Determining the Correspondence Between Covert Speech and Speech Perception

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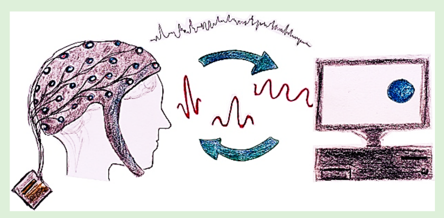
Background

Speech Perception (SP)
Discriminating, identifying, interpreting speech[3]

Imagined speech heard in our mind without moving the lips & tongue[2]

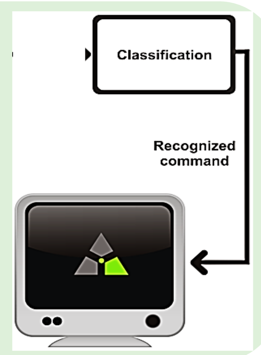
Covert Speech (CS)

Brain-Computer Interface (BCI) System



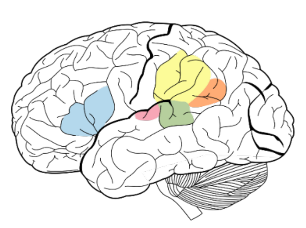
1. Measurement of electrical brain activity via **EEG**

2. **Signal processing and translation** of collected EEG signals

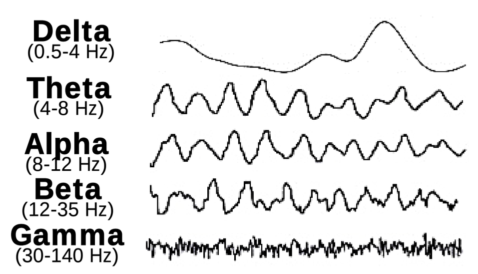


Previous Research

CS & SP produce similar **activation patterns** in common **language processing** brain regions[5][6][7][8][9]



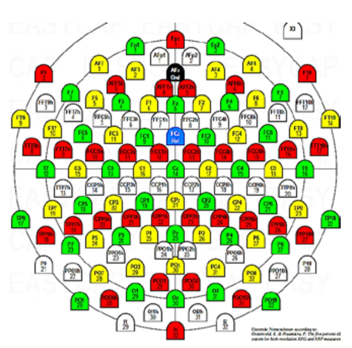
CS & SP share a **correlation** for certain **neural oscillations** (frequencies)[4]



Objective

Determine the topographical and frequency-related correspondence between CS and SP

Method & Analyses



Used EEG with a 64/128 channel cap

(SP Condition)

Arch
Archbishop
Gran
Grandmother
Kin
Kindergarten
Mar
Marketplace

Participants heard 8 words

(CS Condition)

Mentally rehearsed the word they just heard

1. **Hierarchical Clustering** (groups EEG channels into clusters with shared features)
2. **Principal Component Analysis** (identifies most explanatory features in each cluster)
3. **Ridge Regression** (fits a model between CS & SP)
4. **Permutation Importance Test** (determines which CS features contribute most to the ridge regression)
5. **Event-related Causality** (detects causal relationships = if CS reliably causes SP & if SP reliably causes CS)

Passively Training a Thought Decoding Brain-Computer Interface Can Facilitate Versatile Communication Amongst Children With Disability

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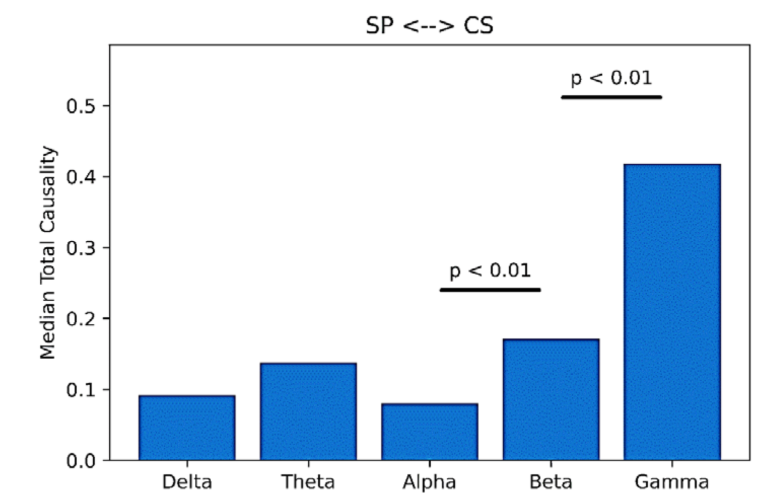
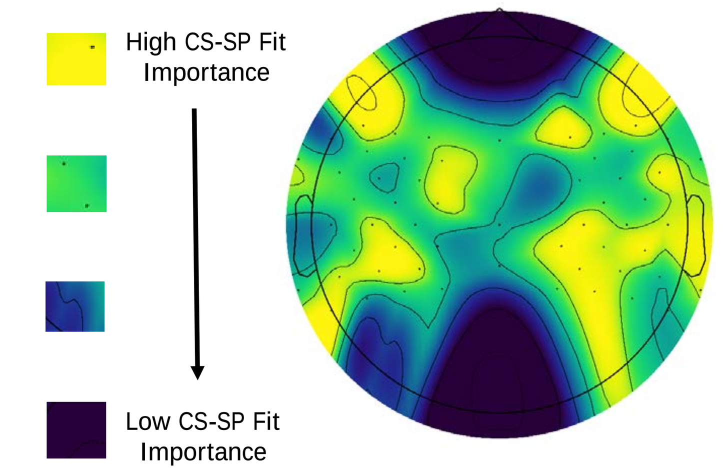
Results

Causality Indices for CS-SP At Different Frequencies



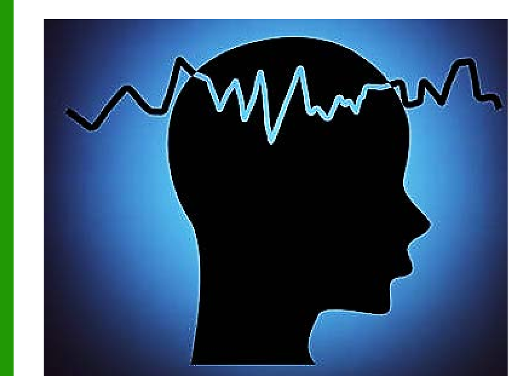
Low gamma-band activity (30-60 Hz) was responsible for most **CS-SP causality**[1][4]

Scalp Topographical Map



The regression found **corresponding relationships** in **various channel clusters**: temporal, frontal, centro-parietal[1][4]

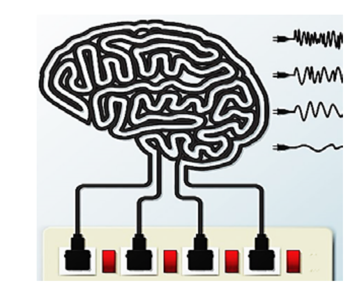
Conclusion



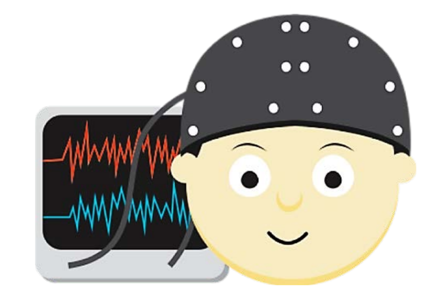
Determining a generalizable CS-SP model requires:

Gamma-band correspondence
||
Spatial correspondence

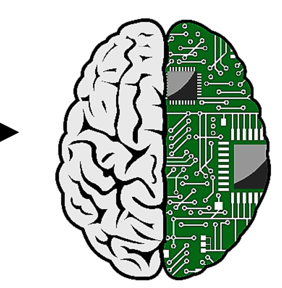
Next Steps



1. Use causality characteristics in various frequencies for model improvement



2. Re-train model by recruiting participants with disability



3. Construct a thought-decoding BCI device

Relevance

Children with **complex communication needs (CCN)** and speech impairments resulting from cerebral palsy (CP), autism spectrum disorder (ASD), Down syndrome, and other disabilities are **restricted** in their participation in **conversational & interactive environments**

Advances BCI technology by training a thought-decoding BCI without constant reiteration of thought = **non-taxing to users**

Our Research

Equitably promotes and supports the **inclusion & rights** of children with disability to participate in society

Enables communication & expression for kids with CCN

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