A WHOLE BRAIN HIGH TEMPORAL AND SPATIAL RESOLUTION SE SIMULTANEOUS MULTISLICE SEQUENCE FOR TASK FMRI AT 7T

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Target audience: MR physicists

Purpose

This study compares a whole brain, high spatial resolution (1.5 mm isotropic) SE simultaneous multislice[1] (SMS) sequence with a GE SMS sequence (matched in spatial resolution) at 7T for fMRI. The SE SMS sequence is enabled by low SAR PINS[2] pulses to achieve good temporal (1.97s) and spatial resolution. Recently, PINS pulses (both excitation and refocusing) have been used in a SE resting state fMRI study[3] at 7T. However, a sagittal orientation had to be adopted to exclude any signal from the body. To overcome this limitation, we have implemented standard (summed) SMS pulses for excitation and used PINS pulses for refocusing, making a transverse acquisition possible. For the standard SMS pulses we have adapted an optimization scheme[4] to further reduce the peak power. A GE SMS sequence was used for comparison using a colour-word Stroop task fMRI.

Methods

Data were collected for 4 subjects (with informed consent) at a 7T Siemens scanner (Siemens Healthcare, Erlangen, Germany) equipped with a 32 channel head coil (Nova Medical, Wilmington, MA, USA). Acquisition parameters are summarized in Table 1. The sequences are matched in terms of spatial resolution and FOV. SE SMS excitation and refocusing pulses have the same time duration and bandwidth. We have used a flip angle of 130 instead of 90 to obtain a homogeneous excitation profile throughout the whole brain. With the optimization of the phases of the excitation pulses, we could reduce the peak power by 26%. Reconstruction of SMS data is done offline in Matlab using a SENSE/GRAPPA reconstruction[5].

Table 1. Acquisition Parameters

	TR (s)	TE (ms)	In plane AF	SMS factor	Excitation FA (Ernst/grey matter)	BW (Hz/Px)	Slice gap	Res. (mm)	SAR
SE SMS	1.97	53	3	3	130	1960	15%	1.5 isotropic	92%
GE SMS	1.39	27	3	3	40	2380	17%	1.5 isotropic	47%

Subjects performed a colour-word interference Stroop task. Functional analysis was carried out with FEAT (v5.98, http://www.fmrib.ox. ac.uk/fsl/). The following preprocessing steps are applied: spatial smoothing (3 mm kernel), drift removal, MCFLIRT motion correction and prewhitening. Sensitivity maps were calculated from raw time series to investigate temporal stability of the sequences. Sensitivity maps were obtained by dividing the temporal mean image by the standard deviation over time and square root of the TR to correct for different numbers of time points.

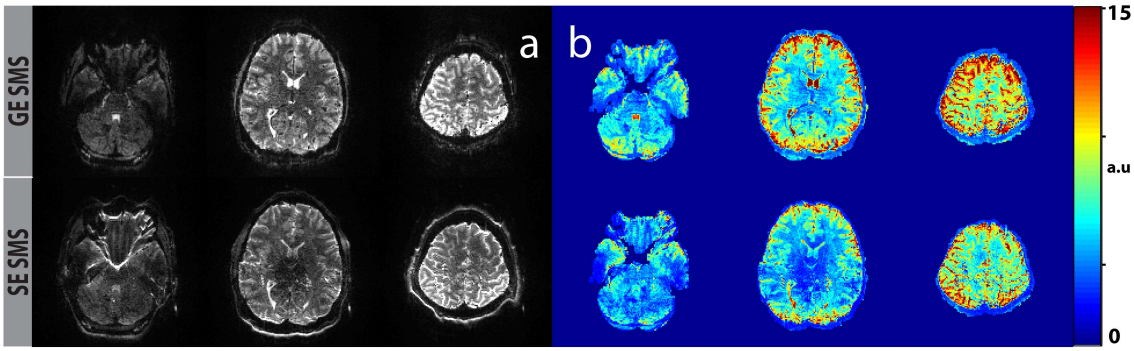

Figure 1. a) Single time point images, note the exquisite contrast for all the sequences. b) Sensitivity maps (in a.u), GE SMS benefits from increased number of time points.

Results & Discussion

Figure 1 shows single time point images and their corresponding sensitivity maps. One can easily see that both methods would benefit from distortion correction and SE SMS suffers from reduced signal especially at the centre of the brain due to the B1 inhomogeneity. SE SMS has however the least dropout in the frontal areas. This advantage of SE can also be seen in Figure 2, where activation clusters (colour/word vs. baseline) are overlaid on mean functional images for a single subject. SE SMS is able to detect much of the activation in the frontal areas where GE SMS is affected by signal dropout. One can also see that GE SMS has larger activation clusters with higher z-scores than the SE SMS. While this was to be expected with regard to the SE acquisition, possible causes for the high sensitivity especially for lower frontal areas could be the reduced within voxel dephasing due to the high spatial resolution and increased number of time points.

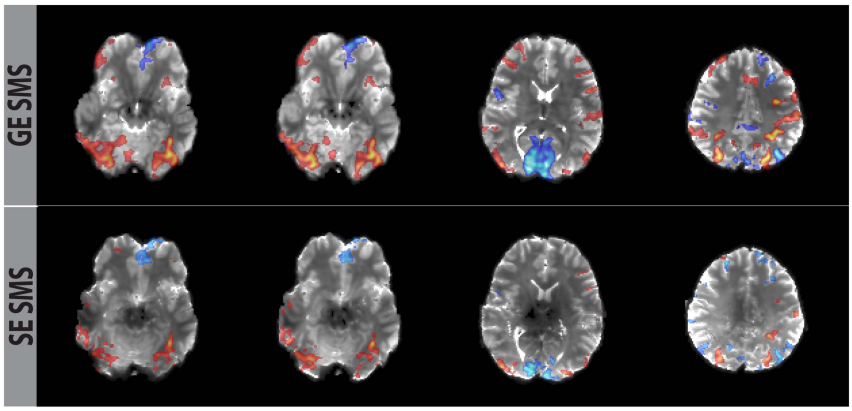

Figure 2. Activation maps overlaid on mean functional images. SE SMS is able to detect activation in the frontal areas and GE SMS boosts statistics with increased number of time points.

Conclusion

We have implemented a high spatial and temporal resolution whole brain SE SMS protocol at 7T using a combination of standard SMS excitation and PINS refocusing pulses and compared it with a matched GE SMS protocol.

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References 1)) Larkman et al., JMR 2001 **2)** Norris, D. et al., Magn Reson Med 2011. **3)** Koopmans, P. et al. NeuroImage 2012. **4)** Wong, E. ISMRM 2012, Abstract 2209. **5)** Blaimer et al., JMRI 2006