Optimization of MDEFT with FLASH-EPI hybrid readout for optimum contrast in selected brain areas

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Introduction In functional MRI there is a great demand for T1-weighted structural whole brain scans with high spatial resolution and a good white matter (WM) and grey matter (GM) contrast-to-noise ratio (CNR). They are used as reference images, since EPI images are of low spatial resolution and contrast. The MDEFT sequence [1, 2] is widely used because of its advantageous contrast characteristics, especially at high field strengths. It consists of a magnetization preparation part starting with a saturation pulse followed by a time delay τ1 and spin inversion. After an additional delay τ2 a readout part follows, normally 3D FLASH [3]. A FLASH-EPI hybrid readout can be used to speed up the sequence [4]. In this work, parameters of an MDEFT sequence with FLASH-EPI hybrid readout and a total acquisition time of 6 min were optimized at 3T to achieve maximum CNR and signal-to-noise ratio (SNR) for cortical WM and GM and to enhance the visibility of certain brain structures like internal capsule (IC), thalamus (Tha), Putamen (Put) and optic radiations. The sequence achieves approximately the same SNR as MDEFT based on a standard FLASH readout with twice the acquisition time at the same field strength with identical spatial resolution and comparable RF equipment [2].

Materials and Methods Measurements where performed on a 3T whole body MR scanner (Magnetom TRIO, Siemens) using an 8-channel array coil (receive-only) and the whole body transmit coil. MDEFT sequence parameters were optimised for 3T and a total acquisition time of 6min according to [4]. Two series of measurements were performed exploring the two-dimensional parameter space (TI, quot) with TI=τ1+τ2 and quot=τ1/TI, each series comprising the parameter set that should in theory yield maximum CNR as shown in Fig. 1: in the first series, TI was changed from 350ms to 850ms in steps of 50ms with a constant quot=44%. In the second series, TI was kept constant (700ms) while varying quot from 30% to 50% in steps of 5%. In all measurements a field-of-view (FoV) of 256mm×224mm×176mm (readout/2D/3D-direction) with an isotropic resolution of 1mm was chosen. For evaluation of SNR and CNR values ROIs were defined manually in the following regions: WM (Trunc of Corpus Callosum), GM (Head of Caudate Nucleus), IC, Tha, Put, optic radiation and WM near optic radiation.

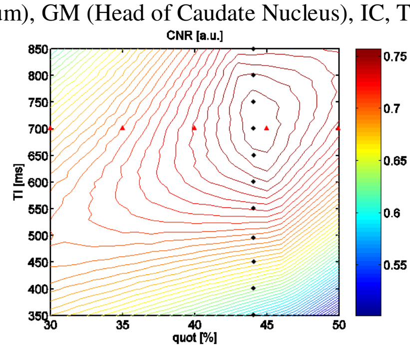

Fig 1: Simulation: CNR in dependence on quot and TI. The black diamonds and red triangles show the parameters for series 1 and 2, respectively.

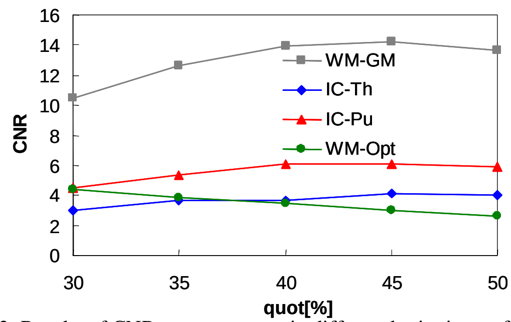

Fig. 2: Results of CNR-measurements in different brain tissues for series 2.

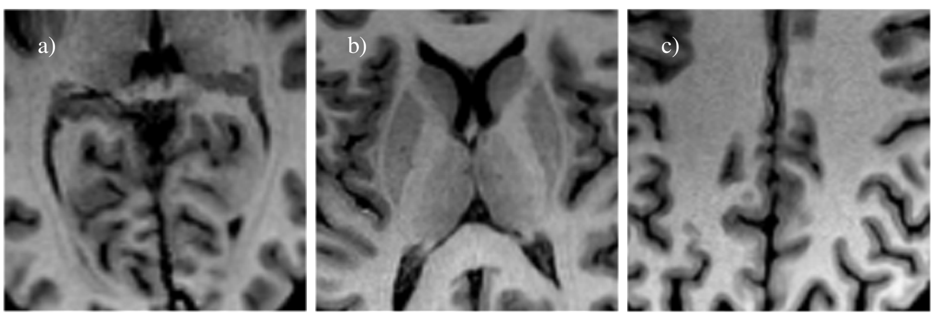

Fig 3: Axial slices showing selected anatomical regions acquired with the optimum parameter set: a) optic radiations, b) basal ganglia, c) upper brain

Results For the first series, the CNR shows a flat maximum centred at about TI=700msec, as predicted by the theory (Fig. 1). For the second series, the CNR of WM-GM shows a maximum at quot=45% (Fig. 2), in accordance with the theory (Fig. 1). CNR between IC and Tha and between IC and Put behaves in a similar way. However, the visibility of the optic radiation decreases slightly with increasing quot (Fig. 2). Thus, the parameters TI=700ms and quot=40% were chosen as best compromise between optimum CNR and good visibility of the optic radiations. Figure 3 shows some anatomical structures acquired with these parameters. Apart from good visibility of the optic radiations (Fig. 3a), an excellent confinement of IC and Tha and Put, respectively, can be seen in Fig. 3b, as well as a good contrast between WM and GM together with suppressed CSF (Fig. 3c).

Discussion Experimental data show good agreement with the simulated SNR and CNR values. According to the simulation, optimum parameters would be TI=700ms and quot=44%. However, for the optic radiations contrast is better at lower quot-values. Since for the other brain areas CNR in dependence on quot shows a rather flat maximum we suggest the optimum parameters TI=700ms and quot=40%. The other parameters are in this case: TR=14.2ms, TE=6ms, BW=283 Hz/px, FA=20°. The total acquisition time of 6min without parallel imaging in comparison to 12min with the standard MDEFT sequence at comparable SNR and CNR values makes this technique extremely attractive.

References

[1] Ugurbil et al., Magn.Reson.Q. 1993; 9:259-277;
[2] Deichmann et al., Neuroimage 2004; 21:757-767;
[3] Frahm et al., J.Comput.Assist.Tomogr 1986; 10:363-368;
[4] Deichmann et al., Neuroimage 2006; 33:1066-1071;