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T11: COCHLEAR IMPLANT ARTIFACT REMOVAL METHODS TO MEASURE ELECTRICALLY EVOKED AUDITORY STEADY-STATE RESPONSES

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In cochlear implant (CI) subjects, electrically evoked auditory steady-state responses (EASSRs) can be detected in the EEG in response to stimulation with periodic or modulated pulse trains. EASSRs are currently being investigated for objective CI fitting. However, the EEG is obscured by electrical CI artifacts, also present at the response frequency. This CI artifact is caused by 1) the radiofrequency link between the external speech processor and internal implant (RF-art), and 2) the CI stimulation pulses themselves (STIM-art). CI artifacts can be removed by blanking which applies a linear interpolation over the duration of CI artifact. This method only works if the CI artifact duration is shorter than the interpulse interval, which is the case for low-rate (<<500 pulses per second, pps) pulse trains, or stimulation in bipolar mode. In monopolar mode, the CI artifacts are larger in amplitude and longer in duration than in bipolar mode, so that blanking cannot always avoid CI artifacts being confused for neural responses, and unreliable threshold level estimations.

In order to characterize the CI artifact, EASSRs were recorded in eight subjects implanted with a Nucleus® device using 500 pps pulse trains presented in monopolar MP1+2 mode. CI artifact amplitude growth functions (AGFs) were used to differentiate between the two sources of CI artifacts. The RF-art does not scale with increasing stimulus intensity. Therefore, the intercept of the AGF and the Y-axis quantified the RF-art, while the slope of the AGF indicated the STIM-art contribution. Furthermore, the CI artifact duration was characterized by applying increasing blanking lengths. With increasing blanking length, the CI artifact contribution at the response frequency is reduced, while the underlying EASSR remains unchanged. The blanking length for which the amplitude at the response frequency saturates is defined as the CI artifact duration. For all subjects, the RF-art was localized in the EEG signals recorded around the CI. The STIM-art spread across the entire scalp, being the most severe close to the CI. In contralateral electrode signals, the mean CI artifact duration was 0.8 ms, with an interquartile range of 0.4ms. Consequently, in all subjects and in all contralateral electrode signals, blanking could remove the CI artifacts when the interpulse interval is 2 ms (i.e. for 500 pps pulse trains). At higher pulse rates, more advanced CI artifact rejection methods were necessary.

An alternative and fully automated CI artifact rejection method, based on Independent Component Analysis (ICA), was developed for the cases in which blanking could not remove the entire CI artifact. EASSR growth functions were measured in five subjects, with 900 pps pulse trains presented in monopolar MP1+2 mode. Electrophysiological threshold levels were determined from these growth functions, based on one- and two-sample Hotelling's T-squared tests. At 900 pps, after ICA based CI artifact rejection, the CI artifact has been removed in the EEG signals recorded in the contralateral and the ipsilateral hemisphere. Furthermore, electrophysiological threshold levels could be successfully estimated within 20% of the subjects' dynamic range.

In summary, blanking (for low rate stimulation [0-500 pps]) and ICA based CI artifact rejection (for high rate stimulation [500-900pps]) can be used for CI artifact removal from the EEG, opening the way to use EASSRs for objective CI fitting with clinical stimuli.

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