

Summary of Project

Shaun¹

¹Monash University

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Abstract

This is an abstract to summarise the work to be done in TMS-EEG

Introduction

Project aims to test the causal role of **attention selection** in human decision-making. It will use **multi-modal techniques** from cognitive neuroscience while participants perform a decision-making task.

Outcome: understanding of neural processes by which **attention** influences **decision-making**.

Importance: decision making compromised in a variety of everyday circumstances and enhancing attention may prove a viable remedial (improving deficient skills) strategy. Project will benefit the knowledge base of cognitive neuroscience, identification of strategies that can enhance attention and mitigate (make something less severe) the negative effects of poor decision making processes across different settings.

Project Description: Establishing the causal influence of attentional selection on perceptual decision making

Decision neuroscience characterizes the core neural mechanisms underpinning perceptual decision making process. It has established the central role of 'decision variable' signals that accumulate sensory evidence and trigger action upon reaching a decision bound.

These decision processes do not operate in isolation and research is needed to understand how they interact with other brain systems that support choice behaviour. One well-established phenomenon is the benefit to perception afforded by directing spatial attention to target location. Attempt to establish the relationship between attention and decision making.

Use of innovative electrophysiological paradigms to finely trace the level of information processing necessary when humans make decisions. These levels extend from sensory encoding through evidence accumulation, motor preparation, and activation of **decision-reporting effector** (EMGs, muscle movements).

CPP may reflect an intermediate evidence accumulation processing stage between sensory encoding and effector-selective decision signals and the signals may be sourced from the *inferior parietal lobule (IPL)*.

Previous Work

identification of an *early target selection signal*, with a *lateral occipito-temporal cortex (LOTc) topography*, that precedes the CPP. This signal, termed as the N2, predicts the onset and the build-up rate of the CPP.

It highlights a role for N2 in influencing the decision-making process, but the full extent is yet to be established.

It is found that N2 occur earlier for targets in the left compared to the right hemifield, correlating the the left and right reaction time. (to be checked with distractor data).

The asymmetry in CPP onset shows the idea of **cerebral lateralisation of visuospatial attention** (i.e. Right hemisphere dominance for **visuospatial attention** is characteristic of most human, since the left occurs faster).

1 Aims and Background

Establish the causal influence of attentional selection in human perceptual decision making. Current relationships are correlational instead of causal. The current project leverages the techniques to include dTMS combined with EEG in order to dissociate the relationship between N2 and CPP.

1. Determine the N2 and CPP EEG latency at individual level
2. dTMS at the LOTC and IPL at N2 and CPP latencies. the impact of dTMS on RT and EEG are also monitored

Hypotheses

The hypotheses are

1. Disruption of IPL at CPP will impact evidence accumulation
2. Disruption of LOTC at N2 will impact target selection, reduce N2 amplitude and slow RT
3. Effect of disruption of the N2 on Rt will be mediated by the CPP
4. Disruption on the right hemisphere will asymmetrically disrupt behaviour (slow left hemifield RT and CPP) but will not be as strong in left-hemisphere sites

Background

Perceptual decision making is a fundamental component of any task in which sensation must be translated into action. The question of how spatial attention might impact on the neural decision process has rarely been considered.

A novel EEG paradigm is able to isolate and independently monitor discrete brain signals that can be unambiguously linked to the neural substrates (underlying substance or layer) of perceptual decisions.

These include signals that directly index sensory encoding, target selection, decision making, motor preparation and action execution, as well as distribution of attention across the visual field and across time.

Damage to one or more of these mechanisms can result in difficulty orienting in space, and therefore the ability to measure each of these processes separately is of paramount importance.

The paradigm innovation employed is composed of the following:

1. Utilisation of a steady-state stimulation techniques in which stimuli are flickered at a fixed rate, generated a band-limited response in the EEG
2. Devisation of a range of tasks in which target identity could only be determined by monitoring continuously presented stimulus streams for gradual stimulus changes. The absence of any sudden stimulus onsets (i.e. the dots are on all the time) eliminates sensory evoked deflections in the event-related potential trace, and revealed a CPP and N2.
3. the preparation and decision-reporting actions can be captured by the LRP and the contralateral mu rhythm and beta-band (8-33Hz) activity.
4. The extent of bias to one side of the visual field can be quantified by measuring the relative hemispheric distribution of posterior alpha-band activity prior to the target onset.

Conclusions from previous work are summarised as follows.

1. the presence of CPP decision signal and the presence of the N2c and the N2i. The peak latencies of the N2s are more closely aligned to the onset of the coherent motion than response execution.
2. the amplitude of N2c, not the N2i, scaled with response time and detection rate
3. the N2c is correlated with onset and build-up rate of the CPP.

The N2i and N2c are occipito-temporal topography which are similar to the N2p. However, the N2cs and N2is are hemispheric specific signals at single trial level. Nevertheless both identifies the LOTC as the generator of the N2pc and the target selection activity.

Utility of using hemispheric specific selection signals in understanding the role of spatial attention in decision making - note that this is to distinguish between N2s and N2pcs

Hemispheric Asymmetries in neglect Visuospatial attention is long held to be lateralised to the right hemisphere. Pseudoneglect is also seen in healthy individuals in the form of subtle processing advantages for stimuli presented to the left hemifield. In previous DP, the lateral biases of spatial attention is established as

1. hemispheric asymmetry in posterior alpha power measured prior to target onset, reflecting a bias in distribution of attention
2. asymmetry in the peak latency of N2c
3. asymmetry in CPP onset time

EEG and fMRI studies of the random dot motion task are observed in both the LOTC and IPL. The MNI (fMRI image) coordinates are consistent with the lateral occipito-temporal cortex as evidenced by EEG, MEG and fMRI of humans and primates for attentional selection.

Objective

- Disruption of sites over the left and right hemisphere while EEG is recorded and observe the hemispheric differences in attentional selection and decision making.
- Demonstrate the utility of target neuro-disruption via TMS to the putative (generally considered) anatomical sources of N2c and CPP
- By alternately disrupting within temporal windows of N2c and CPP, establish the causal role of N2c and CPP in behaviour.
- Show the disrupting of N2c on behaviour is mediated through the influence of N2c on CPP.
- Utility in understanding dissociable neural contributions to spatial attention deficits including spatial neglect, ADHD (attention deficit disorder) and dyslexia.

Method

Three sessions:

1. High resolution structural MRI images will be obtained to localise the LOTC and IPL at subject level.
 - (a) T1 image: repetition time = 2300ms, echo time = 2.98ms, 0.5x0.5x0.5 voxels
2. EEG used to determine the N2 latency and CPP components
 - (a) Baseline: normal methods, using 65/65 cap electrodes, digitised at 1000Hz, epochs between 750 and 2000ms
3. MRI image guided disruptive TMS to LOTC (N2 latency)
 - (a) T1 will be imported to the Brainsight Neuronavigation system, segmented and then will calculate the transformation between MNI coordinated and individual subject space.
 - (b) MNI is used to constrain the targeting of the dTMS to anatomical regions
 - (c) display the location and orientation of TMS coil in real time on the MRI of the subject on screen, placement on the LPTC using the MNI coordinates and transformed to subject coordinate space.
4. (not done) MRI image guided disruptive TMS on IPL (CPP latency).

Participants: 40, 18-45, right handed, no contraindication to TMS or MRI. Excluded if psychiatric illness, neurologic illness, drug dependency, and use psychoactive medications Linear mixed-effect modelling and maximum likelihood ratio tests to examine the effects,

Foreseeable problems

- N2s are on both two sites depending on the location of the target, stimulus needs to account for both - need two coils to get this right since need to stimulate at both sites simultaneously to avoid the participant predicting where the target will take place

- Need to make the TMS not affect the participant's concentration, ie do not give them clues as to when the stimulus occurs. Need to program the stimulus to trigger in accordance with the dots motion (I think that is possible already)