Reduction of the acoustic noise of a Siemens 7 Tesla scanner

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Among the safety regulations for application of MR imaging, the acoustic noise generated by the switching of magnetic gradients of MR-scanners has to be taken into account. This becomes especially important at ultra-high field of 7 Tesla as these scanners can produce noise levels above 130 or even 140 dB. Thus, even with ear plugs the noise limits suggested by the German VDI-Norm 2058 (e.g. 91 dB (A) for exposure of up to 2 hours) may be exceeded. To reduce the noise of our 7 Tesla scanner (Siemens Medical Solutions, Erlangen; 90 cm bore, Avanto gradient coil, Sonata gradient amplifier, max. gradient strength 31mT/m, slew rate 150 µs/(mT/m)) the gap between the gradient coil and the inner tube was filled with sound insulation (E-0-10-25 2layer Barrier composite, E-A-R, Indianapolis) (Fig. 1) and the magnet was covered with the same material. This reduced the noise to a level similar to a conventional 3T scanner.

However, for functional imaging with EPI, the problem of noise generation still remains and may have several effects in addition to the stressful experience which will influence attention and autonomous nervous system functions of the subjects. Especially for auditory fMRI, the scanner noise interferes with the acoustic stimuli, despite protection by ear plugs. Several strategies have been proposed to minimize the direct interaction of noise and acoustical stimulation (e.g. 1, 2). A different approach to this problem is to directly avoid high noise levels by using different imaging protocols (FLASH) at the expense of slower imaging (3). An EPI-sequence (TR 2000 ms, TE 23 ms, FOV 192x256 mm, matrix 96x128, 19 slices, BW 1562, echo-spacing 0.7 ms) reaches a noise level of up to 107 dB peak (101 dB RMS) while FLASH type sequence (TR 122ms, TE 20ms, FOV 160x256 mm, matrix 80x128, 4 slices, FA 15, BW 210 Hz) produces acoustic noise levels of "only" 99 dB peak (95 dB RMS). A further advantage of the FLASH sequence compared to EPI is the strongly reduced geometric distortion of the images. The use of a FLASH sequence offers the possibility to slow down the gradient switching without affecting the image quality. In a multi-step procedure we further reduced the background noise by approx. 50 dB by using a longer gradient rise time (3000µs). Together with an optimized excitation pulse and modified spoiler gradients this reduced the noise level of the dominant gradient coil resonance frequencies by >40 dB at 1300 Hz and by >50dB at 780 Hz (63 dB RMS) (see Fig. 2). The headphone system (MR-Confon) and a foam cushion (Tempur) gave >20 dB suppression of background noise for frequencies above 0.5 kHz and more than 30 dB suppression at 2 kHz. All these measures add up to „low noise" imaging at 7 Tesla with a noise peak level of <50 dB SPL at the subjects ear.

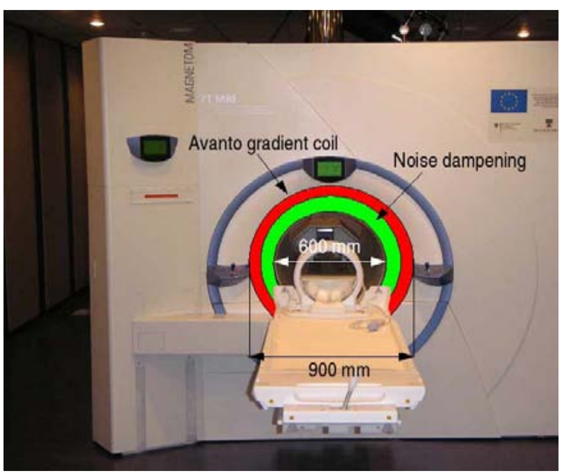

Fig. 1: Schematic view of the sound insulation between the inner tube and the gradient coil of the Siemens 7 Tesla scanner.

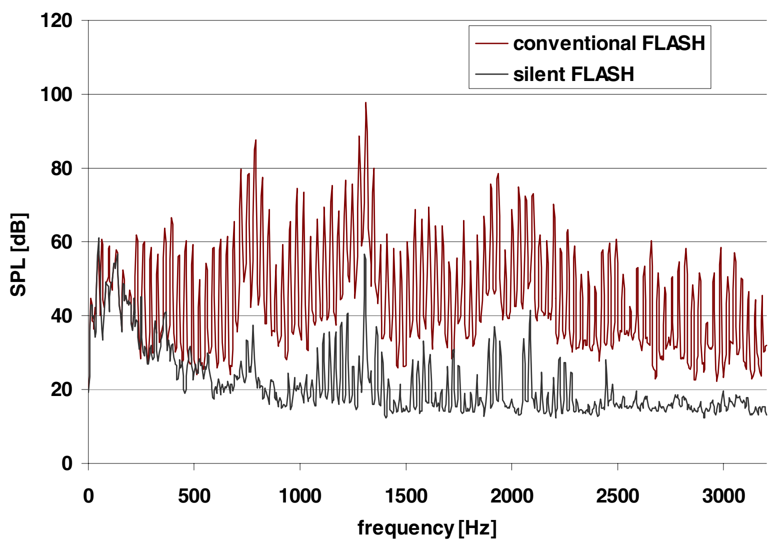

Fig. 2: Spectrogram of the scanner-noise of the two FLASH sequences

References: 1) Belin P, et al. (1999) Neuroimage 10: 417-429. 2) Hall DA, et al (1999) Hum Brain Mapp 7: 213-223.
3) Scheich H, et al. (1998) Eur J Neurosci 10: 803-809.

Acknowledgement: The work was supported by the German BMBF grant "Center for Advanced Imaging"