MRI of Human Brain Activation at 0.5 T, 1.5 T, and 3.0 T: Comparisons of ΔR2* and Functional Contrast to Noise Ratio

P. A. Bandettini, E. C. Wong, A. Jesmanowicz, R. Prost, R. W. Cox, R. S. Hinks*, and J. S. Hyde

*Biophysics Research Institute, Medical College of Wisconsin, Milwaukee, WI, and *GE Medical Systems, Milwaukee, WI*

PURPOSE:

In this study, activation - induced R2* changes and functional contrast to noise ratios are measured at 0.5 Tesla, 1.5 Tesla, and 3 Tesla.

INTRODUCTION:

A major goal in functional MRI is the characterization of the mechanisms which contribute to activation-induced signal changes. Studies have suggested several sources of functional contrast which may contribute in various degrees, depending upon MR parameters (1- 9).

To more accurately determine the contribution of susceptibility - related functional contrast, we observed the activation-induced R2* change dependence upon TE and pulse-sequence at three field-strengths, keeping all other parameters constant. Field dependence of functional contrast to noise was also characterized.

METHODS:

Imaging at 0.5 Tesla and 1.5 Tesla was performed on GE Signa scanners. Imaging at 3 Tesla was performed on a Bruker Biospec 3T/60 scanner. Low-pass, (0.5 Tesla and 1.5 Tesla), and band-bass, (3 Tesla), endcapped quadrature whole brain birdcage transmit/receive rf coils were used.

At all field strengths, single shot blipped gradient-echo and spin-echo echo-planar imaging (EPI) was performed using a three-axis balanced torque head gradient coil. Resolution = 3.75 x 3.75 x 5 mm^3. TR = 1 sec. TE was varied from 10 ms to 250 ms. The same subject was studied at all three field strengths.

At each TE value used, time course series of 200 to 500 sequential images of one axial plane through the motor cortex were obtained during cyclic (20 sec on, 20 sec off) bilateral finger tapping. A single functional image at each field strength was used as a mask in the averaging of pixels for time course measurements. From these time course series, resting, (Sr), and active, (Sa), signal values were obtained. ΔR2 and ΔR2* values were obtained by the slope of -ln(Sa/Sr)/TE. Also, functional contrast to a) physiologic and b) thermal + system noise were measured by dividing the activation - induced signal differences, ΔS, by the standard deviation of regions either in a) resting cortex or b) regions outside of the brain, respectively.

RESULTS and CONCLUSIONS:

Figure 1 shows ΔR2* values obtained from averaged regions at each field strength. While spatial heterogeneity exists in measured ΔR2* values, the similar sizes, (9 to 15 voxels), and locations of the averaged regions allow for a fair comparison. An approximately linear dependence of ΔR2* on field strength is observed.

Measured ΔR2*/ΔR2 ratios are about 3 to 4 at all three field strengths (data not shown).

Table 1 displays measured contrast to noise values at all three field strengths at TE values of 40 ms, 80 ms and 110 ms. The dependence of functional contrast to noise on field strength appears to have a dependence on Bo whose exponent is less than 1.

Physiologic noise dominates over system + thermal noise at all field strengths, and the ratios increase with field strength. From these measurements, it is clear that gains in functional contrast to noise can be obtained if physiologic noise can be removed from functional time course series.

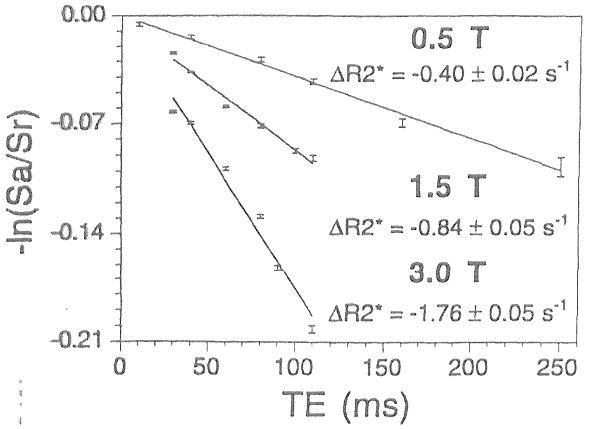

Figure 1: ΔR2* values obtained from slopes of -ln(Sa/Sr) vs. TE. An approximately linear dependence of ΔR2* upon field strength is observed.

	3 Tesla	1.5 Tesla	0.5 Tesla
TE	*ΔS / std (system & thermal noise)*		
40 ms	38.9 ± 0.5	21.3 ± 0.4	3.4 ± 0.3
80 ms	40.6 ± 0.4	27.9 ± 0.6	5.0 ± 0.3
110 ms	36.6 ± 0.5	23.4 ± 0.6	4.2 ± 0.2
TE	*ΔS / std (physiological noise)*		
40 ms	10.1 ± 0.1	6.5 ± 0.1	1.7 ± 0.1
80 ms	11.5 ± 0.1	8.2 ± 0.2	2.5 ± 0.2
110 ms	10.7 ± 0.1	6.8 ± 0.2	2.7 ± 0.1

Table 1: Neuro-functional contrast to system + thermal noise (ROI outside of brain) and contrast to physiologic noise (ROI in resting cortical regions), at 0.5 T, 1.5T, and 3T, across three TE values.

REFERENCES:

1.Menon. R, Ogawa S, Tank, D W, Ugurbil K.*Magn Reson. Med.* 30,380 386 (1993).
2.Bandettini PA, Wong EC, Jesmanowicz A, et al. *NMR in Biomedicine* (In Press).
3.Hoppel B E, Baker J R, Weisskoff R M, et al.*12th Ann.Sci. Mtg., SMRM.* 1993, p.1384.
4.Turner R, Jezzard P, Wen H, et al. *Magn. Reson. Med.* 29, 277-279 (1993).
5.Detre J A, Leigh J S, Williams D S, Koretsky A P. *Magn Reson. Med.* 23, 37 - 45 (1993).
6.Kwong K K, Belliveau J W, Chesler D A, et al.*PNAS,* 89, 5672, (1992).
7.Duyn J H, Moonen C T, de Boer R W, et al.*12th Ann.Sci. Mtg., SMRM.* 1993, p.168.
8.Frahm J, Merboldt K, Hanicke W.*12th Ann.Sci. Mtg., SMRM.* 1993, p.1427.
9.Hajnal J V, Collins A G, White S J, et al. *Magn. Reson. Med.*30, 650-653 (1993).