Boston University Graduate School of Arts & Sciences

705 Commonwealth Avenue
Boston, Massachusetts 02215

BOSTON UNIVERSITY

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

CANDIDATE: **NAN JIA**

DEPARTMENT OR DIVISION: Cognitive and Neural Systems

TITLE OF DISSERTATION: **"DEVELOPING AN OCULOMOTOR BRAIN-COMPUTER INTERFACE AND CHARACTERIZING ITS DYNAMIC FUNCTIONAL NETWORK"**

DATE, TIME, AND PLACE OF EXAMINATION: Friday, December 9, 2016; 1:30pm
Room B02;
677 Beacon Street, Boston MA

EXAMINING COMMITTEE

FIRST READER: Frank Guenther

SECOND READER: Daniel Bullock

THIRD READER: Arash Yazdanbakhsh

CHAIR OF THE EXAMINING COMMITTEE: Eric Schwartz

ADDITIONAL COMMITTEE MEMBERS: Mark Kramer
Earl Miller

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

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

DEVELOPING AN OCULOMOTOR BRAIN-COMPUTER INTERFACE AND CHARACTERIZING ITS DYNAMIC FUNCTIONAL NETWORK

NAN JIA

Boston University Graduate School of Arts and Sciences, 2016

Major Professor: Frank H. Guenther, Ph.D., Professor of Speech, Language, and Hearing Sciences and Biomedical Engineering

ABSTRACT

To date, invasive brain-computer interface (BCI) research has largely focused on replacing lost limb functions using signals from hand/arm areas of motor cortex. However, the oculomotor system may be better suited to BCI applications involving rapid serial selection from spatial targets, such as choosing from a set of possible words displayed on a computer screen in an augmentative and alternative communication application.

First, we develop an intracortical oculomotor BCI based on the delayed saccade paradigm and demonstrate its feasibility to decode intended saccadic eye movement direction in primates. Using activity from three frontal cortical areas implicated in oculomotor production – dorsolateral prefrontal cortex, supplementary eye field, and frontal eye field – we could decode intended saccade direction in real time with high accuracy, particularly at contralateral locations. In a number of analyses in the decoding context, we investigated the amount of saccade-related information contained in different implant regions and in different neural measures. A novel neural measure using power in the 80-500 Hz band is proposed as the optimal signal for this BCI purpose.

In the second part of this thesis, we characterize the interactions between the neural signals recorded from electrodes in these three implant areas. We employ a

number of techniques to quantify the spectrotemporal dynamics in this complex network, and we describe the resulting functional connectivity patterns between the three implant regions in the context of eye-movement production. In addition, we compare and contrast the amount of saccade-related information present in the coupling strengths in the network, on both an electrode-to-electrode scale and an area-to-area scale. Different frequency bands stand out during different epochs of the task, and their information contents are distinct between implant regions. For example, the 13-30 Hz band stands out during the delay epoch, and the 8-12 Hz band is relevant during target and response epochs.

This work extends the boundary of BCI research into the oculomotor domain, and invites potential applications by showing its feasibility. Furthermore, it elucidates the complex dynamics of the functional coupling underlying oculomotor production across multiple areas of frontal cortex.