PARIS LODRON UNIVERSITÄT SALZBURG

Auditory Neuroscience Group

Salzburg Brain Dynamics Lab

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How do human beings process degraded speech?

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How do human beings process degraded speech?

- Study 1 (under review)
    - How does degraded speech modulate neural speech tracking?
- Study 2 (ongoing Taiwan-Austria project)
    - How does *unfamiliar* degraded speech modulate neural speech tracking?

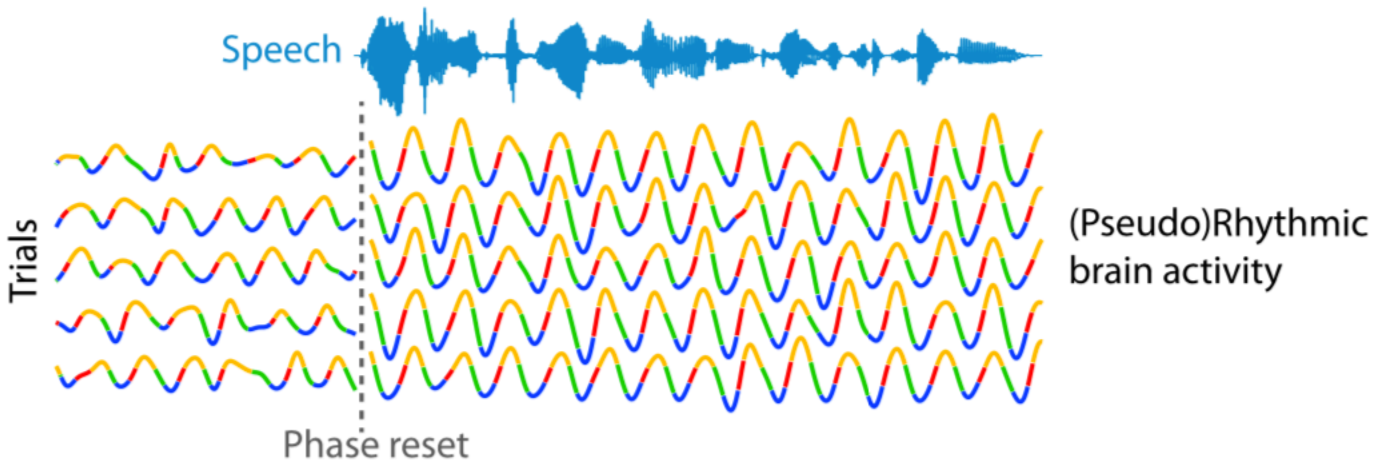
Study 1

How does degraded speech modulate neural speech tracking?

Ya-Ping Chen, Fabian Schmidt, Anne Keitel, Sebastian Rösch, Anne Hauswald, & Nathan Weisz

Neural Speech Tracking

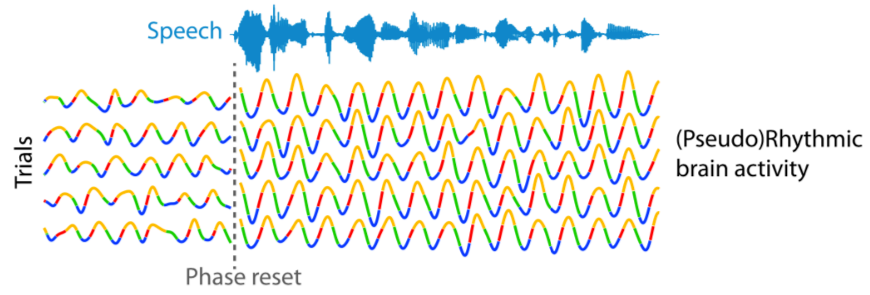
- a.k.a. Neural Speech Entrainment
- temporal fluctuations of speech and neural signals align together



Obleser and Kayser, 2019, Trends Neurosci

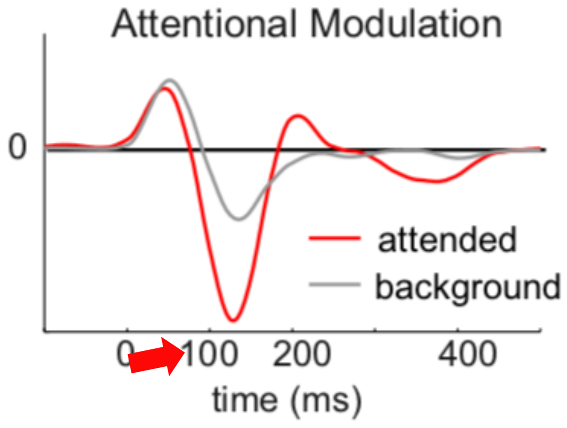
Methods for quantifying neural speech tracking

- **inter-trial phase coherence**
  - e.g. Ding et al., 2014; Rimmele et al., 2015
- **speech-brain phase coherence**
  - e.g. Peelle et al., 2013; Hauswald et al., 2020
- **temporal response function (encoding model)**
  - e.g. Ding et al., 2012; Kraus et al., 2021
- **speech reconstruction (decoding model)**
  - e.g. Puvvada et al., 2017; Decruy et al., 2020

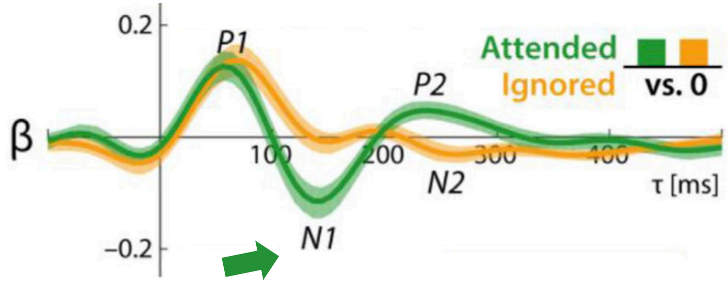


Obleser and Kayser, 2019, Trends Neurosci

Higher neural speech tracking on attended speech

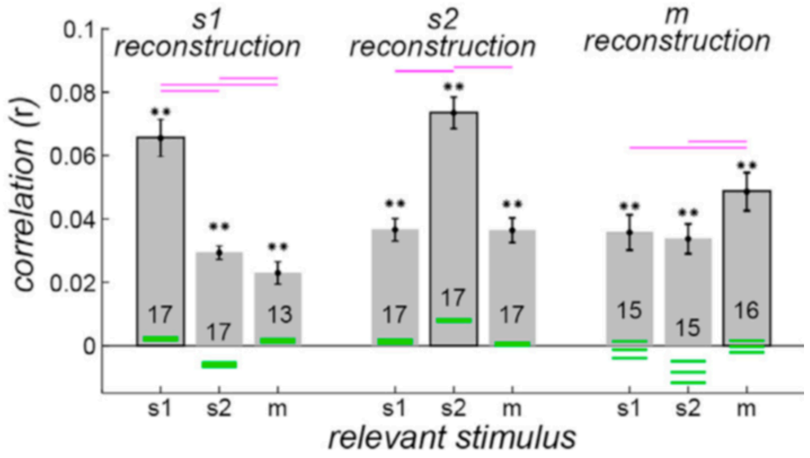


Ding & Simon, 2012



Fiedler et al., 2019

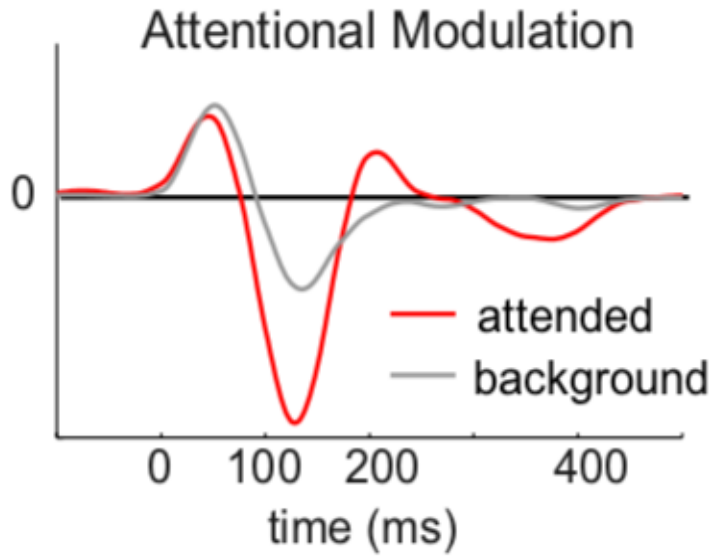
attend s1
attend s2
attend music



Hausfeld et al., 2018

Research Question

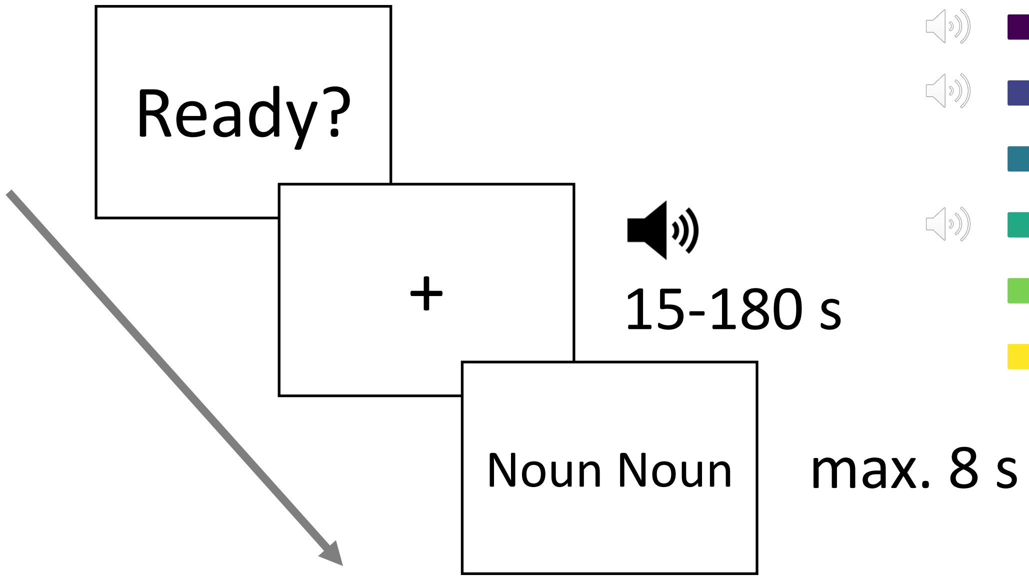
- How does variously degraded speech modulate neural speech tracking?

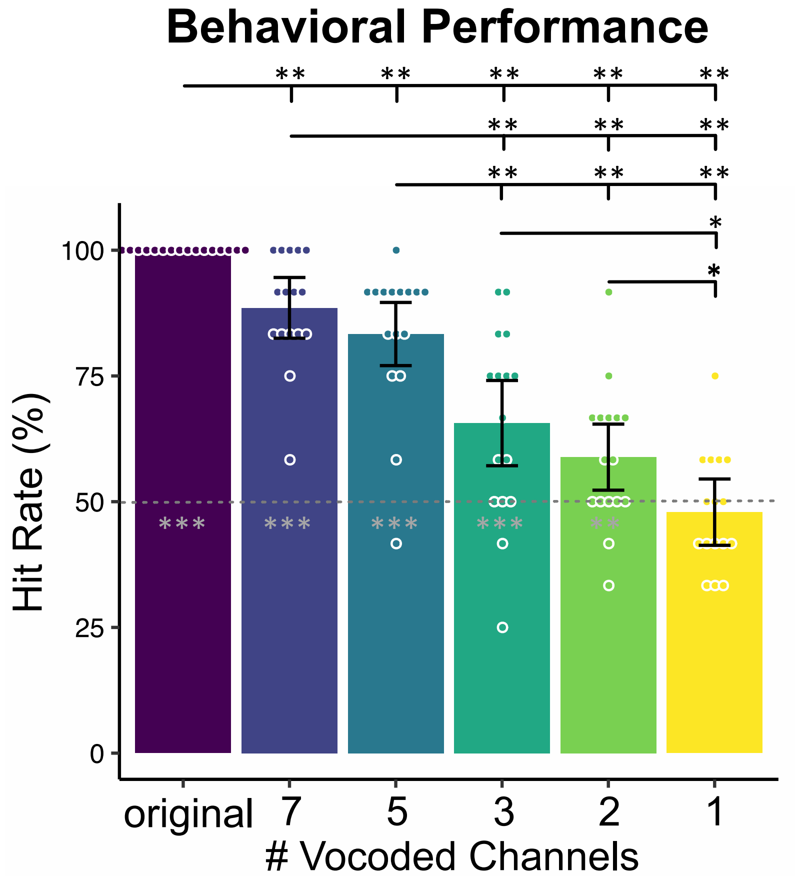


Ding & Simon, 2012

Study Paradigm

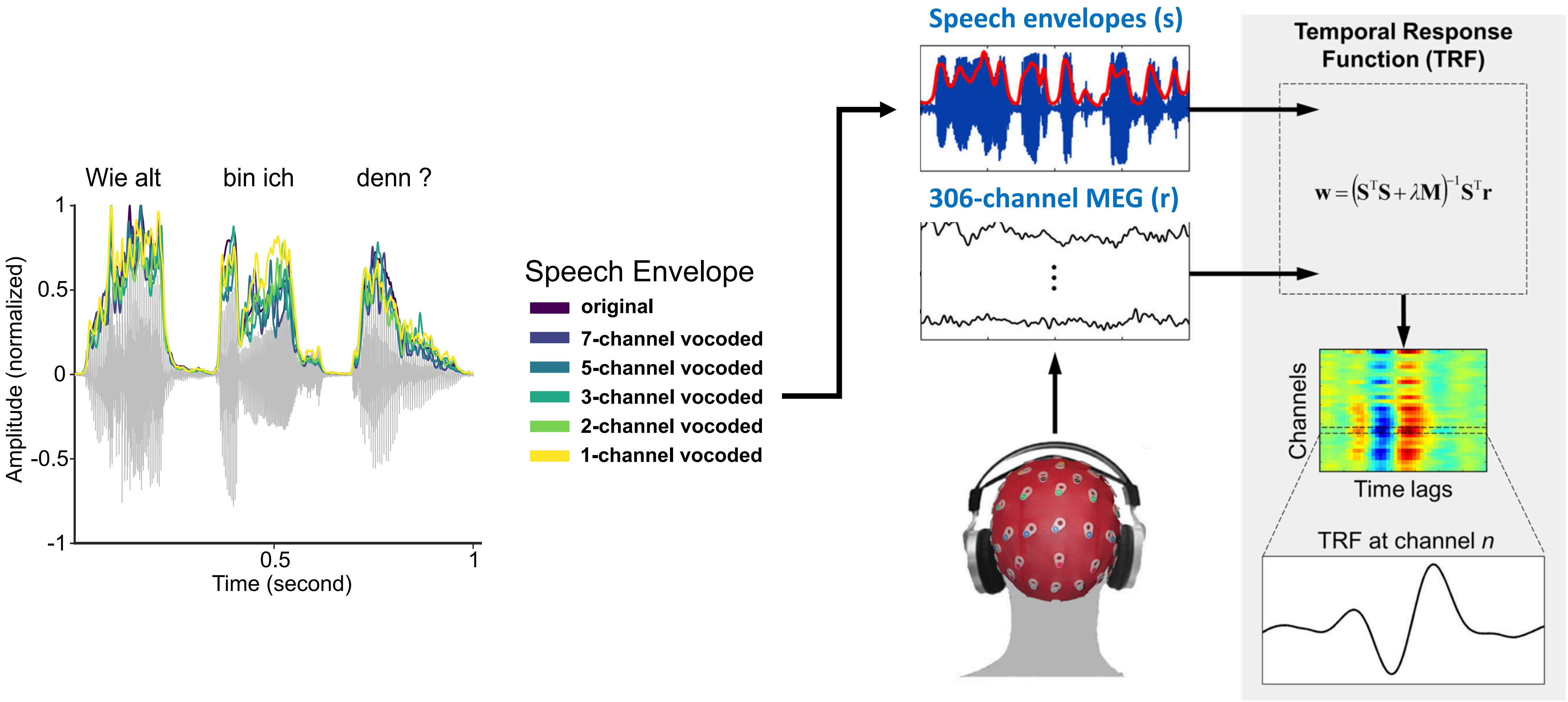
MEG recording





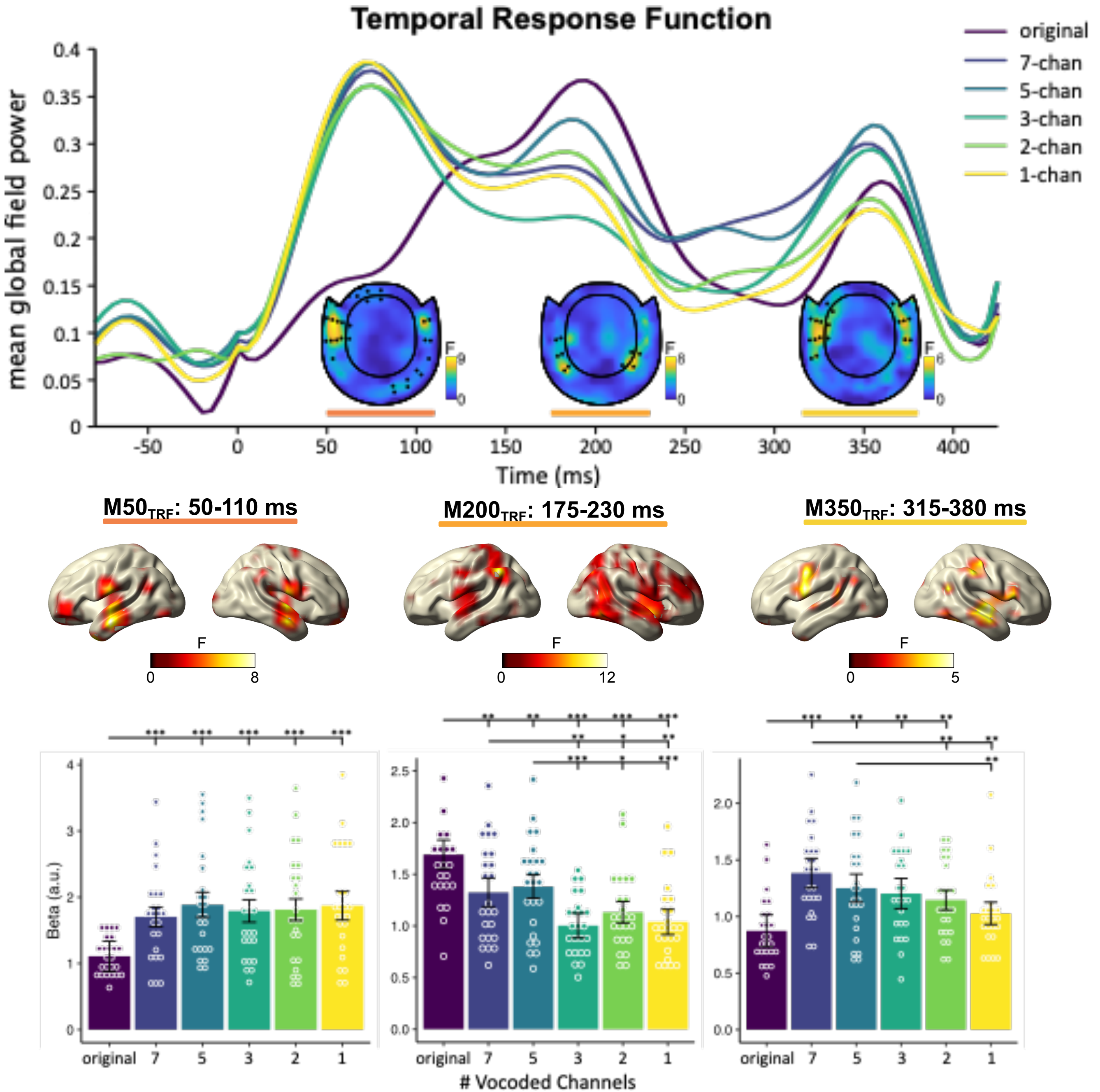
Chen et al., 2022, bioRxiv

Computing TRFs to depict dynamic neural speech tracking



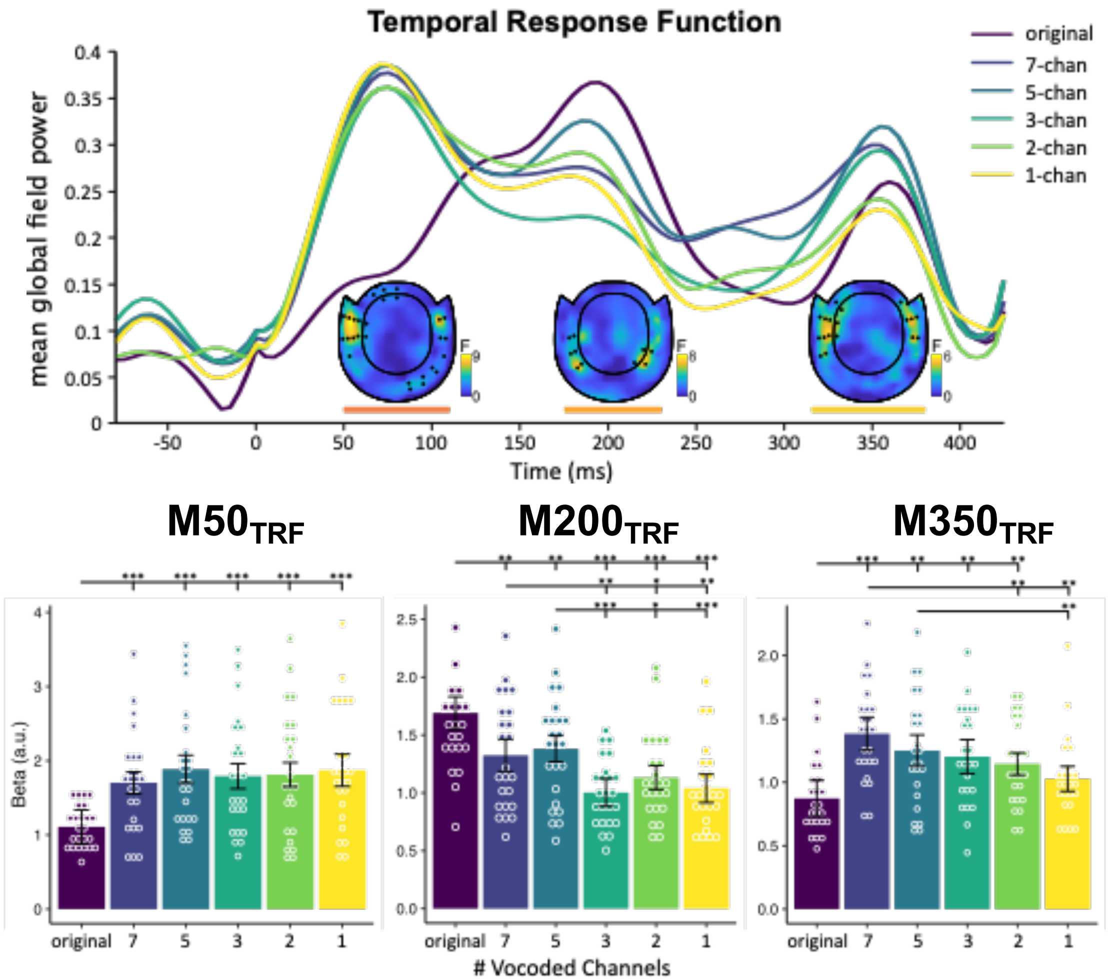
adapted from Crosse et al., 2016, Front Hum Neurosci

3 distinct TRF components

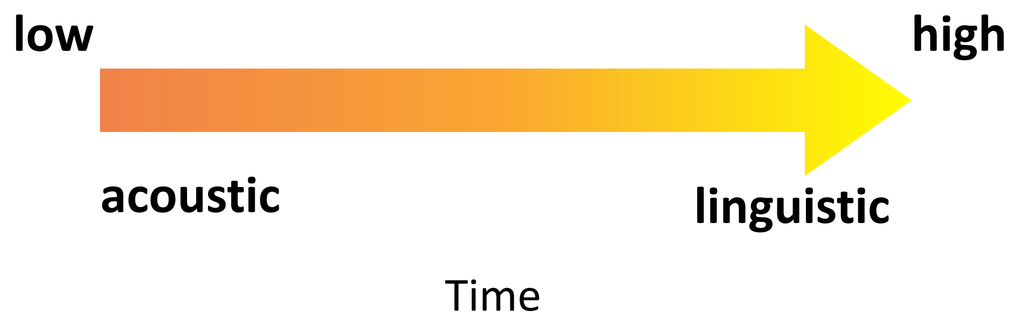


Chen et al., 2022, bioRxiv

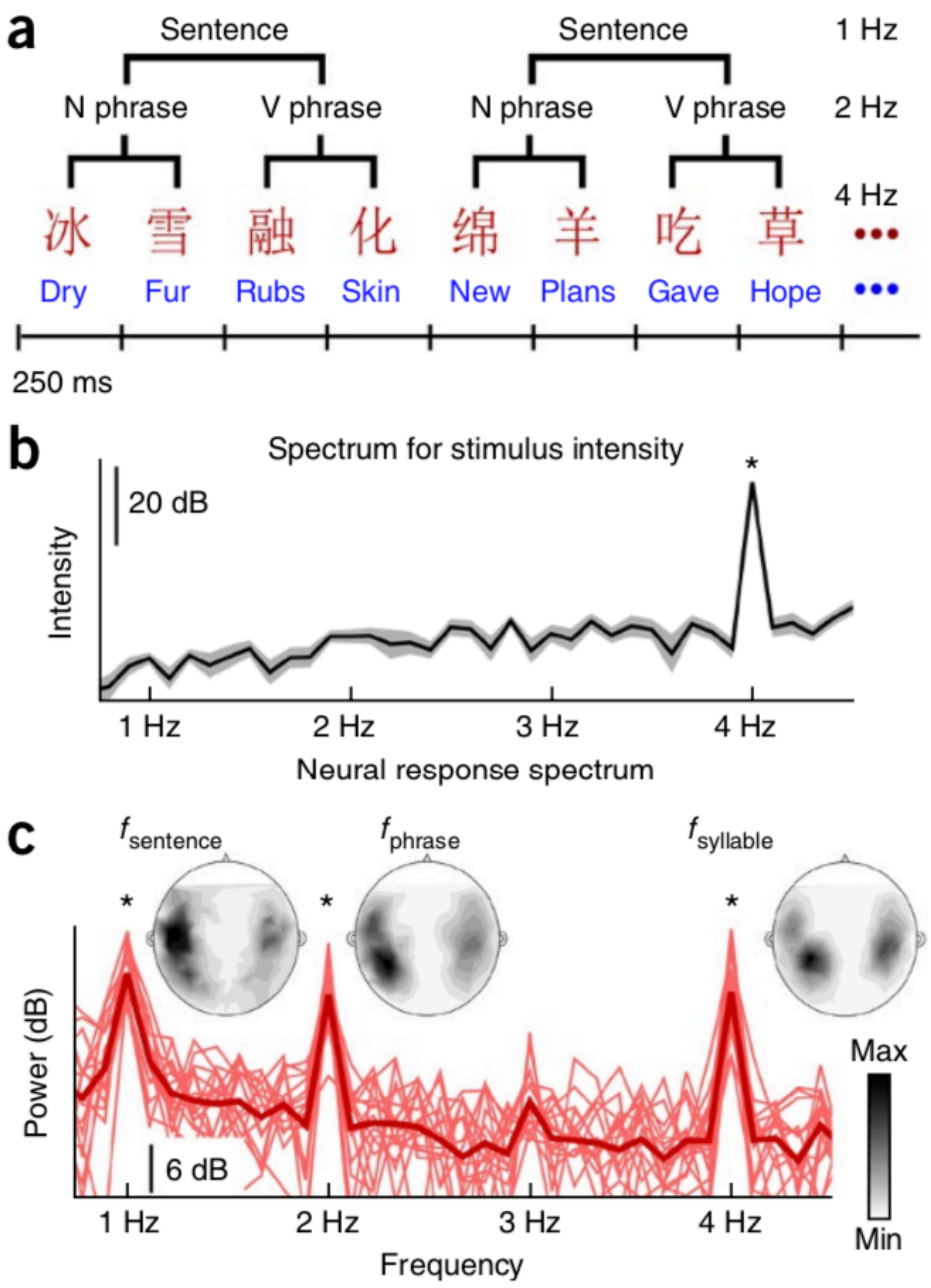
Neural speech tracking shifted among hierarchical speech features over time(?)



Hierarchical Speech Features

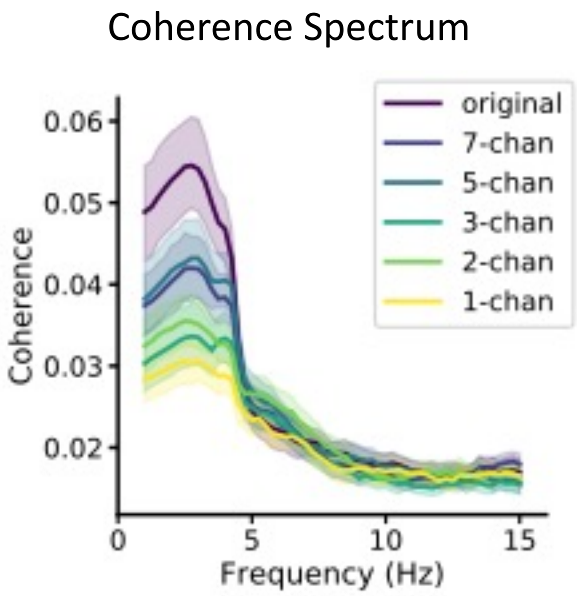


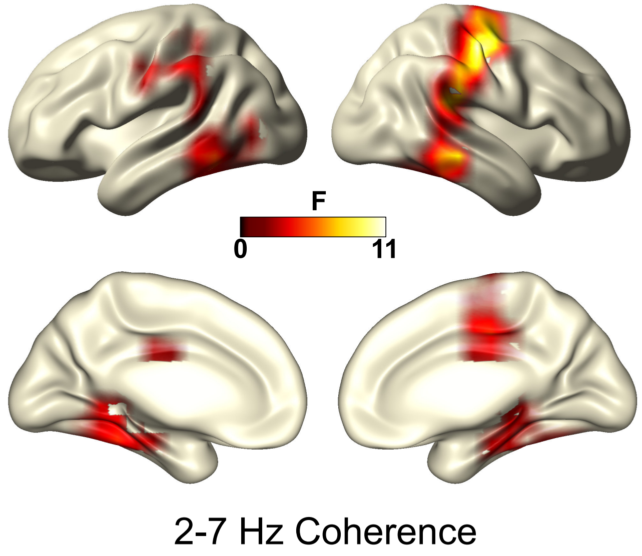
Peak frequency decreases when tracking on a higher linguistic level

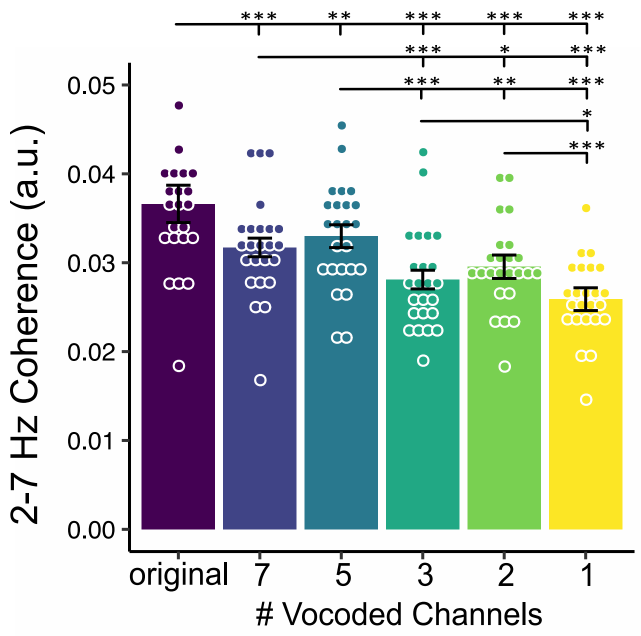


Ding et al., 2016, Nat Neurosci

Speech-brain phase coherence decreased with speech intelligibility

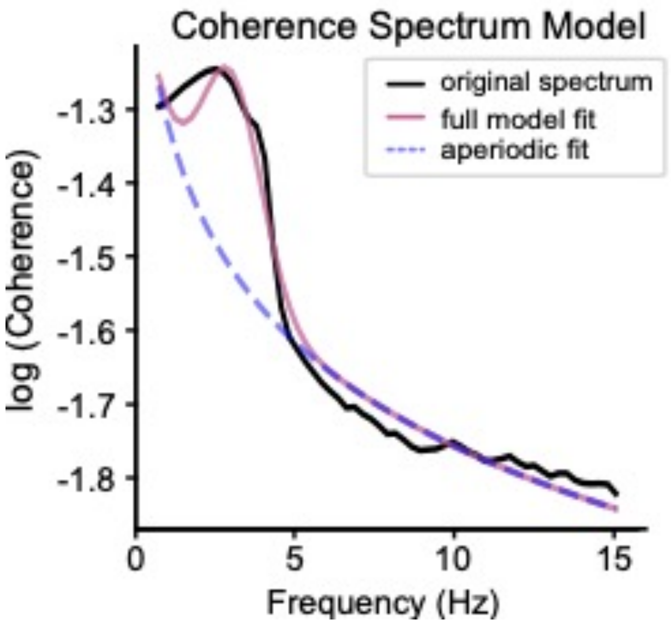


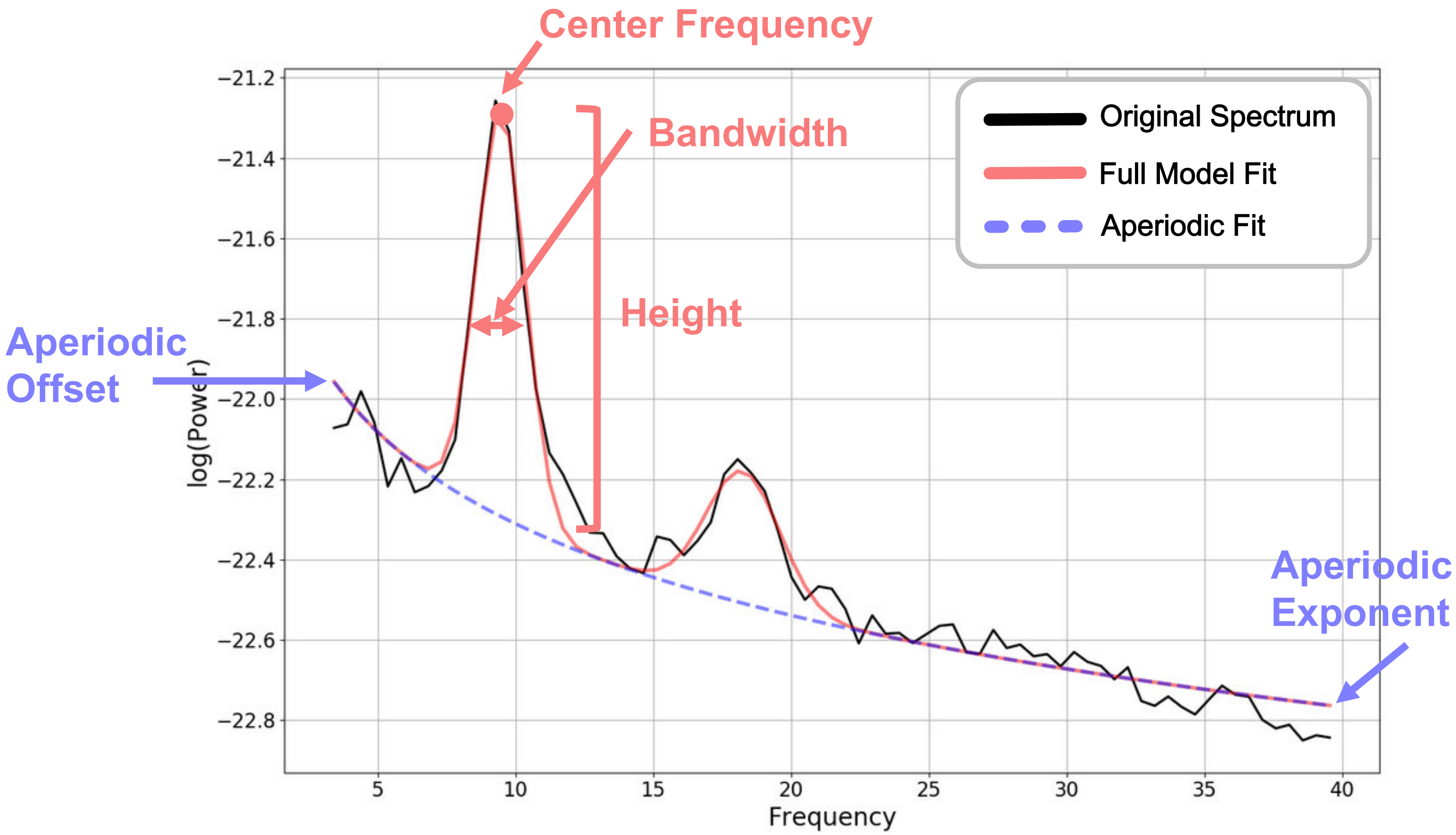




Chen et al., 2022, bioRxiv

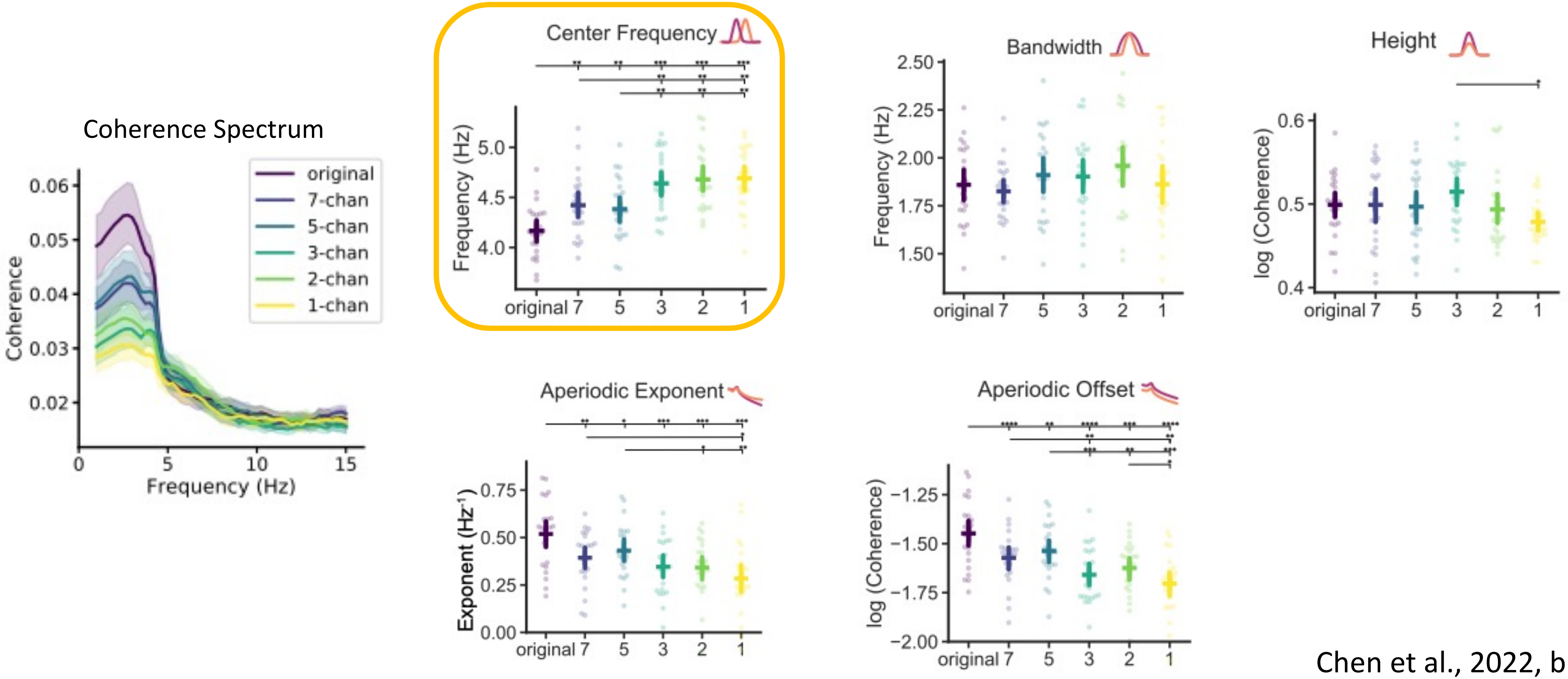
Decomposing coherence spectrum into 5 components





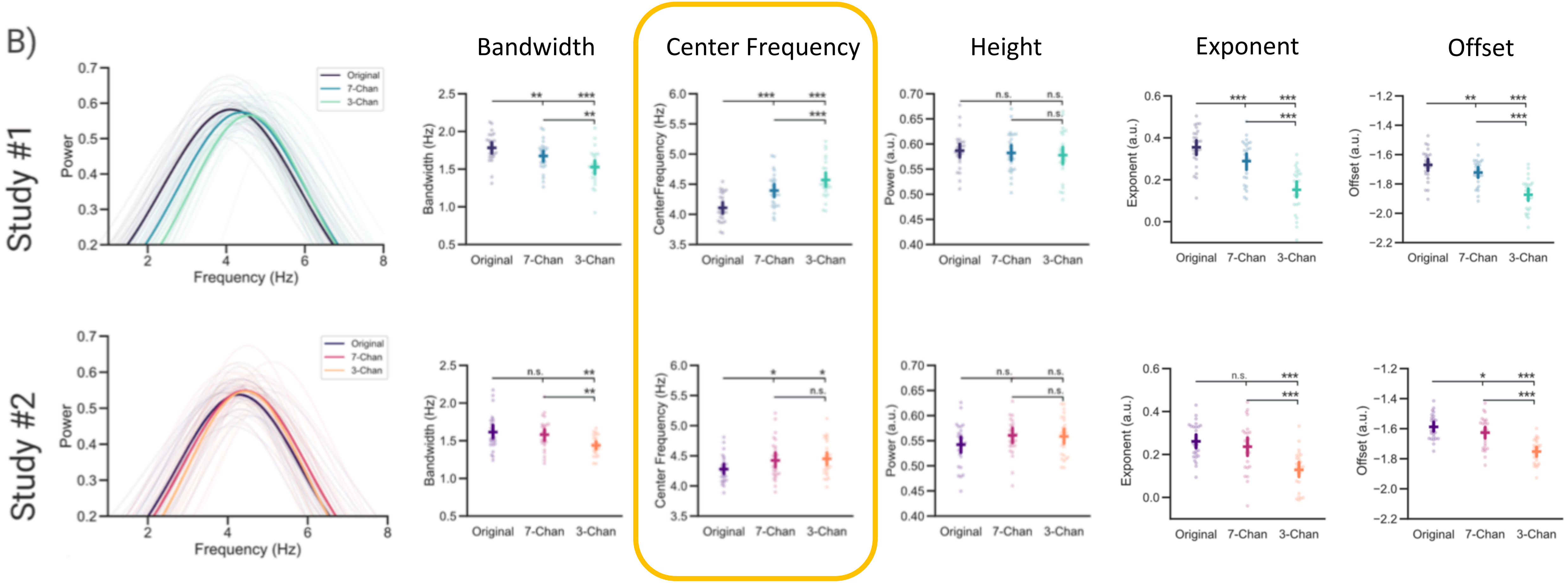
adapted from https://fooof-tools.github.io/fooof/
Donoghue et al. (2020) Nature Neuroscience

Center frequency of coherence spectrum increased when speech intelligibility decreased (1/2)



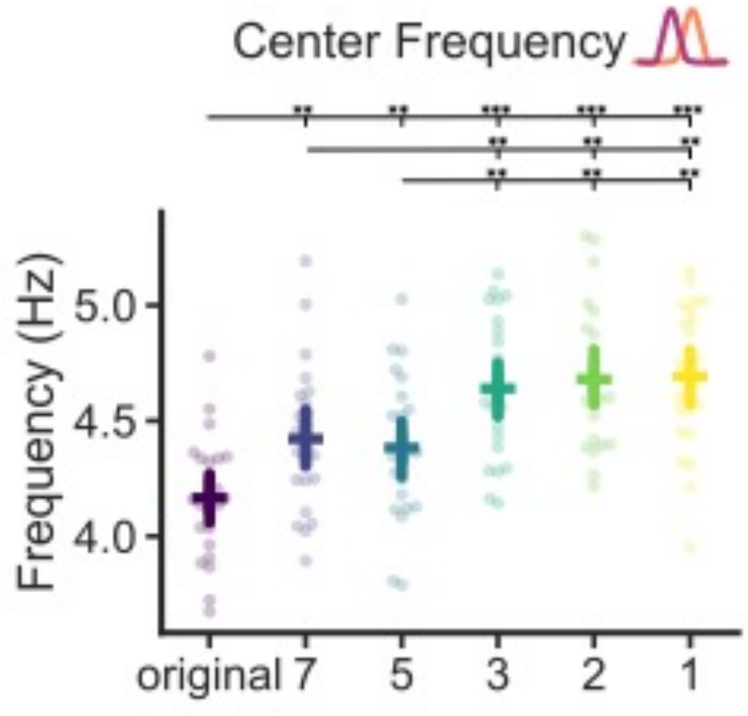
Chen et al., 2022, bioRxiv

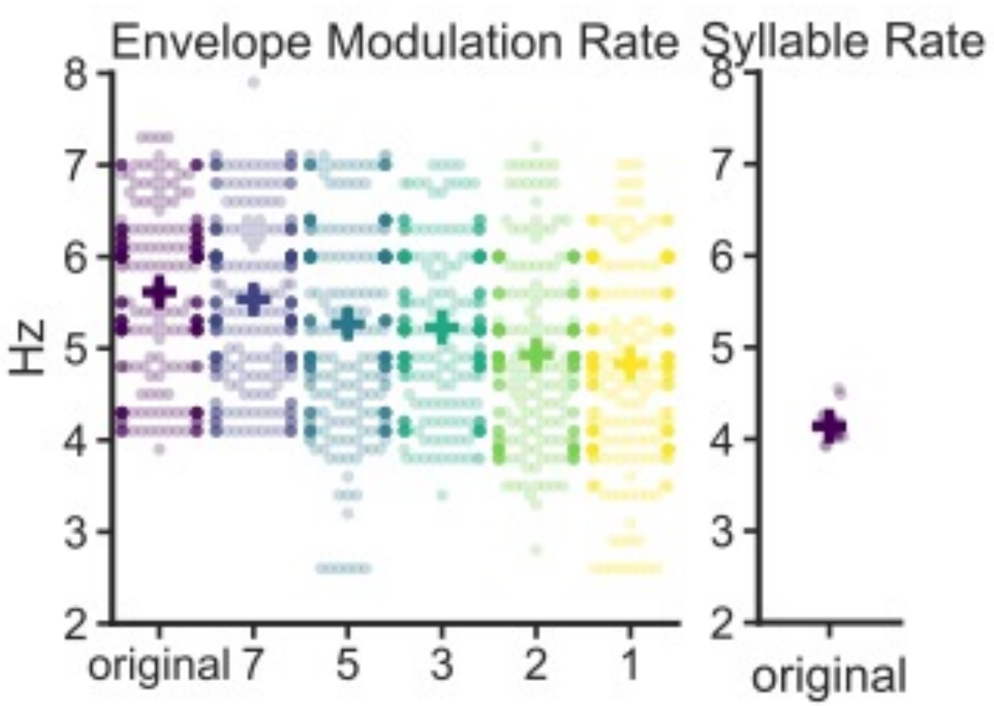
Center frequency of coherence spectra increased when speech intelligibility decreased (2/2)



Schmidt et al., 2022, bioRxiv

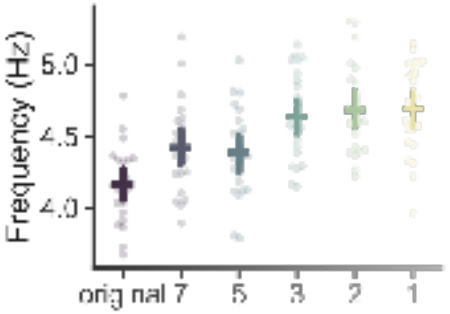
Neural speech tracking shifted to more acoustic level when speech intelligibility decreased



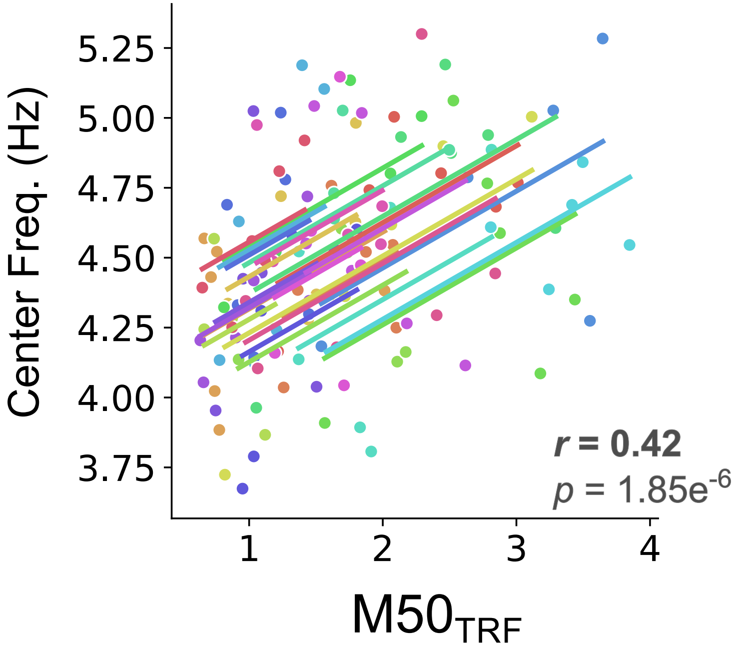


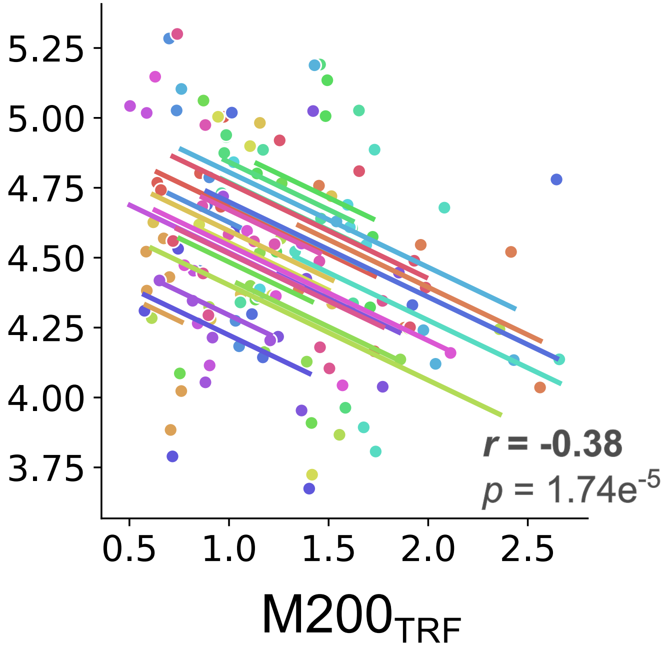
Center frequency explained variances of both $M50_{TRF}$ and $M200_{TRF}$ but in different direction

Center Frequency

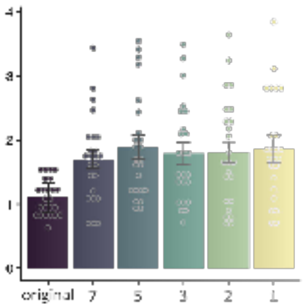


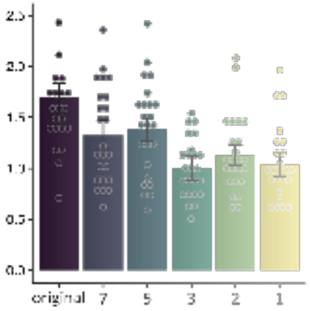
higher freq.
when more degraded





higher amp.
when more degraded



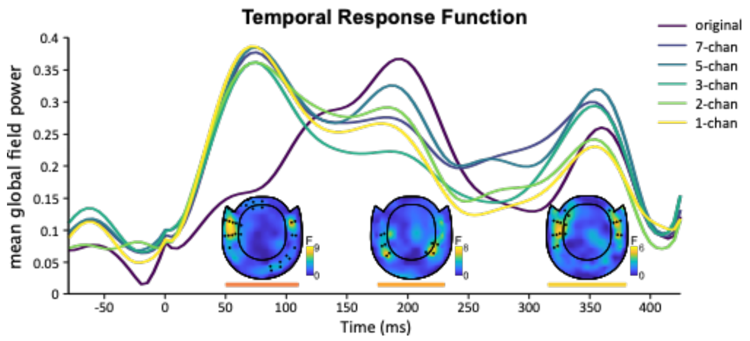


lower amp.
when more degraded

Chen et al., 2022, bioRxiv

Conclusion of Study 1

- Three neural processing stages ($M50_{TRF}$, $M200_{TRF}$, and $M350_{TRF}$) when listening to continuous degraded speech
- Only $M200_{TRF}$ decreased with speech intelligibility.
- Neural speech tracking shifted from more linguistic level to more acoustic level when speech intelligibility decreased.



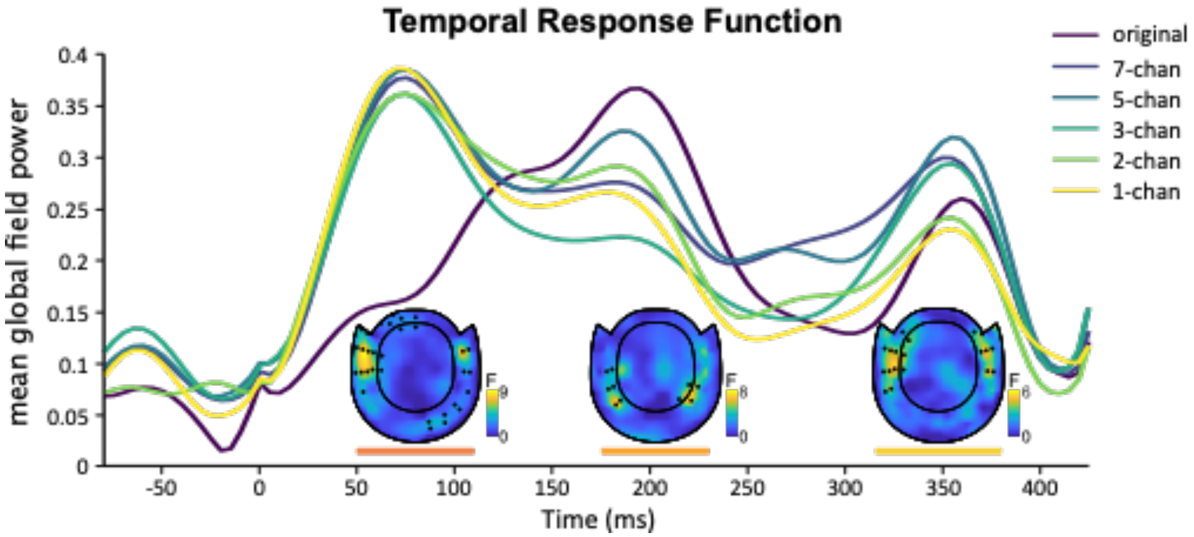
Study 2 (ongoing Taiwan-Austria project)

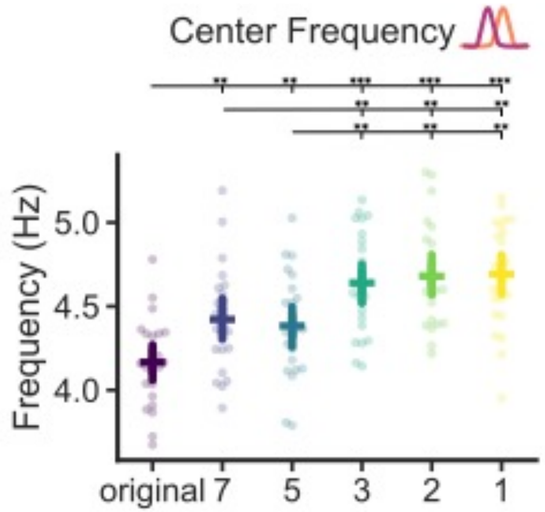
How does ***unfamiliar*** degraded speech modulate neural speech tracking?

PIs: Chih-Mao Huang, Hsu-Wen Huang, Nathan Weisz

According to what we found previously…

- How about unfamiliar speech?
- How about unfamiliar degraded speech?
- How about tonal speech?





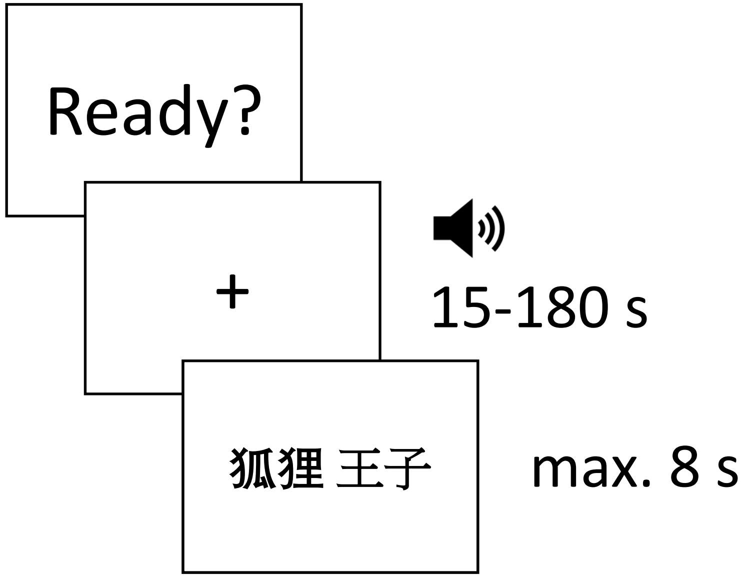
Chen et al., 2022, bioRxiv

Experiment paradigms

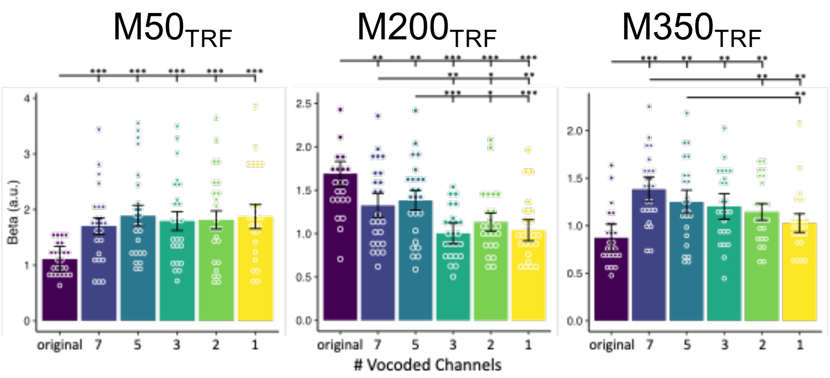
- Mandarin and German version of Little Prince
  - recorded by a person native to both languages
  - original, 7- and 3-channel vocoded

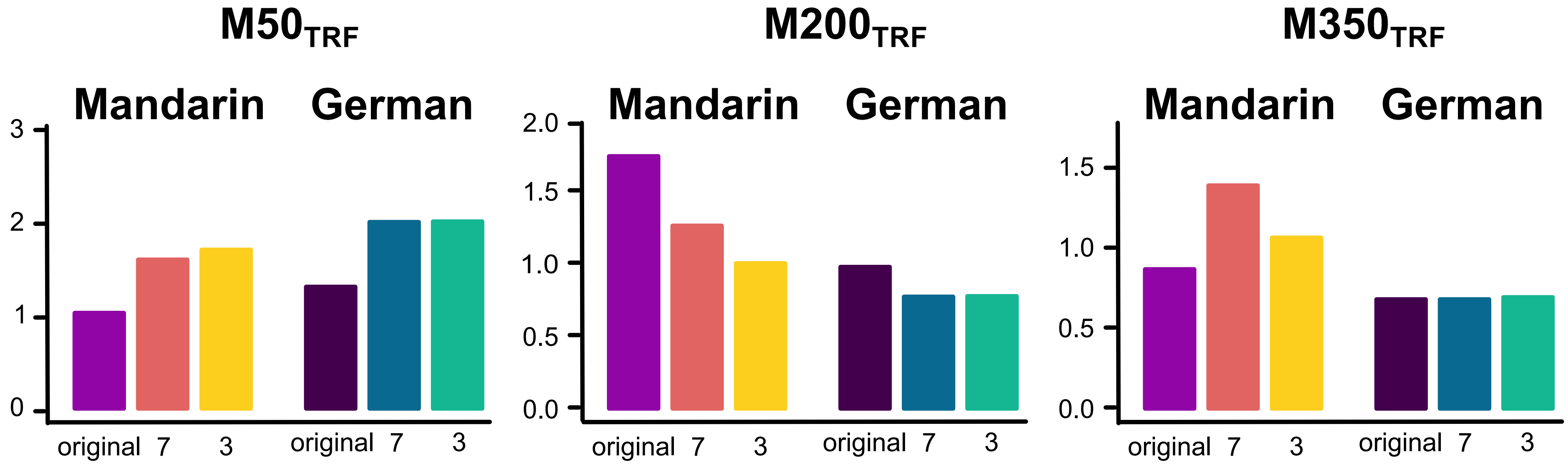
Methods

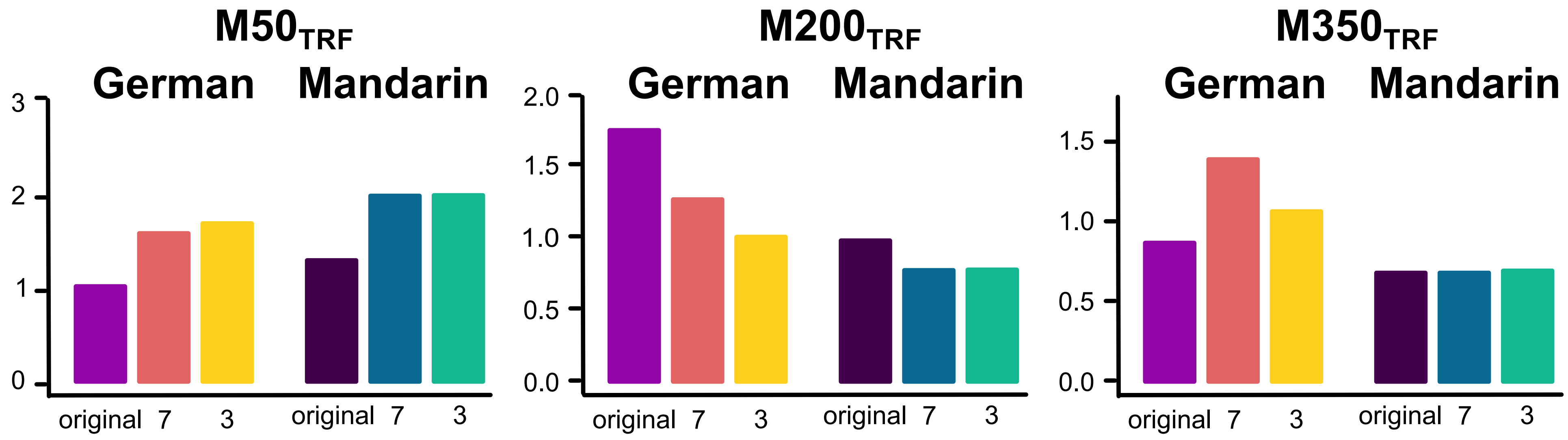
- MEG measurement in Taiwan
- Participant
  - native Mandarin speaker in Taiwan
  - no experience in German
  - basic knowledge in English



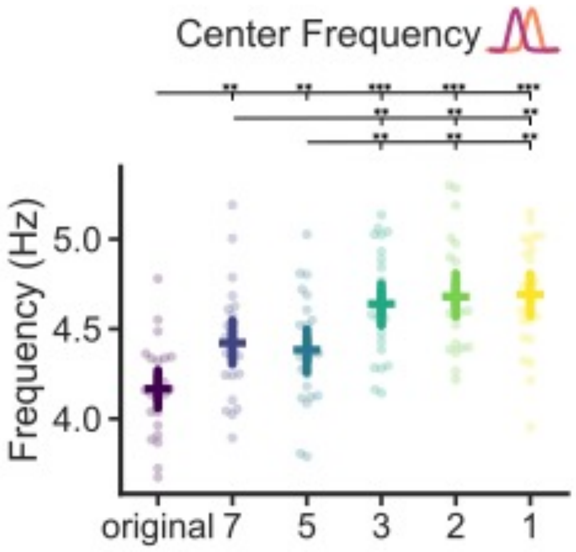
Expected results



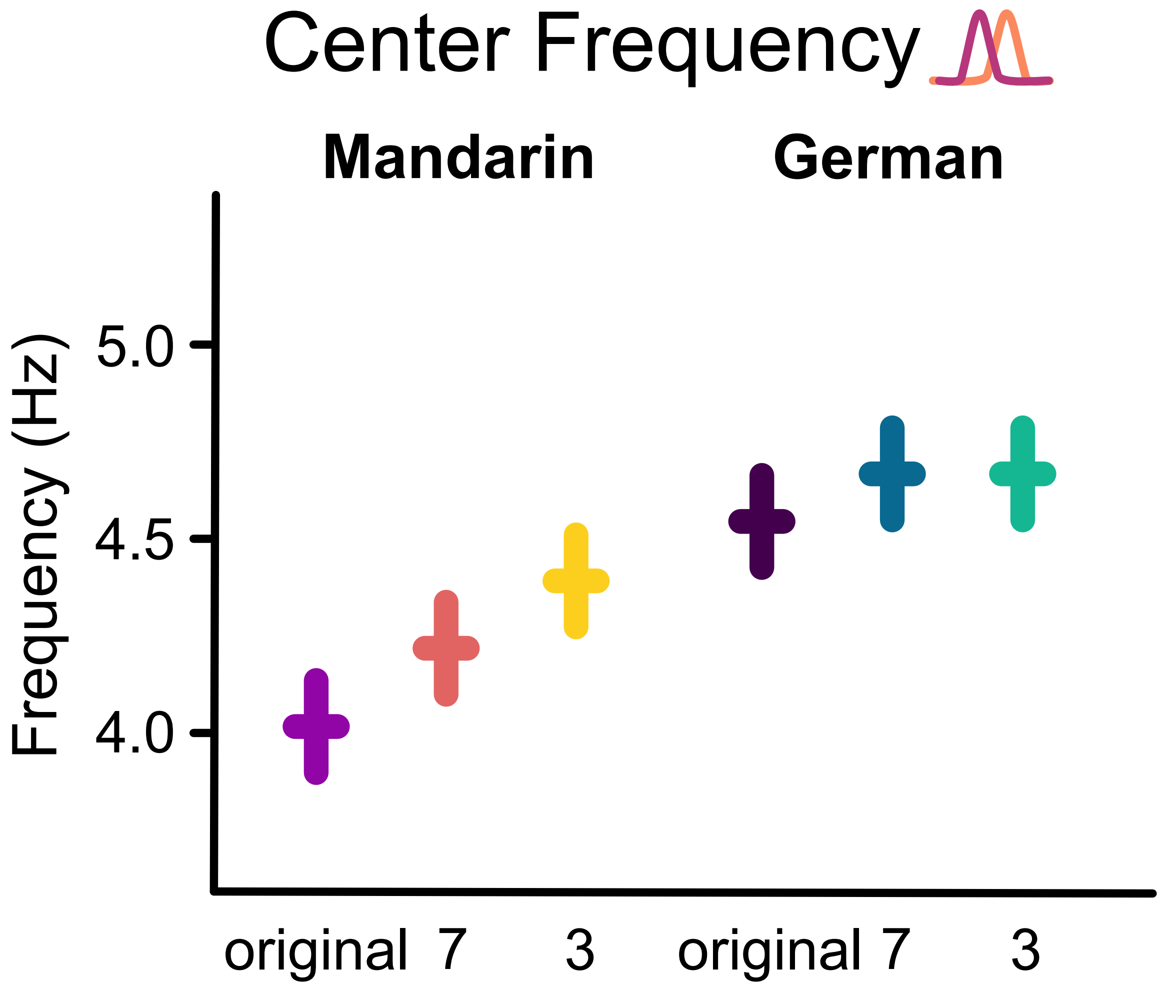



M50TRF
German
Mandarin
M200TRF
German
Mandarin
M350TRF
German
Mandarin
0
1
2
3
0.0
0.5
1.0
1.5
2.0
0.0
0.5
1.0
1.5
original
7
3
original
7
3

Expected results



Chen et al., 2022, bioRxiv



Importance of Study 2

- vocoded effect on tonal speech
- effect of less spectral information and less knowledge of language on shifted neural speech tracking

Auditory Neuroscience Group

Salzburg Brain Dynamics Lab

FWF Der Wissenschaftsfonds.

oead

https://braindynamics.sbg.ac.at/

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