Hidden hearing loss with envelope following responses (EFRs): The off-frequency problem

Encina-Llamas, Gerard; Parthasarathy, Aravindakshan; Harte, James Michael; Dau, Torsten; Kujawa, Sharon G.; Shinn-Cunningham, Barbara; Epp, Bastian

Publication date:
2017

Document Version
Publisher's PDF, also known as Version of record

Citation (APA):
**Introduction**

Recent animal studies have shown that noise over-exposure can cause the loss of auditory nerve (AN) fiber synapses without causing hair cell loss (see Kujawa and Liberman (2015) for a review). This AN fiber synapses loss has been termed "hidden hearing loss" or "synaptopathy," since it is not reflected in the traditional pure-tone threshold. The envelope following response (EFR) has been proposed as a potential objective method to assess synaptopathy in humans (i.e., Bharadwaj et al., 2015). Encina-Llamas et al. (2016) reported different trends in EFR level-growth functions recorded using two modulation depths in normal-hearing (NH) and mild hearing-impaired (HI) listeners. The EFR is a gross encephalographic potential that represents the encoding of the envelope of the stimulus, arising from synchronized neural activity from all excited frequencies and fibers. In this study, a computational model of the AN was used to investigate the effects of off-frequency contributions (i.e., away from the characteristic place of the stimulus) and the differential loss of different AN fiber types on EFR level-growth functions.

**Research Question**

- Can a phenomenological AN computational model explain the different trends observed in the EFR level-growth functions in NH and mild HI listeners reported in Encina-Llamas et al. (2016)?

**Methods**

- **Model:**
  - Humanized AN model (Zilany et al., 2016).
  - 200 characteristic frequencies (CFs), ranging from 0.2 to 20 kHz.
  - Synapses per IHC are simulated by several independent computations of each CF (about 300 per CF). Synaptopathy is simulated by computing less of such independent computations.

- **Levels:**
  - EFR level-growth: 5 to 100 dB SPL, 5 dB steps.
  - Off noise: 30 to 40 dB SNR, 5 dB steps. Fix SAM at 70 dB SPL.

- **Modulations:**
  - Full m = 85%, Shallow = m = 25%

**Synaptopathy:**

- 60% of Mod- and low-SR loss

**Mild hearing-impaired:**

- Mild level-growth functions for the mild-HI group in Encina-Llamas et al. (2016).

**Conclusion**

- EFRs at high stimulus levels are dominated by the off-frequency contributions.
- EFRs are dominated by the responses from high-SR fibers.
- EFR level-growth functions from synaptopathic frequencies in exposed mice show similar trends to EFR functions in some NH human listeners (see paper PS 9 by Aravind Parthasarathy et al.).

**REFERENCES**

- Bharadwaj et al. (2015). Comparison between the NH versus the synaptopathic simulation to match the NH listeners in Encina-Llamas et al. (2016) as in Fig. 4.
