REAL-TIME SINGLE-VOXEL WATER PROTON SPECTROSCOPY AND ECHO-PLANAR IMAGING SENSITIVITY TO THE BOLD EFFECT AT 3 AND 7 T.

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Introduction: Gradient-echo echo-planar imaging (EPI) is the predominant approach to assess localized BOLD signal changes in order to provide real-time neurofeedback. Alternatively, spin-echo single-voxel proton spectroscopy (SVPS) can be used for spatially specific BOLD neurofeedback at 7 T[1]. Here, we compared real-time SVPS and EPI acquisition techniques in order to explore their BOLD sensitivity differences and the signal quality of their time courses.

Methods: The experimental protocol which was used to compare real-time EPI and real-time SVPS consisted of standard functional localizers to determine the primary motor cortex (PMC, finger tapping) and the visual cortex (VC, presentation of a flickering visual checkerboard). In addition, we performed a neurofeedback experiment with PMC as the targeted brain area (PMC NF). EPI images were obtained with a single-shot gradient-echo T2*-weighted sequence with 300 repetitions (TR = 1000 ms, 16 slices volumes, matrix size 64 x 64, voxel size = 3 x3 x 3.75 mm^3, flip angle α = 77°, bw = 2.23 kHz/ pixel, TE = 30 ms at 3 T, TE = 28 ms at 7 T). A single spectroscopy voxel (~1 cm^3) was located over the most active area of the PMC and the VC, respectively. At 3 T, the water spectra were acquired using a spin-echo protocol with 300 repetitions (TE/TR = 30/1000 ms, flip angle α = 90°, bw = 1 kHz, acquisition duration = 512 ms). At 7 T, the acquisition protocol was slightly different, with TE = 20 ms, bw = 2 kHz, acquisition duration = 256 ms. To assess the BOLD dynamics of the EPI time courses, the EPI voxels were averaged within the preselected PMC and VC ROIs. SVPS T2* signal changes were estimated from the water spectra using the optimized linear regression approach[1]. Because the EPI gray-scale voxel intensity (I) was weighted with factor ~exp(R2*), the SVPS T2* time courses were converted using (~exp(-TE/T2*)). The resulting EPI and SVPS time courses were then compared across a group of 7 participants at 3 T (28±7 yrs) and at 7 T (33±9 yrs) in terms of their percent signal change and their t-statistics.

Results: fSVPS and EPI R2*-weighted time courses did not show a significant difference in percent signal changes at 3 T (Table 1; paired one-tailed t-test, df = 6, p > .05). At 7 T, the EPI percent signal changes were significantly higher in the PMC and in the VC runs (p < .05), but not in the NF run (p = 0.24). At 3T, the SVPS t-values were significantly higher than those of the EPI in the PMC NF run (p < .01) but they did not show significant differences in the other runs. A 7 T, the t-values of the PMC NF and the VC time courses did not show a significant difference between SVPS and EPI; however the t-values of the PMC run were significantly lower for SVPS compared to EPI (p<.05).

Discussion & Conclusion: In general, SVPS and EPI acquisitions provided comparably high t-values at 3 and 7 T. SVPS BOLD percent signal changes were higher at 7 than at 3 T, but lower than those of EPI at 7 T. In order to achieve the high data quality needed for real-time EPI as well as real-time SVPS experiments, the higher temporal noise at 7 T requires higher resolution and optimized shimming. We speculate that the lower percent signal changes of the SVPS compared to the EPI acquisition at 7 T might be due to the dominance of microvasculature contributions to the BOLD effect at spin-echo acquisition at ultra-high field[2,3].

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References:

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Table 1: Percent signal changes of the EPI and SVPS time courses.

group average	3 T			7 T		
	PMC	**PMC NF**	**VC**	**PMC**	**PMC NF**	**VC**
EPI	2.2±0.9	2.7±0.7	4.2±1.1	10.6±3.4	10.1±3.9	7.7±3.8
SVPS	2.3±1.1	3.2±1.6	4.0±1.2	6.2±5.4	8.0±6.3	4.3±2.8

Table 2: T-values of the EPI and SVPS time courses, p < .001.

group average	3 T			7 T		
	PMC	**PMC NF**	**VC**	**PMC**	**PMC NF**	**VC**
EPI	26.7±7.4	21.1±8.4	34.4±5.6	27.4±6.5	24.4±7.4	21.9±7.2
SVPS	32.1±5.0	33.3±8.7	30.2±7.8	21.3±12.2	22.3±10.0	18.7±8.2