Functional Neuroimaging of Inner Field-of-Views using FLASH with 2D-Selective RF Excitations

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Introduction

T2*-weighted FLASH [1] offers high spatial resolution without sensitivity to geometric distortions, severe chemical shift-related displacements or excessive echo times. However, its application in BOLD-based functional neuroimaging is hampered by the long acquisition time per section of several seconds limiting the temporal resolution and volume coverage. Because in some applications a restricted brain region is the focus of functional experiments reducing the field-of-view (FOV) in phase-encoding direction could help to shorten the acquisition time but is prone to aliasing. Here, spatially 2D-selective RF (2DRF) [2] excitations are used to acquire a small inner FOV without aliasing in order to decrease the acquisition time and improve the temporal resolution.

Methods

Compared to the standard FLASH sequence the slice-selective RF excitation was replaced by a 2DRF excitation based on a blipped-planar trajectory with the blips applied in phase-encoding direction (Fig. 1). The trajectory was chosen as a compromise between a sufficient sharpness of the excitation profile in slice and phase-encoding direction and a reasonable 2DRF pulse duration considering that a better profile definition is required in slice direction while some profile transition range in phase-encoding direction can be accounted for by oversampling.

Measurements were performed on a 3T whole-body MR system (Siemens Magnetom Trio) using a standard volume head coil. FLASH acquisition were performed with an echo time of 30ms, a repetition time of 62ms, a flip angle of 15° and a spatial resolution of 1x1x4mm^3. The 2DRF pulse was designed to excite a profile of 4x40mm^2 with a profile sharpness of 3mm and 7mm in slice and phase-encoding direction, respectively, and a distance of the side excitations of 350mm to ensure that side excitations as well as N/2 excitations were well outside the object in the applied slice orientations. The resulting 2DRF excitation had a duration of 30ms with a trajectory covering 51 lines. The field-of-view (FOV) was 192x256mm^2 for the standard slice-selective acquisition (12s per section) and 32x256mm^2 for acquisitions with the reduced FOV plus 16mm oversampling in phase-encoding direction (3.2s per section). Bandwidths per pixel were 30Hz for slice-selective excitation and 160Hz for 2DRF excitation due to the prolonged RF pulse duration. For visual stimulation a flickering (5Hz) checkerboard protocol was used consisting of six blocks with 32s activation and 32s control (gray screen), respectively, preceded by 32s control.

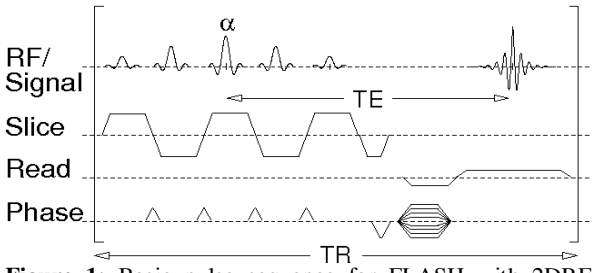

Figure 1: Basic pulse sequence for FLASH with 2DRF excitation based on a blipped-planar trajectory.

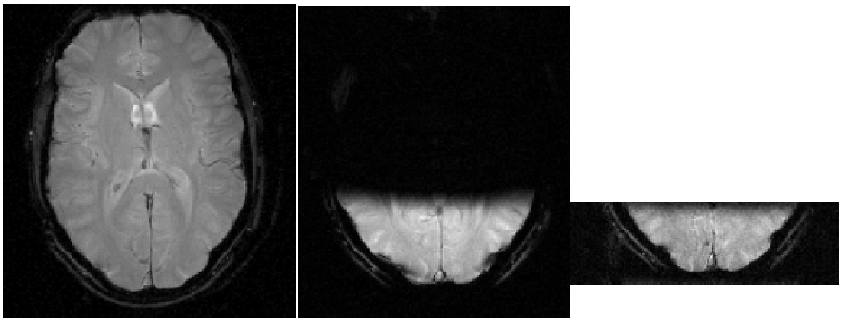

Figure 2: T2*-weighted FLASH MR images obtained with slice-selective (left, 12s) and 2DRF excitation covering the full (middle, 12s) and a reduced FOV (right, 3s).

Functional data analyses were performed using SPM2. The first two images of the dataset were discarded to account for T1 effects. The remaining images were realigned to the third image, resliced accordingly and convolved with a 2mm FWHM isotropic Gaussian kernel. To detect visual activation one regressor consisting of a boxcar function convolved with the haemodynamic response was modelled. The parameter for the height of the model function was estimated using the general linear model and statistically tested.

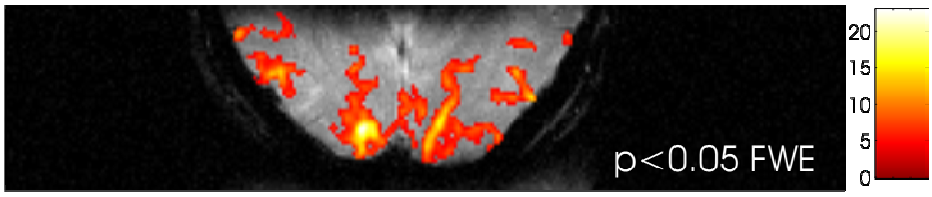

Figure 3: High-resolution activation map of the visual cortex obtained with FLASH using 2DRF excitations and a checkerboard stimulus. The p-values were adjusted for multiple comparisons using familywise error correction (FWE).

Results and Discussion

In Fig. 2 T2*-weighted images are presented. The 2DRF excitation shows a good localisation of the inner field-of-view covering the visual cortex. The results of the statistical analysis for the visual paradigm are shown in Fig. 3. They show a highly significant typical activation pattern to a visual stimulus. The reduced FOV considerably reduces the acquisition time and can improve the temporal resolution of functional FLASH imaging. Although it is accompanied by a signal loss due to the decreased number of Fourier lines its feasibility for distortion-free high-resolution fMRI of specific regions of interest. If temporal resolution is not an issue, e.g. in block design protocols, the time gained could be invested in multiple sections to improve the volume coverage or an even further increased spatial resolution.

References

[1] Haase A et al, J Magn Reson 67, 258-266 (1986) [2] Pauly J et al, J Magn Reson 81, 42-56 (1989)