A Comparative Study of Functional Magnetic Resonance Imaging on two Clinical MRI Systems using an Auditory Paradigm

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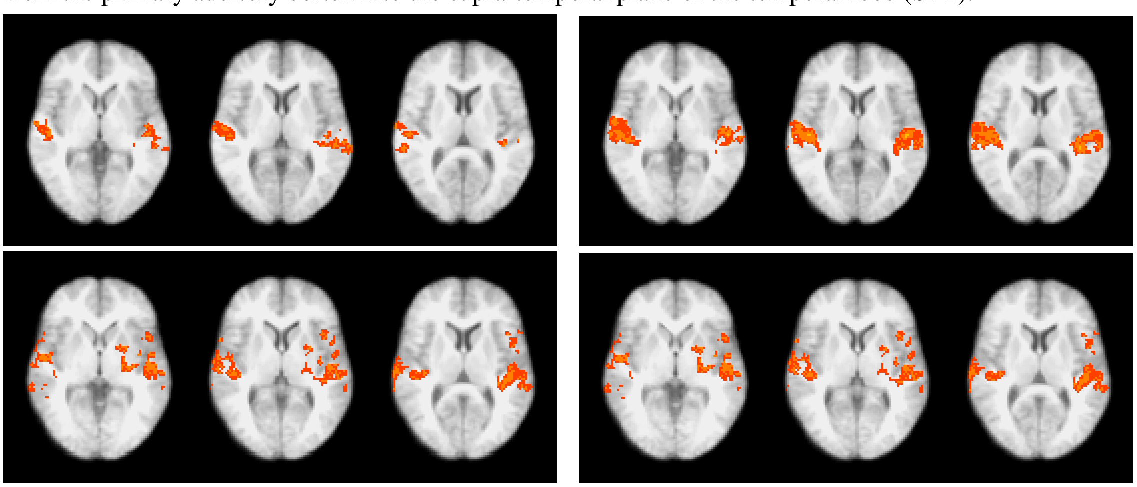
Introduction and Aims Functional Magnetic Resonance Imaging (fMRI) is an established technique in cognitive neuroscience. However, while numerous applications have been hypothesised for fMRI, it has yet to become established as a routine clinical tool. This is due in part to the available hardware, the complexity of setting up paradigms, analysing and interpreting the data. Advances in hardware technology such as multiple element phased array head coils and strong gradients with high slew-rates and noise-reduction measures may allow good fMRI data to be obtained using clinical scanners. This study investigates whether better fMRI data can be obtained from modern scanners with superior hardware by comparing data from an auditory paradigm implemented on a modern Magnetom Avanto and an older Magnetom Symphony (Siemens Medical Systems, Erlangen, Germany).

Materials and Methods A cohort of eight volunteers (six male and two female) was scanned on two scanners using a 3 on/3 off block paradigm. The stimulus consisted of a 1kHz pure sine tone pulsed at 5 Hz and was delivered through the standard set of patient headphones. These were cross-calibrated between scanners using a sound pressure level meter (model 2203, Bruel and Kjaer, Denmark) to ensure the stimulus levels were identical. The paradigm was performed at three stimulus volumes to assess the impact of the scanner noise. The volumes chosen were 66.5 dB, 78.0 dB and 85.5 dB, matched to within 0.5dB between scanners. The hearing threshold of all subjects was assessed using pure-tone audiometry before and after the scans. The Avanto had a 12-element head array coil and 40/40/45 mT m^{-1} (x/y/z) gradients (200 T m^{-1} s^{-1} slew rate) whereas the Symphony had a 2-element CP head array and 30 mT m^{-1} (all axes) gradients (125 T m^{-1} s^{-1} slew rate). A gradient-echo EPI sequence was used to acquire 60 volumes of 36 slices with a slice thickness and in-plane resolution of 3 mm. Sequence parameters were: TR/TE = 3700/50 ms, FOV = 192×192 mm, matrix = 64×64, scan time = 226 s. Data was analysed using FSL (FMRIB group, Oxford, UK[1]) to obtain mean activation across all subjects for each scanner and volume. Clusters of significant activation ($Z > 2$ and a cluster significance of 0.05) were mapped onto an averaged high-resolution T_1 image.

Results All subjects' hearing thresholds were below 26 dB both before and after the scans, demonstrating that there had been no change as a result of the scanner noise. 75% of subjects claimed that they could not hear the 66.5 dB stimulus on the Symphony, but could perceive all stimuli levels on the Avanto. Images of the auditory cortex show the areas of activation increase with stimulus volume. This was statistically significant ($p<0.05$, paired t-test) for both scanners. The data from the Avanto shows activation localised in the region of the primary auditory cortex (Heschl's gyrus), whereas the data from the Symphony is less well defined, extending from the primary auditory cortex into the supra-temporal plane of the temporal lobe (SPT).



Avanto

Symphony

78.0 dB 85.5 dB

Discussion and Conclusions The results demonstrate that auditory fMRI of the same subject group on two different scanners can give different patterns of activation, even when the stimuli and the scanning parameters have been matched. This may be due to the fact that the gradient acoustic noise on the Symphony is greater than that on the Avanto. Previous fMRI studies[2, 3] have shown that Heschl's gyrus gives strong activation at high sound levels, whereas regions in the SPT shows stronger activation at lower sound levels (these regions are involved in differentiating between foreground and background noises). Greater levels of processing and therefore activation are required to distinguish the stimulus from a higher level of background scanner noise arising from the Symphony gradients, which would explain the differences in activation patterns. This illustrates the effect that the scanner acoustic noise can have on the pattern of activation, and the benefits of using scanners with noise reduction technology for auditory fMRI.

[1] http://www.fmrib.ox.ac.uk/fsl

[2] H C Hart *et al.* Hearing Research 171 (2002) 177—190

[3] A Brechmann *et al.* J Neurophysiol. 87 (2002) 423—433