Effect of Ear Canal, Earlobe, and Mastoid References on ABR

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Abstract

The available literature has hinted that larger ABR Wave I amplitudes can be obtained with an ear canal reference electrode, though this practice is not in mainstream clinical use. We created a custom ear canal electrode and compared ABR amplitudes, latencies and thresholds across three reference sites, ear canal, mastoid and earlobe, in a staggered fashion with a two-channel commercial system. Advantages and disadvantages for the three references will be discussed.

Background and Significance

Auditory brainstem response (ABR) testing is a non-invasive procedure which utilizes an array of surface electrodes to measure aggregate evoked responses stemming from the hearing nerve and auditory brainstem (Wilson, Talbot, and Mills, 1991). It is an invaluable tool for assisting in the assessment and determination of possible hearing loss and the presence of neurological lesions within the auditory nerve through the auditory brainstem up to the level of inferior colliculus (Stockard and Rossiter, 1977).

Waves I, III, and V are often clearly exhibited in most individuals when using high stimulus intensity levels, and the overall ABR waveform generally exhibits good test-retest reliability in the same, quiet and cooperating person (Beattie, Zipp, Schafer, and Silzel, 1992). Additionally, latencies are quite similar from person to person despite normal variability in waveform morphology (Stockard, Stockard, and Sharbrough, 1978). The interpeak latency (IPL) for Waves I and V is one useful clinical index of a neurological lesion especially when the IPL is prolonged (Ruth, Mills, and Ferraro, 1988). However, Wave I is sometimes obscured because of poor signal-to-ratio, peripheral hearing loss, and/or the location and placement of electrodes on the head and ears (Hyde and Blair, 1981; Cashman and Rossman, 1983). Lack of a Wave I precludes the use of the Wave I-V IPL measurement.

Research and clinical experience show that an electrode placed superficially within the ear canal may enhance the amplitude of Wave I (Harder and Arlinger, 1981). The reason for this is because the ear canal electrode is closer to the generator, that is, the auditory nerve. The distal end of the auditory nerve is the most likely candidate to give rise to Wave I (Møller and Jho, 1989). While an ear lobe reference may be assumed to be stable, it is thought to be furthest from the auditory nerve and the less parallel with the brainstem dipole when taking the non-inverting electrode (Fz) into account. The mastoid reference may be a better choice, but there is always risk of post-auricular muscle contamination. Thus, it seems worthwhile to (re)examine the clinical utility of the ear canal reference electrode.

Methods

Participants

- Young adults (4 males, 6 females)
- No known neurological problems reported
- Tympanograms with static admittances between 0.3 and 1.8 mmhos and tympanometric peak pressure between -100 and +50 daPa
- Pure-tone audiograms within normal limits
- Completed informed consent form (Study approved by the UALR Institutional Review Board, Protocol #10-012 M1)

Evoked Potential Equipment and Procedures

Participant Instructions

- Napped during ABR recordings
- Breaks were allowed, if requested
- Participants could withdraw at any time

Equipment

- 2-Channel Bio-Logic NavPro Auditory Evoked Potential System
- Proprietary Bio-Logic NavPro insert earphones used (SINSER)
- Electrode montage: Fz referred to stimulus ear and ground on Fpz (impedances kept < 5 kΩ; inter-electrode < 2 kΩ)
- Etymotic Research ER3-14B (10 mm) eartips dually serving as sound port and ear canal electrode (see Electrode Montage)

Custom Ear Canal Electrode

- A straightened paperclip was passed between the plastic straw and foam of the eartip to create a small hole for 32 gauge silver wire to pass through
- One end was left free to be used with an alligator clip electrode lead, while the other was tucked back into the foam for safety
- A small amount of Burdick Lectrosonic transmission gel (Siemens, Milton, WI) was applied around the silver wire before insertion into the ear on the first bend of the anterior ear canal wall
- Construction of the custom ear canal electrode is shown in **Figure 1**

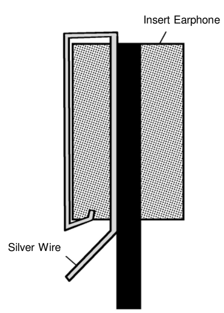

Figure 1. Custom Ear Canal Electrode

Electrode Montage (experimental conditions)

- Fz referred to:
  - Ear Canal vs. Earlobe (see **Figure 2**)
  - Ear Canal vs. Mastoid
  - Earlobe vs. Mastoid

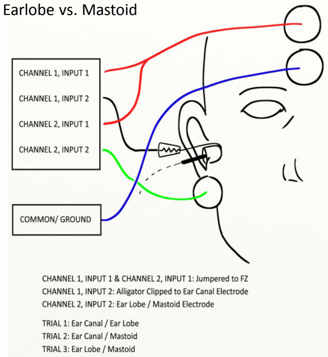

Figure 2. Ear Canal vs. Earlobe Montage

Recording Parameters

# Points	256
Epoch	10.66 ms
Gain	100,000x
Filter Settings	100-3000 Hz
Artifact Rejection	±23.8 µV
Stimulus Type	100 µs click
Stimulus Level	80 dB nHL
Stimulus Polarity	rarefaction
Stimulus Rate	11.3/s
Repetitions	2000

Data Analysis

Two 2-way (3x3) repeated measures ANOVAs were conducted at 80 dB nHL for peak-to-trough amplitude and latency with Wave (I, III, and V) as one factor and Reference Electrode (ear canal, earlobe, and mastoid) as the second factor. Maxwell and Delaney (1985) note that when the sample size is less than a + 10 (where a is the number of levels for the repeated measures), the multivariate approach results are less powerful than the univariate results. For this reason, only the univariate results (within-subject) were analyzed for interpretation, and the degrees of freedom were adjusted using Geisser-Greenhouse corrections for 2-way RM-ANOVAs to circumvent issues of sphericity. Results for the first factor were ignored. Descriptive statistics were also calculated.

Results

Peak Latency

2-way RM-ANOVAs revealed no significant main effect (F(1.974,17.762) = 1.650 ,p = .220); however, there was a significant interaction effect (F(2.468,22.216) = 6.404 ,p = .004).

Peak-to-Trough Amplitude

2-way RM-ANOVAs revealed no significant main effect (F(1.492,13.427) = 3.489 ,p = .071) nor significant interaction effect (F(3.210,28.889) = 1.724 ,p = .181).

Descriptive Statistics

LATENCY	I	III	V
Ear Canal	1.46 (0.10)	3.66 (0.06)	5.37 (0.13)
Earlobe	1.49 (0.11)	3.78 (0.04)	5.36 (0.12)
Mastoid	1.53 (0.08)	3.61 (0.09)	5.43 (0.04)

AMPLITUDE	I	III	V
Ear Canal	0.42 (0.11)	0.35 (0.15)	0.56 (0.18)
Earlobe	**0.38 (0.13)**	0.33 (0.13)	**0.43 (0.16)**
Mastoid	0.43 (0.16)	0.33 (0.14)	0.47 (0.17)

Discussion and Conclusions

- Although the results show no statistical difference among reference electrodes, a difference in peak-to-peak amplitudes approached significance. The earlobe reference may produce smaller Wave I and Wave V amplitudes, and the ear canal may produce a larger Wave V compared to other references.
- Custom ear canal electrode appears to be clinical viable, is cheap, and easy to construct.
- Future research should consider deeper ear canal insertions, gender-specific data sets, and a larger sample size. Until then, this study suggests little difference among the three references.

References

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