A Rapid 3D Partial-Fourier PRESTO-SENSE Method for Functional Motor MRI

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Introduction: High temporal resolution is necessary for an accurate determination of the hemodynamic response to functional stimuli [1]. At the same time high volume coverage is desirable to allow an examination of temporal relations between different brain regions involved in performing a task. Partial-Fourier PRESTO-SENSE [2] seems to be a good candidate for event related fMRI studies because it combines whole brain acquisition with a volume repetition rate of 2 Hz. The functional paradigm used in this study consisted of a task involving brain areas responsible for planning, organization and motor execution as well as the visual system.

Methods: 6 healthy subjects participated in the study. Experiments were performed on a Philips Intera 1.5 Tesla system using a 6 channel headcoil. Imaging parameters of the PRESTO sequence were: FOV=25.6x20.0x11.6cm^3, matrix=64x50x29, TR=29ms, TE_{eff}=44ms, α=11^o. A water selective excitation was performed using binomial (121) pulses. Partial-Fourier acquisition and sensitivity encoding resulted in a scan time of 0.5 seconds per volume. The EPI sequence had the following parameters: FOV=25.6x25.6cm^2, matrix=64x64, TR=500ms, TE=60ms, α=58 ^{o}. 5 slices with a thickness of 4mm were acquired. One block of the functional paradigm started with a 2s stimulus phase during which 3 numbers between 2 and 5 were presented randomly to the subject. Each number corresponds to a finger of the right hand that the volunteer had to tap immediately against the thumb of the same hand. 12 seconds of rest followed. This block was repeated 12 times after an initial acquisition of dummy scans for 14 seconds. Motion correction was performed using the algorithm implemented in SPM99. Low frequencies were filtered with a linear regression technique using a sliding window approach [3]. Statistical data analysis was based on an ANOVA test. To increase the sensitivity of this test, data are slightly filtered temporally using a Savitzky-Golay filter [4]. For each voxel classified as activated, a hemodynamic response is obtained by averaging all stimulation periods. This hemodynamic response was then averaged over all voxels belonging to a region of interest identified by anatomical considerations. Finally, a Gamma variate function was fitted to the resulting curve and its maximum was used in the timing calculations.

Results: Both methods identified identical brain areas involved in the motor task. Calculated temporal differences of the average hemodynamic response between supplementary motor area (SMA) and primary motor cortex (M1), sensori-motor cortex (S1) and M1 and between primary visual cortex (V1) and M1 obtained with PRESTO are given in Table 1. The results for EPI are shown in Table 2, temporal information of the visual cortex is missing due to the limited FOV. The values given for M1 represent the reference time in seconds. Average temporal differences are comparable between both sequences applied, whereas large inter-individual differences were obtained. For the EPI data a confidence threshold of $p<0.01$ was used, whereas it had to be lowered to $p<0.05$ in the PRESTO case in order to detect a reasonable amount of activation.

Subject	SMA-M1	M1	S1-M1	V1-M1
1	-481	6.42	903	1009
2	-638	5.85	172	-443
3	-385	6.80	116	809
4	-643	7.12	65	-90
5	-623	6.28	401	-35
6	-284	5.20	651	176
Average	-509 ± 151	6.28 ± 0.68	385 ± 334	237 ± 560

Table 1: Temporal differences of the average hemodynamic response obtained with PRESTO.

Subject	SMA-M1	M1	S1-M1
1	-396	5.85	203
2	-334	7.69	297
3	-838	6.62	235
4	-890	7.01	596
5	-367	5.60	197
6	-347	6.22	729
Average	-529 ± 261	6.51 ± 0.79	376 ± 228

Table 2: Temporal differences of the average hemodynamic response obtained with EPI.

Discussion: Both sequences found the same motor activation sequence. Compared to the applied single-shot full-Fourier, full-FOV EPI sequence the Partial-Fourier PRESTO-SENSE technique offers the advantage of whole brain coverage within the same scan time and benefits from advantages of a 3D acquisition like diminution of inflow and absence of slice-timing effects. One reason for the lower functional contrast of the PRESTO sequence that necessitated lower confidence thresholds during statistical evaluation might be the shorter effective TE that results in less BOLD contrast, and the SNR loss due to the use of half-Fourier and SENSE approaches applied to the PRESTO technique. In addition, generally lower signal changes due to functional activation were found with PRESTO sequences compared to EPI [2,5]. These might be caused by the additional field gradients that are used to shift the echo signal over one TR period and introduce a high first gradient moment. This gradient moment may dephase magnetization in bigger vessels and therefore would suppress one, sometimes unwanted, signal source of the BOLD contrast at low field strengths.

References:

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