Optimization of Recording Parameters for Enhanced Visualization of Early Auditory Evoked Potentials

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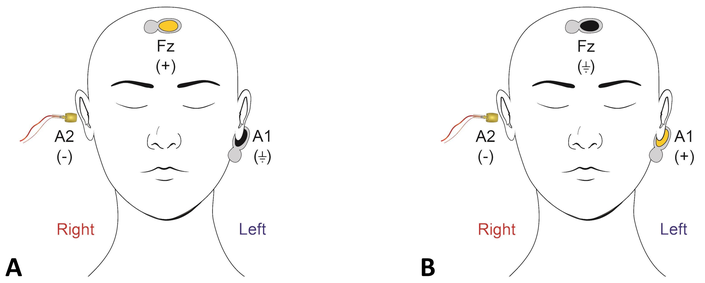

Figure 1. Schematic of **A)** vertical and **B)** horizontal electrode montages. (-) = reference electrode, (+) = active electrode, A2 = right ear canal, A1 = left mastoid, Fz = high center forehead.

MONTAGE GRAND AVERAGES

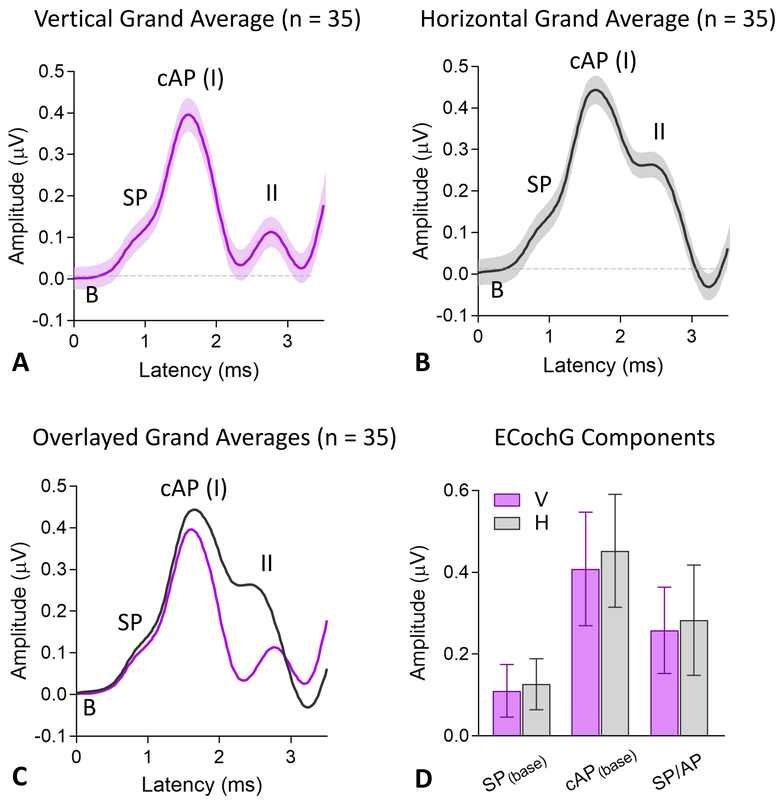

Figure 2. A) Grand average of participants' (n = 35) ECochG traces using a vertical electrode montage. Shaded region = SEM. **B)** Grand average of participants' (n = 35) ECochG traces using a horizontal electrode montage. Shaded region = SEM. **C)** Grand averages (n = 35) of horizontal and vertical ECochG traces, overlayed for qualitative comparison. B/grey dashed line = baseline, SP = summating potential, cAP = compound action potential (also wave I), II = wave II. **D)** Means and 1 SD of ECochG components: SP amplitude (rel: baseline), cAP amplitude (rel: baseline), and SP/AP amplitude ratio. Pink = vertical montage; Grey = horizontal montage. Paired t-tests did not reveal any significant differences between electrode montages across all three components (SP amplitude p = 0.26; cAP amplitude p = 0.1; SP/AP ratios p = 0.35.)

INTRODUCTION

Early auditory evoked potentials (AEPs) – such as electrocochleography (ECochG) and the auditory brainstem response (ABR) – have been widely used to examine the cochlear synapse in humans, which correspond to the compound action potential (cAP) in ECochG and wave I in the ABR. If cochlear synaptopathy occurs in humans, it is paramount to optimize our methods of recording the cAP/wave I component in order to utilize it as a proxy for cochlear synaptopathy.

This study focused on electrode placement, or montage. Theoretical principles suggest that recordings are optimized when electrodes are placed in the same plane as the direction of neural propagation. We tested this by recording early AEPs in horizontal and vertical montages. In doing so, we aim to provide optimized methods for recording the cAP/wave I component.

METHODS

Data Collection

In 35 normal hearing young adults, ECochGs to a 100-μs broadband click (90 dB nHL, alternating polarity) were collected in vertical and horizontal montages, each using a gold-foil tiptrode in the right ear canal as the reference electrode and stimulus transducer. Snap electrodes placed on high center forehead (Fz) and contralateral mastoid (M1) served as active and ground electrodes (vertical active: Fz, horizontal active: M1). For each montage, two repeatable traces were collected and added to produce a single waveform for analysis.

Data Analysis

Seven variables were compared between montages using paired t-tests: SP amplitude (rel: baseline), cAP amplitude (rel: baseline), SP/AP amplitude ratio, cAP peak-to-trough amplitude and latency, and wave II peak-to-trough amplitude and latency. All statistics were performed using GraphPad by Prism version 8.0.2.

SUMMARY & CONCLUSION

Our results indicate that electrode montage plays an important role in the outcomes of cAP/wave I visualization and measurement. ECochGs collected in a vertical montage produced a more robust measure of cAP/wave I characteristics compared to horizontal recordings, producing an average 73.9% increase in peak-to-trough amplitude. A delayed onset of wave II in the vertical montage was consistently observed, allowing cAP/wave I's trough to reach its maximum rather than be cut short. For ECochG components used for standard diagnostic purposes, such as SP/AP ratio, there were no statistical differences and therefore no apparent quantitative advantage to using one montage over the other. Overall, the data presented support recording early AEPs using a vertical montage, especially for the purpose of exploring the possibility of cochlear synaptopathy in humans. These results and conclusions are representative of ECochG recordings using an ear canal electrode (tiptrode) and should not be generalized to recordings using other electrode locations (e.g., tympanic membrane, promontory, earlobe, or mastoid placements).

cAP (Wave I)

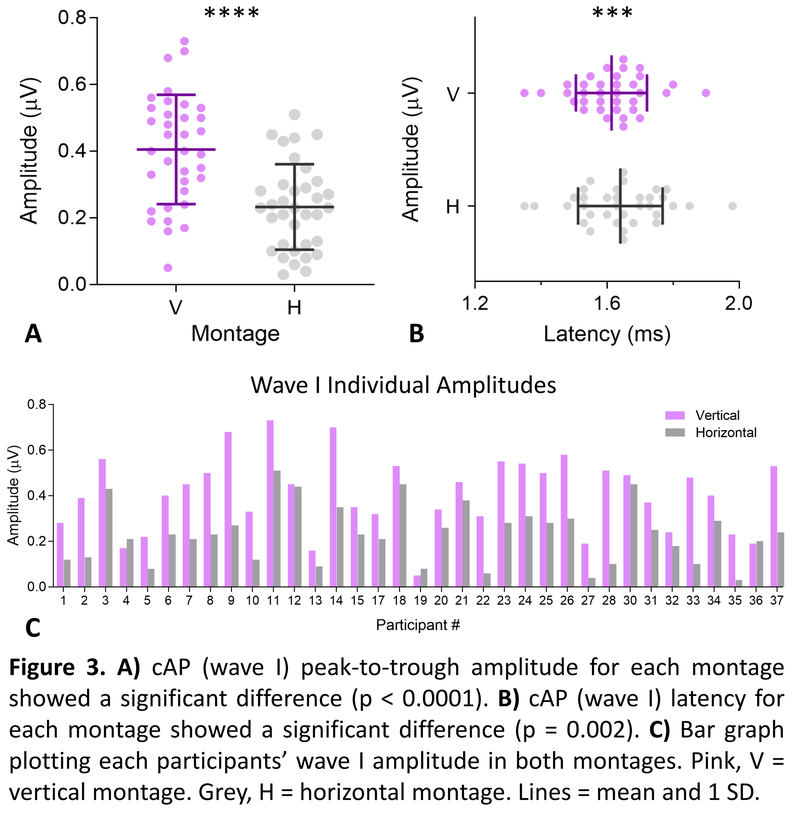

Figure 3. A) cAP (wave I) peak-to-trough amplitude for each montage showed a significant difference ($p < 0.0001$). **B)** cAP (wave I) latency for each montage showed a significant difference ($p = 0.002$). **C)** Bar graph plotting each participants' wave I amplitude in both montages. Pink, V = vertical montage. Grey, H = horizontal montage. Lines = mean and 1 SD.

WAVE II

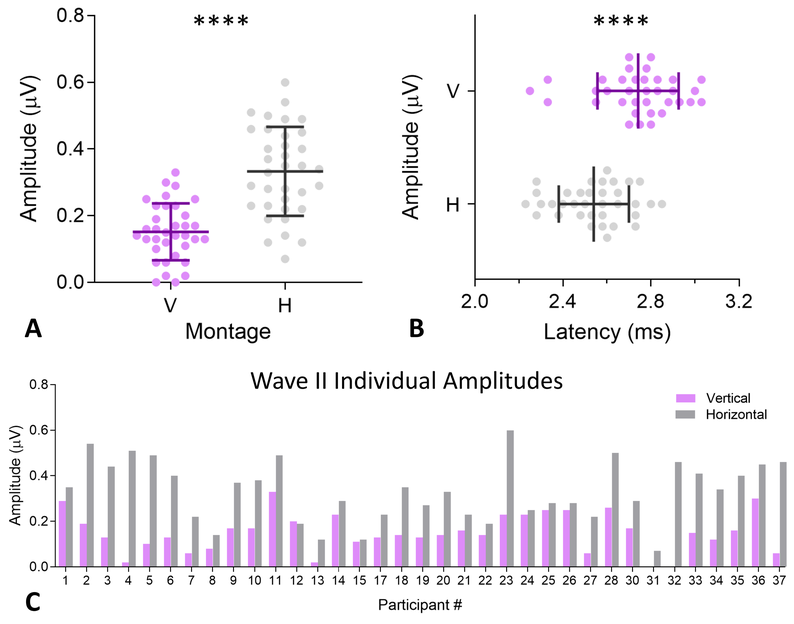

Figure 4. A) Wave II peak-to-trough amplitude for each montage showed a significant difference ($p < 0.0001$). **B)** Wave II latency for each montage showed a significant difference ($p < 0.0001$). **C)** Bar graph plotting each participants' wave II amplitude in both montages. Pink, V = vertical montage. Grey, H = horizontal montage. Lines = mean and 1 SD.