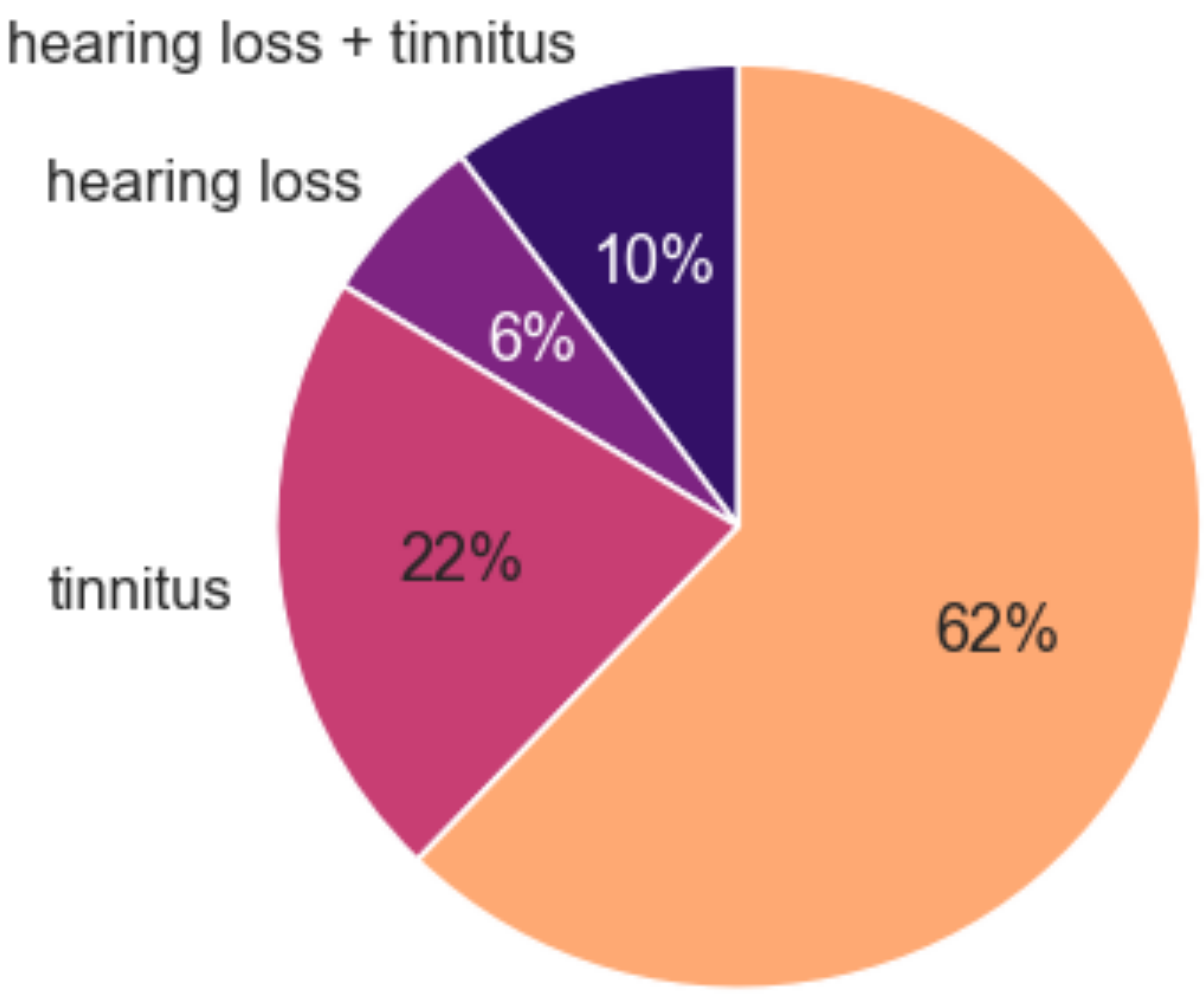
The Neurogram

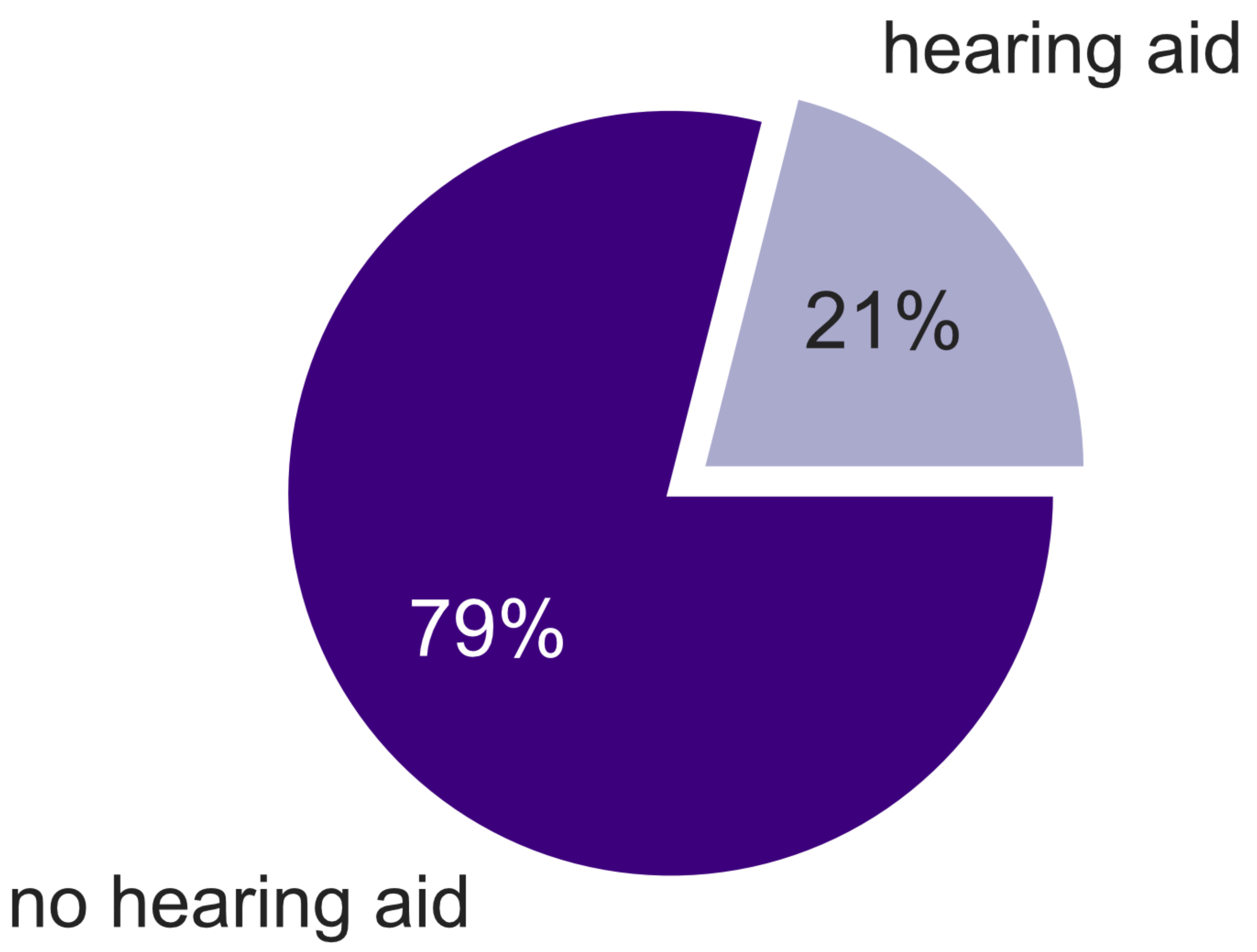
A quantification of real-life hearing impairments using electrophysiology

Wie hört Salzburg?

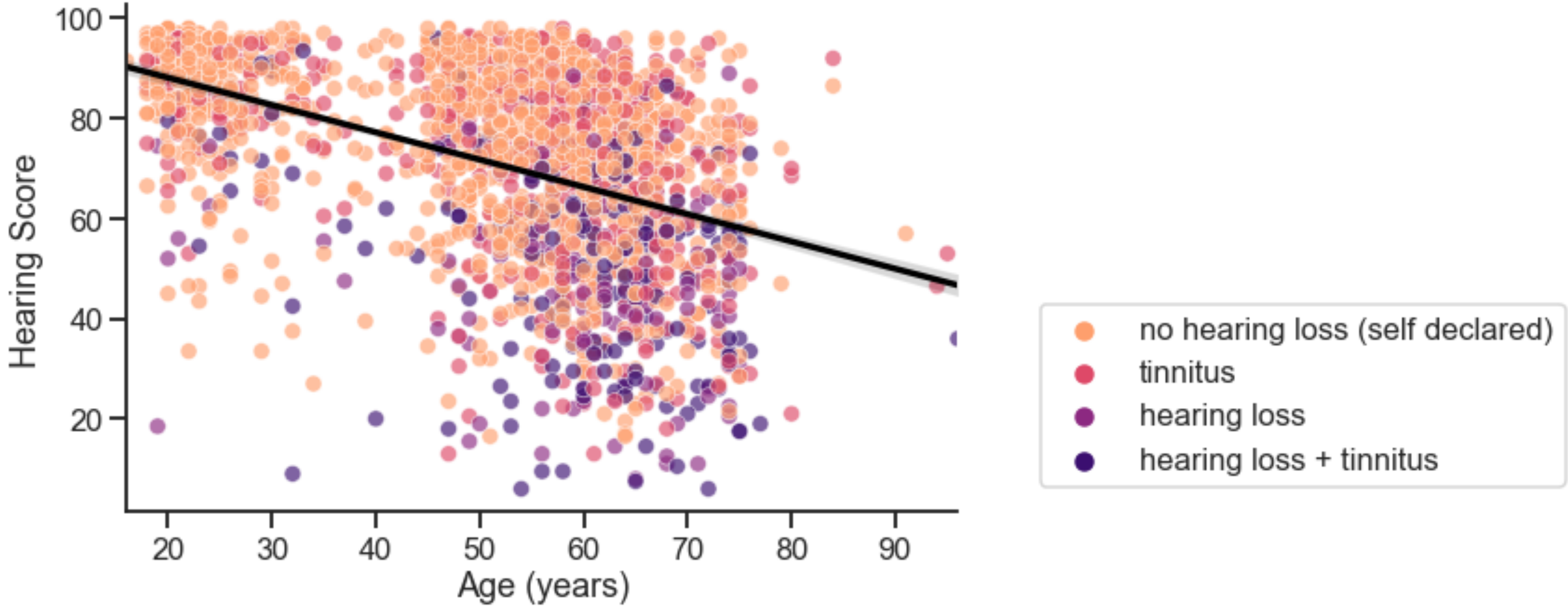
Assessing the prevalence hearing impairments in the population of Salzburg

The state of hearing in Salzburg…

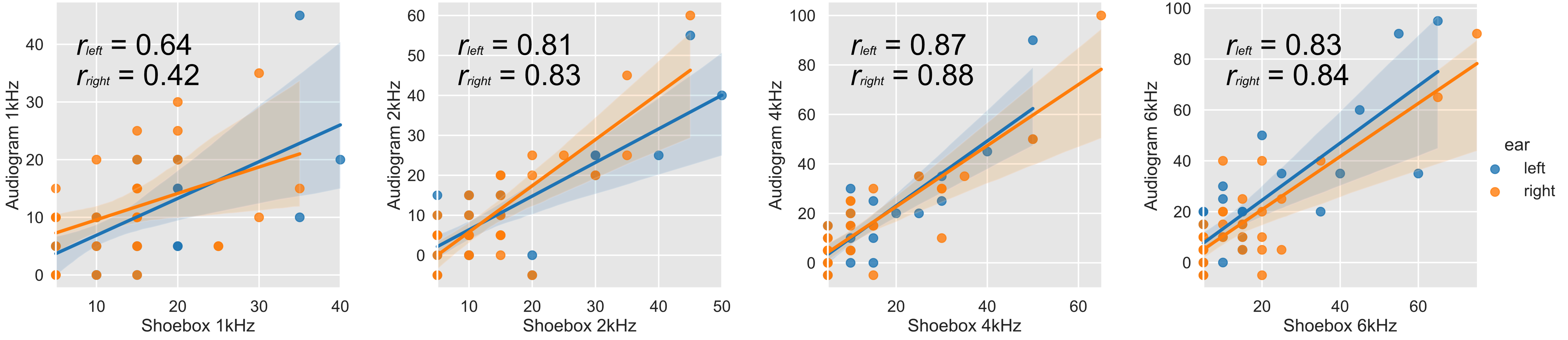




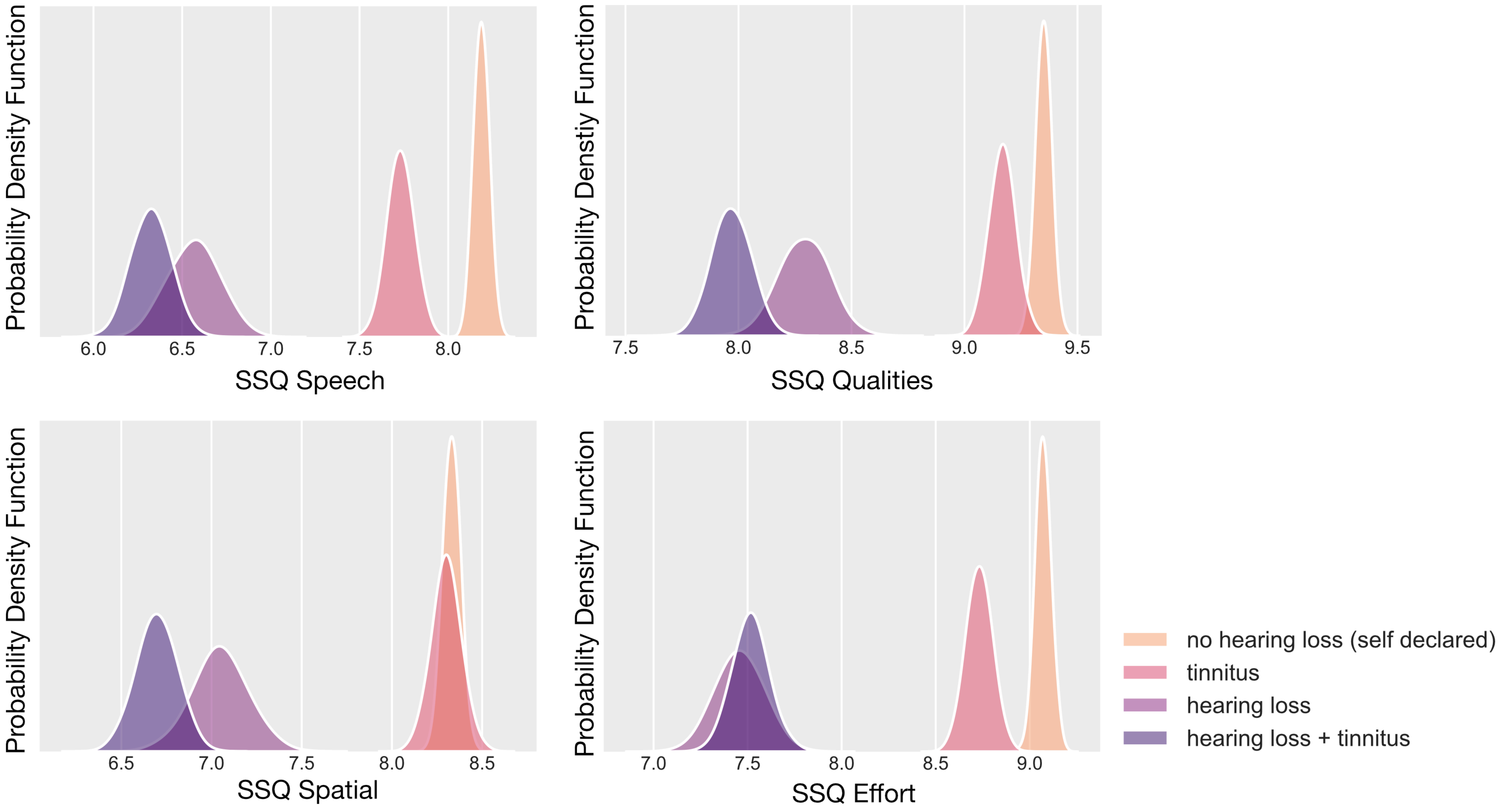
Hearing ability decreases with age



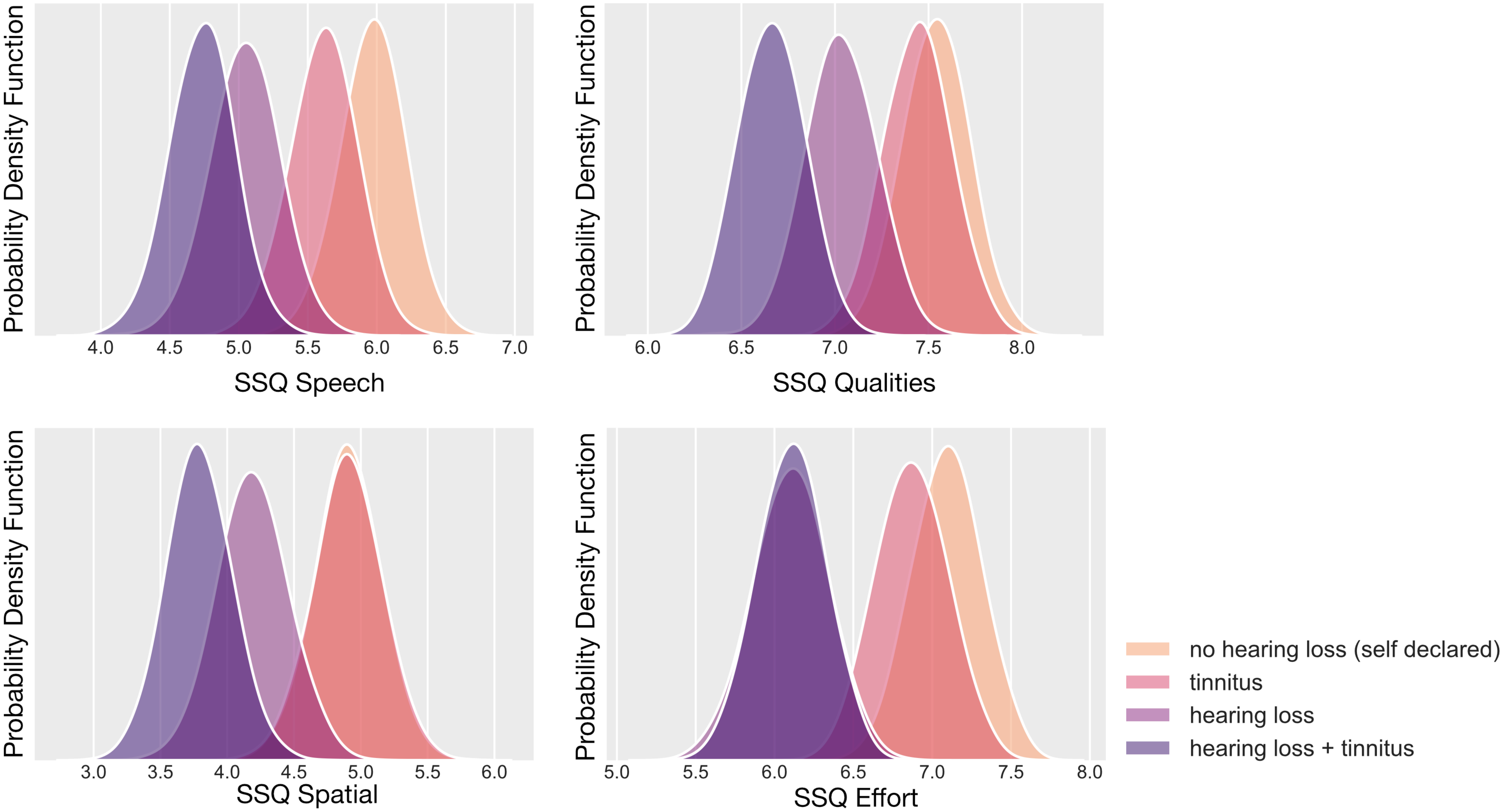
Hearing assessed online relates to standard pure-tone audiometry



Differences in subjective listening reports across different hearing profiles



Differences in subjective hearing reports are not explained by Age and acoustic thresholds



Pure Tone Audiometry

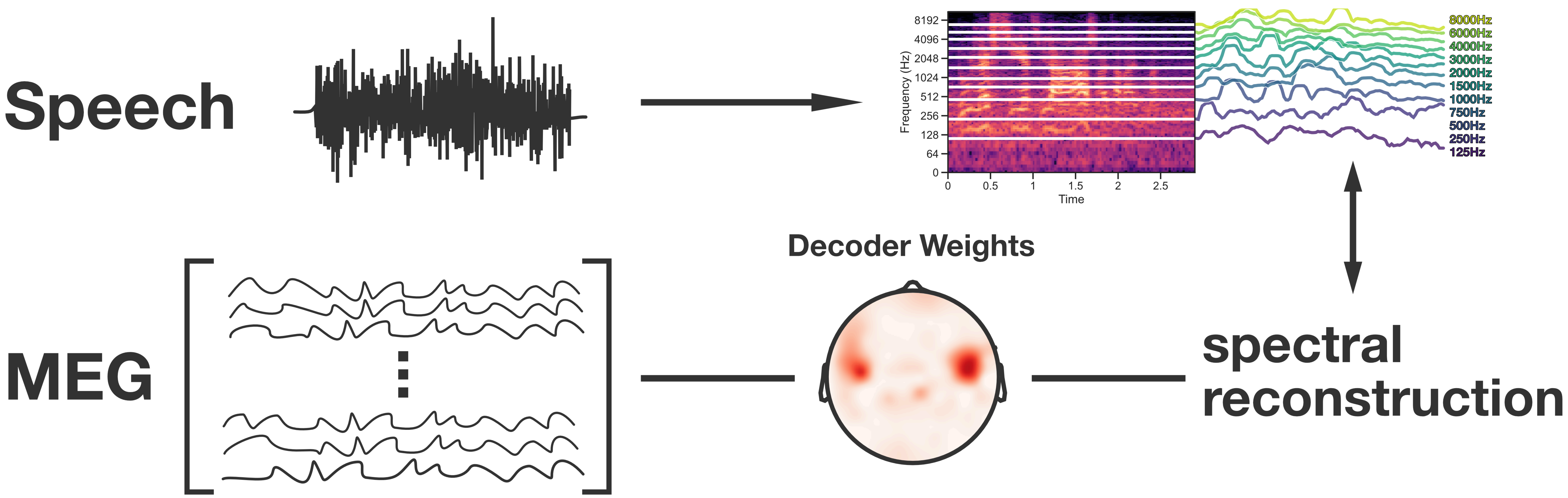
Problem:

- Artificial pure-tones do not reflect real-life listening situations (e.g. cocktail party)
- Supra-threshold hearing loss (i.e. hidden hearing loss) is not captured using PTA
- pure-tone audiometry is not affected until 80–90% of spiral ganglion cells have degenerated (Wu et al. 2019)

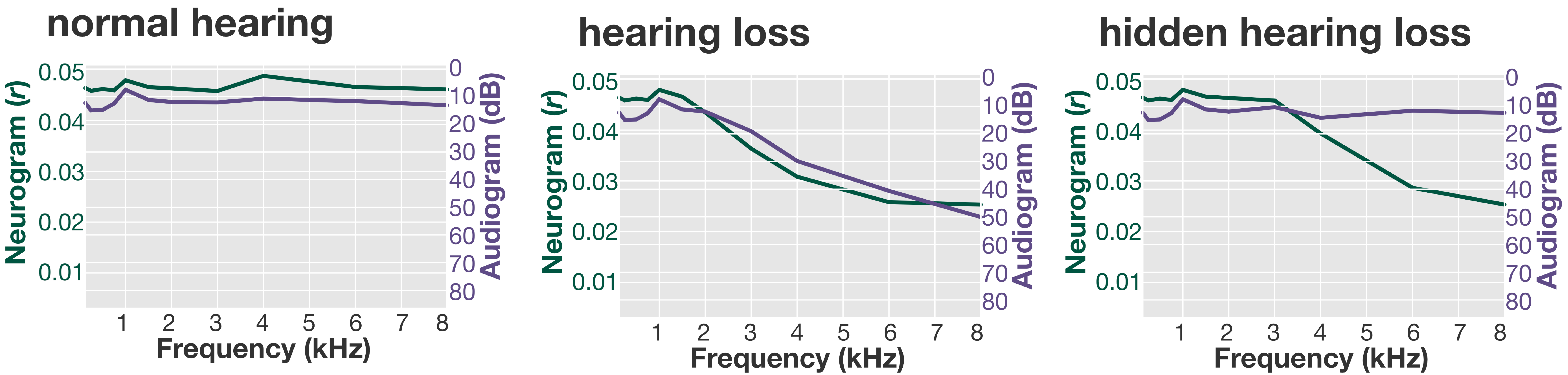
The Neurogram

A quantification of real-life hearing impairments using electrophysiology

Predicting acoustic signals from brain activity to estimate hearing loss



The Neurogram — expected outcomes



Study design & demographics

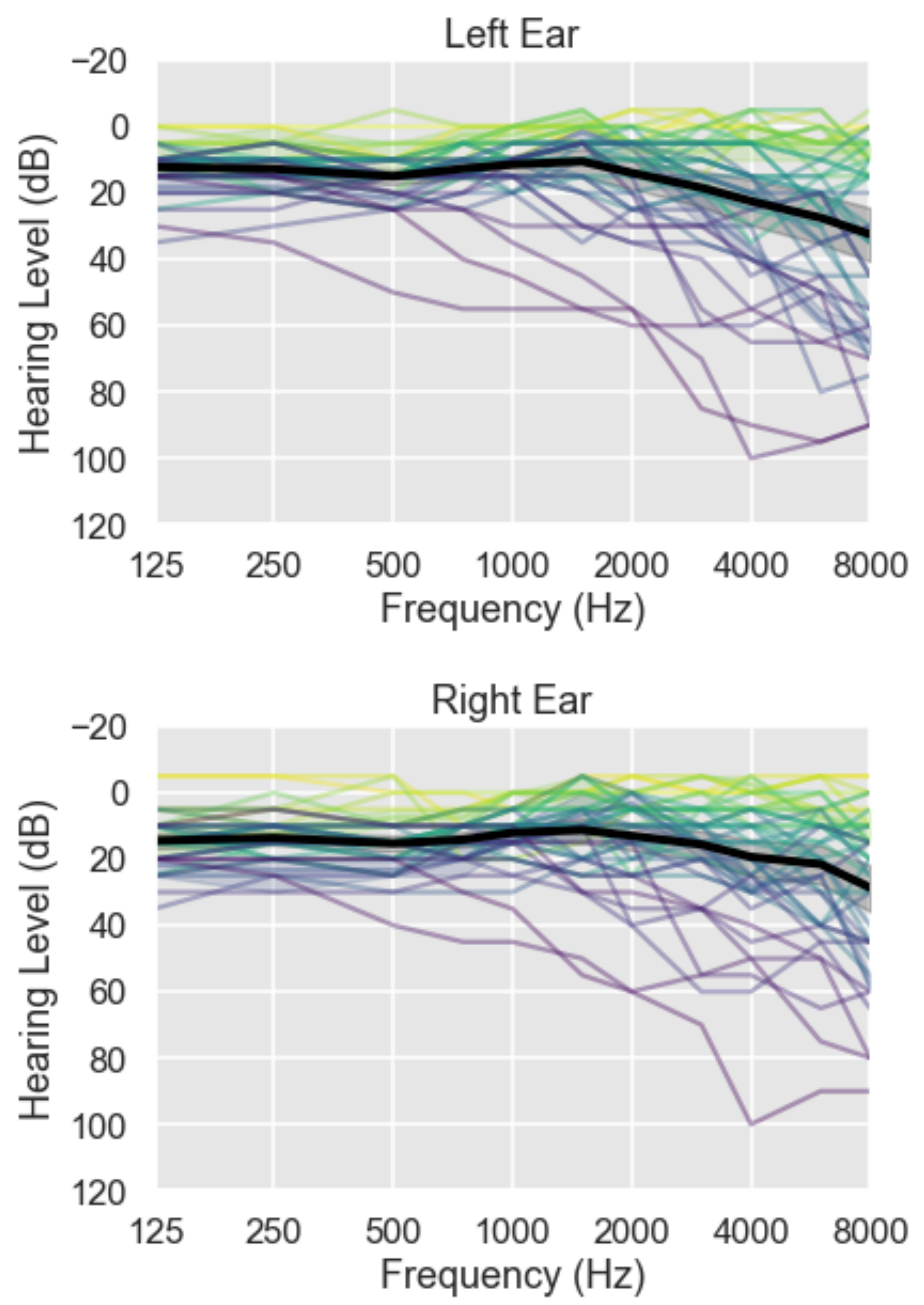
Subjects

- *N*=43
- Age (years): *M*=43.5; *SD*=18.1

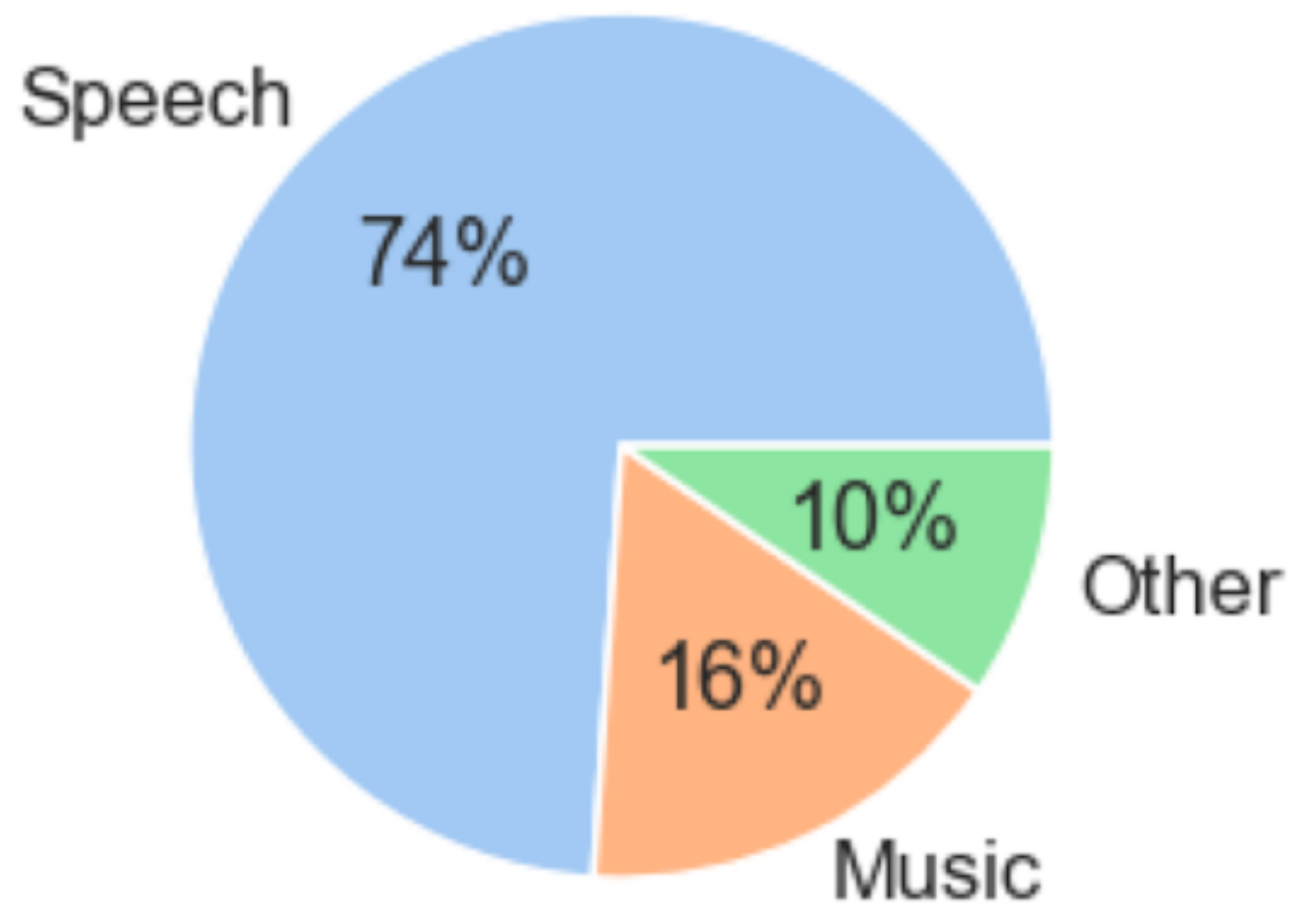
Design

1. Online Hearing Assessment
2. Pure-Tone Audiometry
3. Radio play

Pure-Tone Audiometry



Radio play (~20min)



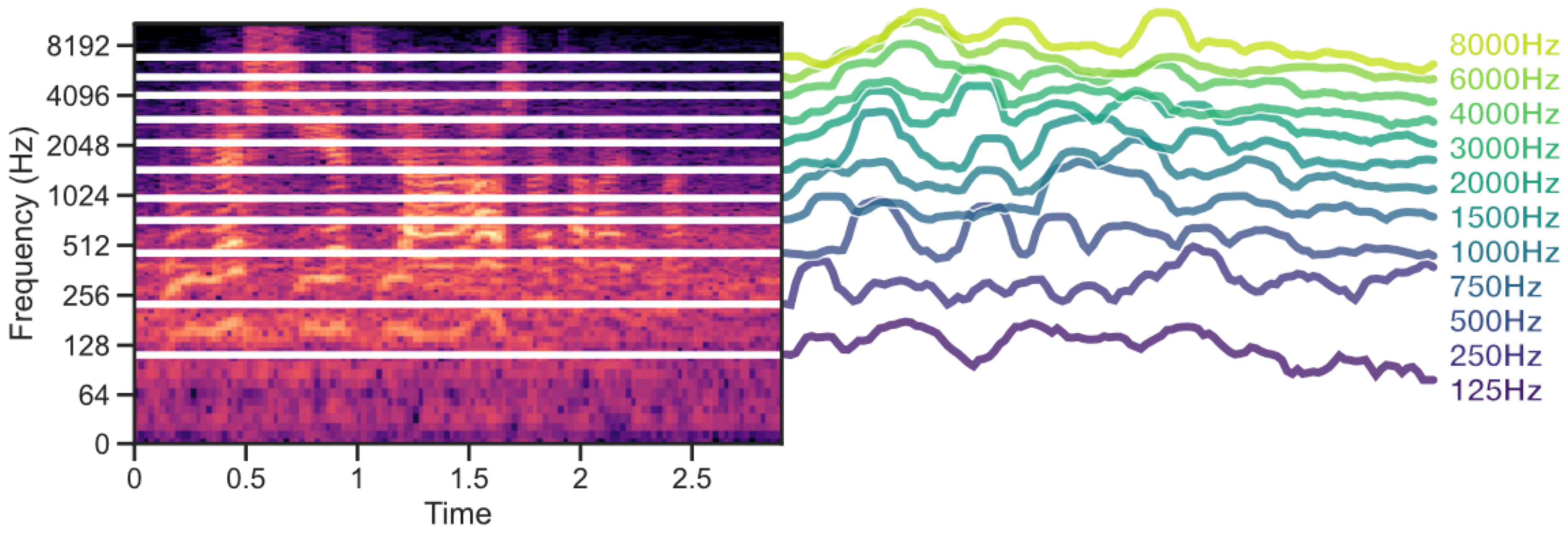
Brain activity measured using magnetoencephalography (MEG)

- Measures..
    - the magnetic field of electric currents in the brain
    - with millisecond time resolution

Neurogram analysis procedure

1) Acoustic Feature Extraction

spectrogram | **acoustic envelopes**

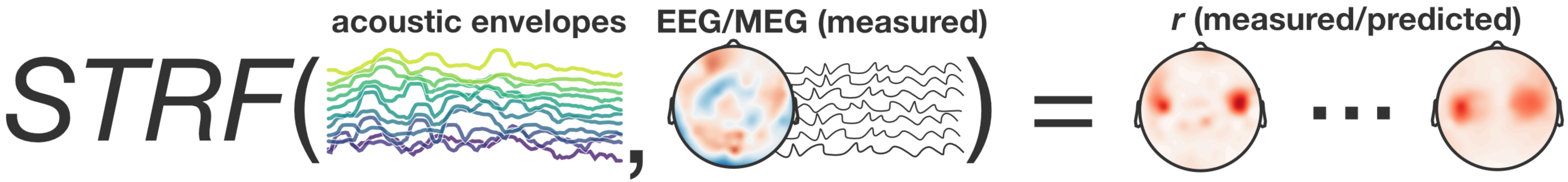


possible modifications

- other acoustic features (e.g. onsets)
- variable amount of frequency bands
- ...

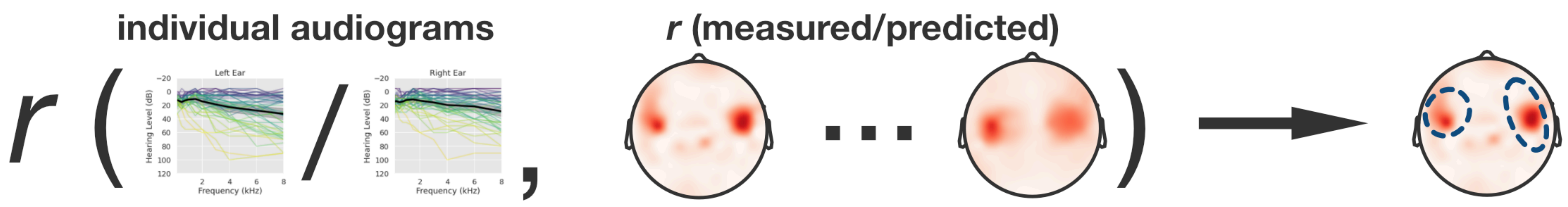
Neurogram analysis procedure

2) Encoding Model



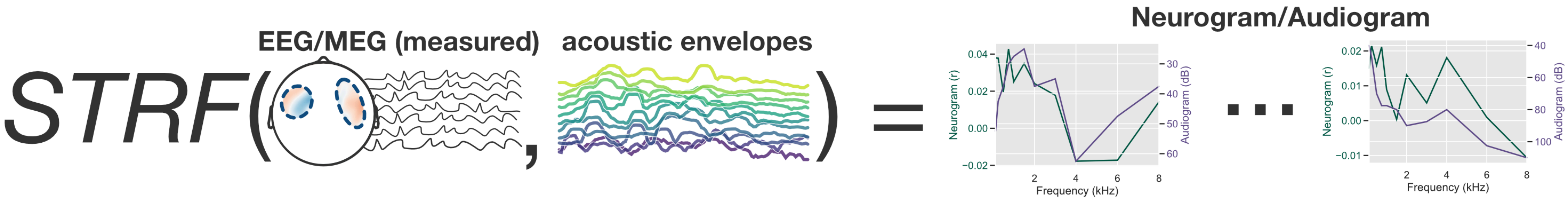
Neurogram analysis procedure

3) Audiogram | EEG/MEG Prediction

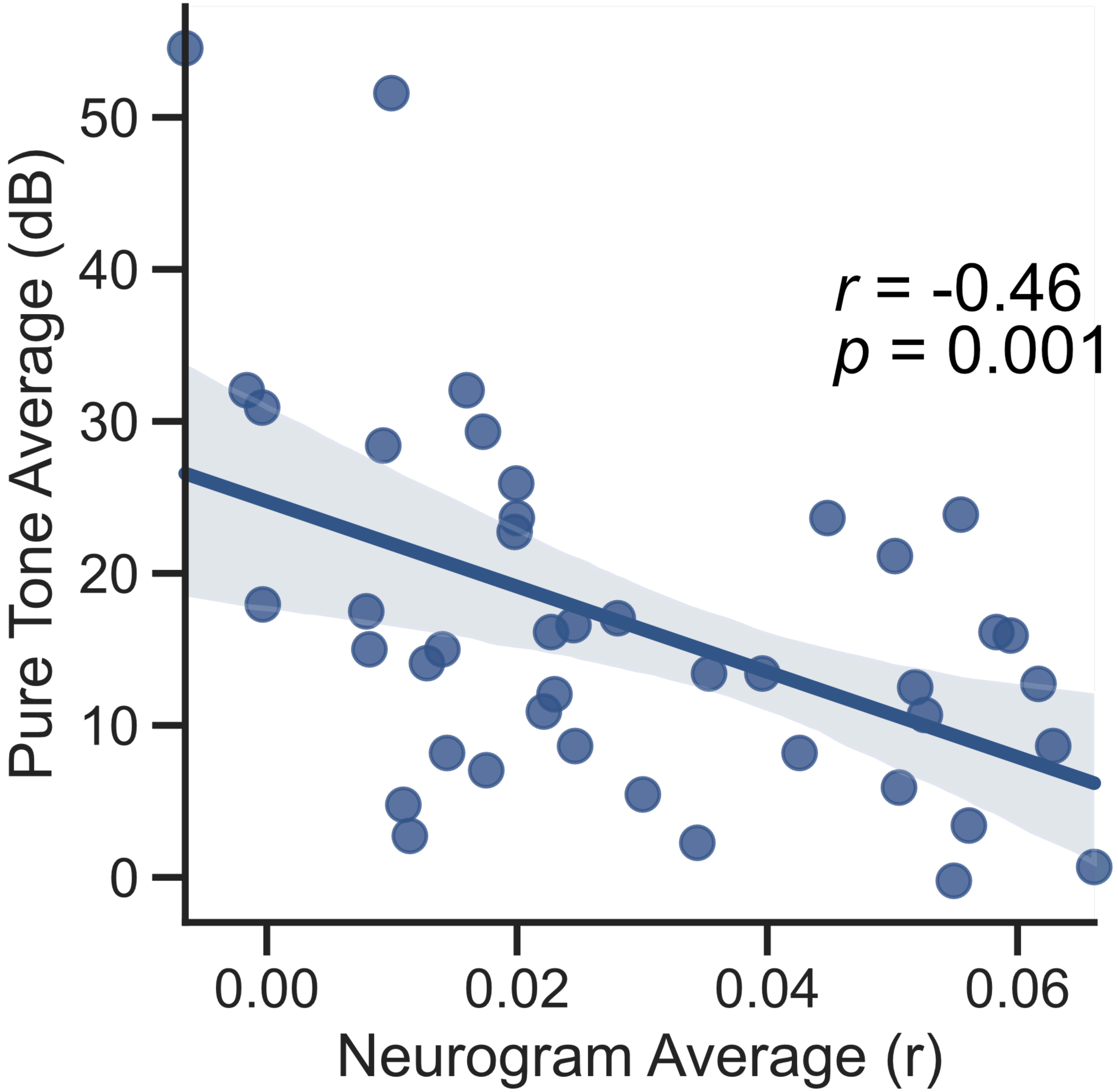


Neurogram analysis procedure

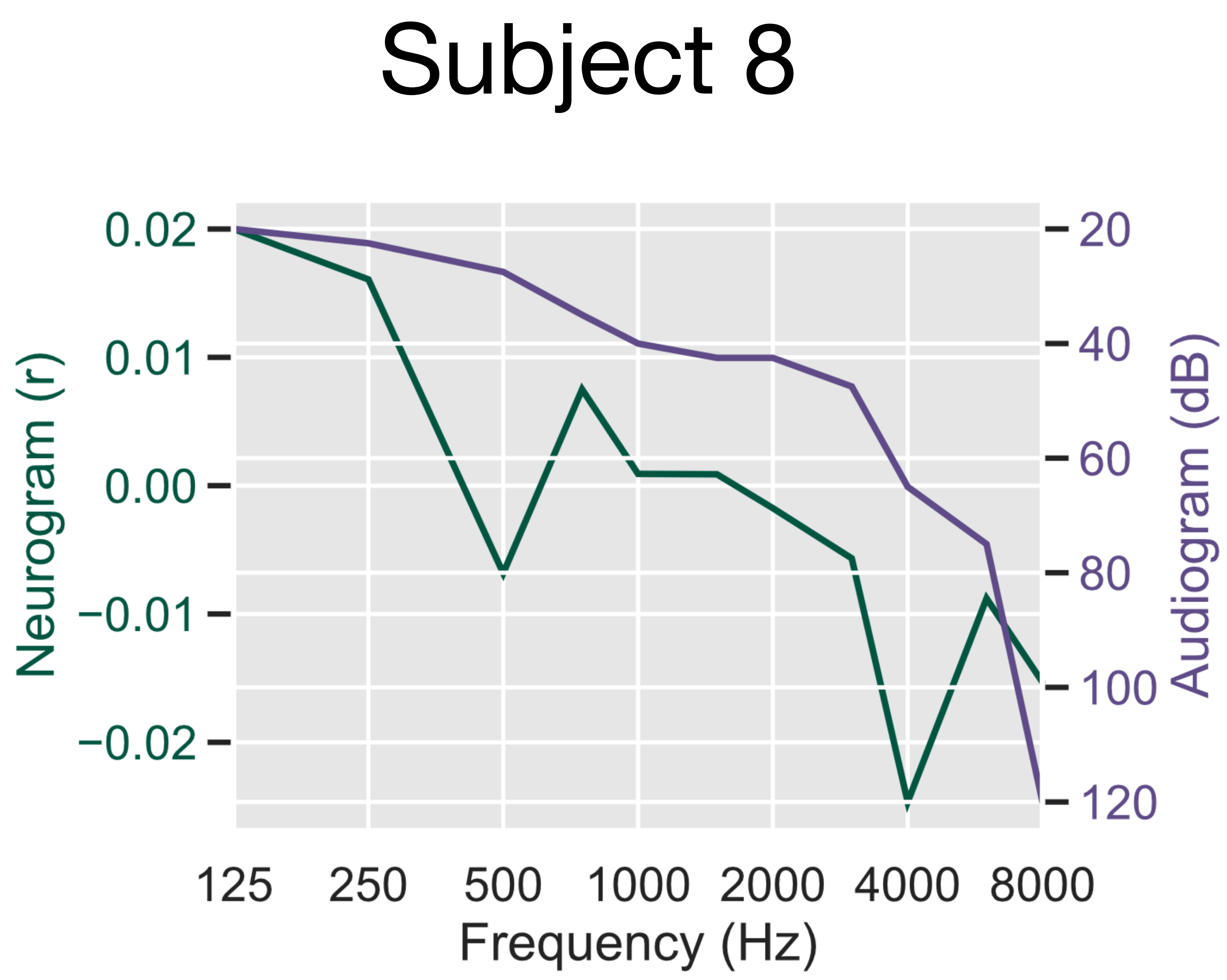
4) Decoding Model

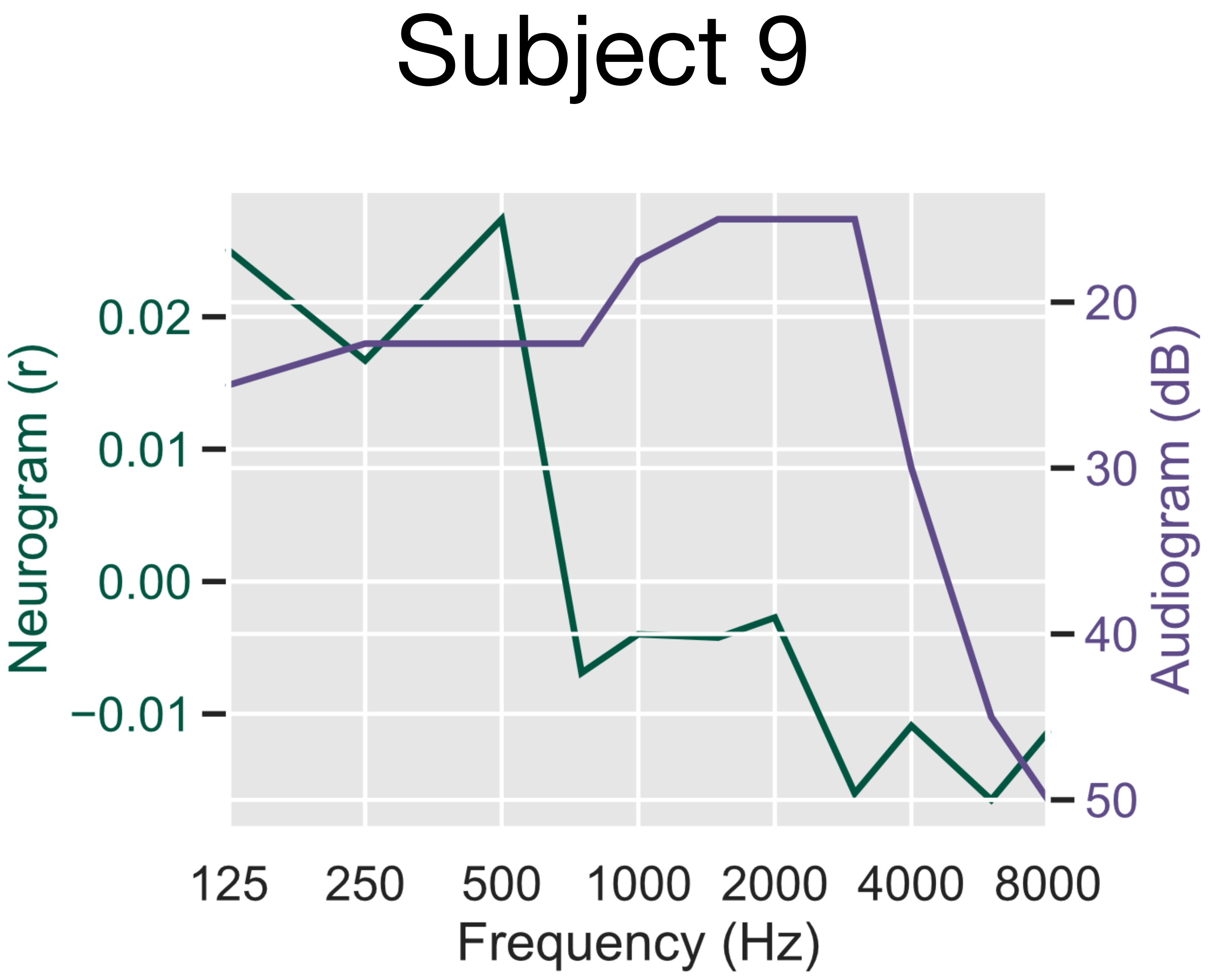


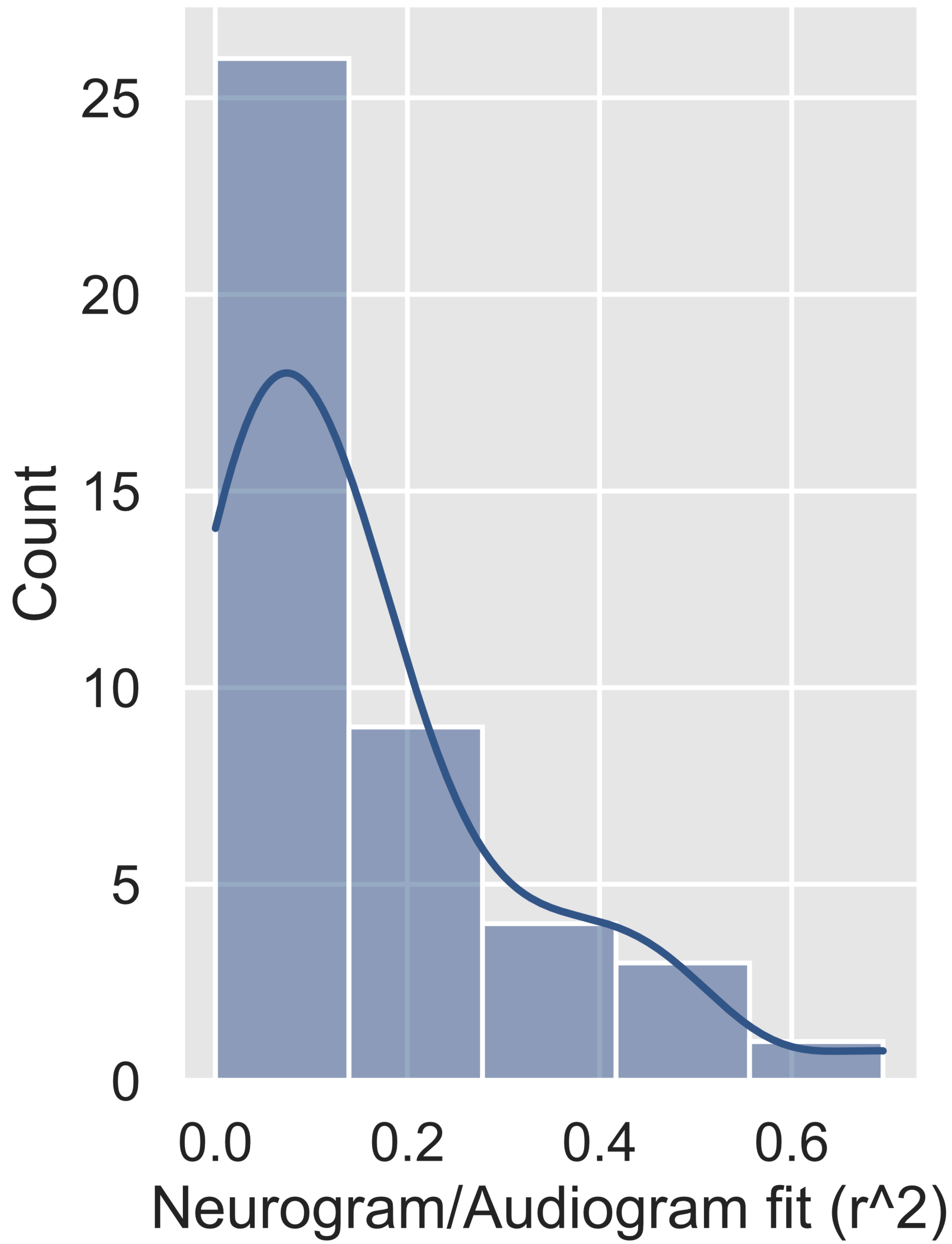
Neurogram averages are related to Audiogram averages



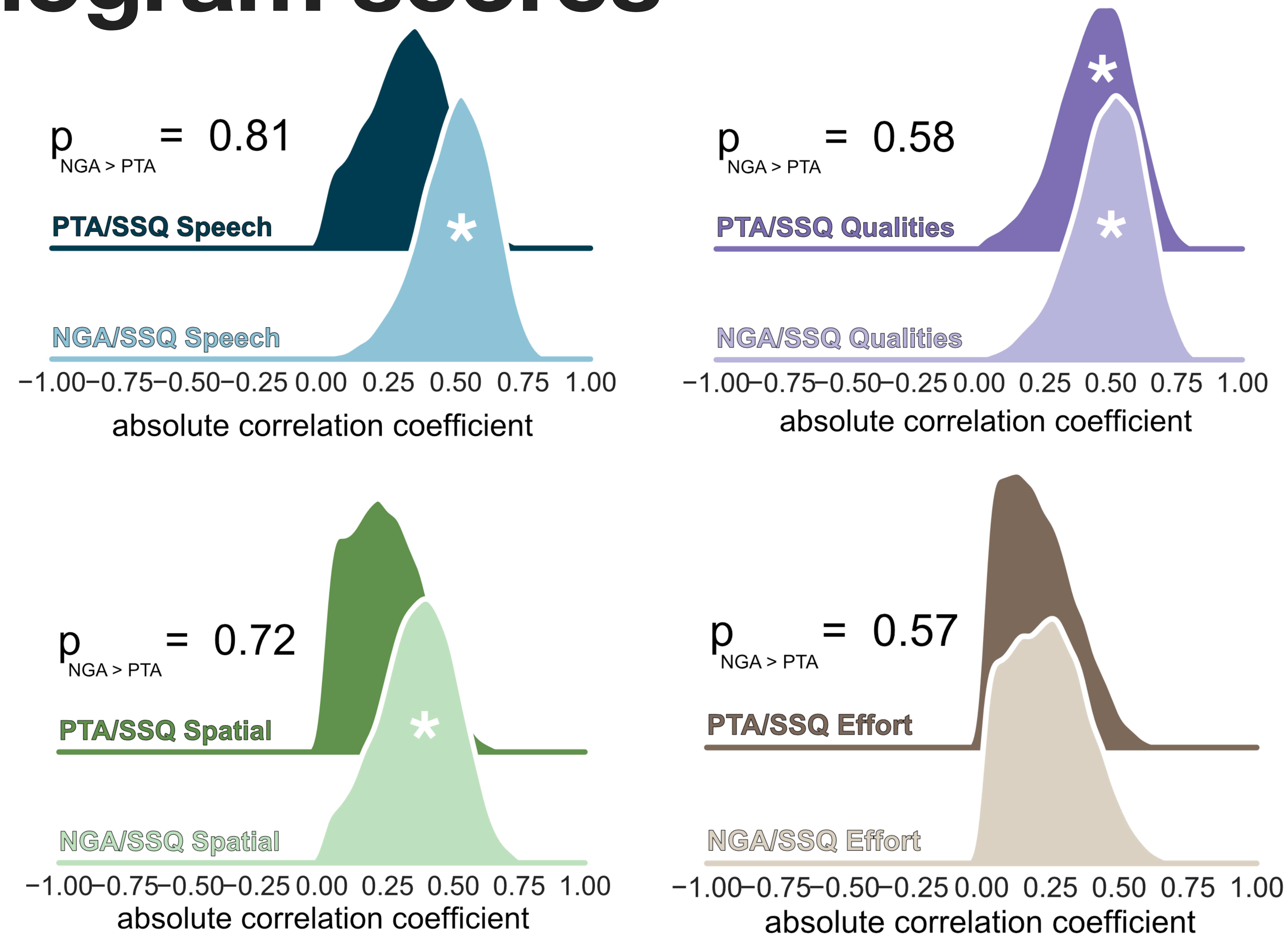
Discrepancies between Neurogram and Audiogram



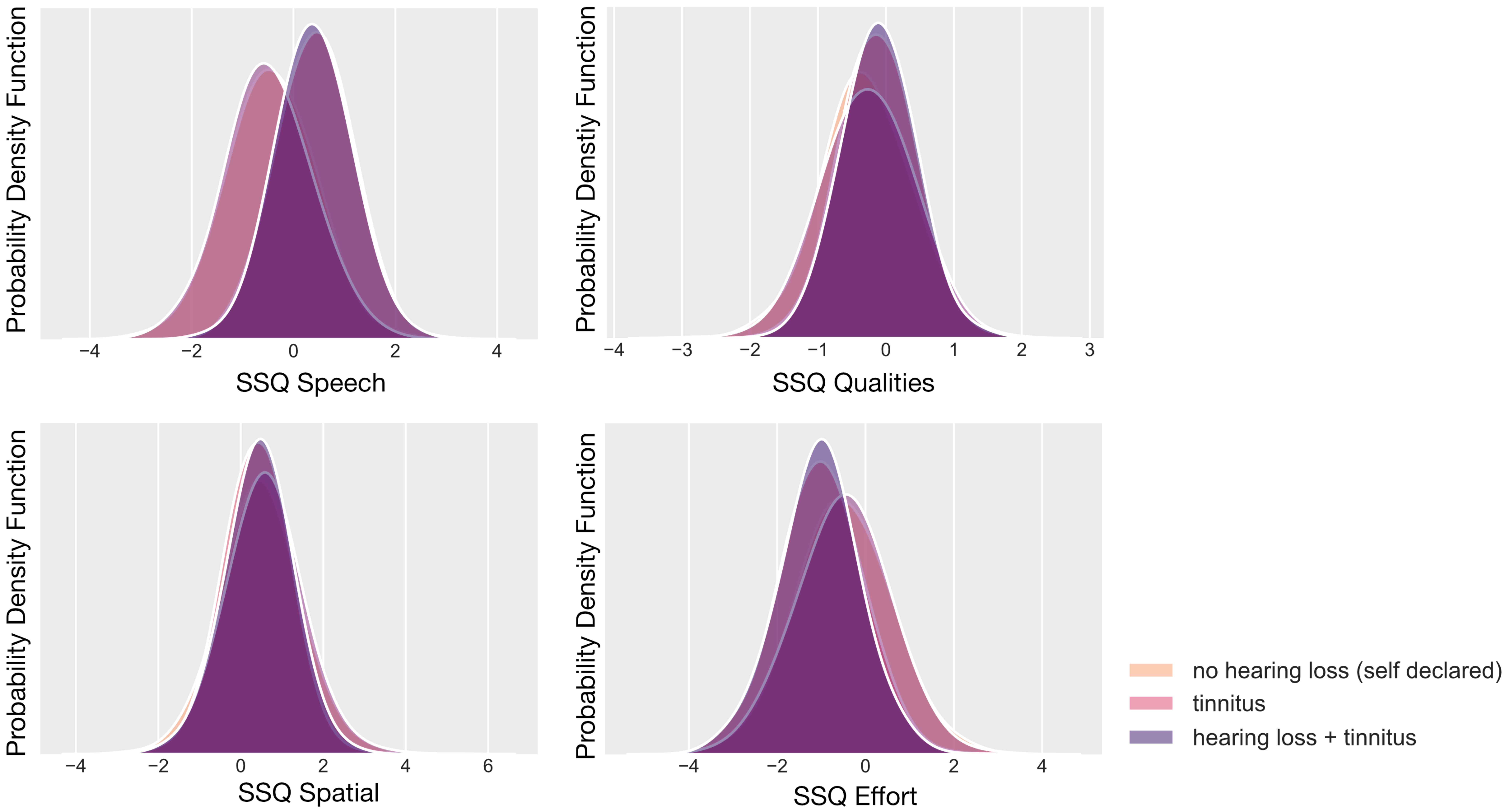




Neurogram scores are more strongly related to subjective reports of hearing impairment than audiogram scores



Closing the gap between reported and "measurable" hearing problems



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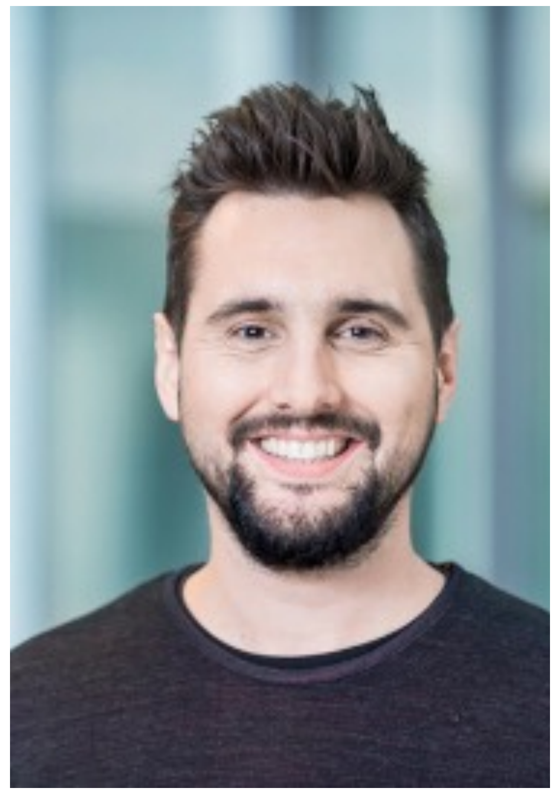

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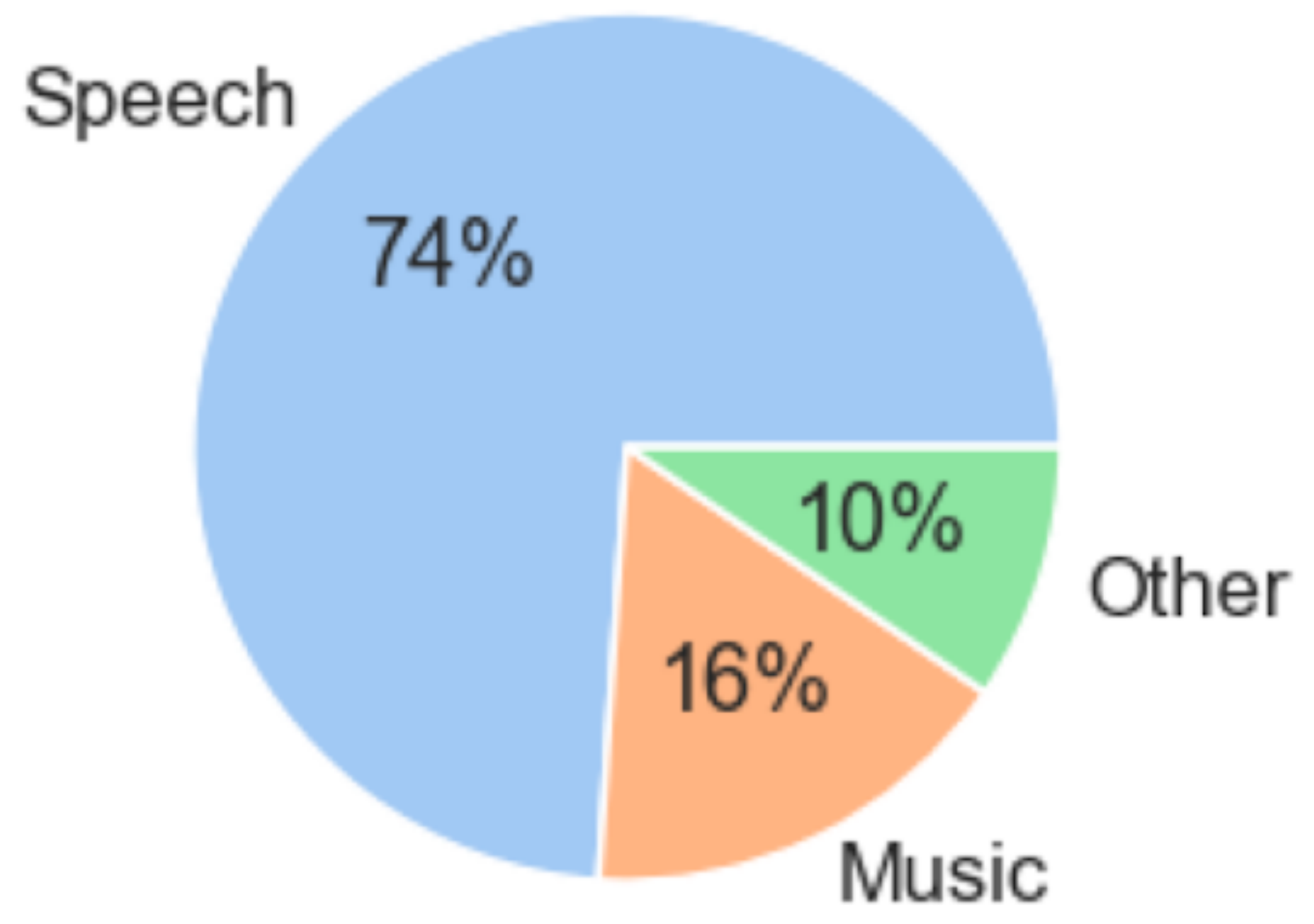
Auditory Neuroscience Group
Salzburg Brain Dynamics Lab

CCNS
Centre for Cognitive Neuroscience

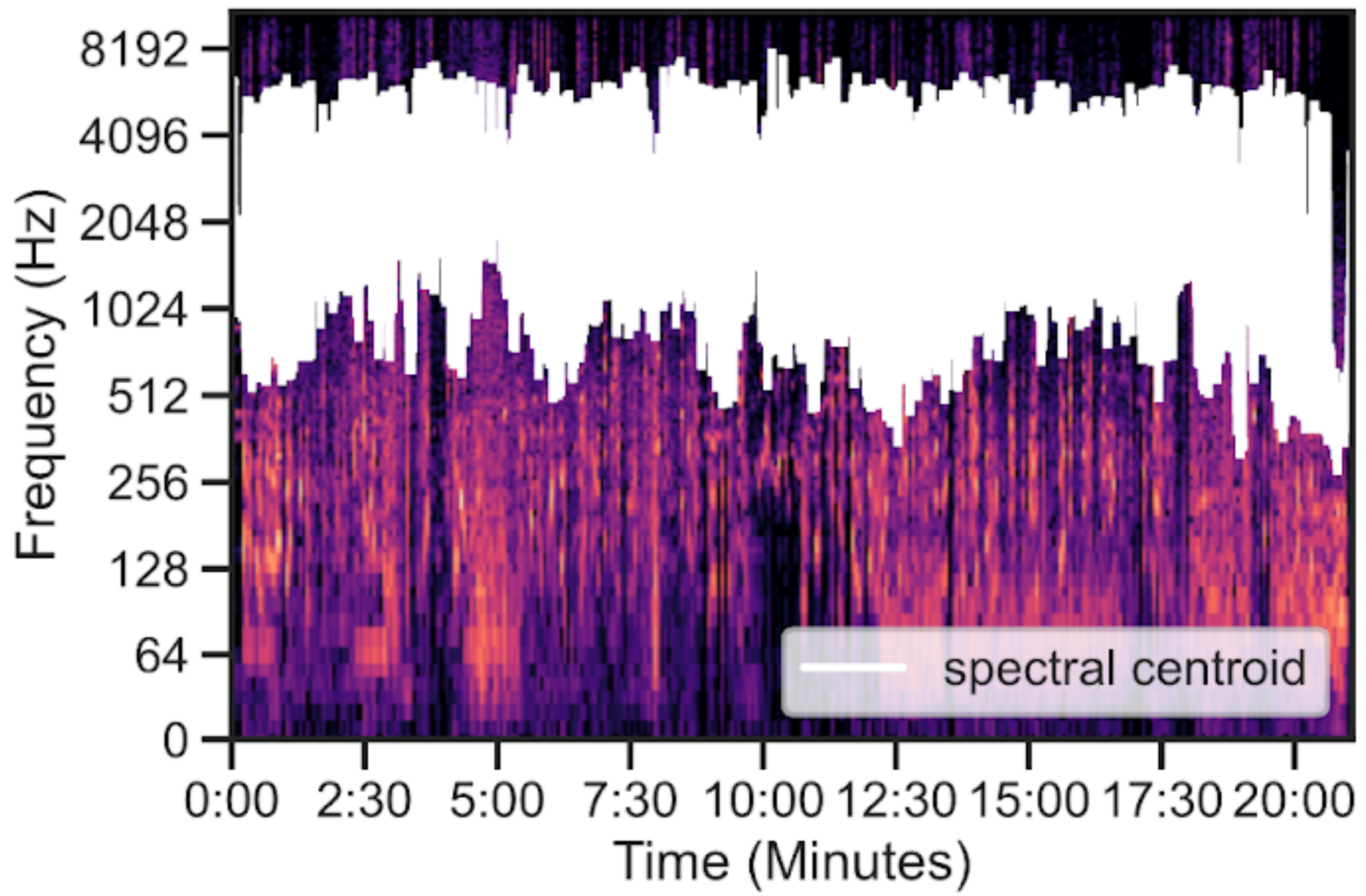
Supplementary Information

Radio Play audio information

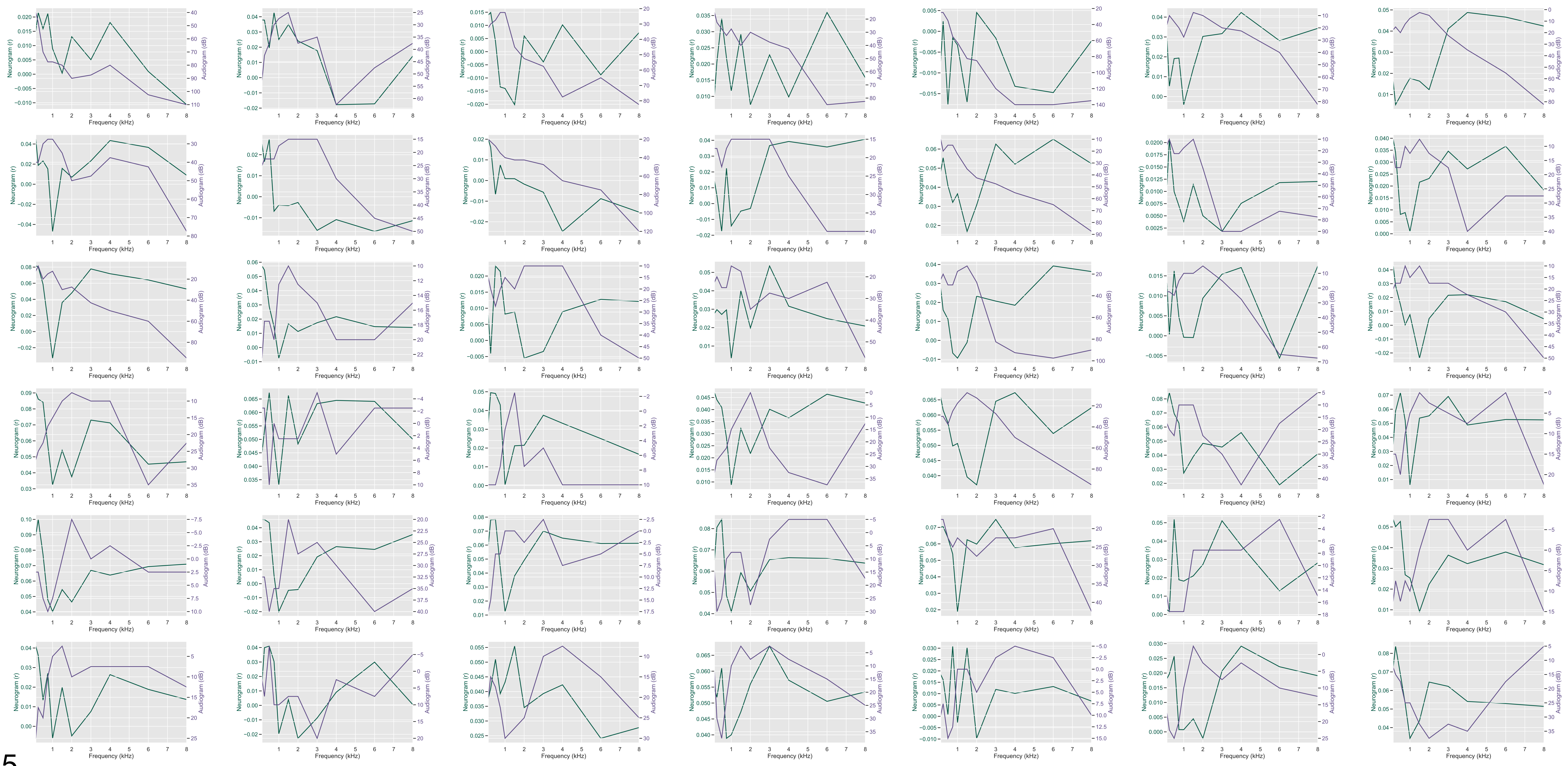
A)



B)



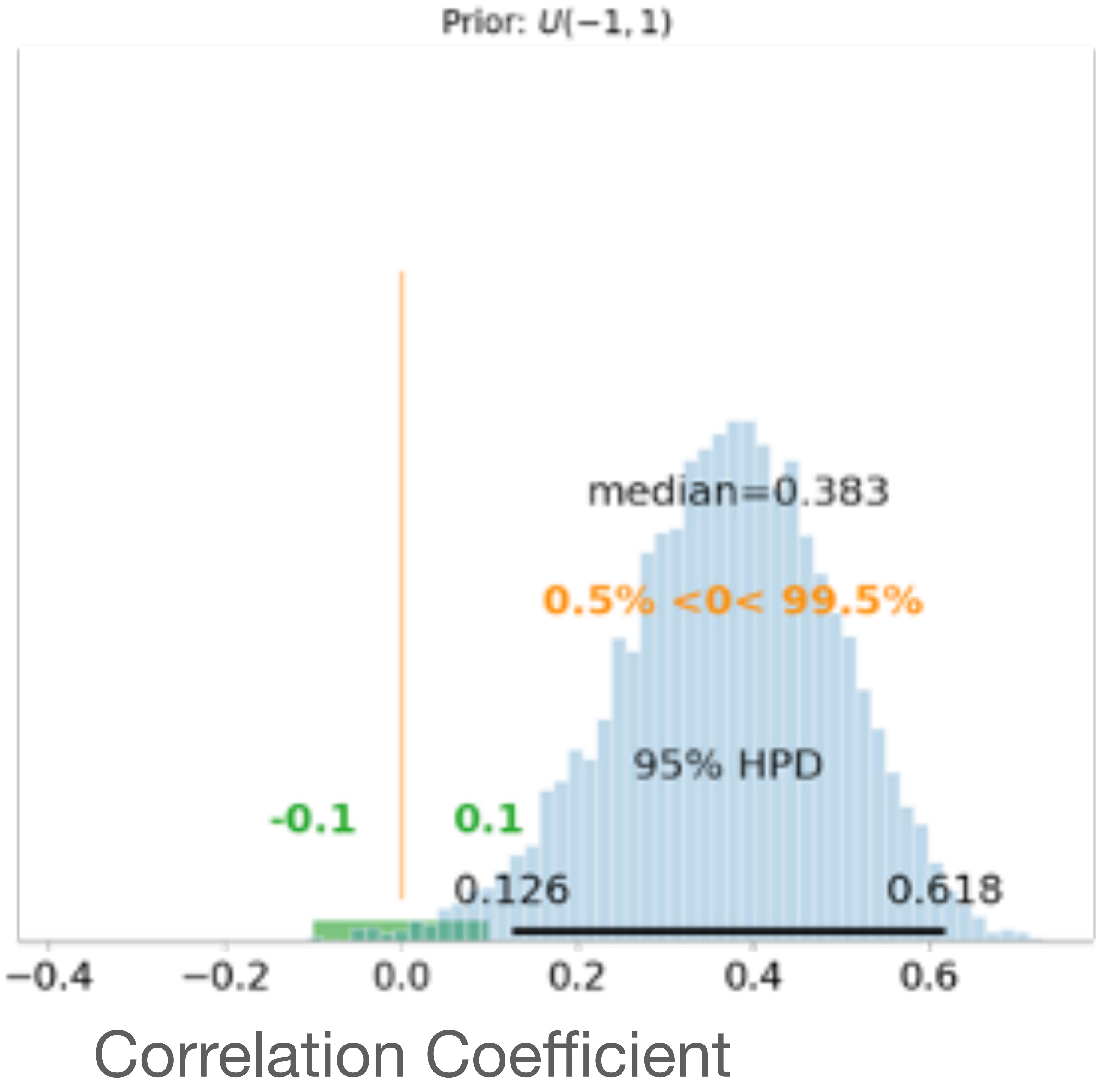
All Audiograms/Neurograms



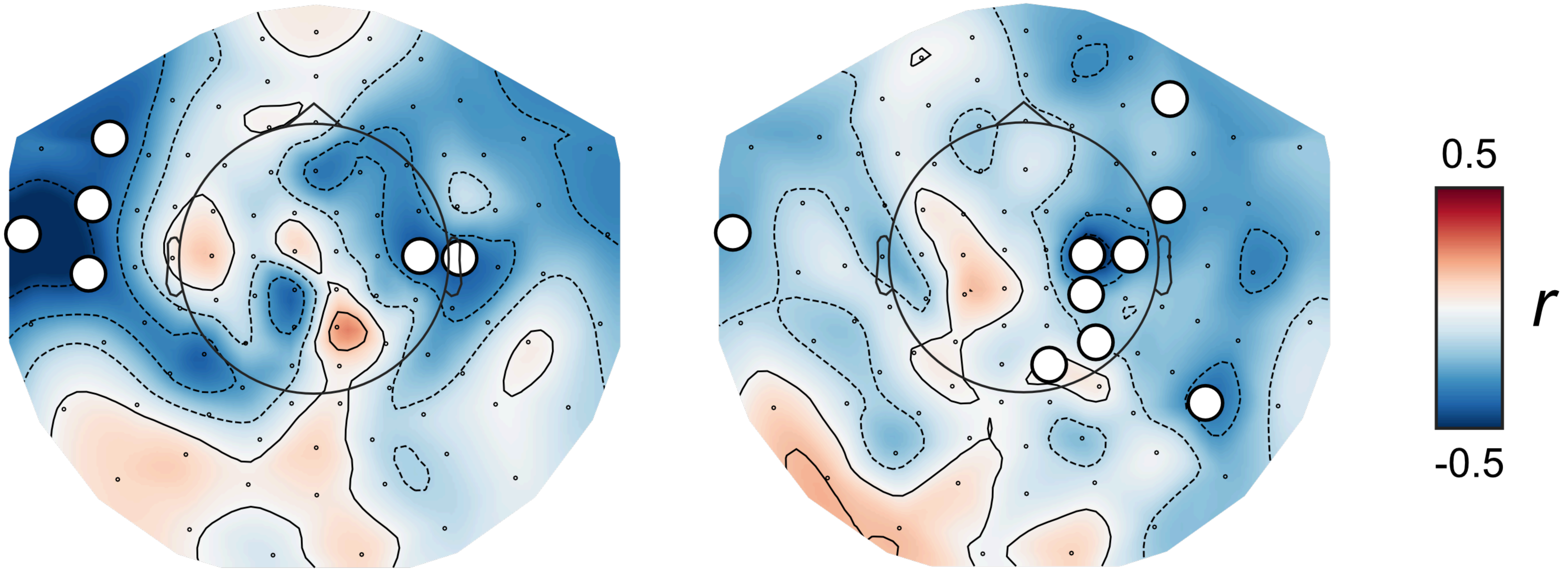
Primer: Bayesian parameter estimation

- Estimating an unknown parameter θ
- θ = Any parameter that we care, but are uncertain about at (e.g. Correlation coefficient, mean, regression coefficient…)

$$P(\theta|D) = \frac{P(D|\theta)P(\theta)}{p(D)}$$



Spectrogram reconstruction accuracy at selected channels can be related to individual hearing levels



Magnetometers

Gradiometers

What predicts a strong relationship between Neurogram and Audiogram

- High variance in goodness of fit (*R2)* between Neurogram and Audiogram across subjects

- Using several predictors (SSQ Scores, Age etc.) to explain the goodness of fit

- Goodness of Neurogram/Audiogram fit is explained best by subjective reports of spatial hearing abilities