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1. Introduction

Hearing aids amplify signals relevant for speech understanding, but the healthy human auditory system is much more intricate. It can isolate weak sounds in highly complex and noisy acoustic environments [1]. This may require some top-down contribution from the efferent pathway, possibly influenced by the listener's intent. While speech perception may be enhanced by this auditory feedback loop, current devices do not mimic this fine-tuning ability. We propose that future devices could benefit from brain-computer interface (BCI) technology. Electroencephalography (EEG) is frequently used for BCI applications, but has some limitations [2]. Traditional research-grade EEG equipment is bulky and sensitive to motion-artifact, which makes it unsuitable for use outside of the laboratory.

2. Objective

- The objective is to develop a wearable EEG recording device capable of transmitting real-time, real-life feedback of a user's speech and sound perception.
- To that end, a custom-fitted earpiece was prototyped and tested to explore the potential of EEG inside the ear canal and around the ear.

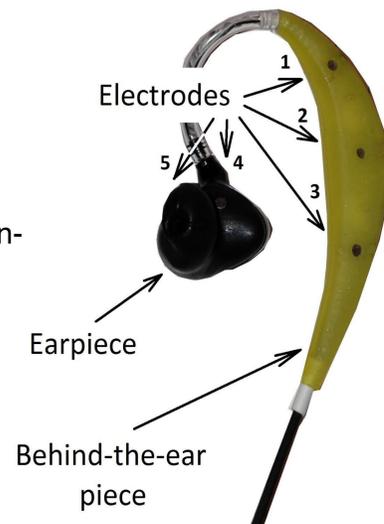
3. Materials and methods

EEG data was recorded simultaneously from an ear-EEG recording device and an electrode cap. Two paradigms were used:

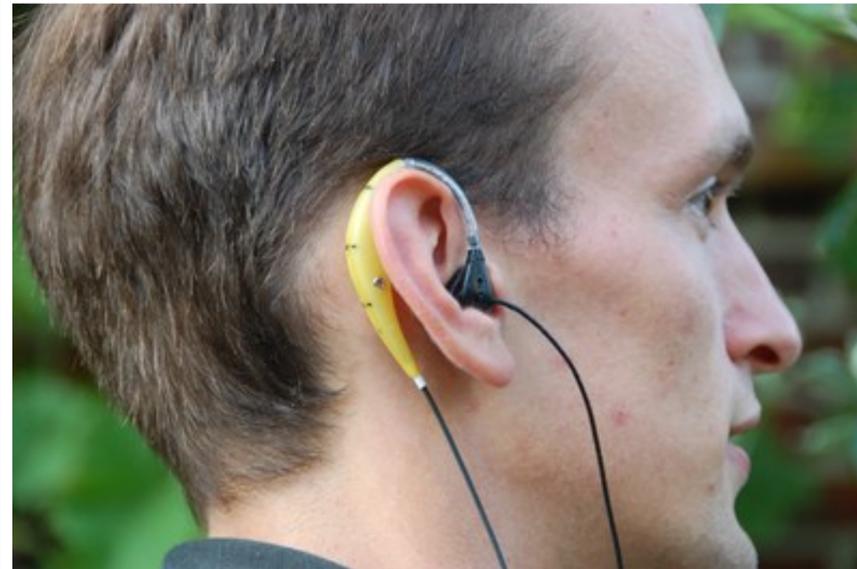
1. Auditory oddball paradigm
2. Mismatch negativity paradigm

The ear-EEG recording device dubbed "EARtrode" consisted of:

- Custom-fitted SonoFit™ [3](EERS, Montreal, Canada) in-ear audio platform
- Behind-the-ear piece
- 5 Miniaturized Ag/AgCl wet electrodes (2 mm diameter)



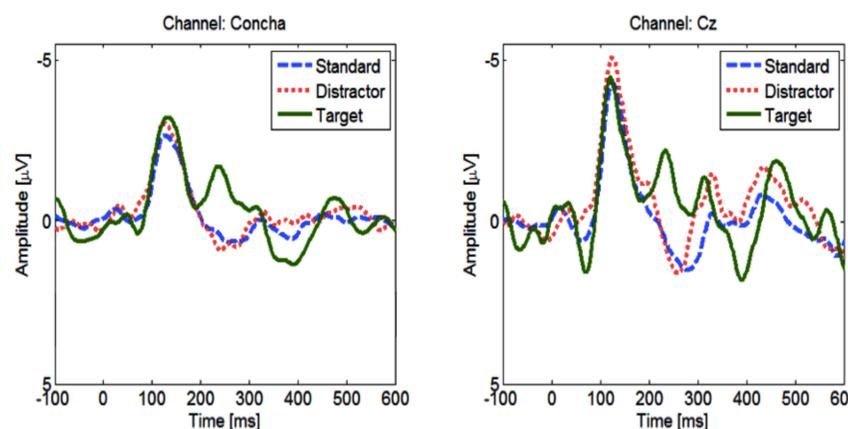
EARtrode™ audio earpiece for EEG recording (Sonomax, Canada)



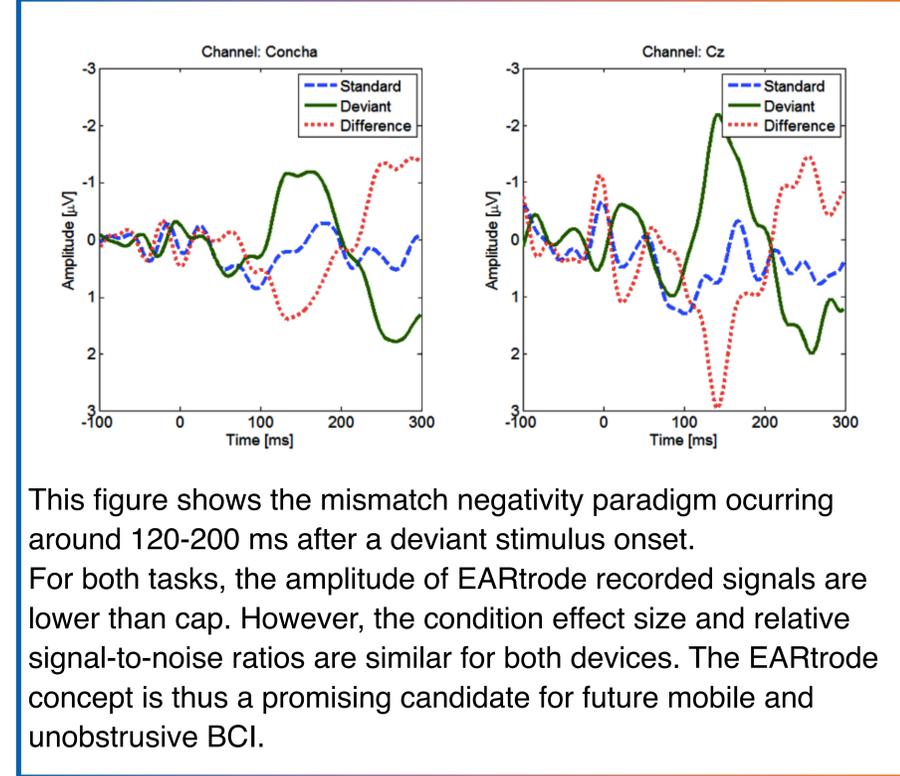
The EARtrode silicone earpiece was inflated inside the ear canal to achieve a tight fit with the hairless, asymmetrical skin surface of the concha. For comparison, a sintered Ag/AgCl electrodes cap was fitted over the EARtrode.



5. Preliminary Results



In this figure, the P300 response of the oddball paradigm to an attended target stimuli is visible around 300-430ms and absent in the standard and distractor conditions. A similar morphology and condition effect is visible for cap and EARtrode ERPs.



This figure shows the mismatch negativity paradigm occurring around 120-200 ms after a deviant stimulus onset. For both tasks, the amplitude of EARtrode recorded signals are lower than cap. However, the condition effect size and relative signal-to-noise ratios are similar for both devices. The EARtrode concept is thus a promising candidate for future mobile and unobstrusive BCI.

6. Conclusions

In the long-term, ear-EEG could be merged with hearing aids to build next generation devices that dynamically adapt to the listener's brain responses. Our next step is to test new applications for the ear-EEG platform, specifically, if an ear-centered smartphone-controlled EEG platform could measure cognitive load. Ear-EEG BCIs may evolve into truly assistive technology if they can be shown to reliably decode mental states.

7. Bibliography

- [1] Giraud, A. L. & al. (1997) Auditory efferents involved in speech-in-noise intelligibility. *Cognitive Neuroscience and Neuropsychology*, Vol. 8-7
- [2] De Vos & al. (2014) Towards a truly mobile auditory brain-computer interface: Exploring the P300 to take away. *Intl Journal of Psychophysiology*, Vol. 91-1
- [3] SonoFit™ Custom Fitting System by Sonomax™

8. Acknowledgement

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