T2 Weighted fMRI Simultaneously Acquired in two Distinct Areas of the Human Brain at Ultra-High Field

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Introduction/Synopsis In this study, a Slab wise magnetization Preparation for Functional Imaging with a T_2 weight (SPIF-T_2) [1] is used. Fifteen oblique slices were positioned to go through the visual- as well as the motor-cortex. This technique is used in conjunction with Parallel Imaging (PI) methods with a one-dimensional reduction factor of four, a half-Fourier technique and a sixteen-channel geometrically adjustable ("flex") volume coil [2] to allow for whole brain coverage while maintaining short acquisition times, necessary to keep Gradient Echo (GE) contributions small. Specific absorption rate (SAR) is reduced by ~4 fold for 15 slices when compared to a multi slice Spin Echo (SE) sequence. This makes it possible to use the more accurate Spin Echo (SE) fMRI (see for instance [1],[3],[4]). Robust activation can be seen in both the visual and motor areas of the brain. This technique can now be applied towards cognitive paradigms corresponding to regions of the brain not previously studied at 7T.

Methods Two normal subjects participated in this study. The experiments were performed at a 7T, 90cm bore system consisting of a Magnex magnet and a Siemens console. The motor-visual paradigm consisted of 10 blocks. Within each block a flashing red checker board was presented for 30s followed by a 30s resting period. The subject was told to finger tap during the presentation of the flashing checker board. The total duration was about 10 minutes. Each 30s period consisted of 5 acquisitions. Each acquisition consisted of the same T_2 prepared 100mm oblique slab going through the visual- as well as the motor-cortex (see Fig. 1). It was subsequently read out by 15 oblique, interleaved GE EPI slices of 2mm thickness each. A sixteen-channel geometrically adjustable volume coil was used. (FOV=19.2x19.2cm^2; matrix=128x128; single shot acquisition; 90 degree pulses; echo time for the preparation slab was 55ms; echo time for the EPI readout employing half-Fourier was 9.6ms to center k-space point. TR in the multi slice EPI train was ~ 38ms per slice leading to 570ms for the 15 slice acquisition following each T_2 preparation module; a 12.2ms fat suppression module in front of each slice is included). For comparison, a dataset with the EPI multi slice readout without the T_2 preparation module was obtained for one of the subjects. Identical readout was played for the prepared and non-prepared acquisitions except that the flip angle was lowered for the non-prepared case to account for the reduced SNR due to the T_2-weighing in the prepared case. In addition, the apparent decay time for the weight of the preparation module had previously been measured by varying, TE_{Slab} [1], yielding 55ms, in excellent agreement with values for grey matter found in the literature (see for instance [3]).

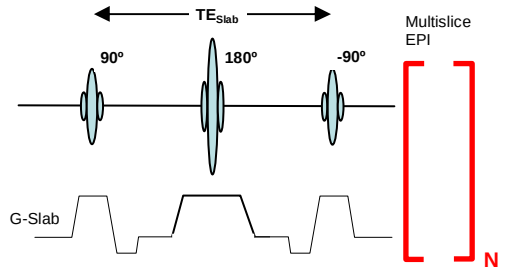

Fig.1 A schematic view of the slab selective T_2 magnetization preparation, consisting of a 90º pulse followed by a refocusing 180º pulse and a -90º to flip back the magnetization along the z axis. Then N slice selective excitation pulses are applied, each followed by EPI readout.

	w/ T_2 Preparation Module		w/o T_2 Preparation Module	
Subject #	Average Activation ΔS/S in [%]	# of activated pixels	Average Activation ΔS/S in [%]	# of activated pixels
1	14.64±0.21	5307	10.19±0.14	7410
2	12.03±0.16	6048		

Tab. 1 Average activations, ΔS/S, and # of activated pixels w/ and w/o the T_2 preparation module. Identical multi slice EPI readout was played for the prepared and non-prepared acquisitions. Except that the flip angle was reduced for the non-prepared case to account for the reduced SNR due to the T_2-weighing in the prepared case.

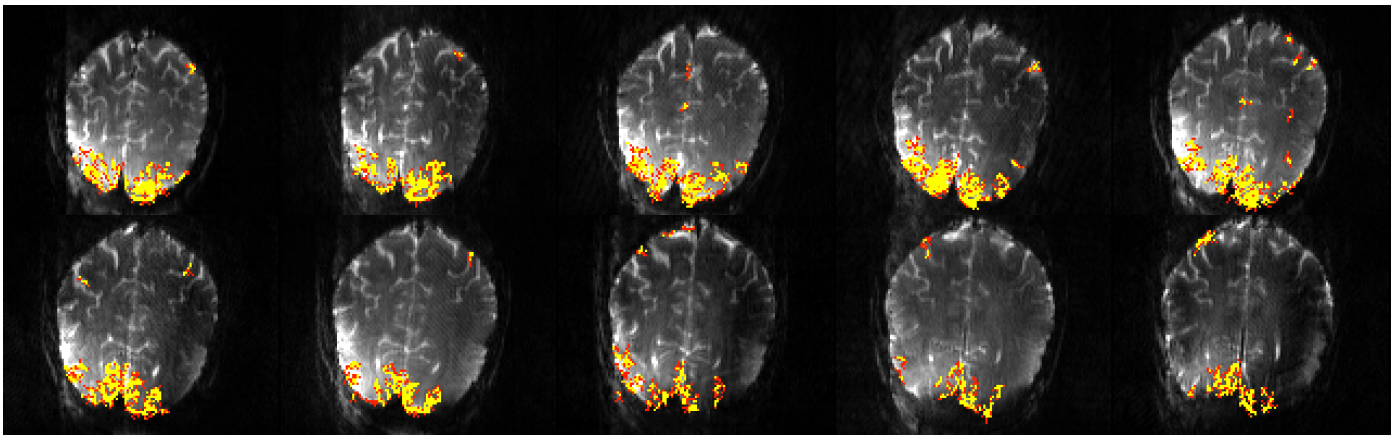

Fig.2 Activation maps for one volunteer using T_2 magnetization prepared multi slice EPI implemented with parallel imaging are shown. The 10 most inferior of the 15 oblique slices acquired are presented. Voxels with p-values≤.0001%, corresponding to 3.9σ, and cluster size threshold of 9 are highlighted.

Results and Discussion Significant BOLD responses were detected in the visual- and motor-cortex (including primary sensorimotor cortex and supplementary motor area) for the two subjects using SPIF-T_2 (see Fig. 2 for the activation maps obtained with parallel imaging). The average activation, ΔS/S, was measured to be (13.25±.13) %. This compares to significantly lower activation of (10.19±.14) for the multi slice EPI without the T_2 weighting preparation module. The number of activated pixels is slightly lower for the T_2 prepared case. The significant overall reduction in SNR due to the T_2-weighting, has been compensated by a reduction in flip angle for the EPI readout in the non-prepared case, however. Power deposition, compared to a multi slice Spin Echo sequence executed with 90 and 180 degree pulses, is reduced by ~4 fold for 15 slices (for the same total data acquisition time). The implementation of SPIF-T_2 with parallel imaging techniques for two simultaneously acquired, distinct areas of the human brain has been demonstrated. Activation in the motor-cortex is less robust than that in the visual cortex. It remains to be determined if this corresponds to a lower sensitivity or a less well controlled motor task for instance. The current implementation still suffers from a significant GE contribution due to the fact that the EPI acquisition is not short enough and there exists a 9.6 ms delay to the center k-space point after excitation. This limitation is imposed by use of a body gradient in the current study. Preliminary tests with a new head gradient suggest a TE of less than 5ms is achievable for an otherwise unaltered setup. Changing to this head gradient system from the currently used body gradient system and further optimizations of this acquisition method and parallel imaging techniques can reduce GE contributions to the overall mapping signals in this sequence further as the time of k-space coverage is reduced; The visual-motor study shown here was chosen as efficient validation measure of this technological development. This technique can now be applied towards cognitive paradigms corresponding to regions of the brain not previously studied at 7T.

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