Mind Reading: Real time decoding of visual perception and imagery

Adnan Niazi[1,2], Philip van den Broek[2],
Mannes Poel[1], Peter Desain[2], Marcel van Gerven[2]

[1]Human Media Interaction Group, Faculty of EEMCS, University of Twente
[2]Donders Center for Cognition, Radboud University, Nijmegen
email: adnaniazi@gmail.com

Introduction

Imagery or 'seeing through the mind's eye' is one of the fundamental facilities humans use to make sense of the world around them. Remarkably, visual imagery engages many of the same cognitive and neural mechanisms that are involved during visual perception (O' Craven et al., 2000).

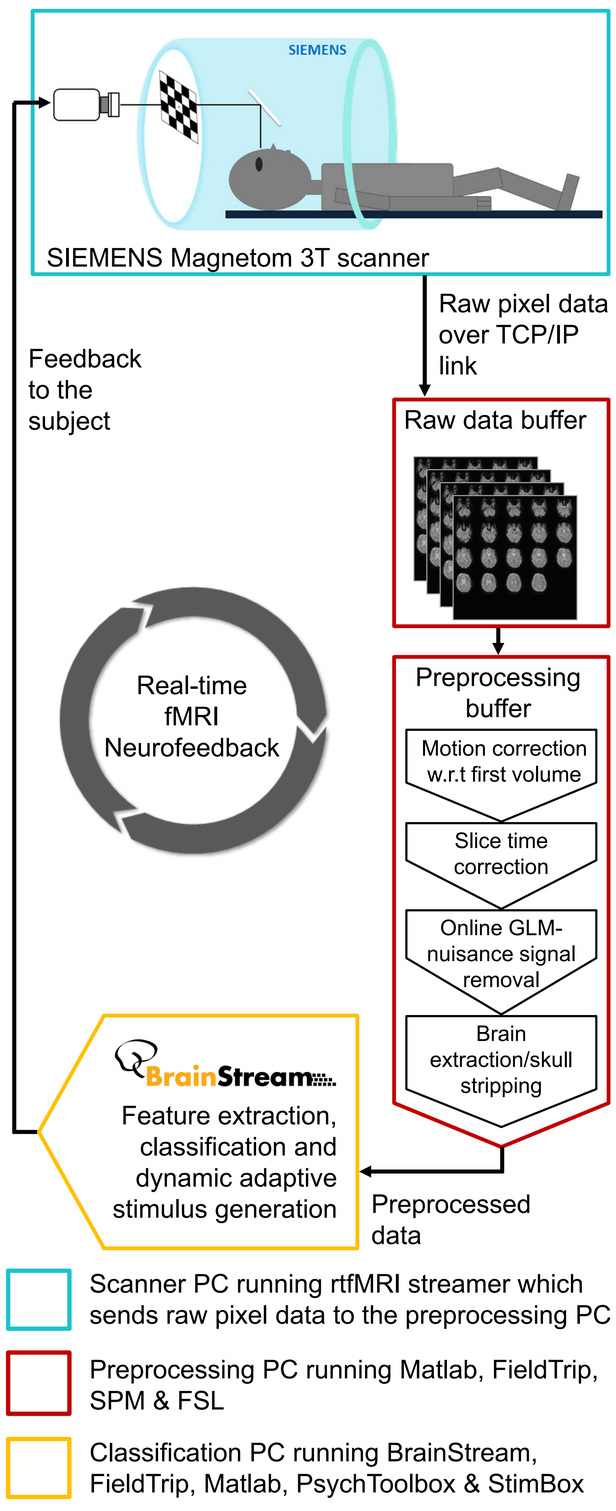
Because visual perception and imagery share the same neural substrates, any decoder trained on perceived stimuli can also be used to decode imagined percepts as well.

In this fMRI study, we train an elastic net logistic regression classifier on perceived stimuli and use it to decode imagined stimuli. Decoding of perception and imagination is done in real time using rtfMRI pipeline developed at the Donders Institute. BrainStream toolbox is used to process data and to present stimulus & neurofeedback to the subject.

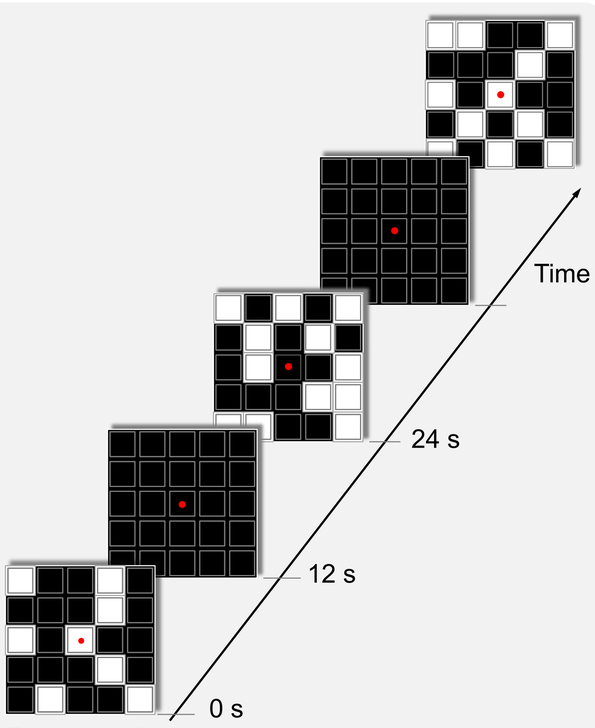
Data Acquisition

- SIEMENS 3T scanner, 32 Channel head coil
- TR = 1500 ms, TE = 30 ms, Flip Angle = 75 °
- 3.3 x 3.3 x 3 mm voxels with 10% dist. factor
- 19 oblique axial slices covering occipital cortex
- Block design with 12 s task and 12 s rest period
- Feedback updated every TR in prediction sessions
- Pipeline delay = 2 TR

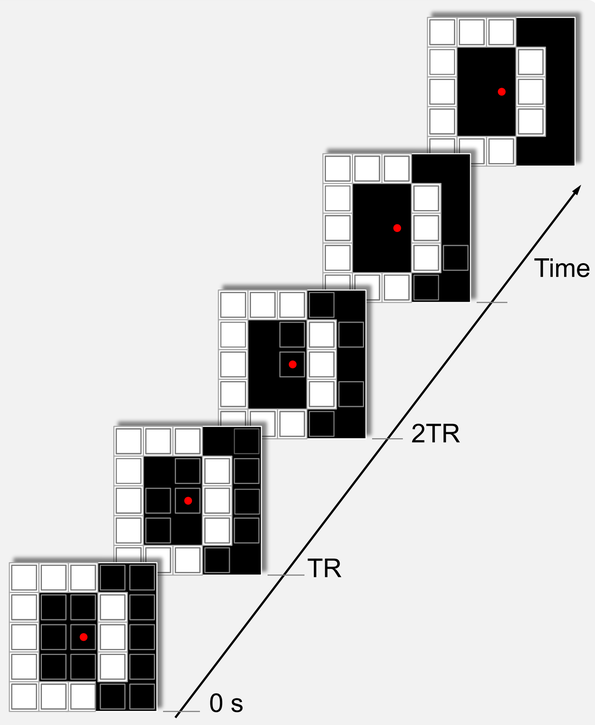
Real-time fMRI setup used for the experiment



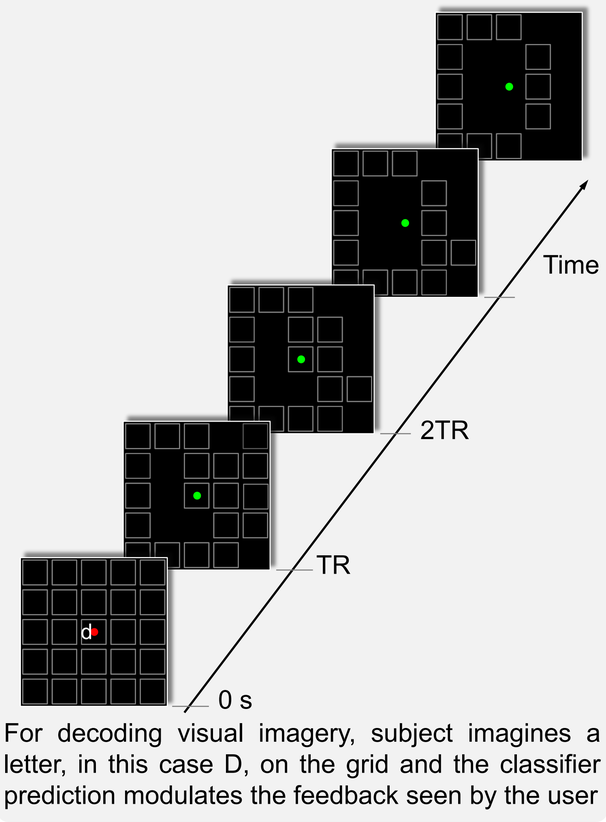
Stimuli



Random flickering checkerboard patterns are used for training the classifier

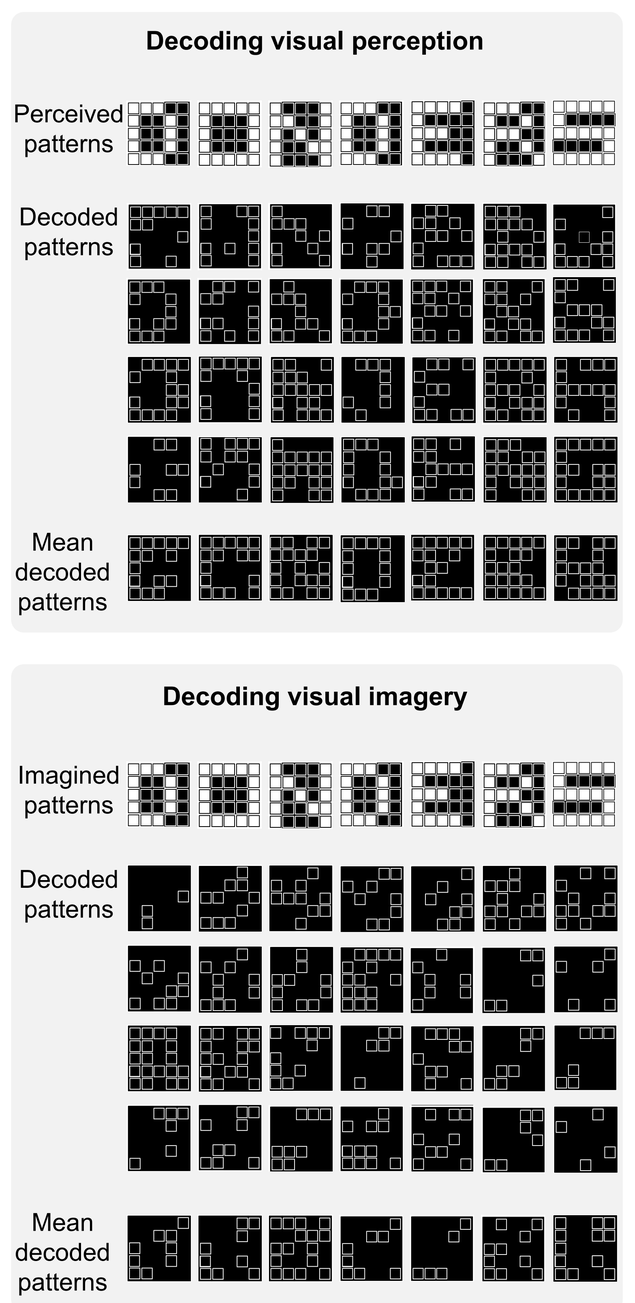


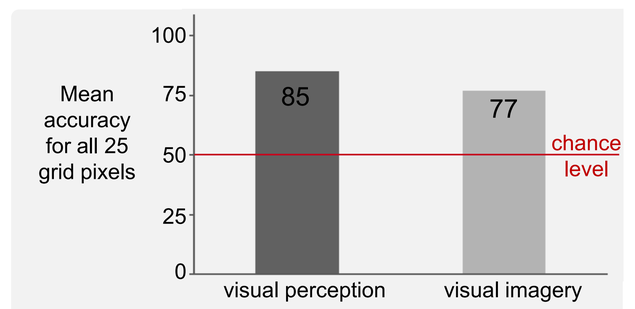
Flickering structured stimuli are used for decoding visual perception. The classifier output is fed back to the subject as shown by empty grey boxes. The prediction improves over time as shown by disappearing grey squares that do not correspond to the perceived stimuli



For decoding visual imagery, subject imagines a letter, in this case D, on the grid and the classifier prediction modulates the feedback seen by the user

Results





Decoding accuracy for visual perception is higher than for visual imagery

Future Improvements

- Incorporating localizer in the real-time pipeline to restrict decoding to retinotopic V1/V2 regions
- Restricting decoding to voxels in grey matter only
- Using Siemens PACE for online motion correction
- Correlating subjects' imagery performance with performance in VVIQ (Vividness of Visual Imagery Questionnaire)

References

O'Craven, K. & Kanwisher, N. (2000) Mental imagery of faces and places activates corresponding stimulus-specific brain regions. *Journal of Cognitive Neuroscience.* 12 1013-1023