PROJECT SUMMARY:

The goal of this project is to decode intended speech production directly from brain activity signals or to predict the thinking of articulation. Magnetoencephalography (MEG), which provides real-time temporal resolution and millimeter-level spatial resolution recordings, will be used to collect brain activity data from 10 ALS (amyotrophic lateral sclerosis) patients with impaired speech and 10 healthy subjects during speech production. Advanced machine learning techniques (e.g., support vector machine) will be used to map the whole-scalp MEG recordings to speech units at three lexical and sematic levels, phonemes, words, and phrases. We expect the speech unit classification accuracies will be significantly above chance level. This project will provide a solid foundation for the development of efficient brain-computer interfaces (BCIs), which are highly needed for the communication of individuals with locked-in syndrome (paralyzed, but fully aware) due to brain damage or neurodegenerative diseases (e.g., ALS). In addition, the project will potentially advance the understanding of the neuromechanism of speech decline due to ALS and may lead to timely diagnosis and therapeutic intervention.

RELEVANCE:

This proposed research is highly relevant to the Intent of the U.T. BRAIN initiative, which is to forge new research partnership and increase the team's competitiveness for future federal grant applications in neurotechnology and neuroscience. Specifically, the following aspects will be addressed:

1. This research will **forge new research partnerships** between UT institutions and institutions in Texas, including UT Dallas, UT Austin, Dell Children's Medical Center (Austin), Cook Children's Hospital (Fort Worth), and Texas Neurology (Dallas). This interdisciplinary team has a diverse background and specialized skills including Biomedical Engineering, Computer Science (machine learning), Speech Science and Disorders (due to motor neuron diseases), Neuroscience, Neuroimaging (MEG), and Neurology. This unique team also has access to unique resources (access to target patients and MEG facilities) to address the challenging but critical neurotechnology and neuroscience problems in speech communication of individuals with locked-in-syndrome or ALS.

2. This research will **significantly increase the team's competitiveness for future federal grant applications**. If awarded, the currently proposed research will provide preliminary data and stronger publication records for the team's future grant applications to NIH BRAIN or National Institute of Deafness and Other Communication Disorders (NIDCD).

To our knowledge, this is the first study on decoding intended speech production from MEG signals in three lexical and semantic levels (i.e., phonemes, words, and phrases) and the first speech study on ALS using MEG. In terms of data analysis, our approach is novel, because it will decode speech from the whole-scalp recordings rather than from some specific regions. Moreover, recently developed machine learning algorithms will be used in data analysis.

Dr. Wang (Principal Investigator, UT Dallas) will lead the project, coordinate the collaboration, and be responsible for experimental design, data analysis, and algorithm development. Dr. Ferrari (Co-Investigator, UT Austin and Dell Children's Medical Center) and Dr. Hernandez (Co-Investigator, Cook Children's Hospital) will be responsible for data collection and processing at their sites, respectively. Dr. Heitzman (Consultant, Texas Neurology) will refer patients with ALS to participate in this study. Dr. McManis (Consultant, UT Austin and Dell Children's Medical Center) will help the coordination of the use of MEG at Dell Children's Medical Center. All of these senior personnel will be involved in the interpretation and dissemination of the results.