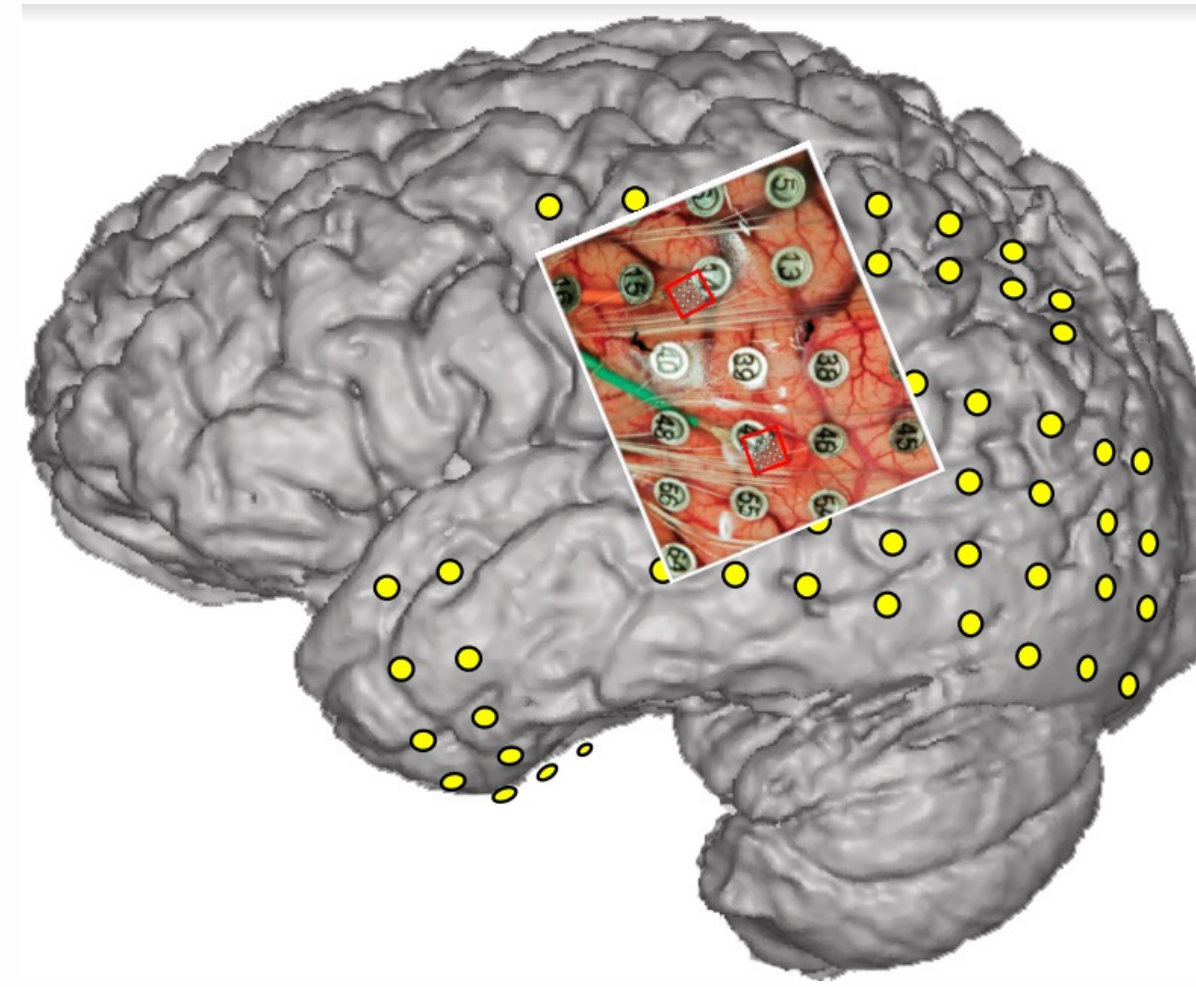# Speech Processing in Humans: Insights from Neural Signals

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Mentor: Dr. Bradley Greger – Neural Engineering Lab

Research Focus

+ Analyzing neural signals from the Face Motor Cortex and Wernicke's Area of a human brain (during speech) to understand language processing

+ Utilizing a dataset from an epilepsy patient for the purpose of examining correlations between speech perception and production

+ Deriving common trends in speech processing, the identification of speakers/other nuances, and exploring the relationship between the Wernicke's Area and Face Motor Cortex

+ Contributing to the studying of comprehension of language, speech disorders, and neurological processes

+ Delivering the dataset on open-source platforms and publishing its relevant findings for a refined understanding of brain-speech interactions and their clinical implications

Face Motor Cortex, Word = "yes"

Wernicke's Area, Word = "no"

PCA with K-means Clustering on Neural Signal Data - Wernicke's Area (3D)

YES		NO		YES - Round 2		NO - Round 2		HOT	
Start	End	Start	End	Start	End	Start	End	Start	End
53.644	60.275	108.925	109.540	157.068	157.918	252.768	253.382	283.799	284.220
61.102	61.736	111.155	111.626	159.319	160.114	254.819	255.514	286.164	286.672
63.849	64.424	113.518	114.215	161.566	162.346	256.969	257.662	288.467	288.836
65.798	66.378	116.159	116.863	163.367	164.741	259.215	259.939	290.847	291.216
67.828	68.432	118.754	119.522	166.265	167.075	261.505	262.276	293.196	293.228
69.677	70.337	121.688	122.397	168.585	169.267	263.900	264.633	295.434	295.608
71.806	72.386	124.339	124.995	171.024	171.783	266.384	267.184	297.856	298.011
73.963	74.543	126.962	127.610	173.318	174.088	268.745	269.447	300.155	300.348
76.020	76.846	129.553	130.231	175.483	176.261	270.948	271.592	302.556	302.721
78.366	79.053	132.061	132.768	177.760	178.539	273.332	273.935	304.874	305.060
80.688	81.385	134.721	135.379	180.365	181.143	×	×	×	×
82.949	83.673	137.538	138.245	182.735	183.564	×	×	×	×
85.188	85.896	140.216	140.860	185.164	185.955	×	×	×	×
87.395	88.099	143.010	143.679	187.495	188.375	×	×	×	×
89.767	90.457	145.564	146.296	189.962	190.753	×	×	×	×
91.892	92.659					×	×	×	×

| COLD		HUNGRY		THIRSTY		HELLO		GOODBYE	
Start	End	Start	End	Start	End	Start	End	Start	End
316.080	316.658	346.714	347.139	377.452	377.844	414.482	414.929	447.455	448.023
318.165	318.655	348.709	349.213	379.564	380.116	416.775	417.277	450.126	450.673
320.291	320.731	350.887	351.483	381.820	382.370	418.836	419.448	452.629	453.254
322.352	322.994	353.194	353.914	384.269	384.880	420.964	421.524	455.164	455.791
324.558	325.099	355.711	356.247	386.482	387.014	422.901	423.456	457.858	458.546
326.656	327.364	357.976	358.530	388.731	389.262	425.066	425.691	460.344	460.930
329.225	329.783	360.164	360.742	390.995	391.600	427.369	427.933	462.643	463.308
331.709	332.210	362.459	363.003	393.230	393.828	429.866	430.452	465.168	465.827
334.199	334.700	364.834	365.389	395.394	396.001	432.279	432.855	467.575	468.170
336.698	337.225	367.209	367.763	397.722	398.306	434.732	435.228	470.268	470.843
×	×	×	×	×	×	437.017	437.607	×	×
×	×	×	×	×	×	×	×	×	×
×	×	×	×	×	×	×	×	×	×
×	×	×	×	×	×	×	×	×	×

Progress & Timeline

Fall'22:
+ Onboarding/Familiarizing with the Project, Lab, and Technologies

Spring'22:
+ Curating, captioning, and time-stamping the dataset
+ Initial testing with Google Cloud's Speech to Text and OpenAI's APIs
+ Utilizing MATLAB to produce spectrograms for pattern identification

Fall'23:
+ Data pre-processing tasks for Machine Learning, testing environments
+ Setting up ASU research computing services for the project
+ K-Nearest Neighbors, Principal Component Analysis

Spring'24:
+ Compressing, structuring, and organizing data for the purpose of building and training a Convolutional Neural Network

Future Work: Open-sourcing dataset, publishing findings over Fall'24

Tools & Technologies

Project Statistics

Duration of Experiment: 15:25.567367s

Size of Dataset: 32 (Channels) x 27767022 (Records: 30000 per second)

Channels: 16 (Face Motor Cortex) + 16 (Wernicke's Area)

Experimental Words: yes, no, hot, cold, hungry, thirsty, hello, goodbye, more, less, alphabets, numbers

Speakers: (3) Interviewer, Participant, Observer

Repetitions: 1 to 50 Samples (varying word to word)

Wernicke's Area: Responsible for a human's ability to comprehend languages, process grammar, and interpret/recognize speech

Face Motor Cortex: Generates signals to direct body movement
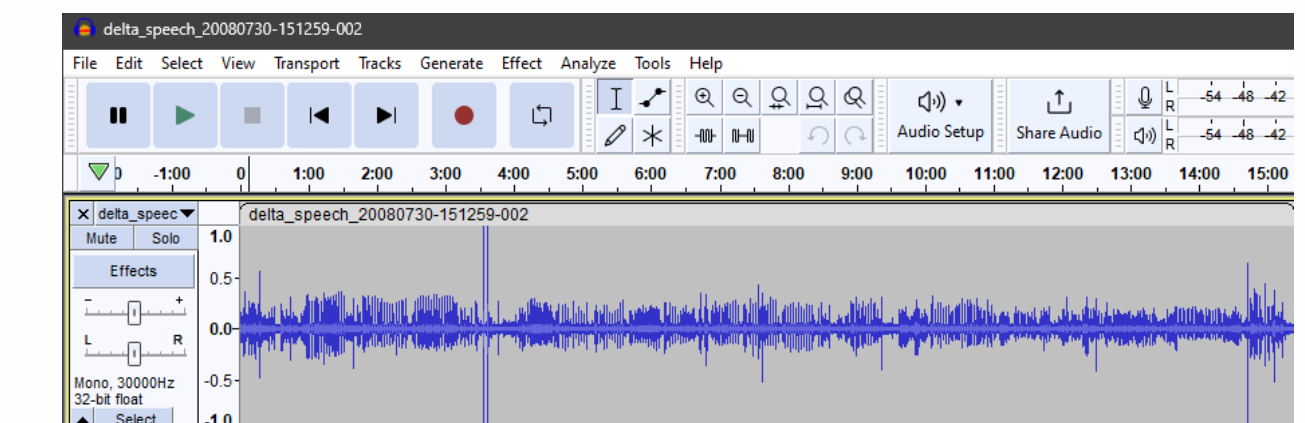
Relevant Readings & Resources

Extracting Features from Time Series (Christian Herff and Dean J. Krusienski)

Neural Decoding of EEG Signals using Machine Learning (Maham Saeidi and Waldemar Karwowski)

Classification of Spoken Words using Surface Local Field Potentials (Spencer Kellis, and Bradley Greger)

Decoding Spoken Words using Local Field Potentials Recorded from the Cortical Surface (Spencer Kellis)

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