REPORT ON THE 28TH ANNUAL MEETING OF THE EUROPEAN SOCIETY OF MAGNETIC RESONANCE IN MEDICINE AND BIOLOGY, LEIPZIG, GERMANY, 6–9 OCTOBER, 2011

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Some 600 participants from around the world attended the 28th annual meeting of the European Society of Magnetic Resonance in Medicine and Biology (ESMRMB). The meeting took place in Leipzig, Germany, over 3 days and was a good opportunity to share the latest achievements in magnetic resonance imaging (MRI). Around half the presentations described technical aspects of new hardware and software; the other half was devoted to applications of MRI in clinical settings and scientific research. Each day there were courses on five different topics. Other selected sessions were aimed at giving the physical background to a range of imaging techniques and their advantages and limitations.

The conference hosted 2 round tables, 8 plenary lectures, 374 presentations, 24 courses, and 395 posters, making for an intense meeting. There were also 14 commercial presentations and exhibitions from 25 hardware and software companies. In the educational sessions, experts gave lectures skillfully synthesising knowledge.

An obvious trend was the use of high (3–4 T) and ultra high field (7 T) scanners. Some lectures showed detailed images of structural and functional organization of the brain obtained from powerful 7 T scanners. With better signal to noise ratio, the images have higher information content (Figure 1), and this improvement can be used to either increase resolution or decrease acquisition time. A 7 T scanner can achieve a resolution of 200 µm. With such small voxels, gray matter can be resolved into 6 cortical layers –Figure 2.

However, high spatial resolution does create new difficulties. Blood flow through vessels causes pulsation of the brain that was not a problem at lower magnetic fields, and similarly with motion from breathing, muscle tremor and head movement. Operators of 7 T machines report that they only record a few high resolution images a month that don't have motion artifacts, and it might be that image resolution of around 200 µm is a natural barrier for living organisms.

Because of the greater spatial resolution from 7 T machines, accurate brain segmentation is easy. If we take brain images from a 7 T scanner and slices from a post mortem brain, each anatomical detail can be seen in the MRI image. Moreover, functional imaging has new capabilities – BOLD (blood oxygen level dependent) signal have over 2 times higher amplitude in 7 T scanners than

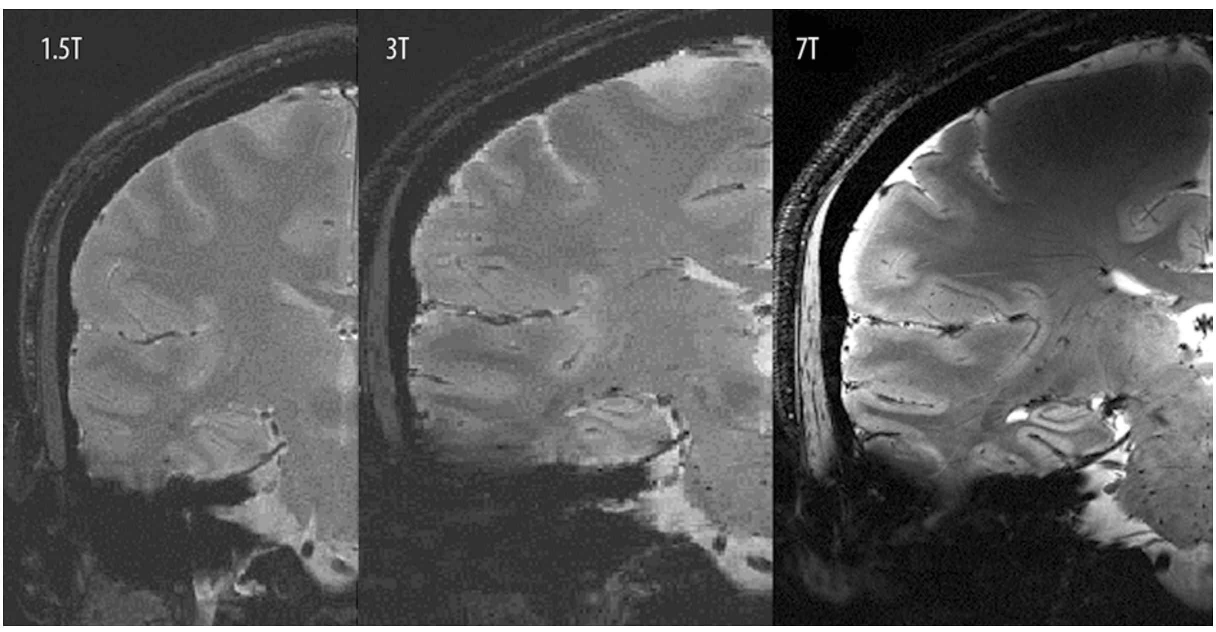

Figure 1. How spatial resolution increases with magnetic field: 1.5 T, 3 T, and 7 T. Images from Siemens Erlangen.

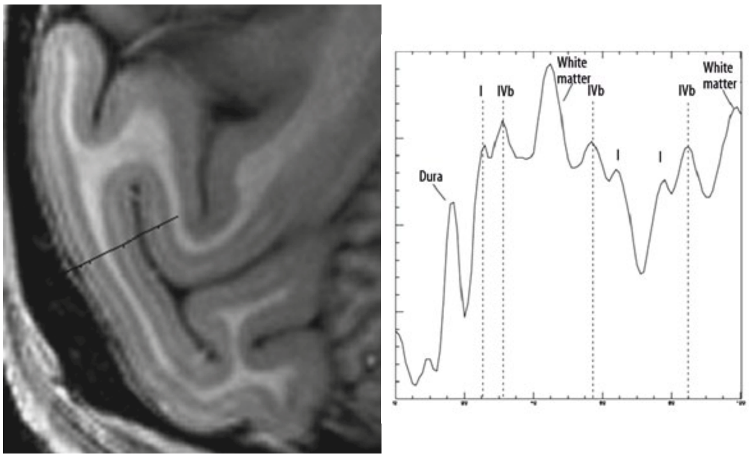

Figure 2. T 1-weighted image from a 7 T scanner. Resolution: 250×250 µm. At right is a cross-section of cortex along the black line at left. Source: Siemens Erlangen.

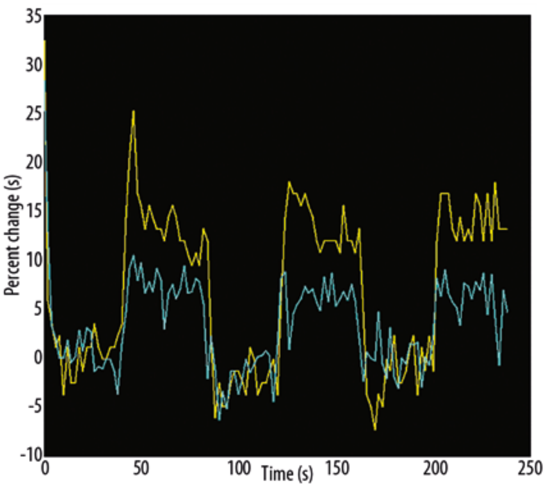

Figure 3. BOLD signal from 7 T scanner (yellow) and from 3 T scanner (blue). Source: Siemens Erlangen.

in 3 T scanners (Figure 3). BOLD signal origins from the difference in oxyhemoglobin contents in blood supplied to neurons engaged in particular task realization. Active region needs more oxygen than passive one to perform a task. Higher oxygen ratio in blood causes smaller local magnetic field inhomogeneity so achieved MR signal has slightly higher amplitude. The larger the inductive field is, the greater the difference in signal amplitude between the state of arousal and the of rest is greater.

MRI does not measure neuronal activity directly (as an EEG does) but indirectly through changes in blood composition. In 7 T images, the main source is vessels next to neurons, whereas in 1.5 T scanners the signal comes mainly from large vessels further away from active neurons. 3 T scanners are an intermediate case, with mostly small and micro vessels. In general, the higher the field, the more reliable the picture.

Most medical and scientific work is done on 3 T scanners. According to manufacturers, there are over 1000 such devices around the world but only 35 units operating at 7 T. The 7 T scanners are not used in clinics and there are still many technical issues to be solved.

Higher fields improve image quality but unfortunately create problems with tissue heating due to absorbed electromagnetic waves. Due to this limitation, there is a tendency to develop parallel imaging techniques. Modern MRI systems are equipped with multi-element and multi-channel RF coils (up to 128 receiving channels). Multi-channel receiving coils record the same signal in parallel, resulting in a better signal to noise ratio and speeding up data acquisition. When techniques like SENSE, GRAPPA or GEM are used, imaging speed can be increased over a dozen times.

A new digital coil was on offer from Philips. The company have integrated a coil and a miniature analog to digital converter, reducing signal loss and distortion during its transmission to the server. They claim a 40% reduction in distortion, a gain which can be put to use to improve contrast or shorten examination time.

A relatively new concept in MRI is traveling wave RF transmission, where an object is excited by radio waves without the need for conventional RF coils and magnetic gradient coils. The technique is still under development, but this year the first images were presented. It seems that problems with excitation quality have been overcome. A substantial benefit of eliminating gradient coils is reduction in auditory noise. In a conventional MRI system, the coils are switched at high speed and high voltage, generating sound of around 100 dB. The new method will make MRI scanners quiet and comfortable. In addition, there is also a smaller effect on EEG equipment used during simultaneous EEG-fMRI.

Another hardware improvement is the use of multiple transmitters of radiofrequency impulses for tissue excitation (Tx RF impulses). Special coils enable selective signal saturation: e.g., for spinal imaging, only atoms which are located in the spinal area are excited and all surrounding tissues are, by dint of saturation, left unexcited. The use of multiple transmitters also allows for more uniform excitation of a chosen area so that the final image is clearer. As a result, automatic segmentation algorithms work better and can easily distinguish, for example, gray matter from white matter.

There were also a number of software improvements and new imaging sequences. The latest processing strategies allow the same image quality to be obtained with fewer measurements.

Hyperpolarized contrast agents were announced. We saw images acquired with the use of hyperpolarized carbon-13, the isotope present in all living tissues. By amplifying the carbon-13 signal more than several thousand times, images of where this compound accumulates in the body can be produced. We are at the beginning of an era when hyperpolarized contrasts will revolutionize clinical diagnostics. A current limitation, however, is that the polarization time lasts no longer than 10–40 s, which is inadequate for typical clinical examinations. Nevertheless, several scientific groups are working on making chemical compounds that will last at least a few minutes.

Numerous educational, clinical and scientific sessions covered fMRI, which is still a developing technique. Currently, scientists are mainly aiming at recording neuronal networks in their resting state. There were also a few presentations about connecting fMRI and EEG in this area.

Interesting topic in this case was simultaneous EEG-fMRI of the resting brain. One innovative proposal was to record the brain in its resting state using spontaneous EEG activity as regressors. This allows one to examine neuronal networks, such as the thalamo-cortical path in the visual cortex, using the alpha rhythm. Recording EEGs during fMRI examination is still novel, but it can produce better and sometimes surprising results.

There were two stimulating debates. In the first, a question was asked whether ASL (arterial spin labeling) was ready to replace the traditional DSC (dynamic susceptibility contrast) technique. Both techniques parametrically map blood flow in the brain, but the second needs a contrast agent to be injected into a vein while the other does not. Instead, ASL uses blood as the contrast agent, magnetized just before it enters the region of interest. Blood excitation is achieved by a special sequence of RF pulses and magnetic gradient coding. Arguments in favour of each technique were presented by the inventors – Prof. Golay (ASL) and Prof. Ostergaard (DSC). At the end of the session, audience members voted: according to the result, ASL is not yet ready to replace DSC, but we are not too far from it.

A second debate led by Derek Jones was about DTI (diffusion tensor imaging) which allows the diffusion direction of water molecules to be determined. For each voxel a diffusion tensor is calculated which specifies the average diffusion of all particles inside. The diffusion data can be used to reconstruct nerve tracts (fiber tracking). The question for discussion was whether DTI can be used in clinical diagnosis, and it involved a radiologist, a physicist and an anatomist. The lively debate revealed many positive and negative features of DTI. According to the radiologist this technique is amazing and completely ready for the clinic, but the physicist did not agree. He thought that the technique had many limitations and is completely unpredictable. The anatomist considered that nerve tracts reconstructed by DTI were reliable, but only for a small percent of all tracts in the brain. Prof. Suneart from Belgium expressed the opinion that it is better to know something than nothing, but anyone who uses DTI must be aware of how it works and its limitations. Voting indicated that exact 40% of participants were in favor of using DTI in the clinic, 40% were against and 20% had no opinion.

Summing up, the ESMRMB conference was conducted on a very high level. Its educational value was superb and the opportunities for knowledge sharing were invaluable. Technically, the conference was perfectly planned. All sessions ran without delay and without problems. We will be there for the next congress and recommend it to anyone involved in MRI.