COMPARISON OF MULTI-BAND MULTI-ECHO AND MULTI-ECHO AT 3T

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Target Audience: MR physicists, Neuroscientists

Purpose: Following a recent implementation[1] of a Multi-Band[2] Multi-Echo[3] (MBME) sequence at 7T for resting state fMRI that showed improved sensitivity, the potential benefits of MBME with respect to a single band multi-echo (SBME) were investigated at 3T using an event related design.

Methods: Twelve subjects were scanned on a 3T Siemens Tim Trio system (Erlangen, Germany) while performing a cued Gabor grating task with visual feedback using a 32 channel head coil for signal reception. Responses were recorded via button boxes. In a single session, subjects performed the task twice, one with a MBME protocol and one with a SBME protocol, in pseudo-randomised order. Analysis of the reaction times and task performance showed no significant differences between the protocols ($p = 0.886$ and $p = 0.781$, respectively). Both of the protocols had an in-plane acceleration factor of 2 was and were reconstructed online with GRAPPA[4]. The multiband reconstruction was also carried out online with the slice GRAPPA algorithm[2]. The remaining protocol parameters are listed in Table 1.

Table 1. Acquisition parameters for SBME and MBME protocols.

Protocol	TR (s)	TEs (ms)	MB factor	Bandwidth (Hz/Px)	Resolution (mm^3)	Slice Gap	Flip Angle	No. of volumes
MBME	0.809	14,32,49	3	2368	3.5 x 3.5 x 3.0	17 %	56°	510
SBME	2.430	14,32,49	1	2368	3.5 x 3.5 x 3.0	17 %	80°	170

Echoes were combined using TE weighting[5] and concatenated in temporal direction to a 4D NIFTI file. All data were preprocessed with a 5 mm FWHM smoothing kernel, 100 s high pass filtering and exclusion of the first 6 volumes. The data were cleaned using FSL MELODIC (vs3.14, http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/MELODIC) and FSL FIX[6,7] by removing non-BOLD related components. FIX was trained using the provided training sets with similar acquisition parameters: 'Standard' for SMBME and 'HCP_2000' for MBME. FSL FEAT (vs6.00, http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/FEAT) was used for generalised linear modelling at the single subject level with the responses (left and right combined) as a single regressor and group level analysis using a two-sample paired T-test. Significance thresholds were calculated using mixture modeling (http://fsl.fmrib.ox.ac.uk/fsl/fslwiki/Mm)[8].

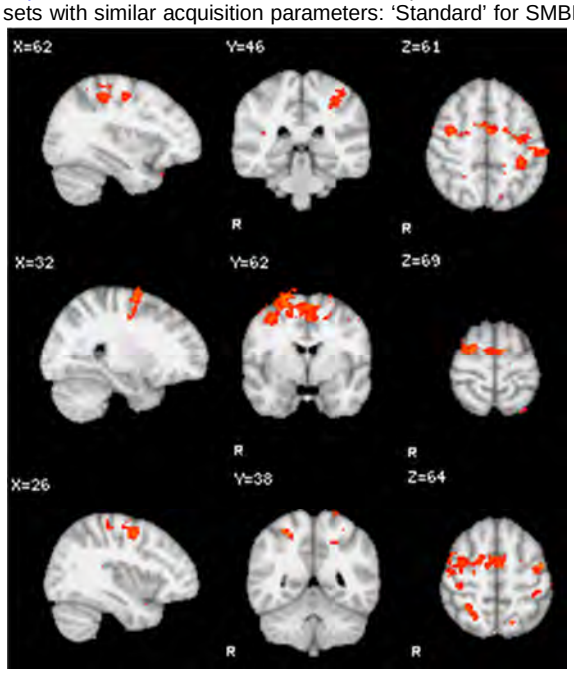

Figure 1. Saggital, coronal and axial slices (columns) showing significantly activated voxels only for MBME for several clusters (rows).

Results: Figures 1 and 2 show significantly activated voxels, either **only** for MBME (red) or SBME (blue) group level analysis, respectively. Figure 1 shows that MBME performs significantly better than SBME in several parietal regions and the lateral frontal cortex, around areas which are generally activated during the Gabor task. Figure 2 shows that voxels activated **only** for SBME around cerebral spinal fluid (CSF), along the superior saggital sinus. The group difference image was masked with a binary non-brain, CSF, grey matter (GM) and white matter (WM) mask to calculate the number of significant voxels for both groups. Table 2 shows the number and percentage of significant voxels. SBME shows almost four times more significant voxels outside the brain than MBME, as is visualized in figure 2.

Discussion: These results show that the distribution of significant voxels between non-brain, CSF, GM and WM regions is different for MBME and SBME. MBME is significantly better than SBME in several GM areas. Most activation of CSF, WM and non-brain voxels is concentrated around GM voxels for MBME. This is probably due to the combination of relatively low resolution data and the 5 mm smoothing kernel. The results also show that for SBME, additional significant activation is concentrated in CSF, along the saggital sinus. This is probably artifactual signal which FIX was unable to remove. MBME has increased temporal resolution which allows for a more efficient removal of non-BOLD related components.

Conclusion: Implementation of Multi-Band in a Multi-Echo sequence shows improved sensitivity in several GM areas and benefits more from automatic non-BOLD related signal removal than a standard Multi-Echo sequence in a standard resolution, event related design at 3T.

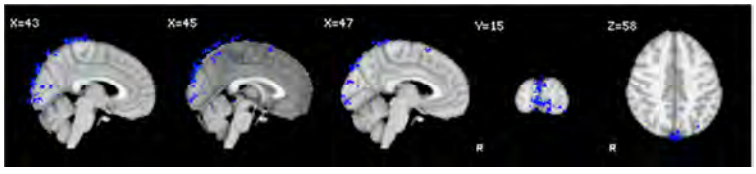

Figure 2. Three saggital, a coronal and an axial slice showing significantly activated voxels only for SBME.

Table 2. Table listing the number of significantly activated voxels and percentages in CSF, GM, WM and outside the brain.

Binary Mask	Voxel count	Percentage (%)
MBME group	2394	100.00
Non-brain	119	4.97
CSF	604	26.73
GM	849	35.46
WM	786	32.83
SBME group	2554	100.00
Non-brain	497	**19.46**
CSF	741	29.01
GM	929	36.37
WM	387	15.15

References: 1) Boyacıoğlu et al., ISMRM abstract 1502 2014. **2)** Blaimer et al., 2006 JMRI vol.24 p444-450. **3)** Poser et al., 2006 MRM vol.55 p1227-1235. **4)** Griswold et al., 2002 MRM vol.47 p1202-1210. **5)** Chiew and Graham, 2011 IEEE T-MI vol.30 p1691-1703. **6)** Salimi-Khorshidi et al.,2014 NeuroImage vol.90 p449-468. **7)** Griffanti et al., 2014 NeuroImage vol.95 p232-247. **8)** Woolrich et al., 2005 IEEE T-MI vol.24 p1-11.