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BOSTON UNIVERSITY

ANNOUNCEMENT OF FINAL ORAL EXAMINATION FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

Revised

CANDIDATE:	**Emily Stephen**
DEPARTMENT OR PROGRAM:	**Computational Neuroscience**
TITLE OF DISSERTATION:	**"Characterizing Dynamically Evolving Functional Networks in Humans with Application to Speech"**
DATE, TIME, AND PLACE:	**Monday, August 3, 2015 at 10:00a.m.** **Boston University** **Compnet Room B02** **677 Beacon Street** **Boston, MA 02215**

EXAMINING COMMITTEE

FIRST READER:	**Dr. Frank Guenther**	
SECOND READER:	**Dr. Mark Kramer**	
THIRD READER:	**Dr. Jason Ritt**	
CHAIRMAN OF THE EXAMINING COMMITTEE:	**Dr. Uri Eden**	**Email: tzvi@bu.edu**
ADDITIONAL COMMITTEE MEMBERS:	**Dr. Jonathan Brumberg**	

Members of the committee are asked to confirm attendance by replying directly to the Chairman of the Examining Committee.

ALL MEMBERS OF THE SCHOOL OF MEDICINE FACULTY ARE INVITED TO ATTEND.

CHARACTERIZING DYNAMICALLY EVOLVING FUNCTIONAL NETWORKS IN HUMANS WITH APPLICATION TO SPEECH

EMILY STEPHEN

Boston University School of Medicine, 2015

Major Professor: Frank Guenther, Ph.D., Professor, Department of Speech, Language and Hearing Sciences

ABSTRACT

Understanding how communication between brain areas evolves to support dynamic function remains a fundamental challenge in neuroscience. This challenge may be addressed through functional connectivity analysis, in which statistical coupling measures are employed to detect signatures of interactions between brain regions. Because the brain utilizes multiple communication mechanisms at different temporal and spatial scales, and because the neuronal signatures of communication are often weak, powerful connectivity inference methodologies require continued development specific to these challenges.

Here we address the challenge of inferring task-related functional connectivity in brain voltage recordings. We first develop a framework for detecting changes in statistical coupling that occur reliably in a task relative to a baseline period. The framework characterizes the dynamics of connectivity changes, allows inference on multiple spatial scales, and assesses statistical uncertainty. This general framework is modular and applicable to a wide range of tasks and research questions.

We demonstrate the flexibility of the framework in the second part of this thesis, in which we refine the coupling statistics and hypothesis tests to improve statistical

power and test different proposed connectivity mechanisms. In particular, we introduce frequency domain coupling measures and define test statistics that exploit theoretical properties and capture known sampling variability. The resulting test statistics use correlation, coherence, canonical correlation, and canonical coherence to infer task-related changes in coupling. Because canonical correlation and canonical coherence are not commonly used in functional connectivity analyses, we derive the theoretical values and statistical estimators for these measures.

In the third part of this thesis, we present a sample application of these techniques to electrocorticography data collected during an overt reading task. We discuss the challenges that arise with task-related human data, which is often noisy and underpowered, and present functional connectivity results in the context of traditional and contemporary within-electrode analytics. In two of nine subjects we observe time-domain and frequency-domain network changes that accord with theoretical models of information routing during motor processing.

Taken together, this work contributes a methodological framework for inferring task-related functional connectivity across spatial and temporal scales, and supports insight into the rapid, dynamic functional coupling of human speech.