Predictive coding in natural environments

Project proposal for fMRI reseacrh @ CCNi

Tuesday 29th January 2008, (draft) *Lars Muckli*

Slide 1. The Problem

With this project we aim to investigate cortical feedback and visual prediction in ***natural visual scenes***.

1.1 Background

In recent years, using simple long range apparent motion stimuli, we have shown that feedback to V1 carries important spatial-temporal information which is predictive for future visual processing. (Muckli et al. 2005, Schwiedrzik 2007)

1.2 Hypothesis

We assume that visual expectancy is altering the processing in early visual areas (V1/V2/V3) even for processing of complex visual scenes!

1.3 Why is it important (what is the projected impact)?

Support for the memory-prediction framework (Jeff Hawkins 2004). A whole theory of the brain central principles are feedback and prediction.

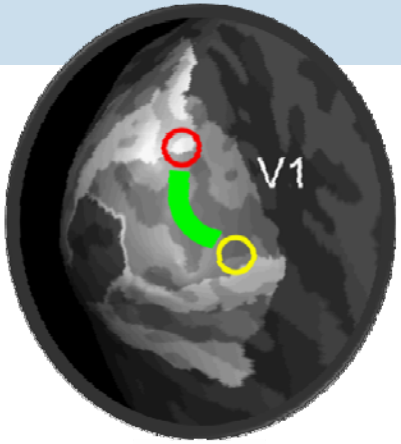
1.4 Envisaged publication?

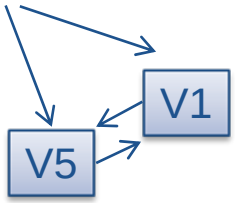
Nature Neurosci. / Neuron / J.Neurosci. (new method *fMRI-prediction*, neuroscience scope)

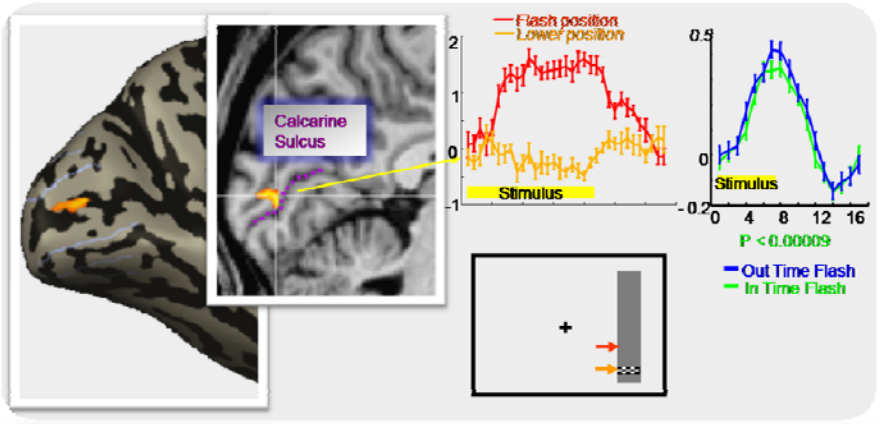
The Problem -Background

- In recent years my group has gathered evidence in favour of a central role of ***feedback*** and ***prediction*** for cortical processing

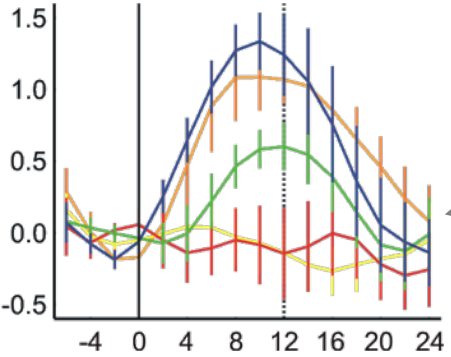
Muckli et al. (2005) PLoS	Wibral et al. (under revision)	Schwiedrzik et al. (2007) Vis Res	Alink et al. (2007) SFN Abstract
BOLD feedback in V1	EEG timing of feedback	functional relevance of prediction	Temporal precise predictions in V1

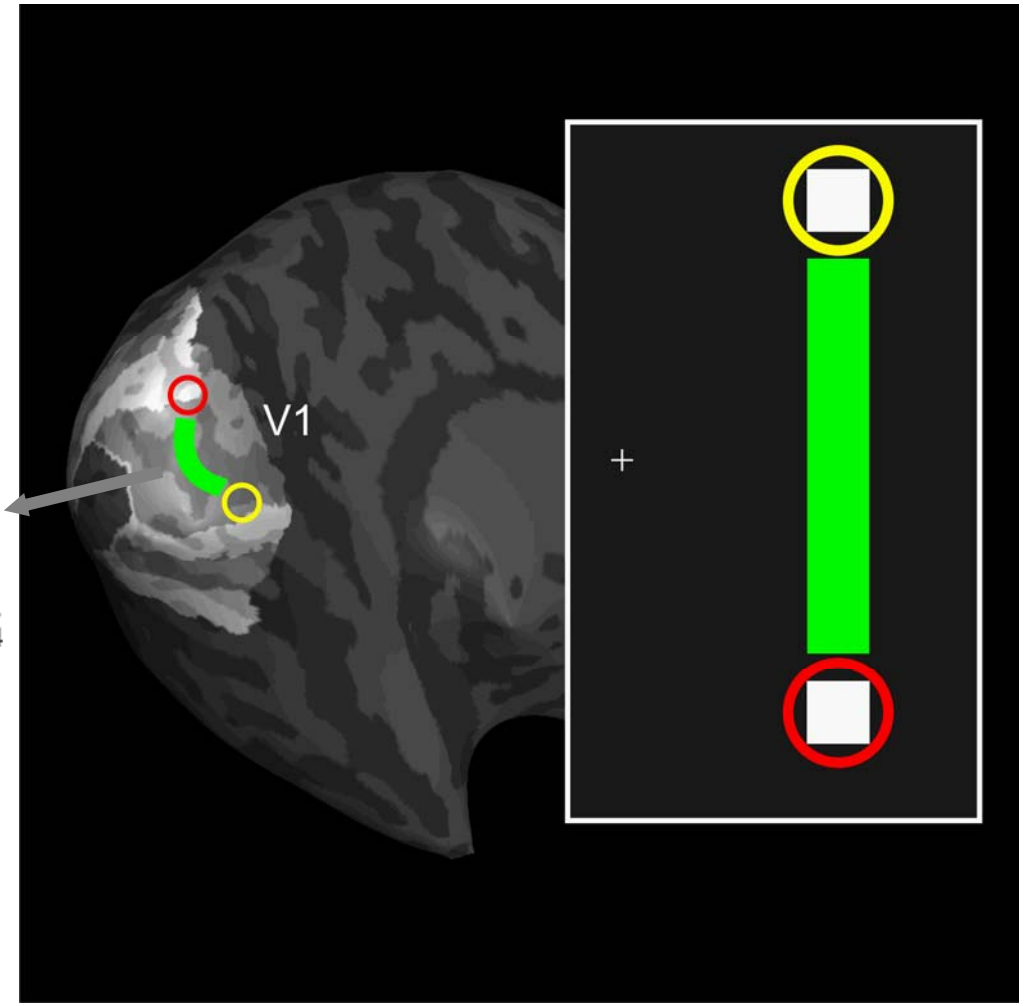


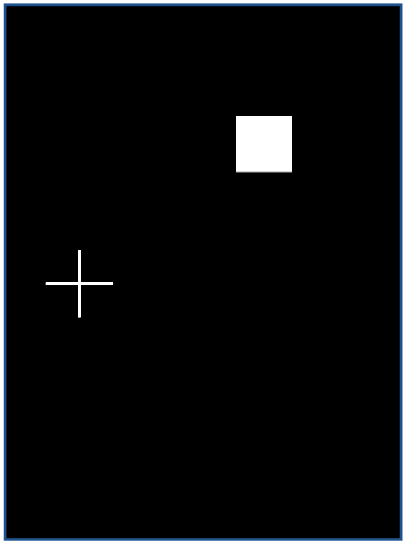




1 The Path of Apparent Motion in Primary Visual Cortex (V1) *(Muckli et al. 2005, PLoS - Biology)*







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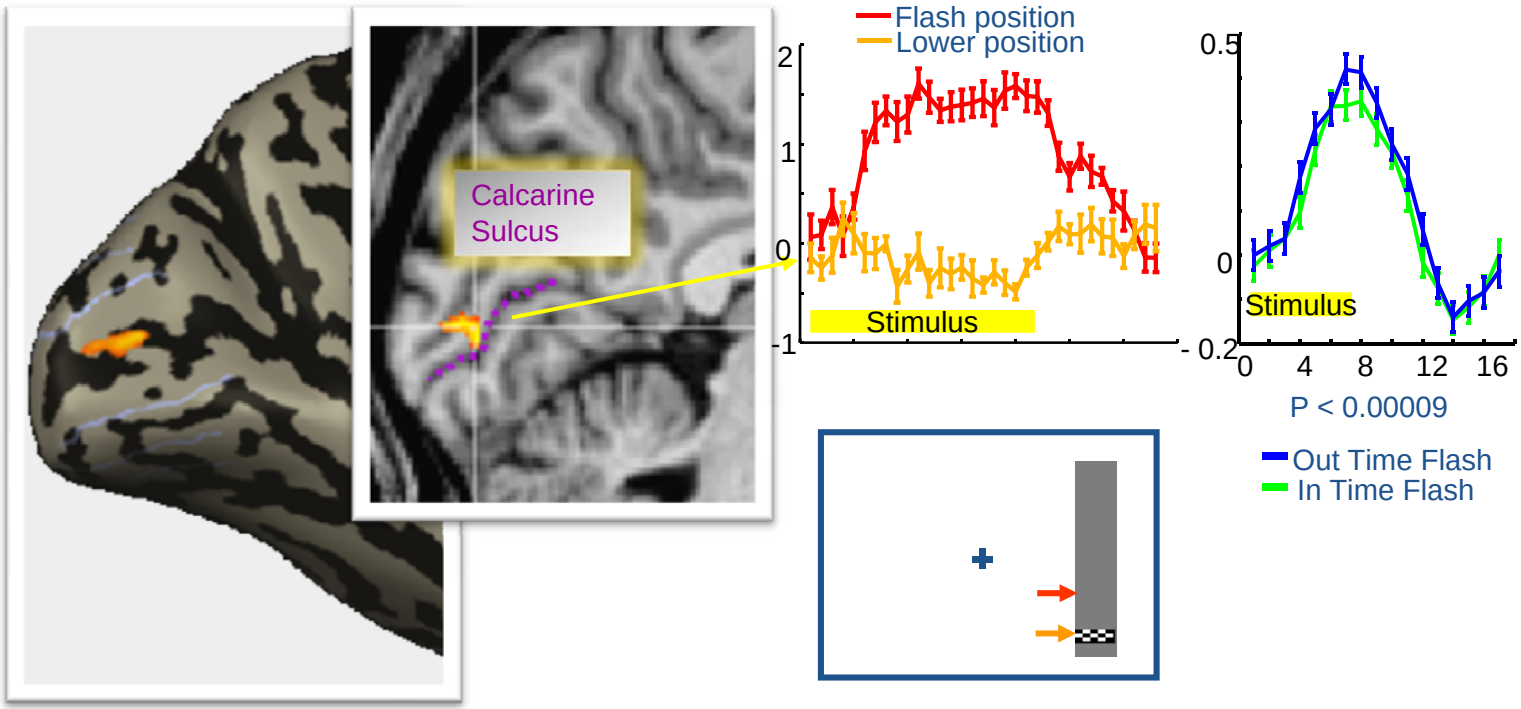
Temporal precise predictions in V1

(Schwiedrzik et al. 2007, Vis Res.; Alink et al under prep. SFN 2007)



Slide 2. Experimental design

Stimulation paradigm:

Sequence of three rapidly presented natural stimuli (apparent motion) that trigger expectation of a 4th stimulus that is presented after a delay and may or may not match the expectation. (Han et al 2006)

2.1 Participants:

15+5 normal subjects

2.2 Conditions:

2x3x2 factorial design. 1) Expectancy vs. no-expectancy. 2) Short-medium- long delay 3) match vs. non-match

2.3 Sequence design:

rapid-event-related, 2 back history controlled

2.4 Control conditions:

detect match versus non-match

2.5 Software:

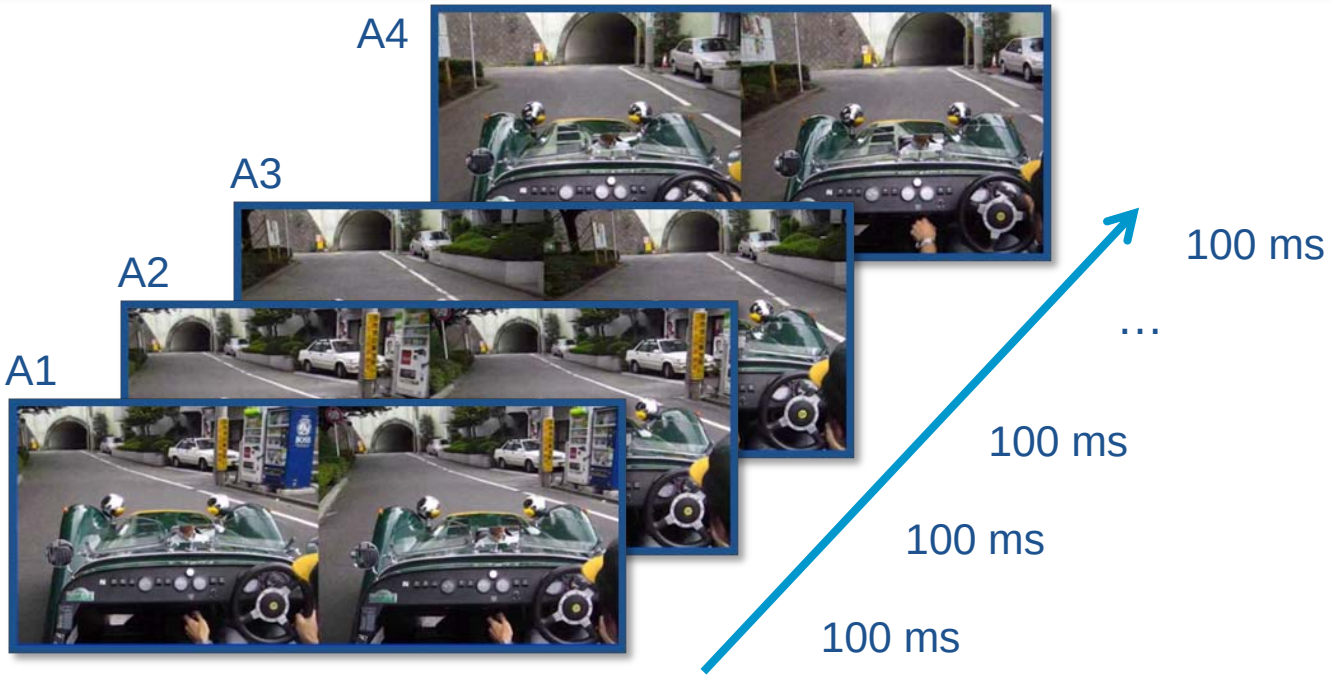
presentation, binocular stimulation –natural 3d visual scenes

2.6 Hardware:

eye-tracker, visual-stimulation, behavioural response

2. Experimental Design
2.0 Stimulation paradigm:

stimulation



Conditions (2x3x2 design)

	Short	Medium	Long
Expectancy (A1-A2-A3)	Match/non-match	Match/non-match	Match/non-match
No Expectancy (A2-A1-A3)	Match/non-match	Match/non-match	Match/non-match

Slide 2. MRI Parameters

2.7 Type of design:

fMRI-prediction (new design) like fMRI adaptation (but stimuli are not repeated but predicted), rapid event-related fMRI. Retinotopic mapping to map ROI in V1, V2, V3.

2.8 Sequences:

Hopefully PSF (Hennig/Speck Freiburg), EPI Sequence with Pace Moco, *IPat 2 (*to be tested)

2.9 Spatial coverage:

Probably 3.2 x 3.2 x 3.2 mm^3 iso-voxel, 16 slices, 10 % gap

2.10 Timing:

TR 1000ms, 448 (7'28'') volumes per run, 6-12 runs, 45'-90' overall duration (2 sessions). For retinotopic mapping TR 2000ms (polar angle: 396 Vol., eccentricity 348) 45'.

2.11 Options:

Eye-tracking (possibly in all subjects or subset). Calibration 15'

Slide 3. Analysis

3.1 Analysis package:

BVQX,

3.2 Retinotopicaly constrained ROI analysis

V1/V2/V3 - complex

3.3 fixed effects design

3.4 Pre-processing details:

No spatial smoothing, High-pass temporal filter etc., as in (Weigelt 2007)

3.5 Analysis strategy:

General Linear Model, Deconvolution of rapid event related fMRI.

3.6 Level of confidence in mastering the above aspects and People involved: Fabiana De Carvalho (Stimpreperation, fMRI Recording, fMRI Analysis, writing) Fraser Smith (Stimulation programming, fMRI recording and analysis) Lars Muckli (planning, supervision, initial recording, Analysis , writing) some training needed (all have prior experience more than one fMRI study completed)

4.1 Expected result

FMRI –PREDICTION

- Time dependent attenuation for predicted stimulus (extrapolated time frame)
  - match < non-match
  - expected < non-expected
- Parametric modulation of effect for
  - short -> medium -> long delay
  - Shorter duration in V1
  - Longer lasting effects in V5

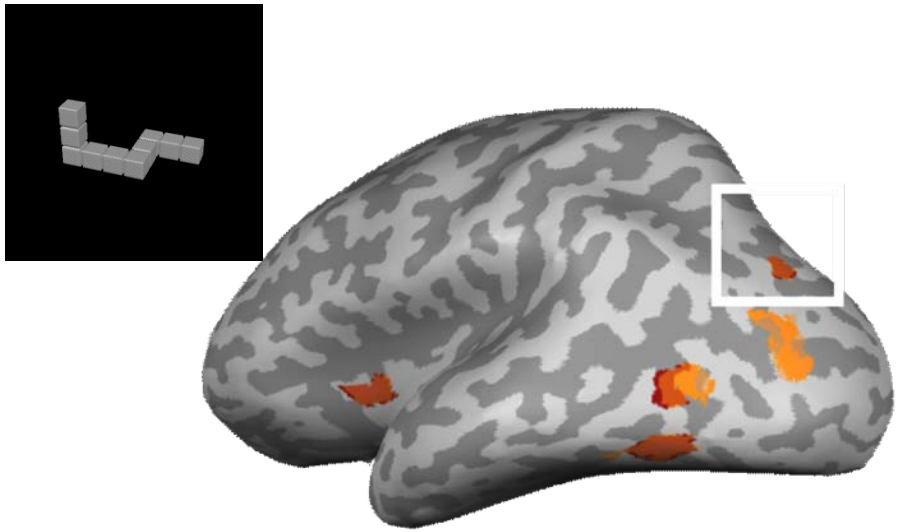
4.5 Strategy

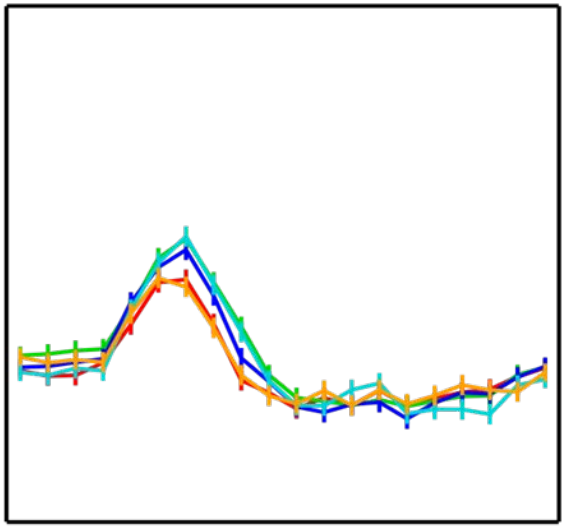
4.5.1 What would be the optimal result (high-risk) :

Match and expectancy effects and parametric effects of delay modulation: BUT parametric variation for fMRI-adaptation is very difficult to observe (see example Weigelt et al. 2007, JNS)

4.5.2 What would be a fallback options if a) does not work?

Adaptation to the predicted scene at least in higher visual areas (spatial invariant processing in LOC, V5). If we do not get signal attenuation from V1 / V2 we can report fMRI-prediction effects in higher visual areas (LOC, V5)





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5. Summary of requested CCNi resources

5.3 scanning hours			Raw	Analyzed
Pilot Experiment	5 subjects 2 h each	10h	10GB	10GB
Main Experiment	15 subjects 2 h	30h	30GB	30GB
Retinotopic mapping	15 subjects 1 h	15h	15GB	15GB
Storage space		55h	55	55

Slide 5. Summary of requested CCNi resources

5.1 Stimulation: - Presentation & NNL-goggles

5.2 Response: 2 button pad

5.3 Number of scanning hours – 55

5.4 Analysis tools – BV

5.5 GRID use – if BV is running on the grid (pending)
110 GB of storage area

Slide 6: Ethics and grant

Ethics: not- yet applied for (revision)

Grant funding:

2007: Applied for European Research Council ERC-startup grant (rejected)

2007: Brazilian post grad studentship grant (Fabiana)

2008: Applied for BBSRC (decision pending)