Can auditory stady-state responses reflect place-specific cochlear dispersion?

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Can auditory steady-state responses reflect place-specific cochlear dispersion?

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Introduction

The cochlear travelling wave propagates from the base to the apex, resulting in an increasing phase with distance from the cochlear base. Together with the tonotopic organization of the cochlea, this results in a frequency dependent delay of the resonance, a phenomenon known as cochlear dispersion. Previous studies showed the applicability of auditory evoked potentials (AEP) to investigate cochlear dispersion along the basilar membrane (BM) (e.g. Dau et al., 2000). In contrast to those studies, the present study maximizes the response in a given frequency region, aiming to objectively estimate local cochlear dispersion in humans.

Hypothesis

For the same bandwidth and intensity, stimuli compensating for the phase response at a particular cochlear location will elicit the most "peaky" response at this position, giving rise to the highest-amplitude of the evoked potential.

Method

1. Auditory steady-state responses (ASSR) with Schroeder tone complexes (Schroeder, 1970) as stimulus.

   - A greater ASSR magnitude was elicited in response to the negative Schroeder tone complex than to the positive Schroeder tone complex.
   - Similar ASSR magnitudes were obtained in response to both gcIR and time-reversed gcIR.
   - TLM simulations also show small differences between the BM response to the tested conditions.
   - Despite the small size of the effect, the same pattern as with the Schroeder tone complexes were observed.

2. ASSRs with a train of compressive gammachirp impulse responses (gcIR; Irino and Patterson, 2001) or a time-reversed version of them as stimulus.

   - Even though dispersive effects in the on-frequency channel may be represented at a peripheral level, the across-frequency asynchrony of the BM excitation may dominate the "summed" response.
   - The ASSR response is therefore dominated by the synchronized activity across frequency.
   - Brainstem responses, as reflected in the ASSR, are not sensitive enough to reflect frequency-specific cochlear dispersion.

Results

1. Schroeder Tone Complexes

   - The ASSR magnitude in response to Schroeder tone complexes with $f_c = 1\,\text{kHz}$.

2. Gammatone Impulse Responses

   - Fig. 3: ASSR magnitude in response to Schroeder tone complexes with $f_c = 1\,\text{kHz}$.

3. Simulations of frequency selectivity and dispersion using a linear transmission line model (TLM; Epp et al., 2010) were generated with the same stimuli.

4. Similar ASSR magnitudes were obtained in response from $0\,\text{dB SPL}$ to $90\,\text{dB SPL}.

5. TLM simulations also show small differences between the BM response to the tested conditions.

Conclusions

- Even though dispersive effects in the on-frequency channel may be represented at a peripheral level, the across-frequency asynchrony of the BM excitation may dominate the "summed" response.
- The ASSR response is therefore dominated by the synchronized activity across frequency.
- Brainstem responses, as reflected in the ASSR, are not sensitive enough to reflect frequency-specific cochlear dispersion.


