Automatic response selection - functional imaging of practice effects

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INTRODUCTION

Humans are able to learn and select responses to sensory inputs according to arbitrary rules[1].

This study investigates the changes in BOLD response occurring with practice of a stimulus-response mapping.

Our specific interest is in investigating learning-related changes in the motor cortex, SMA, basal ganglia and parietal cortex.

We used a simple stimulus response selection task a group of volunteers practised over eight days. BOLD signal was measured at the beginning and end of this practice period.

EXPERIMENT

13 subjects (7 female), right handed, aged 18-38 years

Stimulus response selection task

4 stimuli, 4 responses, each shape mapped onto a button press with one finger

Practice

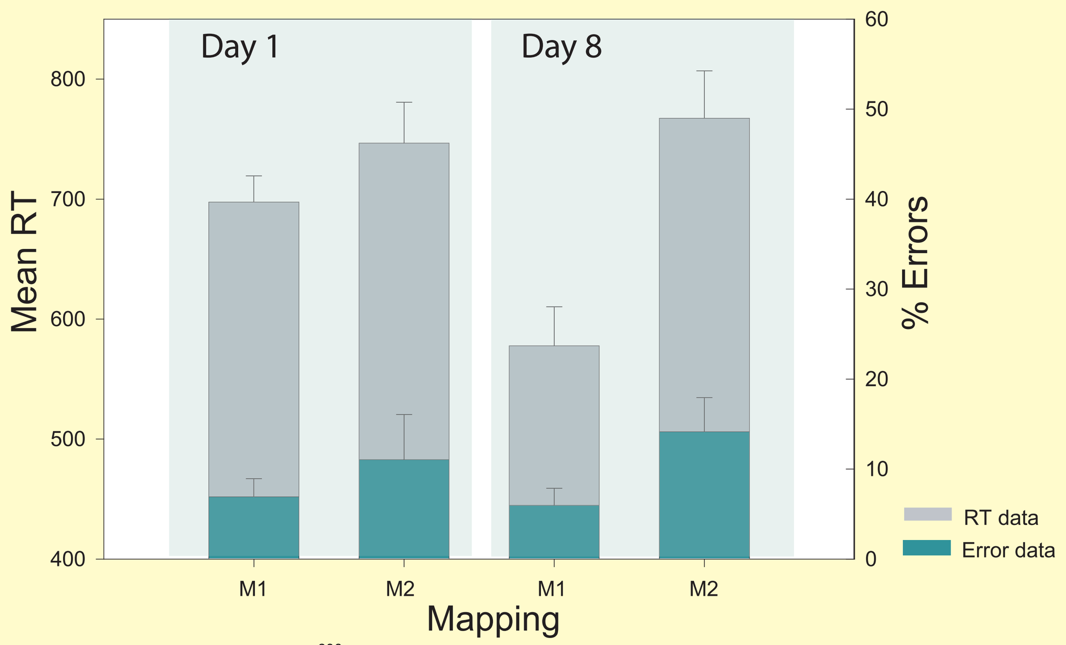
6 days, ~25 min. session, total trials: 3480 (4 x 870)

Design

M1 - highly practised mapping, M2 - less practised mapping

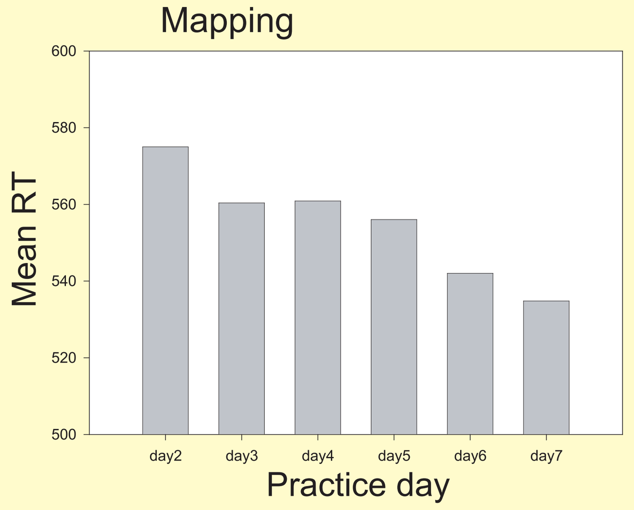
day1	day2	day3	day4	day5	day6	day7	day8
scan M1, M2	practice M1	practice M1	practice M1	practice M1	practice M1	practice M1	scan M1, M2

Behavioural data



RT data
Day p<.06
Map p<.000
Day x Map p<.000

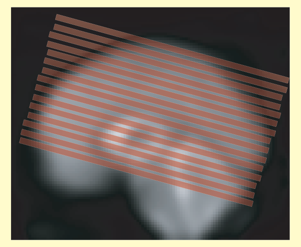
Error data
Day
Map p<.04
Day x Map p<.06



fMRI

Acquisition

3-Tesla Bruker MR-system
Gradient EPI
TR = 1.1 sec
21 slice acquisition
4 mm slices, 3.9 x 3,9 mm in-plane resolution



Data processing and analysis

SPM99[2]

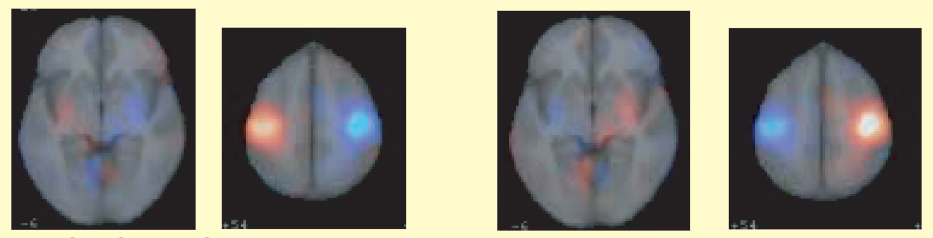
Preprocessing
Slice timing and motion correction, field map undistortion[3]

First level analysis
Modelling each scanning session separately:
8 runs, 3 events (left, right and incorrect responses), 6 movement parameters, no explicit masking

Random effects analysis
Masked[4] normalisation of contrast images to mean of scanning day 1 and 8
Images smoothed with 8 mm FWHM Gaussian kernel
12 subjects included (one excluded for medical reasons)
Explicit masking using thresholded mean of 12 subjects' mean EPI

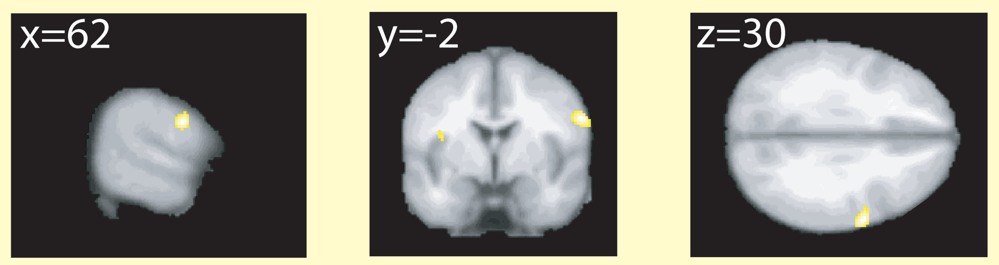
WHOLE BRAIN ANALYIS

BOLD response to button presses

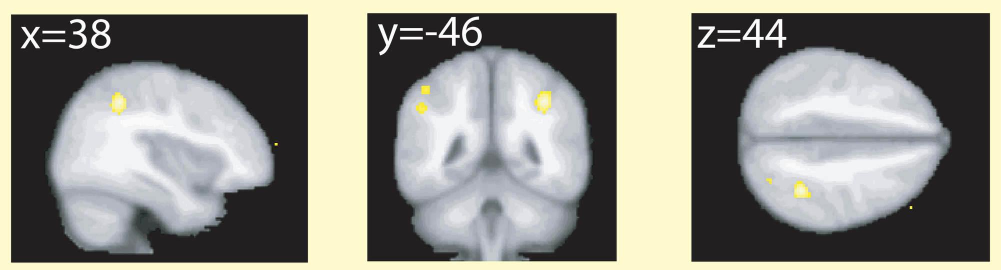


We observe reliable activation in the contralateral motor cortex and basal ganglia, as well as ipsilateral cerebellum.

Day 8 (reversed - practised) - day 1 (reversed - practised)



right pre-motor cortex



bilateral parietal cortex

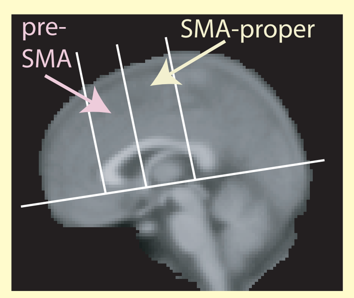
.001 uncor.

Greater activation can be seen in the pre-motor and parietal cortex on day 8 (compared to day 1) for the unpractised mapping (compared to the practised mapping).

ROI DEFINITION

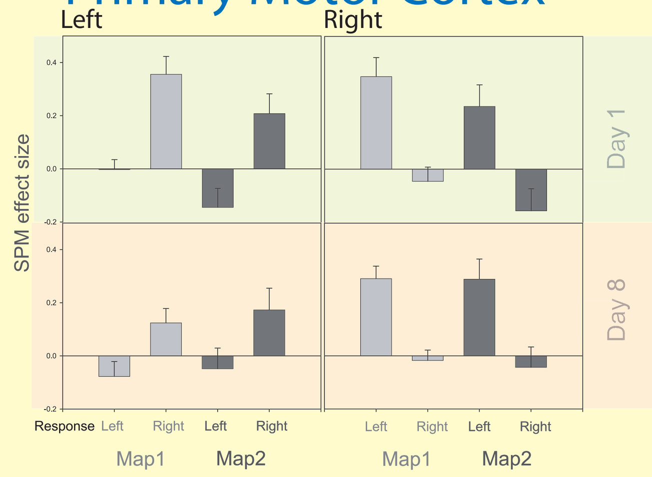
Region of Interest Analysis

Using SPM Marsbar toolbox[5]
SMA-proper, pre-SMA based on Picard and Strick[6]
Basal ganglia: putamen, globus pallidus traced on MNI template
Parietal cx - average coordinates from Simon et al [7]
[+/-23, -67, 50], 10 mm sphere
Motor cx - hand knob area based on Yousry et al [8]
[34/-32, -32, 58], 5 mm sphere



ROI ANALYSIS - CORTICAL

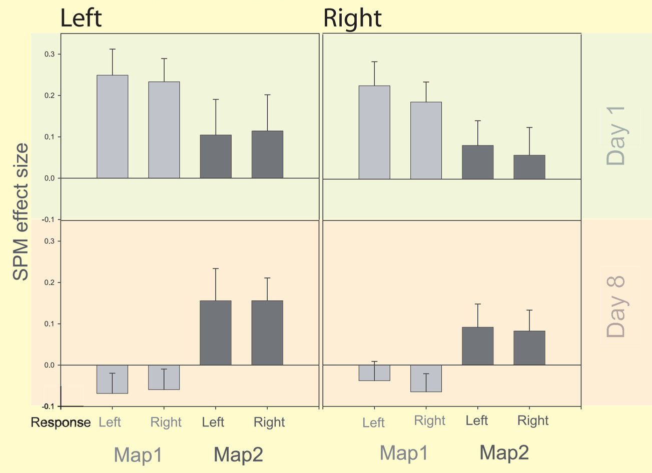
Primary Motor Cortex



Day n.s.
Map p< .006
Day x Map n.s.

We observe no significant practice related changes in the motor cortex.

Parietal Cortex

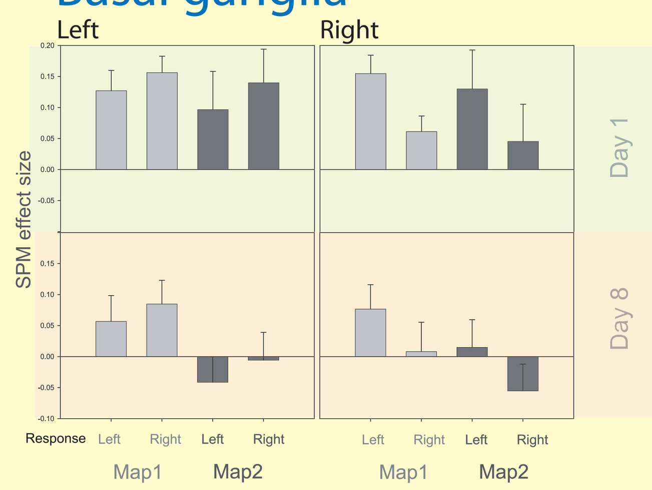


Day p<.000
Map n.s.
Day x Map p<.001

An overall decrease in activation is observed in the parietal cortex from days 1 to 8.
Reversing the mapping on day 1 causes a strong reduction of activation in parietal cortex, but after practice, the reversal causes parietal cortex to reactivate.

ROI ANALYSIS - SUBCORTICAL

Basal ganglia



Day p<.000
Map p<.004
Day x Map p<.05

The basal ganglia show consistent activation across the reversal on day 1, but after practice they deactivate for the reversed mapping.

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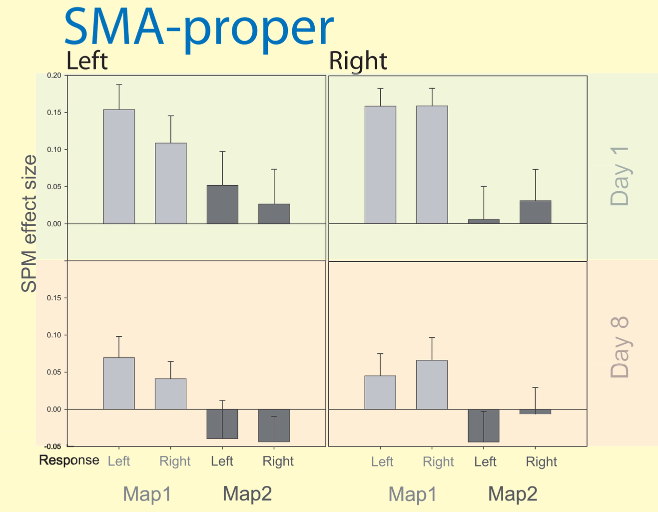
ROI ANALYSIS - CORTICAL

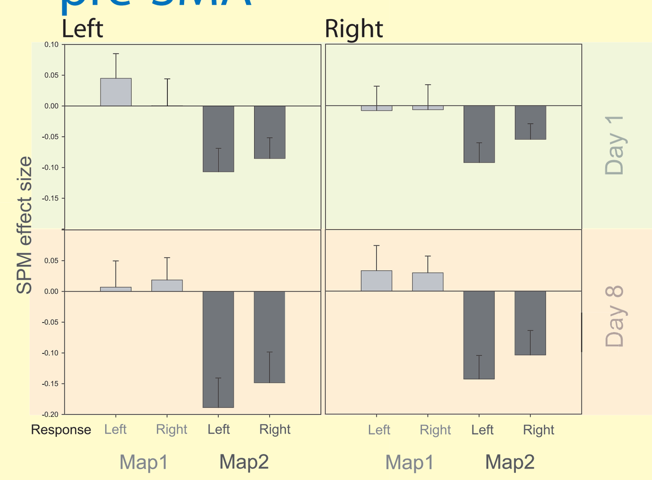
SMA-proper



Day p<.000
Map p<.000
Day x Map n.s.

Activation reduces overall. On day 8 we only observe activation for the practised mapping.

pre-SMA



Day n.s.
Map p<.000
Day x Map p<.001

No pre-SMA activation is observed for mapping 1 on either day. Strong deactivation is seen for the reversed mapping, an effect which increases after practice.

CONCLUSIONS

There was a general reduction of activation in the motor system with practice.

After practice, the basal ganglia and SMA deactivate for the reversed mapping, but the parietal cortex reactivates.

We suggest that the basal ganglia and SMA may be encoding the learned stimulus response mapping, so that they must be deactivated in order to perform the reversal.

The parietal cortex may be responsible for performance when the S-R mapping is novel or a strong prepotent S-R mapping is competing with the current task.

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