

Using auditory steady-state responses to evaluate auditory nerve integrity in normal-hearing and mild hearing-impaired listeners

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Publication date:
2016

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

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Citation (APA):

Encina-Llamas, G., Dau, T., M. Harte, J., & Epp, B. (2016). Using auditory steady-state responses to evaluate auditory nerve integrity in normal-hearing and mild hearing-impaired listeners. Poster session presented at 39th midwinter meeting of Association of Research in Otolaryngology, San Diego, CA, United States.

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Introduction

Hearing impairment (HI) has traditionally been defined according to an increase in pure-tone threshold as measured by an audiogram. There is, however, emerging evidence that just evaluating threshold sensitivity does not fully characterize functional deficits in auditory processing. Recent animal studies have shown that noise over-exposure can cause loss of auditory nerve fiber (ANF) synapses — known as deafferentation (see Kujawa and Liberman (2015) for a review) — without causing hair cell loss. Furman *et al.*, (2013) reported that deafferentation occurs predominantly to low-spontaneous rate (low-SR) fibers, which have higher thresholds and therefore respond to higher acoustic intensities. Consequently, these ANF synapse losses do not alter detection of thresholds, but do degrade the encoding of supra-threshold sounds. The loss of ANF synapses might be a primary neural degeneration that precedes both hair cell and ANF cell body loss (Kujawa and Liberman, 2015).

ASSR are gross electroencephalography (EEG) potentials that follow the envelope of periodic acoustic stimuli.

- ASSR magnitudes grow monotonically and compressively (slopes lower than 1) with increasing stimulation level (Encina-Llamas *et al.*, in press).
- It is suggested in the present study that ASSR growth-level functions may be a potential tool to evaluate ANF integrity.

Hypothesis

- ASSR growth-level functions with shallow modulation ($m=25\%$) have similar slopes as ASSR functions with high modulation ($m=85\%$) but with lower magnitudes.
- For preferential low-SR deafferentation: ASSR magnitudes for shallow modulation depths are reduced for higher stimulation levels, diverging from typically non-deafferentated level-curves.

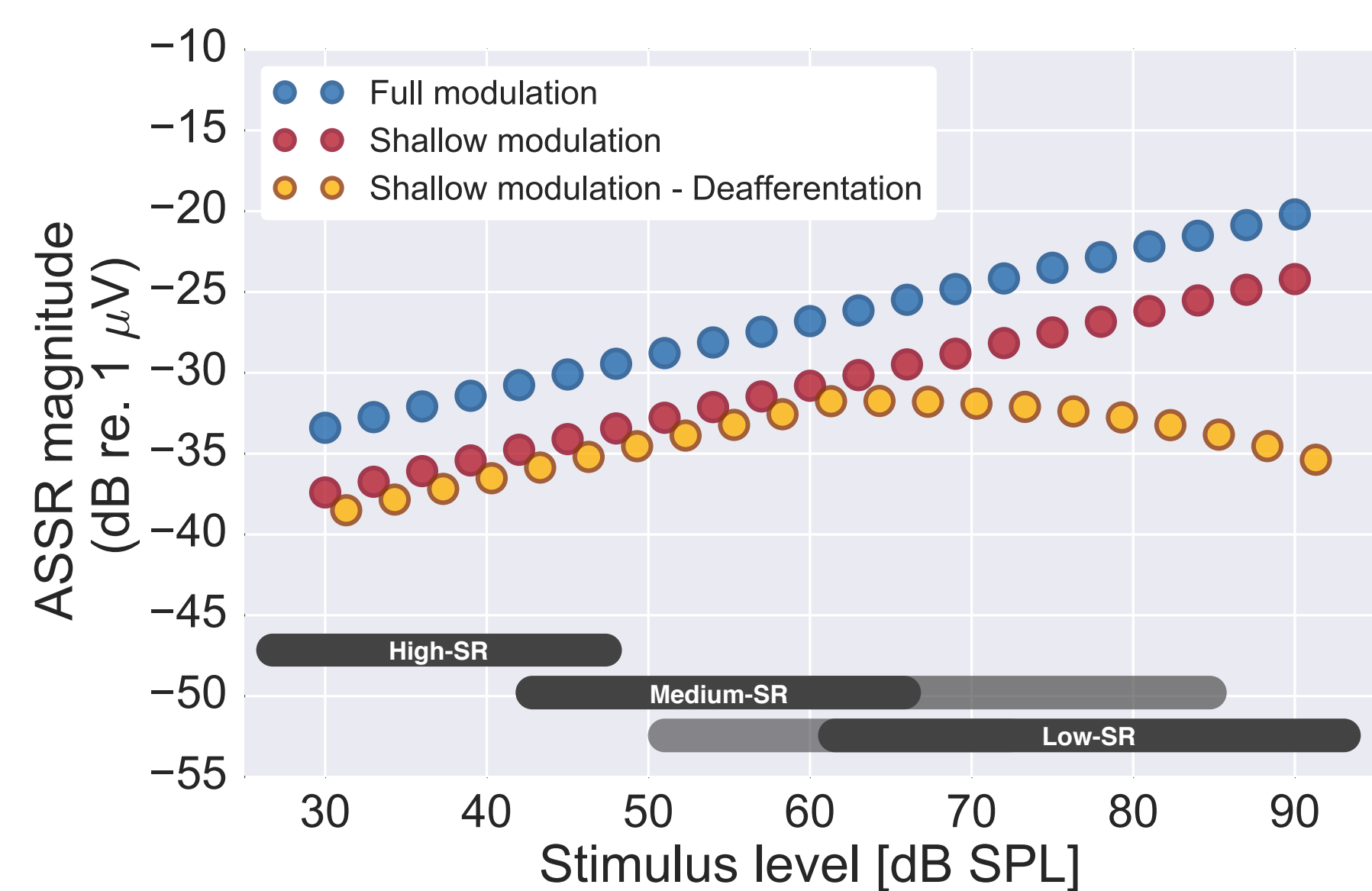


Fig. 1 Hypothesized ASSR growth-level functions for audiometrically normal-hearing listeners when using sinusoidally amplitude modulated (SAM) tones with full modulation (blue trace), shallow modulation (red trace), and shallow modulations in the presence of deafferentation (yellow trace). See Bharadwaj *et al.*, (2014)

Methods

- Subjects: 9 young NH listeners (3 females). 4 mild HI listeners (1 female) impaired at $CF \geq 4$ kHz

- Equipment: Biosemi ActiveTwo EEG system. Sound presented via ER-3 earphones mounted on an ER-10B+ OAE probe

f_c : 2 kHz @ f_m : 93 Hz
 m : 85%, 25%
 Levels: 34 to 87 dB SPL

Results

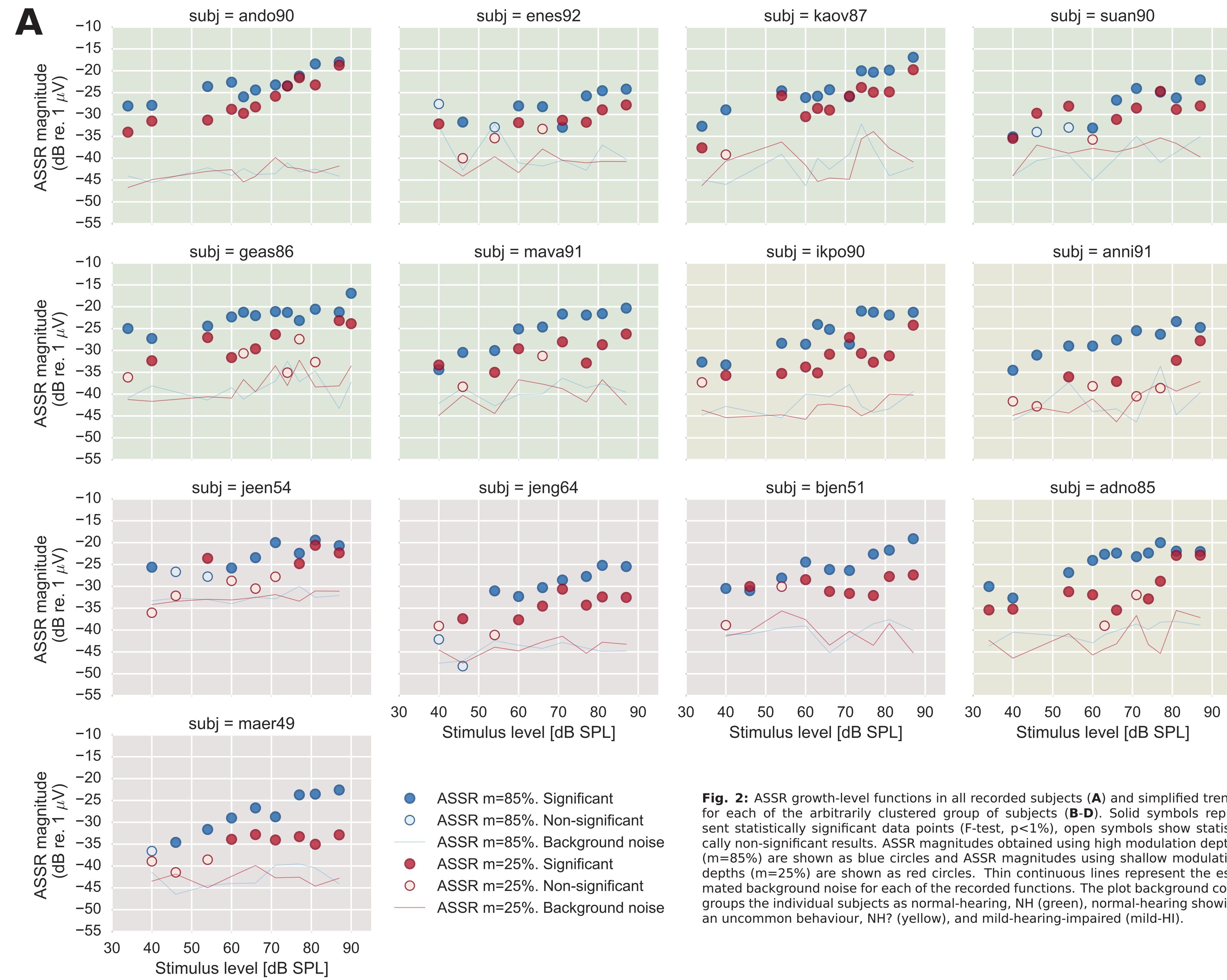
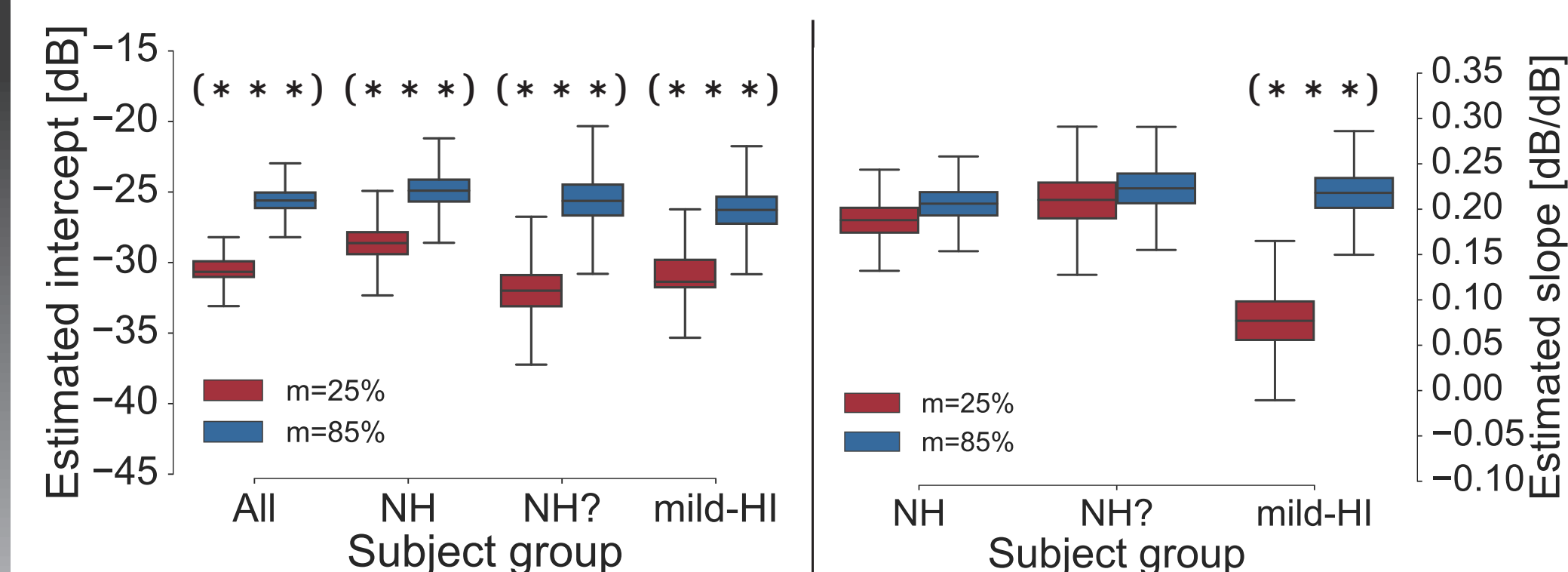


Fig. 2: ASSR growth-level functions in all recorded subjects (A) and simplified trends for each of the arbitrarily clustered group of subjects (B-D). Solid symbols represent statistically significant data points (F-test, $p < 1\%$), open symbols show statistically non-significant results. ASSR magnitudes obtained using high modulation depths ($m=85\%$) are shown as blue circles and ASSR magnitudes using shallow modulation depths ($m=25\%$) are shown as red circles. Thin continuous lines represent the estimated background noise for each of the recorded functions. The plot background color groups the individual subjects as normal-hearing, NH (green), normal-hearing showing an uncommon behaviour, NH? (yellow), and mild-hearing-impaired (mild-HI).

Discussion



A mixed model post-hoc analysis revealed that:

- ASSR magnitudes are statistically different for each modulation depth, both in the whole dataset and within each of the three arbitrary subject groups.
- Slopes estimates for modulation high and shallow modulations in the mild-HI group are statistically different, but not in the other groups.

Future work

- For shallow modulation and levels above 60 dB SPL, it appears that ASSR magnitudes are reduced for the mild-HI group when compared with the NH group. For the NH? group, ASSR growth-level functions seem to reduce initially but fully recover at very high stimulus levels, i.e. non-monotonic.
- The effects of off-frequency contributions to the ASSR at high stimulus intensities and the test-retest variability intrinsic to physiological signals need to be investigated. It is inappropriate to speculate on the potential effect size of deafferentation until more data is available, so it is vital to minimise other factors that could confound the interpretation of ASSR growth-level curves.
- A phenomenological model can be used to disentangle the possible contributing factors to the ASSR growth-level functions. The relative loss of the different groups of SR fibers, the degree of deafferentation, and the off-frequency contributions at a cochlear level will be investigated.

Conclusion

- ASSR growth-level functions obtained at shallow modulation depths show different slopes in non-impaired frequencies in NH and mild-HI listeners.
- ASSR growth-level function have the potential tool to evaluate the integrity of the peripheral hearing system at supra-threshold levels.

ACKNOWLEDGMENT

This work was funded by the Oticon Center of Excellence for Hearing and Speech Sciences (ChES5) at the Technical University of Denmark (DTU).

REFERENCES

- Bharadwaj *et al.* (2014). Cochlear neuropathy and the coding of supra-threshold sound. *Front Syst Neurosci.* 8:26.
- Encina-Llamas *et al.* (in press). Evaluation of peripheral compression and auditory nerve fiber intensity coding using auditory steady-state responses. *ISAAR 2015.*
- Furman *et al.* (2013). Noise-induced cochlear neuropathy is selective for fibers with low spontaneous rates. *J. Neurophysiol.* 110(3):577-86.
- Kujawa and Liberman (2015). Synaptopathy in the noise-exposed and aging cochlea: Primary neural degeneration in acquired sensorineural hearing loss. *Hearing Res.* 330:191-199.