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Live demonstration of a portable, affordable, and versatile auditory evoked potentials recording system mostly based on off-the-shelf electronics

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Motivation: The high cost of commercially available auditory evoked potential (AEP) recording systems and their susceptibility to electromagnetic interferences such as the electrical-power network (50/60 Hz and harmonics) create obstacles that restrict the use of AEPs in specific clinical, research, education, and dissemination scenarios. To address this issue and encourage the utilization of AEPs in these fields, we have developed a low-cost AEP recording system that is highly robust against electromagnetic interferences. This system also offers the required flexibility for conducting advanced AEP experiments using complex stimuli.

System description: The fundamental principle of the proposed AEP system is the synchronous recording of both (1) a differential-mode electroencephalogram (EEG), i.e., the signal resulting from the difference between the active and reference electrodes (containing AEPs contaminated by electromagnetic noise), and (2) a common-mode EEG, i.e., the average signal of both electrodes (from which it is feasible to estimate the common mode noise, mainly associated to the power line electromagnetic interference). By appropriately scaling and subtracting the common-mode EEG from the differential-mode EEG, a denoised EEG can be obtained. To implement this functionality, our research team has developed a specific hardware device, complemented by affordable consumer electronics components such as a personal computer, an audio interface, and audio cables. The system operates on Matlab software (The Mathworks Inc., Natick, MA), and its estimated cost is approximately one-tenth of the price of other commercial alternatives.

System performance: Experiments conducted in non-laboratory settings, such as living rooms or university lecture rooms, have shown that by suppressing the common-mode EEG from the differential-mode EEG, the level of electromagnetic noise is significantly reduced. This results in AEP recordings of comparable quality to those obtained in traditional shielded booths within a lab environment. In addition, Matlab software offers the necessary flexibility to conduct advanced AEP experiments, allowing for the presentation of complex stimuli and the application of sophisticated methodologies like deconvolution [1,2] and latency-dependent filtering and down-sampling [3] to process the recorded EEG. The proposed system was presented at the "2023 International Workshop on Advances in Audiology" in Salamanca, Spain (May 25-27, 2023) [4]. A video showcasing a live demonstration of a recording session during the workshop is available [5].

Conclusion: Suppressing the common-mode EEG from the differential-mode EEG is a strategy that substantially increases the robustness of the system against electromagnetic interference. Importantly, this feature alleviates the need for an electromagnetic shielded booth, thus enabling AEP experiments to be conducted in non-laboratory settings. The improved portability, combined with the system"s affordability and flexibility, opens up new opportunities for research, education, and clinical diagnostic. For instance, this system could be particularly suitable for applications such as remote assessments, animal research, training, science-dissemination, education purposes, and for research groups with limited budgets interested in AEP technologies.

Live demonstration: The upcoming IERASG conference will feature a demonstration highlighting the proposed system´s ability to perform AEP experiments without the need for a shielded booth. During this demonstration, click-evoked auditory brainstem and middle latency responses will be recorded simultaneously at different levels. In addition, this demonstration will also include an analysis of the noise affecting the EEG, including myogenic noise and interference from the electrical-power network.

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