Inferring Functional Human Language Pathways

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***Short Abstract* — The goal of our ongoing research is to provide insight about fundamental networks involved in human language processes by applying statistical and spectral tools to time series data recorded from intracranial electrodes that were implanted in human subjects. When applied to these macroscale recordings, these tools generated results that describe how the underlying neural populations processed information and communicated with each other during a verb generation task. We investigated how these interactions evolved forward in time by performing our analysis on temporal windows that spanned the conceptualization to articulation stages of word generation.**

***Keywords* — Active network/pathway inference, Human language processes, Electrocorticography.**

I. Background Information

UNDERSTANDING the neural circuitry supporting human language processes, from conceptualization to articulation, has proven to be a persistent and fundamental problem in medical and biological research. The goal of this work has been to answer how language forms and spreads through the brain by modeling massive amounts of human physiological data with well-developed statistical and spectral tools to illuminate meaningful patterns for analysis.

Researchers at the Tandon Lab (at UTHSC-H) [1] have amassed a collection of data recorded by hundreds of intracranial electrodes (electrocorticography or ECoG) while human subjects participated in a series of standard language tasks. This data contains the temporal and spatial precision desired for this study, as the sequential stages involved in language processes have alarmingly rapid durations and occur in functionally distinct regions that are sometimes anatomically located within millimeters of each other [3,5].

We implemented several techniques to deduce influences and connectivity patterns between brain regions, from which we will infer networks and pathways of interactions to construct a map of active human language processes.

Acknowledgements: This work was supported by a training fellowship from the Keck Center for Interdisciplinary Bioscience Training of the Gulf Coast Consortia (Grant No. T15 LM007093) and the National Science Foundation (DMS-0739420 EMSW21-VIGRE).

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II. Methods

The statistical method implemented, pairwise Granger Causality [4,6], infers the direction and relative magnitude of the influences that occurred between selected groups of modeled time series data (that originated from electrode recordings). We extended pairwise Granger causality to multidimensional analysis to address the consideration of completeness within the data [2].

Modern studies have demonstrated the value of investigating spectral patterns within ECoG data. Specific frequency bands are believed to encode how cortical areas process information and communicate with distant regions during during high-level cognitive tasks (such as verb generation) [1,3].

Hence, we focused our attention on the frequency-dependent Granger Causality function. Additional well-studied tools, the Direct Transfer Function and Partial Coherence, were applied to the data as complementary measures of exploring (indirect and direct) connectivity in the spectral domain.

III. Results and Conclusions

The results from the causal influence analysis are interpreted as revealing how the brain regions underneath the electrodes interacted with each other during the time window being investigated. Our preliminary findings have been consistent with modern studies of language. Upon further investigation, we expect to find the visual word form area to be a significant neural driver. Prior studies have shown promising results from both single and multichannel analysis [2,3], so we expect to achieve similar, viable and valuable results as our research continues.

References

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