Temporal Dynamics on Decoding Target Stimuli in Rapid Serial Visual Presentation using Magnetoencephalography

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Introduction

Background

- Rapid serial visual presentation (RSVP) has been widely used in brain-computer interface (BCI) as a high efficient paradigm.
- RSVP-BCI has been applied in many areas such as data categorization, face recognition,speller and website evaluation.

Introduction

Motivation

- Little has been known about the temporal dynamics of the neural activity that triggered by target stimuli in RSVP.
- Besides the successful engineering applications of RSVP-BCI, the underlying neural activity is still unclear.

Introduction

This work

- The temporal dynamic of target event-related responses in a static RSVP paradigm was investigated using paired structural MRI and MEG signal with different frequency bands.
- The MVPA was applied on MEG epoch responses to estimate the decoding power dynamic.

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Task Design

- Recruited 10 college students (7 males and 3 females, aged 23.79$\pm$3.6).
- During a block, 100 pictures were shown to the subject in random ordered sequences at a rate of 10 Hz.
- The chance of target pictures (odd ball) was set to 4%.

Figure: Target picture

Figure: Non-target picture

MEG and MRI acquisition

- MEG data were scanned with a whole-head CTF MEG system with 272 channels at the MEG Center of Institute of Biophysics, Chinese Academy of Sciences.
- MRI data were scanned with a 3.0 T MRI scanner.
- The MRI Center of Institute of Biophysics, Chinese Academy of Sciences.

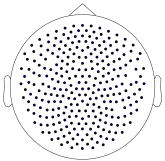

Figure: 272 MEG sensors

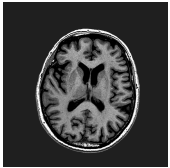

Figure: MRI image

MEG Preprocessing

- The MEG data were preprocessed using *MNE* software.
- Suppressing artificial noise using ICA method. The artificial sources were zeroed out from raw data.
- The bands used in this research were Delta, Theta, Alpha bands, and two custom bands: U07 and U30 band.

Table: Filter bands

Filter Name	**Freq band**
Delta	$1 - 4Hz$
Theta	$4 - 7Hz$
Alpha	$8 - 12Hz$
U07	$0.1 - 7Hz$
U30	$0.1 - 30Hz$

MVPA

- Feature extraction was applied to training data, using xDAWN algorithm. Number of components was set as 6.
- Support Vector Machine (SVM) was applied as classifier.
- The MVPA was applied in a 10-folder cross-validation protocol. In each folder, we use one run as testing data and others as training data.

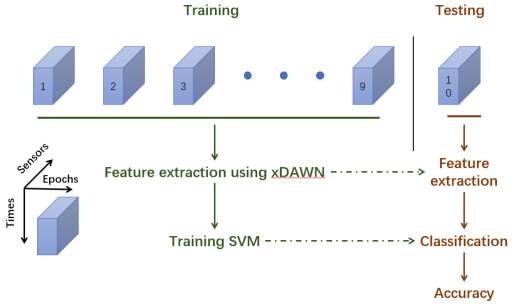

Figure: Cross validation process

Cortical Neuronal Activation Estimation

Surfaces The subject-specific cortical surfaces were build based on the MRI data using *freesurfer* software.

Model A forward model was calculated to project the MEG data into cortical surfaces using the *'oct6'* space.

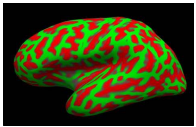

Figure: Surface

Table: oct6 space

Spacing	Value
Sources per hemisphere	4098
Source spacing (mm)	4.9
Surface area per source (mm^2)	24.0

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MEG Signal Visualization

We plot the evoked response of target pictures:

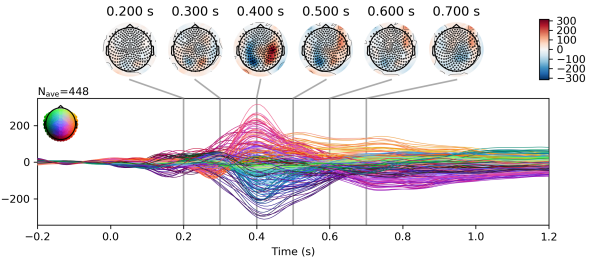

Figure: Evoked of U07 band

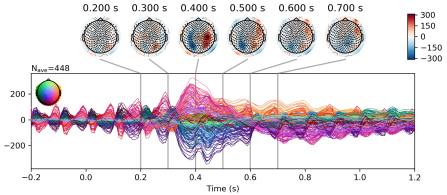

Figure: Evoked of U30 band

MVPA Scores

The band of *U07* yields highest classification scores:

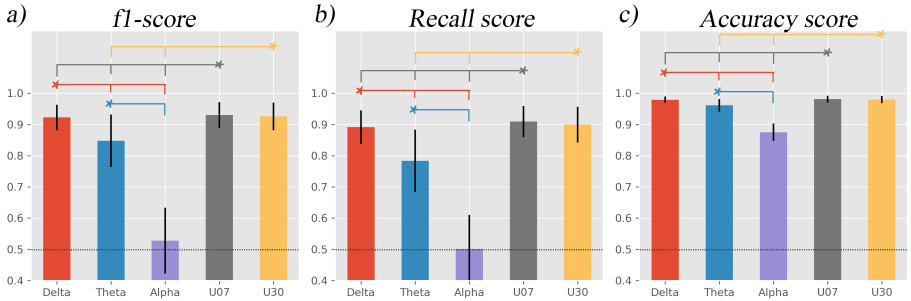

Figure: Scores across different bands

MVPA Scores

The sources in temporal resolution:

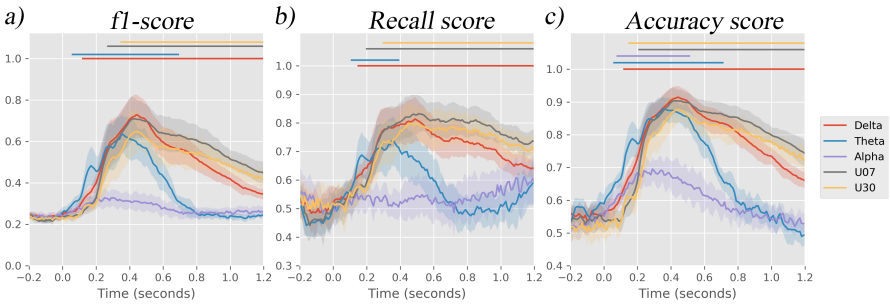

Figure: Scores in temporal resolution

Cortical Neuronal Activation

The activity in surfaces:

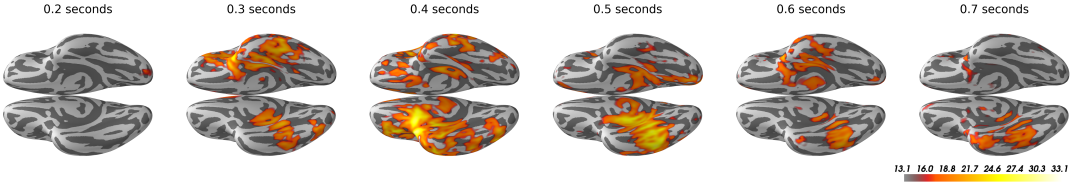

Figure: Activity in surfaces

Cortical Neuronal Activation

The activity in surfaces:

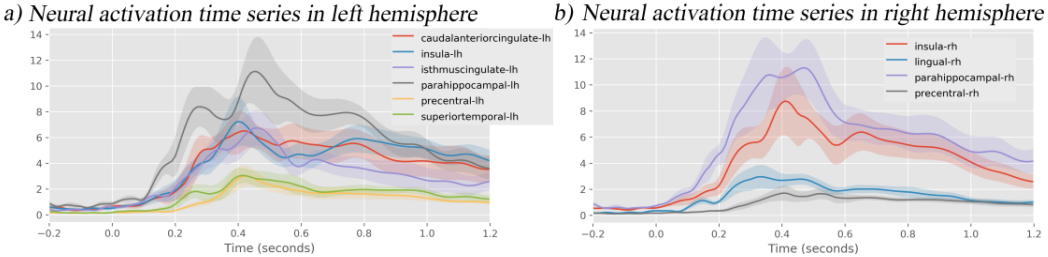

Figure: Activity in surfaces

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Conclusion

- The temporal dynamic of target event-related responses in a static RSVP paradigm was investigated using MEG signal with different frequency bands.
- The MVPA results showed that the *U07* band signals ($0.1 - 7Hz$) yielded highest decoding accuracy, and further uncover the decoding power dynamic reached its peak at around 0.4 second after target stimuli onset.
- The cortical neuronal activation identified the target stimuli triggered regions, like *bilateral parahippocampal cortex*, *precentral gyrus* and *insula cortex*.

Acknowledgements

Big thanks