Tracking trial to trial changes in brain activity related to cognitive automatization

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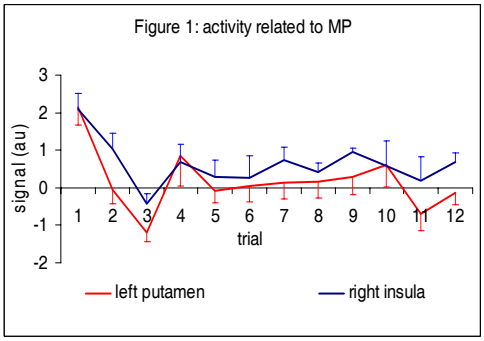
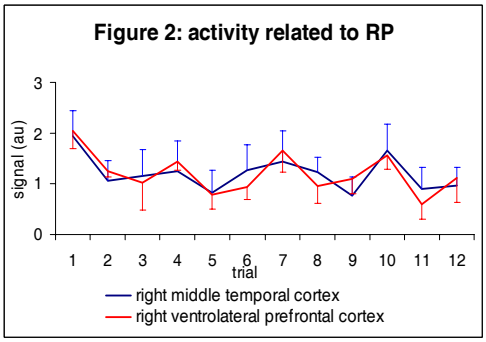
Introduction. Lack of sensitivity of fMRI techniques has limited the possibility to study brain activity that changes from trial to trial. Recent developments in fMRI techniques, such as parallel imaging, have greatly increased the sensitivity of fMRI. This has given new possibilities to look at trial to trial changes in brain activity. One mechanism that may cause brain activity on a trial to trial basis is cognitive 'automatization' . Automatization is assumed to occur in tasks that feature a constant stimulus response association. It is unclear however, at what rate automatization occurs, and if it occurs at the same rate for different cognitive processes.

Method. Scans were performed with a 16-channel detector at 3.0 T (SENSE-EPI, TE/TR 32/2000, voxel size: 2.33mm) [1]. Six subjects performed a Sternberg task, with a constant memory memory-set of five letters (memory-phase (MP)) per trial (18 s), followed by a probe-stimulus (target or non-target) after a 10s delay (response-phase (RP)). The task included 14 trials with presentation of the same memory-set, and was repeated four times, with different memory-sets. Scans were registered, smoothed with a Gaussian filter (9.2 mm3), followed by a multiple regression analysis (regressors for MP, RP per trial) which produced tmaps for activity strength for MP and RP for each trial.
Tmaps were spatially normalized to MNI305 space to create group activity. Group activity maps were calculated based on a voxel wise t-test, using a pooled variance map. Voxels were regarded to be active with a $t > 3.71$ ($p< 0.00001$, uncorrected). Neighboring active voxels were combined in regions of interest (ROI) for MP and RP. In these regions we tested the signal change from trial to trial for MP and RP with a linear GLM and comparing each consequent trial with activity in trial one.

Results. Reaction time showed a decrease from first to last trial ($t=2.27$; $p = 0.04$), indicating behavioral evidence of automatization. Despite the small number of repeats per trial, we found a large network of activity for MP as well as RP.
For MP, activity in left putamen showed a significant decrease from trial 1 to 2. Activity in other regions, (DLPFC, parietal cortex, insula, visual cortex) was significantly decreased by trial 3, (see fig 1). In RP, the right ventrolateral prefrontal cortex (VPFC) and right middle temporal cortex showed a significant decrease from trial 1 to 2, (see figure 2), while the left VPFC, right prefrontal cortex, right inferior frontal cortex, left thalamus, right middle temporal cortex) showed significantly decreased activity by trial 3.





Discussion. Our results show that with the increased sensitivity of parallel scanning it is possible to track trial to trial cognitive adaptation in the brain. Results indicate changes in brain activity associated with automatization occurring in the first few trials of a task. Activity in putamen as well as right VPFC and tight middle temporal cortex appeared to be specific for the first trial of the task.

[1] de Zwart JA, et al. Magn Reson Med. 2004 Jan;51(1):22-6.