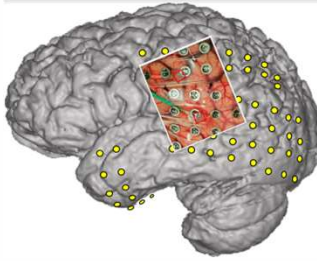


Speech Processing in Humans: Insights from Neural Signals

Students: Tushar Tyagi (CS Junior @ ASU); August Hays-Ekeland
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



Fall'22:

- + Oct - Dec: Onboarded/Familiarized with the Project, Lab, and Technologies
- Spring'22:**
- + Jan - Mar: Curated, captioned, and timestamped the dataset
- + Mar: Tested the data with Google APIs, and ChatGPT, for initial analyses
- + Apr - May: Coded in MATLAB producing collections of spectrograms for pattern identification, and data visualization of experimental words

- Findings & Results -

Up to this point, two significant discoveries regarding the analysis of neural signals during human speech have been made.

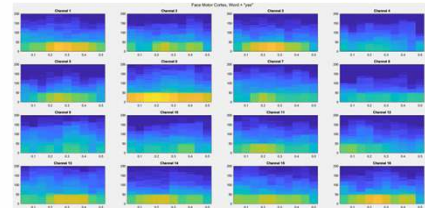
- 1) As evident in the spectrograms displayed to the right, plotting each channel over multiple iterations of an experimental word has provided valuable insights into the predominant channels associated with each word.
- 2) Likewise, the K Means graph, also visible on the right, has revealed distinct clusters that the research team has been able to discern across all observed channels for different words.

Ongoing research continues to delve further into potential connections between the Wernicke's Area and the FMC, along with speaker identification, and other common trends.

> Progress/Timeline <

YES		NO		YES-Round2		NO-Round2		HOT	
Start	End	Start	End	Start	End	Start	End	Start	End
103.641	120.225	120.352	129.640	187.048	187.738	254.119	255.544	233.191	234.220
11.522	21.738	181.955	181.026	163.391	160.134	256.363	257.662	236.344	236.672
162.040	164.424	183.538	184.235	181.560	182.346	253.215	253.939	238.407	238.836
120.761	126.310	186.163	186.863	183.567	184.141	261.565	262.716	239.812	239.746
17.620	16.432	188.754	189.522	186.285	187.075	263.360	264.033	239.18	239.220
118.617	119.321	121.088	122.387	188.265	189.317	266.384	267.184	238.444	238.660
11.668	12.388	124.339	124.995	111.024	111.783	268.145	268.447	237.868	238.011
12.267	12.643	126.262	127.057	112.288	114.688	270.249	271.052	238.651	238.368
18.020	18.648	128.953	130.231	115.480	116.261	272.322	273.036	238.586	238.721
18.366	19.020	132.081	132.789	117.760	118.539	X	X	238.894	238.060
18.668	19.385	135.721	136.279	120.465	121.143	X	X	X	X
18.949	19.673	137.538	138.245	122.735	123.564	X	X	X	X
19.181	19.893	140.734	141.860	125.184	126.056	X	X	X	X
18.736	18.693	143.070	143.879	127.485	128.375	X	X	X	X
18.717	18.461	145.564	146.290	130.262	130.753	X	X	X	X
31.052	32.653	X	X	X	X	X	X	X	X

COLD		HUNGRY		THIRSTY		HELLO		GOODBYE	
Start	End	Start	End	Start	End	Start	End	Start	End
176.000	176.615	348.743	349.133	177.452	177.664	434.482	434.925	437.455	438.045
138.361	138.655	348.709	349.213	179.664	180.116	436.725	437.277	438.128	438.673
132.019	132.701	352.807	353.403	181.650	182.319	438.518	439.440	439.453	439.754
132.252	132.934	353.334	353.934	184.269	184.880	438.864	439.524	439.544	439.731
124.558	125.089	355.111	356.247	186.425	187.074	442.301	443.456	437.850	438.546
128.692	129.344	357.976	358.530	188.711	189.362	429.066	429.691	438.344	438.990
129.225	129.783	360.844	360.742	190.990	191.600	427.369	427.933	436.843	437.300
133.109	133.240	362.459	363.000	193.200	193.628	429.869	430.452	436.981	437.617
134.193	134.700	364.834	365.369	195.394	196.081	432.279	432.895	437.575	438.170
138.690	139.225	367.039	367.763	197.722	198.366	434.712	435.346	438.260	438.945
X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X
X	X	X	X	X	X	X	X	X	X



Fall'23:

- + Aug - Sep: Data pre-processing for Machine Learning tasks, testing environments, setting up ASU research computing services for the project
- + Oct: Studying ML techniques/models appropriate and relevant to the data type, size, etc.

Future: Complete ML analyses, open-source dataset, & publish findings

| Statistics & Definitions |

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)

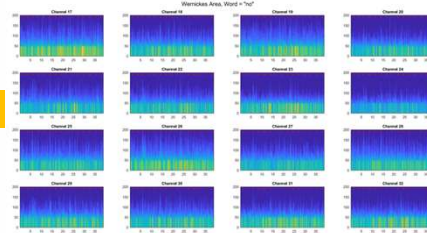
Experimental Words: yes, no, hot, cold, hungry, thirsty, hello, goodbye, more, less, alphabets, numbers

Speakers: (3) Interviewer, Participant, Observer

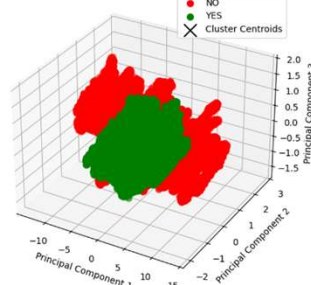
Repetitions: 1 to 50 Samples (varying word to word)

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

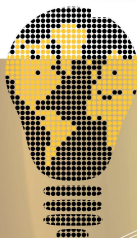
Face Motor Cortex: Generates signals to direct body movement



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



Tools & Technologies!



Grand Challenges Scholars Program

~ Relevant Readings & Resources ~

- L1: Extracting Features from Time Series (Christian Herff and Dean J. Krusienski)
- R1: Neural Decoding of EEG Signals using Machine Learning (Maham Saeidi and Waldemar Karwowski)
- L2: Classification of Spoken Words using Surface Local Field Potentials (Spencer Kellis, and Bradley Greger)
- R2: Decoding Spoken Words using Local Field Potentials Recorded from the Cortical Surface (Spencer Kellis)

