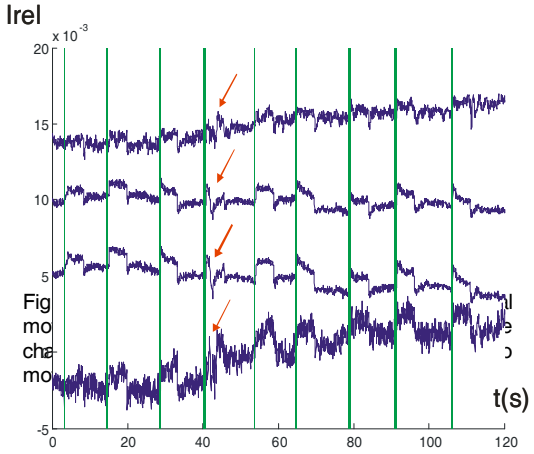
Rapid simultaneous measurement of stimulus related signal changes in visual and motor cortex with MR-encephalography

J. Hennig[1], T. Grotz[1], O. Speck[1], and K. Zhong[1]
[1]Dept. of Radiology, Medical Physics, University Hospital Freiburg, Freiburg, Germany, Germany

MR-Encephalography (MREG) (1) also called inverse MR-imaging (2) have been introduced as an extremely fast technique to monitor physiological changes with frame rates of 20-100 Hz by use of simultaneous readout with multiple small RF-coils. Without spatial encoding gradient the spatial source for each channel is determined by the sensitive volume of each coil. One-dimensional encoding under a readout gradients can be introduced without penalty sampling speed. As a basis to study the temporal relation between activation in visual and motor areas we have built a coil area using two coil element bilaterally covering the visual cortex and 2 freely movable coils to be placed on the motor cortex. We present first results of MREG of simultaneous visual and motor activation.

Materials and methods

All experiments were performed on a 3T scanner (Trio, Siemens), Measurements were performed with a gradient spoiled FLASH-sequence with TR=50 ms. The stimulation paradigm was a modification of the attention fixation task we routinely use for visual stimulation: During presentation of an alternating checkerboard a fixation point is presented at the center of the screen. The subject is asked to perform 5s bilateral finger movement after each change in the colour of the fixation point. Time interval for the color change was randomized to lie between 10-15 s. Three experimental runs with duration of 20s(initialization)-120s(measurement) each were performed. Areas of activation were determined by running a conventional EPI-based experiment for identification of the activation areas in the visual and motor cortex. For MREG an oblique slice covering both cortices was selected, experiment was performed with slice selection but without any further spatial encoding gradient. Data were analyzed using home-build MatLab-tools as well as using EEGLab.



Results

All experiments showed identical results. Fig.1 shows the signal intensity Irel as the mean of the first 10 datatpoints of each FID (acquired at te=10ms) along time. The green vertical lines represent the times of colour change of the stimulus. The stimulus dependant relative signal change in the visual cortex is in the order of 0.2 %. Fig.2 shows the averaged response over the stimulus episodes. Signal response shows a rapid signal increase over the first second especially in the visual cortex, whereas signal rises more gradually in the motor cortices. Fig.3 shows the difference FIDs 1s before and 2s after activation. The periodic modulation of the FIDs is due to subcutaneous fat. The difference FID in the visual cortex shows the typical pattern of a change in signal amplitude, whereas motor response reflects a change in T2*. This is indicative of different mechanisms underlying the observed signal change.

Discussion

The very rapid signal change in visual cortex upon stimulus presentation is much faster than a typical BOLD-response, the difference FIDs reveal, that this effect is not (primarily) due to a BOLD-effect. A possible hypothesis to explain this finding may be an inflow effect from increased arterial perfusion. Our experiment with TR=50 ms and 30° flip angle leads to appreciable signal saturation, therefore any change in inflow can be expected to lead to appreciable signal changes. The absence of a BOLD-effect in the visual cortex – which is in contrast to earlier results – may be due to the fact, that the underlying checkerboard stimulation has already led to a saturation of the BOLD-effect. The motor response also shows a fast initial increase but then continues to rise with a time constant typical of a BOLD-response, which is also on accordance with the observed T2*-change in the FIDs.

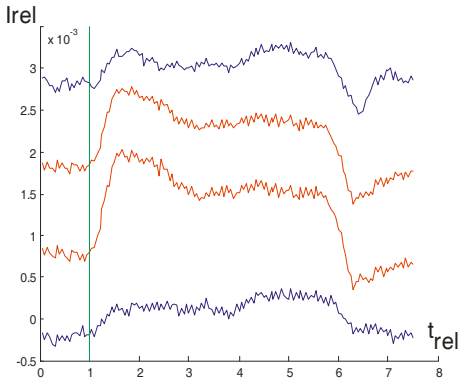


Fig.2 Average signal time course over the episodes of stimulus presentation.

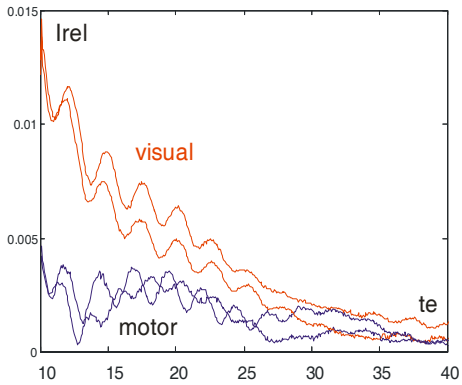


Fig.3 Difference of FIDs 2s after- 1 s before stimulus presentation.

Conclusion

The feasibility of rapid simultaneous MREG-measurement following the signal change in different areas of activation has been demonstrated. The observation of the full FID (rather than a single T2* weighted signal intensity as in conventional fMRI) allows to distinguish the BOLD-effect from other physiological effects. Further experiments are required to test the hypothesis, that the fast signal change is due to fast onset of perfusion. This can be achieved by using inflow sarturation and/or flow dephasing gradients to distinguish parenchymal signal from flowing blood.

References: (1) Hennig J, Zhong K, Speck O. Neuroimage. 2006 Oct 27, epub ahead of print. (2)Lin FH, Wald LL, et al. Magn Reson Med. 2006 Oct;56(4):787-802. (3) availble at http://sccn.ucsd /eeglab