Generating Natural, Intelligible Speech From Brain Activity in Motor, Premotor, and Inferior Frontal Cortices

Christian Herff et al., (2019).

Frontiers in Neuroscience, 13:1267.

presented by Robert Gericke [T2RG] | BCI-SEM | 25.01.2022

BCI Communication

- Text based
  e.g. Matrix Speller, via Handwriting [S9AA]

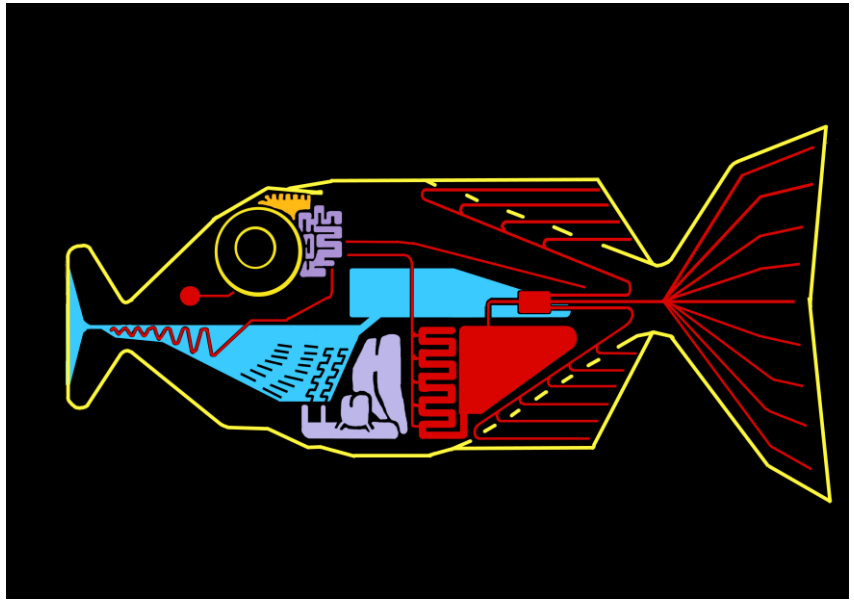
- Speech (Audio) based
  - Acoustic, prosodic, linguistic cues
  - Pitch, timing, stress, emphasis and pauses



[Treder & Blankertz, 2010]

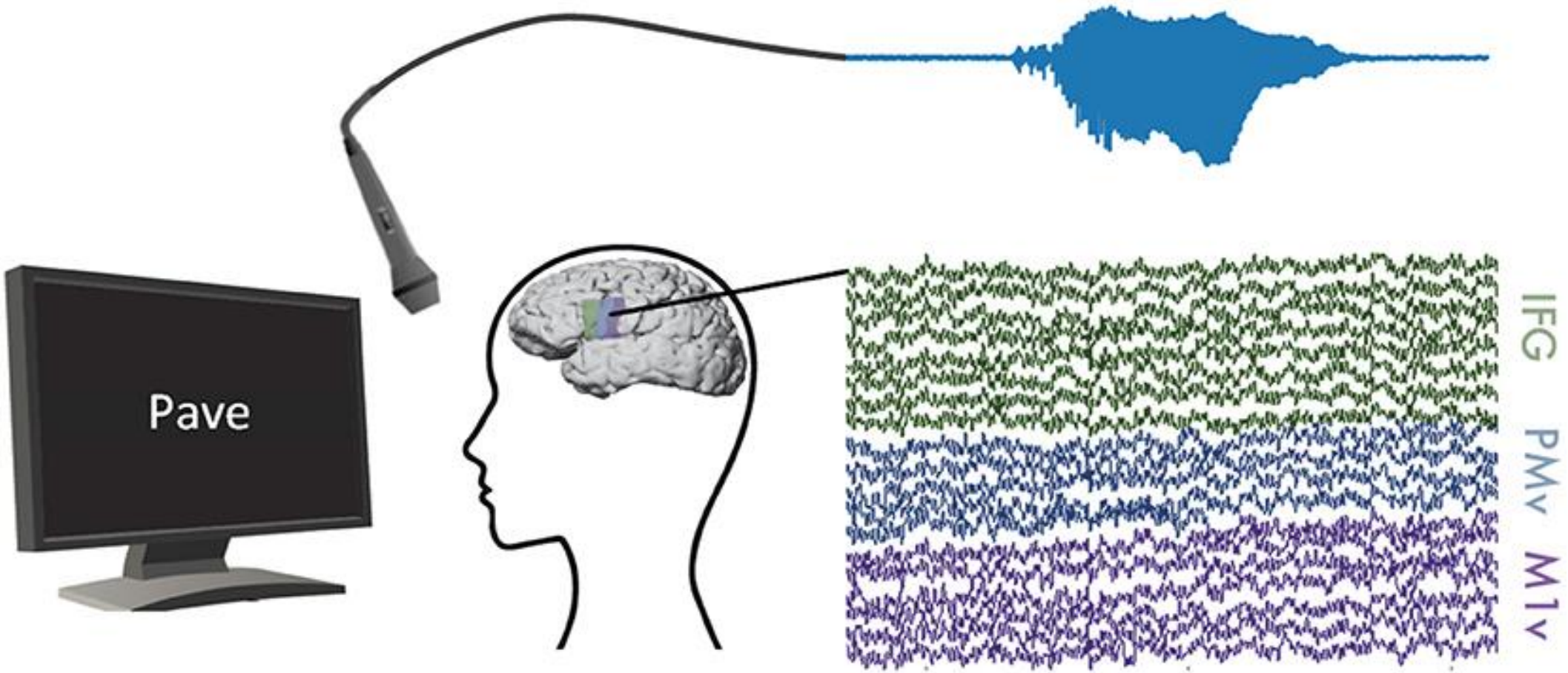
Agenda

- Data Recording
- Signal Processing
- Speech Synthesis
- Results
- Discussion



[The Hitchhiker's Guide to the Galaxy]

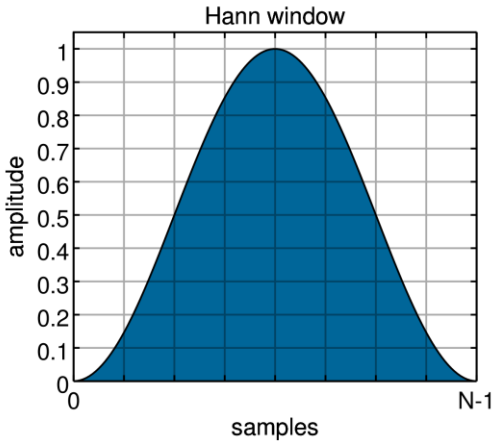
Data Recording



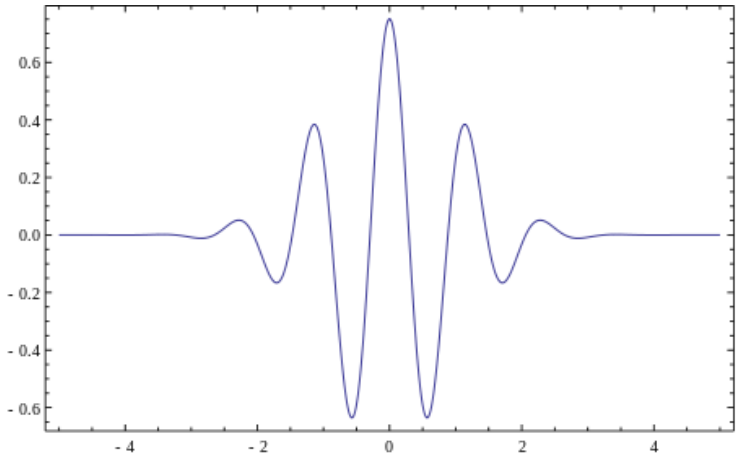
[Herff et al., 2019]

Signal Processing

- 64-channel ECoG at 2kHz, Bandpass filtered between 0.5 and 300 Hz
  - Linear detrending
  - High gamma band (70-170 Hz)
  - Logarithm of squared signal (logarithmic power)
  - 450ms Windows downsampled to 20Hz
    => 64x9 = 576 features
  - PCA: 576 -> ~100 features
- Audio at 48 kHz
  - Downsampled to 16kHz
  - 150ms Hanning Windows



https://commons.wikimedia.org/wiki/File:Window_function_(hann).png



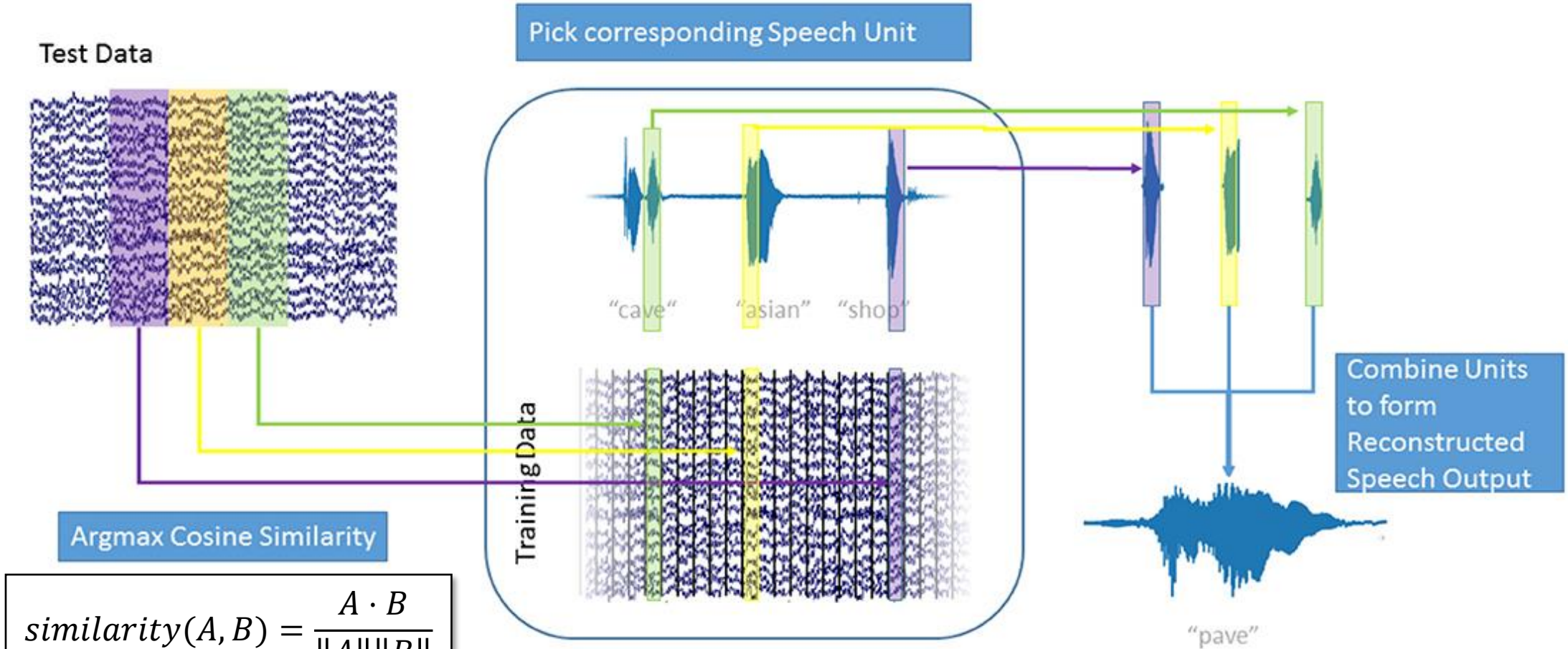
https://commons.wikimedia.org/wiki/File:MorletWaveletMathematica.svg

Speech Synthesis

Unit selection:

- Concatenates units of speech
- Two cost terms
  - Target cost
  - Concatenation cost
- Requires iterative optimization

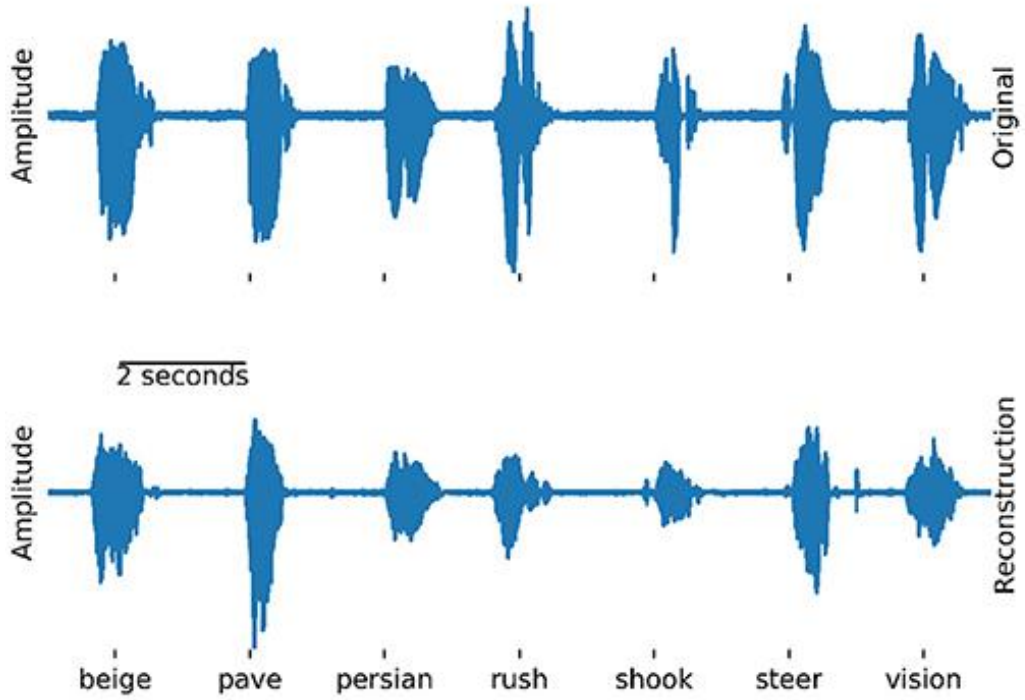
Speech Synthesis

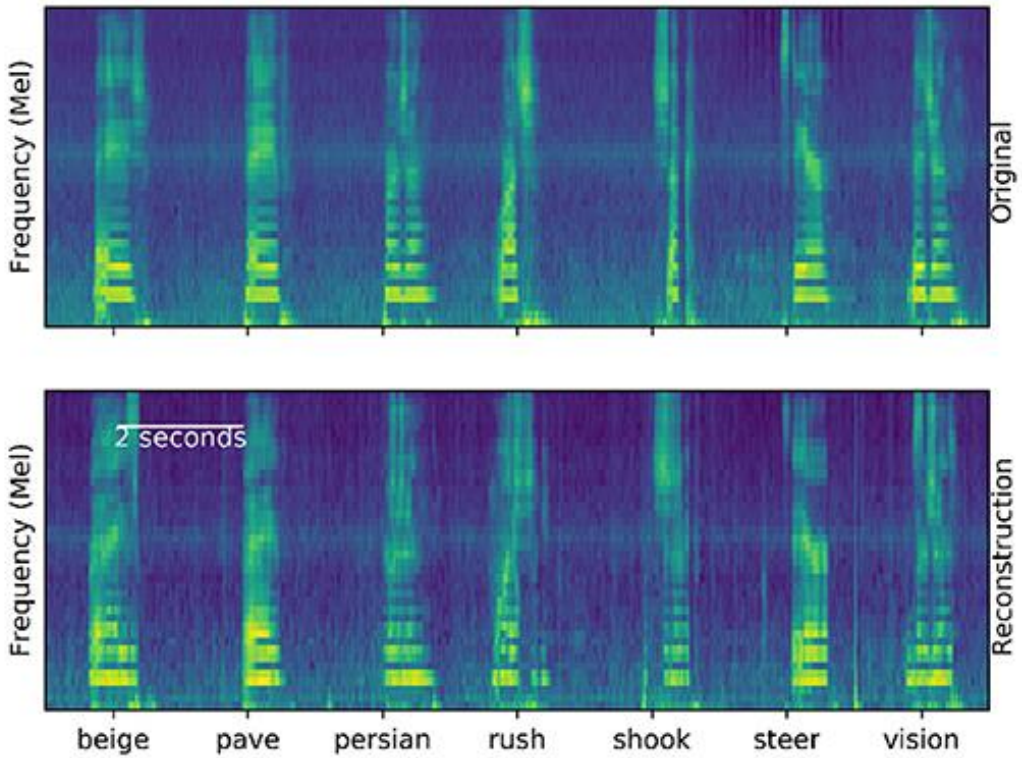


$$similarity(A, B) = \frac{A \cdot B}{\|A\|\|B\|}$$

[Herff et al., 2019]

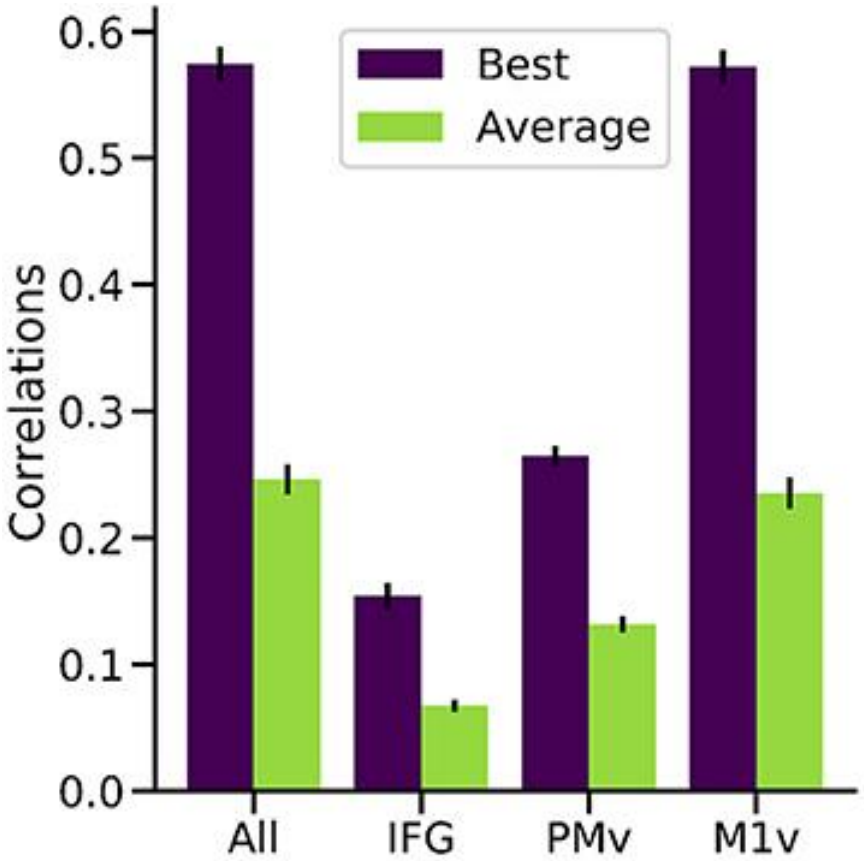
Results

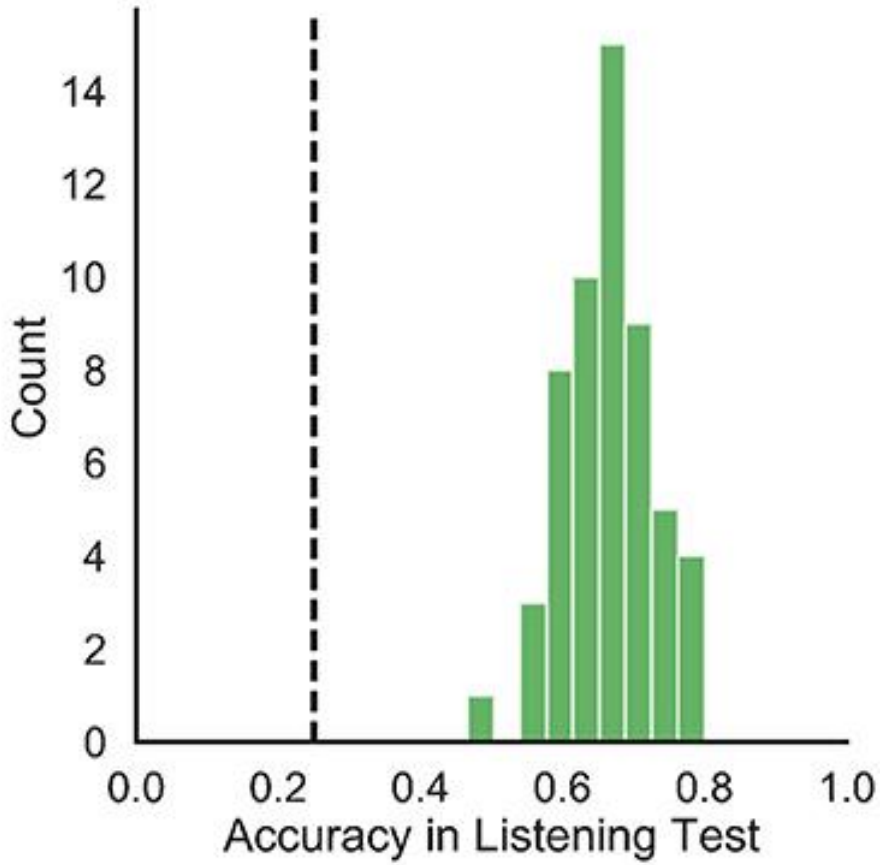




[Herff et al., 2019]

Results





[Herff et al., 2019]

Discussion

Summary

- BCI generating natural intelligible speech
- Simple pattern matching scheme invariant to language
- Real-time ready

Limitations

- Tested on limited set of simple words
- Offline evaluation
- Training for already impaired people

References

- Herff, C., Diener, L., Angrick, M., Mugler, E., Tate, M. C., Goldrick, M. A., Krusienski, D. J., Slutzky, M. W., & Schultz, T. (2019). **Generating Natural, Intelligible Speech From Brain Activity in Motor, Premotor, and Inferior Frontal Cortices.** *Frontiers in Neuroscience*, *13:1267*.
- Treder, M. S., & Blankertz, B. (2010). **(C)overt attention and visual speller design in an ERP-based brain-computer interface.** *Behavioral and Brain Functions*, *6*(1), 28.

Q&A

Any Questions?