INTRODUCTION

Amyotrophic lateral sclerosis (ALS) is the most common adult motor neuron disease with a lifetime risk of approximately 1 in 10,000 people. One of the most notable features of ALS is its rapid progression, leading to muscle weakness and ultimately to death by respiratory failure. People with severe movement impairations from ALS or other conditions can benefit from interfaces that can operate without patient physical movement, called a brain-computer interface (BCI). To assess viability of using motor imagery for brain-computer interfaces, we collected real and imagined motor task time-series data using functional magnetic resonance imaging (fMRI). This study aims to evaluate the feasibility of using fMRI and SVM methodologies for developing real-time brain-computer interfaces.

METHODS

ALS participants were recruited through the Motor Neuron Clinic at the University of Michigan. Healthy control participants were recruited through the local community. The study was approved by the University of Michigan Institutional Review Board (HUM000219).

RESULTS

Cross-sectional Analysis

Each set of 136 volume time-series data were split into two-halves. To remove the common visual-cortex response from the time-series data we explicitly masked the cortex, removing the visual area, the cerebellum and bulk-white matter using the WFU PickAtlas tool in SPM2. To assess accuracy of SVM determination of brain-state, we trained the SVM on the first half -- Real #1 -- of the overt motor task as well as the first half -- Imagined #1 -- of the motor imagery task. We then tested the overt-task SVM predictions against the second half of the overt motor task (R2) and independently against the two halves (I1 and I2) of the motor imagery task. The motor imagery was also used to train and subsequently test the two halves (I1 vs I2) of that run:

Longitudinal Analysis

A total of 3 sessions were acquired. First two sessions were within 2 weeks. The healthy control participants subsequently returned 6 months later, while the ALS participants returned 3 months later for their third session. All imagining parameters and experimental parameters were identical across all three sessions. Training utilizes all 136 (censored) time-points. Testing used all 136 (censored) time-points.

SVM training/testing could be performed based on a variety of data sets:

Pre-processing

• Omitted physiological correction and slice-timing correction
• FLS 4.1.7: mcFlirt – realignment
• SPGR: co-registration and spatial normalization
• Removed occipital cortex (WFU PickAtlas)

Support Vector Machine

• AFNI – 3dsvm for training and testing
• Censored: 90%>BOLD=10%

CONCLUSION

We have applied support-vector-machine methodology to determine brain-state in both a healthy-control population and for the first time in an amyotrophic lateral sclerosis patient population, whom can directly benefit from BCI technologies. We have shown that brain-state prediction is relatively stable over a 3-6 month time period since training.

Future Work

We are implementing a project to introduce real-time feedback through the use of real-time fMRI [6].

This work is supported by NIH/NINDS R01-NS052514 and Department of Radiology/University of Michigan BRS Award.

References


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