Dissociating prediction and attention in the brain: a combined TMS-EEG study

Published: 08-07-2009
Last updated: 04-05-2024

The main objective is to test the hypothesis that predictions are implemented in the human brain by modulating the strength of backward connections from higher-order to lower-order areas. This modulation of effective connectivity will be assayed by...

Ethical review	Approved WMO
Status	Pending
Health condition type	Other condition
Study type	Interventional

Summary

ID

NL-OMON32937

Source
ToetsingOnline

Brief title
Prediction and attention: a TMS-EEG study

Condition

- Other condition

Synonym
n.v.t.

Health condition

niet van toepassing

Research involving
Human

Sponsors and support

Primary sponsor: Radboud Universiteit Nijmegen
Source(s) of monetary or material Support: Ministerie van OC&W

Intervention

Keyword: anticipation, attention, TMS, visual perception

Outcome measures

Primary outcome

The effect of TMS on the three stimulation sites will be assessed using concurrently measured EEG. We will test whether stimulation to LOC, OFA, and vertex differentially affect the TMS-induced evoked potential, as a function of predictability and attention. We hypothesize that predictability will lead to a strengthening of backward connectivity (Friston 2005), in a stimulus-specific manner and irrespective of the attentional set. Attention is hypothesized to have an additive effect on backward connection strength that does not interact with predictability (Morishima, Akaishi et al. 2009).

Secondary outcome

We will also measure behavioural performance (reaction times and error rates) during the experiment, as the subjects task is to respond as quickly as possible to one of the two shapes. We will probe whether, at the low intensities of TMS applied, the RT gain for anticipated stimuli will be diminished or abolished by TMS intervention.

Study description

Background summary

It is thought that one of the fundamental organization principles of the brain is the ability to predict upcoming events in the environment (Rao and Sejnowski 2002; Friston 2005; Bar 2007; Enns and Lleras 2008). For example, when you grab a cup of coffee, your brain predicts how your hand is moving through space, and how the coffee cup will feel when you have grabbed it (Blakemore, Goodbody et al. 1998; Wolpert and Ghahramani 2000). When the coffee cup feels different than you had expected (e.g., cold when you thought the coffee was still hot), you immediately notice something isn*t quite right. Predictions thus allow the brain to ignore predictable (and therefore uninteresting) events in the environment, while enhancing the saliency of new, unexpected events. Using prior knowledge to predict upcoming events also has substantial computational advantages, effectively constraining the vast amount of incoming sensory information by our predictions.
Predictive mechanisms have been observed at many stages of neural information processing, ranging from the retina (Srinivasan, Laughlin et al. 1982; Hosoya, Baccus et al. 2005) and primary sensory cortices (Sharma, Dragoi et al. 2003; Naatanen, Jacobsen et al. 2005) to higher-order perceptual regions (Summerfield, Trittschuh et al. 2008). In fact, many neurocognitive phenomena like the suppressed activity for expected simple visual (Summerfield, Trittschuh et al. 2008), auditory (Naatanen, Jacobsen et al. 2005) or somatosensory (Blakemore, Frith et al. 1999; Voss, Ingram et al. 2006) events, and the enhanced activity for unexpected linguistic events (Kutas and Hillyard 1980; Hagoort, Hald et al. 2004) can all be seen as activity modulations related to prediction and prediction error.
Although predictive mechanisms appear to play a large role in shaping our perception, cognition and action, it is largely unclear how such mechanisms are implemented in the brain. A recent framework - known as *predictive coding* - provides a good working hypothesis. In this framework, it is proposed that prior knowledge allows the generation of expectations at multiple hierarchical levels in the neocortex (Mumford 1992; Hawkins 2004; Friston 2005). Expectation-related information (predictions) is fed back to preceding cortical areas, such that feedforward sensory input is interpreted at each cortical stage within the context of the prior expectation (Rao and Ballard 1999; Rao and Sejnowski 2002) (see Figure 1). This framework has recently received increasing empirical support (Summerfield, Egner et al. 2006; Garrido, Kilner et al. 2007; den Ouden, Friston et al. 2008).

One key hypothesis of predictive coding is that higher-order regions in the cortical hierarchy try to predict their input via feedback connections (Hawkins 2004; Friston 2005). In this project, we will test this hypothesis by assessing feedback connection strength as a function of prediction and attention. Subjects will be trained to expect either faces or objects on a trial-by-trial level by a predictive cue. Moreover, they will have to make a judgment on one of the categories, thereby manipulating attention. Just before presentation of the stimulus, a low intensity TMS pulse will inject current in the occipital face area (OFA, a higher-order visual area involved in the representation of faces)(Pitcher, Charles et al. 2009) or the lateral occipital complex (LOC, a

higher-order visual area involved in the representation of objects) during various levels of anticipation and attention to motion, and the consequence of the injected current on downstream areas will be registered using EEG (Morishima, Akaishi et al. 2009). This allows us to trace signal transmission from higher-order to lower areas in the cortical hierarchy as a function of prediction and attention.

Study objective

The main objective is to test the hypothesis that predictions are implemented in the human brain by modulating the strength of backward connections from higher-order to lower-order areas. This modulation of effective connectivity will be assayed by investigating TMS-locked evoked potentials in the occipital cortex.
The secondary objective is to dissociate the relative contribution of prediction and attention, two key forms of top-down influence on visual processing, within the same paradigm. We will be able to orthogonally manipulate these two factors by varying predictability and relevance of the stimuli.

Study design

The study is designed as a crossover experiment with healthy adult volunteers.

The study will investigate the role of LOC and OFA during expectation of visual stimuli of faces and objects. Stimulation of both regions will be compared to vertex stimulation. We expect that stimulation of LOC and OFA will lead to larger visual evoked potentials during anticipation of objects and faces, respectively. This effect is expected independently of the relevance of the stimuli. Furthermore, we expect a modulation of TMS-induced visual evoked potentials by relevance: attending to objects/faces will lead to a larger TMS-induced potential over LOC/OFA, irrespective of whether this stimulus category is anticipated.

Subjects will come for a total of four sessions - one session to acquire the anatomical image of the brain and establish the active motor threshold (see below), and one session for each of the three targets regions: LOC, OFA, and vertex.
Prior to the experiment, participants are informed about the study in detail and about the possible risks. They are screened using a questionnaire to ensure their eligibility for participation. In the first session of the pilot experiment, participants will practice with the behavioural task. Afterwards, we will establish subjects* active motor threshold (aMT) as determined using TMS pulses. The aMT is defined as the lowest TMS intensity needed to evoke a reproducible and measurable (with electromyography) muscle twitch in the first dorsal interosseus of the right hand (Rossini et al. 1994). The aMT provides an

indication of the excitability of a participant*s brain and will be used to determine the stimulation intensity in the later TMS sessions.
In sessions 2-4, participants receive single TMS pulses at 80% of the participant*s aMT to LOC, OFA and vertex, respectively. The placement of the coil will be guided an anatomical MRI scan of the individual subject. The stimulation locations will be determined using the BrainSight TMS-MRI co-registration system. This system allows to navigate the TMS coil in relation to the individual anatomical MRI in real-time with millimetre accuracy. Each session will consist of 2 expectancies (predicted, unpredicted) X 2 stimulus types (faces, objects) X 2 attentional levels (attended, unattended) X 50 trials. Each trial is expected to last 5 sec. The participant will therefore receive 400 pulses to the stimulated site, over a period of 45 minutes, including several breaks. Sessions 2,3, and 4 are spaced at least 7 days apart and will be counterbalanced across subjects.

Intervention

We will use single-pulse TMS during the anticipitory phase of the experiment, and we will measure brain activity with help of EEG. Earlier studies have shown the effectivity of this set-up, using low intensity single-pulse TMS (80% of aMT)(Morishima et al 2008).

Study burden and risks

The magnetic field used during the experiment are of limited size and short duration, and there is no indication of an influence on health. Because we will use single-pulse TMS with a low intensity (80% of aMT), the burden and risks are negligible.

Contacts

Public
Radboud Universiteit Nijmegen

Postbus 9101
6500 HB Nijmegen
Nederland
Scientific
Radboud Universiteit Nijmegen

Postbus 9101
6500 HB Nijmegen
Nederland

Trial sites

Listed location countries

Netherlands

Eligibility criteria

Age
Adults (18-64 years)
Elderly (65 years and older)

Inclusion criteria

Right-handed individuals, with normal or corrected-to-normal vision and no history of neurological or psychological disorders are included.

Exclusion criteria

- Pacemaker
- Metal parts in head or mouth
- History of brain surgery
- History of epilepsy or first-grade family member with epilepsy
- Psychological or neurological disorder
- Pregnancy

Study design

Design

Study type:	Interventional
Intervention model:	Crossover
Masking:	Open (masking not used)
Control:	Uncontrolled

Recruitment

NL

Recruitment status:	Pending
Start date (anticipated):	01-07-2009
Enrollment:	40
Type:	Anticipated

Medical products/devices used

Registration:	No

Ethics review

Approved WMO

Date:	08-07-2009
Application type:	First submission
Review commission:	CMO regio Arnhem-Nijmegen (Nijmegen)

Study registrations

Followed up by the following (possibly more current) registration

No registrations found.

Other (possibly less up-to-date) registrations in this register

No registrations found.

In other registers

Register	ID
CCMO	NL27976.091.09