Visual BOLD-fMRI with 32 channel phased-array coil at 3.0T MRI system: comparison with 12 channel coil

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Introduction: Recently, a 32-channel 3T receive-only phased-array head coil was developed for human brain imaging and showed significantly increased image signal-noise-ratio(SNR) in the cortex compared to a larger commercial eight-channel head coil [1] .The sensitivity and specificity of BOLD-fMRI maps are expected to be improved with higher image SNR. The increase in image SNR, however, is not fully utilized if the fMRI time-course noise is dominated by non-thermal noise[2,3] , such as physiological noise. The purpose of this paper is to evaluate how much this 32-channel coil can benefit the BOLD-fMRI.

Methods: Ten healthy subjects(six female, four male, age 20-26 years, IRB approved) were scanned at a 3T Siemens MAGNETOM Trio, a TIM System (Siemens Medical Solutions, Erlangen, Germany). Each subject was scanned with both a 32-channel phased array and a 12-channel matrix coil. For each coil, single shot gradient echo EPI data at two different spatial resolutions ($2\times2\times2$-mm^3 and $3\times3\times3$- mm^3) was collected. The stimulus paradigm was a block design alternating between 30 seconds blocks of fixation and 5Hz black-white radial alternating checkerboard except that the first block was prolonged to 60 seconds to calculate the time course SNR, which was defined as a ratio of the average voxel-wise time course signal over time course standard deviation. Functional data were preprocessed using SPM5 in accordance with the standard procedure: slice timing correction, realignment to the mean image and spatially smoothing with a 4mm FWHM isotropic Gaussian kernel for 2×2×2-mm3 resolution and 6mm FWHM for 3×3×3-mm3 resolution. Statistical analysis was performed at the individual level using both the non-smoothed and smoothed functional data.

Results and Discussion: Figure 1 shows the representative activation maps from very similar sections of one subject with $2\times2\times2$-mm^3 resolution using 12 channel coil and 32 channel coil. Similar activations were showed in terms of the center (foci) of activation from each coil, but the 32 channel coil resulted in a higher sensitivity for the detection of activated area (11.53 cm^3 activation for 12 channel coil and 15.34 cm^3 activation for 32 channel coil). The quantitative activated volume values were listed in Table 1 and time-course SNR values in GRE-EPI images are summarized in Table 2 for healthy subjects. At $2\times2\times2$-mm^3 resolution acquisition without spatial smoothing, the mean amount of activation was increased by 32% using 32 channel coil and showed significantly higher sensitivity($P=0.05$) . This could be traced to higher time-series SNR of 32 channel coil at $2\times2\times2$-mm^3 resolution acquisition. The other three conditions failed to show significantly higher sensitivity for the detection of activated volume using 32 channel coil in comparison with a 12 channel coil, possibly because there are already sufficient SNR for activation detection at the lower resolution or smoothed reconstruction. In agreement with prior studies, the tSNR reaches a limit asymptote as the image SNR increased with 32 channel coil or as the spatial resolution lowered.

Conclusions: The high image SNR from a 32 channel coil for brain imaging at the visual cortex is beneficial for high-resolution fMRI, but may provide no significant benefit for lower resolution fMRI. A 3D acquisition of $2\times2\times2$-mm^3 isotropic resolution is suggested for using a 32 channel surface brain coil to perform visual cortex fMRI.

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Table 1. Activated Brain Volume (cm^3) with 12 Channel Coil and 32 Channel Coil

	Activativation (12 channel)	Activativation (32 channel)	Gain	Significance (P Value)
$2\times2\times2$ mm^3 Non-Smooth	7.64±2.64	10.07±3.87	1.32	0.05
$3\times3\times3$ mm^3 Non-Smooth	17.27±4.40	17.91±4.32	1.04	0.61
$2\times2\times2$ mm^3 Smooth	27.45±6.76	28.18±9.59	1.03	0.79
$3\times3\times3$ mm^3 Smooth	36.22±7.92	34.60±7.69	0.96	0.43

Table 2. Temporal Signal-Noise-Ratio(tSNR) in GRE-EPI Images

	tSNR (12 channel)	tSNR (32 channel)	Gain	Significance (P Value)
$2\times2\times2$ mm^3 Non-Smooth	34.2±2.7	45.5±5.7	1.33	<0.001
$3\times3\times3$ mm^3 Non-Smooth	83.5±10.2	97.8±11.1	1.17	0.002
$2\times2\times2$ mm^3 Smooth	102.6±17.0	110.4±23.6	1.08	0.103
$3\times3\times3$ mm^3 Smooth	179.5±38.0	196.4±27.2	1.09	0.075

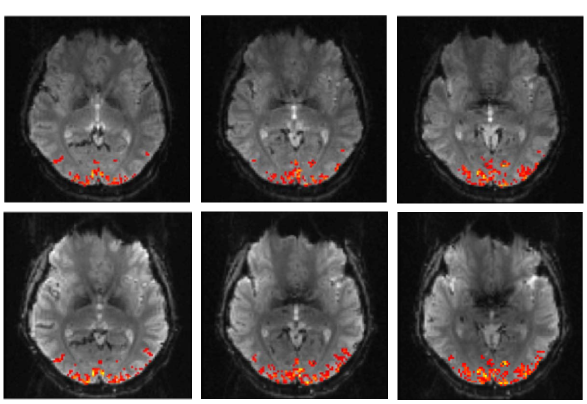

Fig.1. Representative activation maps obtained for $2\times2\times2$-mm^3 using 12 channel coil (top) and 32 channel coil (bottom). Shown are two contiguous slices at similar imaging sections from same subject.

Reference

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