An LCD Monitor for Visual Stimulation fMRI at 7 Tesla

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Introduction

In many fMRI studies dedicated projection systems or MR-compatible goggles are utilized to present the visual stimuli [1, 2]. These systems are significantly more difficult to apply at very high field strengths (B_0 > 4 Tesla) due to the longer magnet bores or the sensitivity of the displays to the stronger field. In this work we present a fully compatible TFT monitor for fMRI that can operate within magnetic fields of up to 7 Tesla.

Materials and Methods

The new presentation system (Fig. 1) consists of two main components: A modified 17" TFT-LCD (LTM170E4-L01, Samsung, Suwon, South Korea) and a controlling unit outside the magnet room. Both units are connected via a 12 meter-long signal cable, so that the display can be placed at magnet iso-center. To minimize RF interference, the signal cable and the monitor casing are completely RF-shielded. The TFT-LCD itself is shielded by a metallic-coated glass plate which does not affect the screen brightness. The cold cathode fluorescent lamp (CCFL) backlight of the original monitor was replaced by a nonmagnetic LED backlight consisting of 100 white SMD-LEDs. The LED backlight provides the same brightness and color temperature as the CCFL. The controlling unit can be connected to a PC via a standard VGA-cable.

Phantom measurements were performed to evaluate RF noise during standard fMRI sequences due to the presence of the display. Therefore, 2 EPI series (TR = 2530ms, TE = 27ms, α = 90°, SL = 3mm Matrix = 64x64, FOV = 210mm, BW = 1630Hz/px) were acquired: first without monitor and second with the switched-on monitor 20cm away from the magnet bore of the 7T-MR-system (Magnetom 7T, Siemens, Erlangen, Germany). For signal reception, a 24-channel Rx/Tx-coil (Nova Medical, Inc., Wilmington, USA) was used.

To demonstrate the utility of the new presentation system, fMRI experiments where performed. The visual stimulus consisted of a flickering checkerboard (1 Hz rate) with a dot at the center as a visual fixation help (cf. Fig. 1), which was presented via a mirror to the volunteer. After the acquisition of T1-weighted GRE images for image registration the BOLD fMRI experiment was performed with same EPI parameters as above. The fMRI study consisted of 6 checkerboard stimulation blocks (30 s each) separated by 30 s rest blocks where the monitor was showing a white image. Activation maps were calculated with SPM 8 (Wellcome Department of Imaging Neuroscience, University College London, London, England).

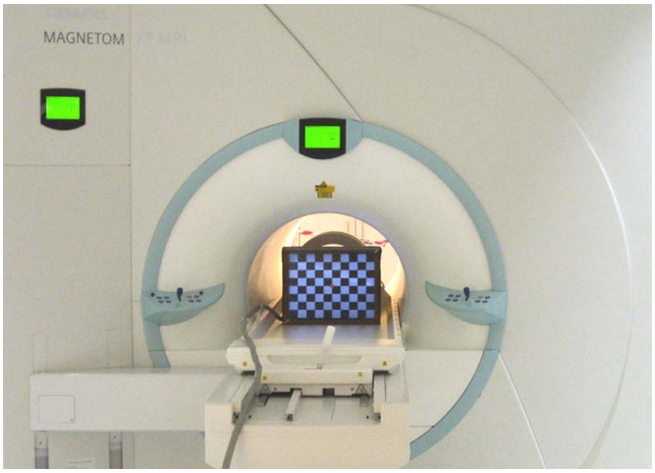

Fig.1: Display at the iso-center of a 7T-system presenting a checkerboard stimulus for fMRI.

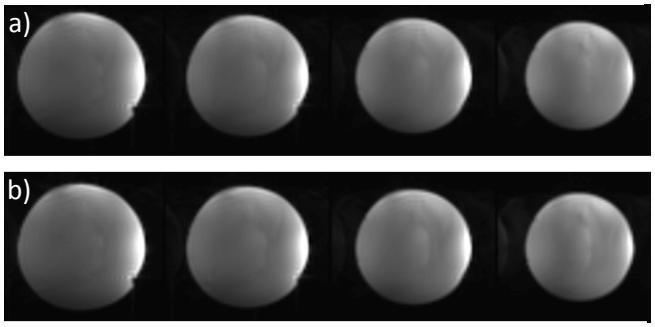

Fig.2: Comparison of different slices acquired with EPI where the monitor was switched off (a) and switched on (b).

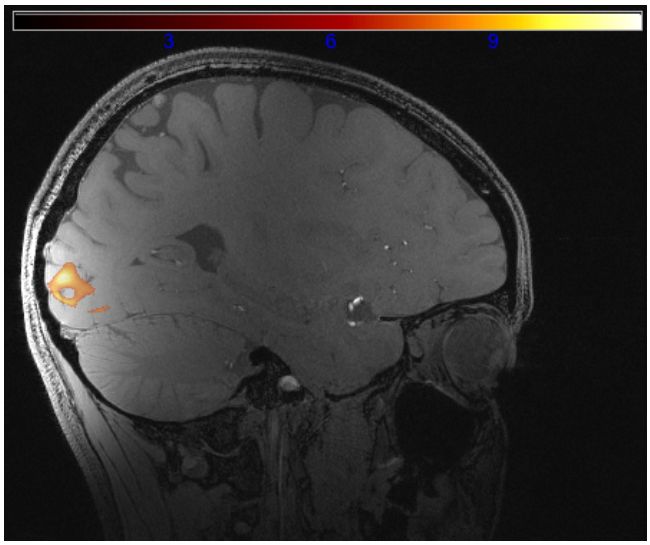

Fig.3: Calculated activation maps for visual stimulation at 7T.

Results and Discussion

With the monitor being active a 20% lower SNR was measured; however, no distinct RF-induced artifacts could be detected (Fig. 2). The image displayed on the LCD was affected neither by the static nor the dynamic (gradients, RF) magnetic fields. The activation map (Fig. 3) does not contain artifacts caused by the presence of the display, and activation of the visual cortex is clearly visible.

The monitor proved to be suitable for visual stimulation fMRI up to 7T. The monitor provides a spatial resolution (1280×1024) that is significantly higher than common LCD projectors (1024×768). It is easy to handle and can be placed very close to the volunteer or patient. Additionally, the display could be used as a real-time image display in MR-guided interventional procedures or as an in-room communication and feedback system.

References

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[2] M.B. Hoffmann et. al., Clinical Neurophysiology 120 (2009) 108–116