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The influence of pitch modulation on the performance of a BCI-based language training system.

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Introduction: Aphasia is a language impairment observed, e.g., after a left hemispheric stroke, that has a substantial impact on patients' quality of life. In the chronic period, conventional language training methods unfortunately have limited to no effect. We have proposed a new intensive (30 hours, multiple sessions per week) language training using a brain-computer interface (BCI), which revealed significant and lasting improvements of multiple language aspects when tested on ten patients with chronic aphasia [1]. Six loudspeakers surrounding the subject's head were used in this training to deliver spatially distributed word stimuli of a six-class auditory oddball protocol. While it is desirable to translate the training in the future into offices of local practitioners or to patients' homes, installing the six loudspeaker arrangement there may be prohibitive. To prepare a later headphone-based setup and resolve front-back confusions typically observed in simulated sound directions, we explore the influence of pitch modulation of word stimuli.

Material, Methods and Results: We compared the ERP effects of the conventional spatial loudspeaker setup (6D condition) with a condition that enriches word stimuli by pitch modulations expected to help subjects determine the spatial direction of a presented word (6D-Pitch). Seventeen native Dutch speakers participated in the experiment. A Dutch sentence, whose last word was missing, cued the target word from one of the loudspeakers. Subsequently, a pseudo-random sequence of 90 word stimuli per trial was delivered. While the target word matched the previously presented sentence, the other five did not. Subjects were requested to pay attention to this target word. This abstract reports on two (6D and 6D-Pitch) out of overall four conditions delivered in a single session. In 6D, all sounds were played at the same pitch; in 6D-Pitch, sounds played from the front and back were played at a higher and lower pitch, respectively. Sixty-four channels of EEG and vertical EOG of the right eye were measured. Per subject and condition, the ERP responses to targets and nontarget were averaged over trials before computing the grand average ERP response over subjects. In addition, the binary classification performance using ToeplitzLDA [2] and a BCI simulation (choosing one out of six classes) were investigated using 4-fold chronological cross-validation.

Grand average ERPs showed only minor differences between the 6D and 6D-Pitch conditions. Compared to word ERPs of healthy subjects reported in [1] we observed a higher P300 amplitude ($1.8\,\mu V$ vs. $1.3\,\mu V$), which could have been caused by slightly different preprocessing. The mean binary target vs. non-target classification accuracy (AUC) was 0.745 for 6D and 0.747 for 6D-Pitch (not significant). On the other hand, the mean accuracy (chance level = 0.167) for choosing one out of six words based on 15x6 epochs was slightly higher (not significant) for 6D-Pitch (0.868 vs. 0.850).

Discussion: Pitch-enriched cues are known to help resolve front-back confusions in spatial sound presentations. Thus pitch information might be important also for the user acceptance of a future headphone-based training setup with simulated sound directions. As our current study revealed that additional pitch cues do not impede the classification performance in the loudspeaker condition, we expect that no substantial performance drop will be observed for incorporating pitch information also in a future headphone condition, which would allow for a substantial simplification of the current loudspeaker-based aphasia training setup [1].

References:

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