear EEG

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Introduction: Brain computer interfaces are promising for the active and passive control of hearing device settings. For every day BCI applications alternatives to the classical EEG cap electrode placement are needed. We have developed the cEEGrid, a behind-the-ear electrode grid (Fig A-C) designed for concealed EEG acquisition over the course of a day [1]. Here we explored the possibilities of decoding auditory attention to different concurrent music streams using the cEEGrid. We used a previously established auditory attention paradigm of [2] and compared attention decoding for high-density scalp EEG and cEEGrid EEG data acquired concurrently.

Material and Methods: From 20 participant 84 scalp cap EEG and 18 behind-the-ear EEG channels were recorded simultaneously. Three concurrent music streams (duration 3 s) were presented, differing in the music instrument, the direction (front, left, right) and the number of beats (3,4,5 respectively). Listeners were instructed to pay attention to either the left or the right stream (but never the central stream) and to indicate with a (post-stimulus) button press whether the melody of that stream was ascending, descending or alternating. ERPs were computed for the two conditions and a classifier (LDA) was trained on the data.

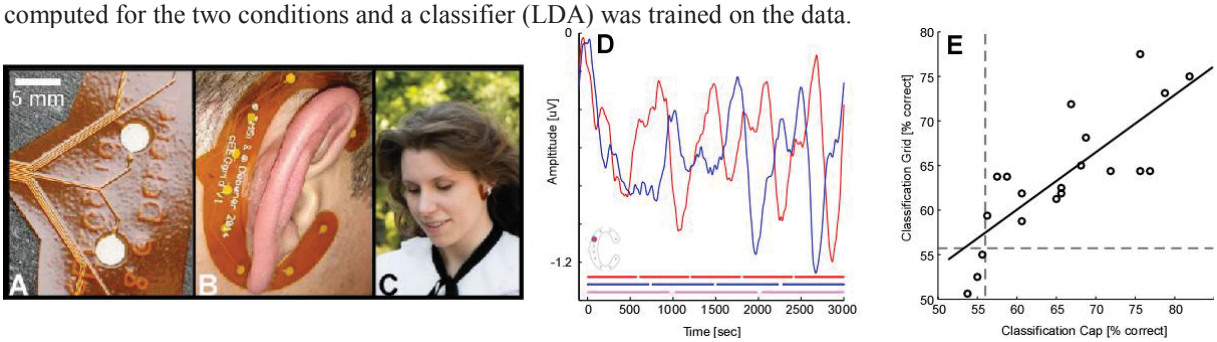

Figure 1. *The cEEGrids are designed as semi-disposable electrode grids. The flexprint material includes several layers of a biocompatible polymide, the conductive parts consist of gold plated ends, pure copper traces, and conductive Ag/AgCl based polymer thick film ink. B) The ten electrodes per ear are arranged in a c-shape and positioned around the ear using an adhesive. A small amount of electrode gel assures a low impedance electrode-skin contact. C) The cEEGrids do not attract attention when worn outside the lab. D) Grand average ERP of the left (blue) and the right (red) attended stream for one cEEGrid electrode (indicated in inset). The horizontal markers indicate the sounds in the three streams (pink: center stream - 3 notes, blue: left stream - 4 notes, red: right stream – 5 notes). E) Classifcation accuracy for scalp EEG and cEEGrid. The dashed lines show the 56% chance level.*

Results: The grand average ERP for the cEEGrid electrodes indicated the number of tones in the attended stream (Fig. D). On average classification was above chance-level with an accuracy of 64% (range 51% - 78%; chancel level 56%) for the cEEGrid and 66% (range 54%-82%) for the scalp EEG. 17 of the 20 datasets were classified above chance for both setups (Fig E). Task performance for identifying the melodic content of the attended stream varied between 45% and 99%. A non-significant correlation between cEEGrid classification accuracy and task performance was found (r=0.43, p=0.06). Better task performance led to a higher classification accuracy.

Discussion: The data recorded with the cEEGrid allowed the identification of the direction of attention above chance level in 3 seconds long music segments. The accuracies between cEEGrid and scalp EEG data are comparable. From a usability standpoint the classification accuracies should be increased, which could be achieved by implementing artefact attenuation, longer trials and advanced classification procedures.

Significance: Unobtrusive and convenient placement of EEG electrodes improves the user acceptance of BCIs. Here we show for an auditory BCI paradigm that informative signals can be extracted from the behind-the-ear cEEGrid electrodes.

References

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