Steady-state Cochlear Microphonic

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ABSTRACT

Introduction: Early hearing loss diagnosis has an impact on the individuals and their family's life, but, on the other hand, allows quick intervention and better quality of life. For this reason, diagnostic techniques must be improved to provide more accurate and better prognosis. Currently, one of the biggest challenges in early auditory diagnosis is the identification of auditory neuropathy/desynchrony (AN/AD). The condition is characterized by impaired peripheral auditory function with preserved integrity of the outer hair cells (OHC) (Starr et al., 1996). Its precise location is not defined and may differ in different cases, but it is believed to be in the internal hair cells (IHC), in the synapses between the IHC and the auditory nerve and in the nerve itself, or even in several of these structures (Doyle et al., 1998). Cochlear function tests, particularly cochlear microphonic (CM) needs to be included in the Neonatal Hearing Screening (NHS) protocol in all children with absent or changed auditory brainstem responses (ABR), aiding the diagnosis of AN/AD (Rance et al., 1999). Auditory steady-state response (ASSR) are repetitive evoked potentials whose frequency components remain constant over time (Regan, 1989). The easiness in recording and objectivity in identifying responses, using standardized statistical procedures, are turning ASSR into an increasingly used technique, as it adds essential information for the choice of an effective therapeutic and rehabilitative approach for patients with hearing disorders (Hall, 2006; Duarte et al., 2008; Picciotti et al., 2012; Korczak, et al., 2012). CM detection is obtained with transient stimuli and analyzed in the time domain. However, this study addresses the detection of ECoG, especially CM, with steady-state stimuli and its analysis in the frequency domain. An auditory steady-state stimulus stimulates a specific region of the basilar membrane and the amplitude modulation causes the stimulation intensity to vary periodically, in the modulation frequency. The cochlear response to this type of stimulus has energy both in the carrier frequency of the stimulus and in the modulation frequency. The stimulus itself has energy only at the carrier frequency of the stimulus and in bands above and below it, but it has no energy at the modulation frequency. The energy at the modulation frequency will appear only during the stimulus transduction process by the cochlea (Soares et al., 2018).

Objective: To develop a steady-state technique for recording cochlear microphonic.

Methods: 26 volunteers were analyzed, with pure hearing thresholds up to 25 dBHL. The stimulus was generated by the MASTER system coupled to the Audiometer, with insert earphone, inside the acoustic booth. The following derivation was used: Ground at the right clavicle, Reference G2 contralateral lobe and Active G1 in the external auditory canal (EAC). The Gold TTE25 Tip Trode Electrode 13mm electrode was used inside the EAC, the others were disposable electrodes by Meditrace 200. In the first experiment, we used tones of 500, 1000, 2000 and 4000 Hz, modulated at 95 Hz and presented together to the left ear at intensities of 60, 70- and 80-dB SPL. In the second experiment, tones of 500, 1000, 2000 and 4000 Hz, modulated at 95 Hz, were independently presented to the left ear at 80 dB SPL intensity. For the third experiment, tones of 500, 1000, 2000 and 4000 Hz were modulated in the frequencies of 95 Hz, 130, 160, 190 and 220 Hz and presented together to the left ear at 80 dB SPL. All experiments obtained records in the presence and absence of masking and at least one record with a clip earphone for each participant. Several sweeps were used to improve the signal-to-noise ratio. The maximum number of used sweeps was 36 on average to obtain a value of $p < 0.05$. When the expected significance level was reached, it was confirmed in at least 2 subsequent sweeps. The collection was interrupted in the presence of a high rate of rejected stimuli.

Results: The first experiment aimed to specifically study the envelope tracking component of the steady-state CM. A multi-factor analysis of variance for repeated measures (ANOVA) showed a significant interaction ($F(2.10)=11.686$, $p=0.002$) between condition (with and without masking) and stimulus intensity (60, 70- and 80-dB SPL). The post-hoc analysis (Fischer LSD) showed significantly higher amplitudes of responses without masking at 70 and 80 dBSPL intensities. The amplitudes at 80 dBSPL were significantly higher than the amplitudes at 70 and 60 dBSPL, in both conditions. The difference between the amplitudes of the responses at 70 and 60 dBSPL reached significance only in the condition without masking. The considered critical p was 0.05. The second experiment verified the effects of carrier frequency on the steady-state MC. The analysis of variance (ANOVA) of simple repeated measures was significant ($F(4.4)=7.284$, $p=0.0002$). The post-hoc analysis (Fischer LSD) showed significantly higher amplitudes of responses to the combined stimulus in comparison to the isolated stimuli. The amplitude of the response to the 4000 Hz stimulus is significantly higher than to the 1000 and 500 Hz stimuli. The third experiment was carried out to investigate the effect of the modulation frequency on the responses. The simple analysis of variance for repeated

measures (ANOVA) was significant (F(4.4)=3.304, p=0.0210) and the post-hoc analysis (Fischer LSD) showed significantly higher amplitudes for the stimuli modulated at 95, 130 and 160 Hz in comparison with at 190 and 220 Hz. In the carrier frequencies of 95, 130, 160 Hz the amplitudes were not significantly different. Conclusion: Recording the steady-state cochlear microphonic can be performed at intensities of 60 to 80 dB SPL. The ideal carrier frequencies for the recording are 500, 1000, 2000 and 4000 Hz, combined. The ideal modulation frequency for the recording is 95 Hz.

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