QUIET SHORT ECHO TIME GRADIENT ECHO MRI

Martin Ott[1], Felix Breuer[1], David Grodzki[2], Martin Blaimer[1], Simon Triphan[1,3], and Peter Jakob[1,4]

[1]MRB Forschungszentrum für Magnet-Resonanz-Bayern e.V., Würzburg, Bavaria, Germany, [2]Siemens AG, Erlangen, Bavaria, Germany, [3]Diagnostic and Interventional Radiology, University Hospital Heidelberg, Heidelberg, Germany, [4]Department of Experimental Physics 5, University of Wuerzburg, Würzburg, Germany

Target audience: This work aims for people who are interested in MR acoustic-noise experiments and improving patient comfort.

Purpose: High acoustic-noise levels are a common problem in rapid MR Imaging. In the past, not only fMRI [1] but also clinical standard sequences [2, 3, 4] were part of research regarding acoustic noise reduction. Standard GRE sequences can reach up to over 110 dB(A) when short echo times (TE < 2 ms) and repetition times (TR < 50ms) are employed or/and small slice thickness (ST < 2mm) is required. In this work, we aim to reduce these noise levels in GRE imaging significantly. To this end, a novel prototype sequence approach is described, allowing for significant noise reductions by the use of half-pulses combined with dynamic partial-k-space acquisition**.** First image results are presented.

Methods: The focus is on short echo times, thin slices and low slew-rate. Therefore we restrict the slew-rate of all gradients to avoid acoustic noise generation and apply the following methods as illustrated in Figure 1:

1) The use of half-pulse excitations with long duration which require no or only minimal slice rephasing moments and hence slower gradient activity. Therefore we can excite thin slices without generating large rephasing moments. The linearity of k-space excitation allows to average the signal of two measurements with opposite slice selection gradient polarity to one k-space with common RF-pulse

2) Strong asymmetric echo in readout-direction is applied in the k-space-center to keep the TE in the contrast relevant k-space close to the demanded TE.

3) For peripheral k-space we allow a higher TE and set the duration of the readout-dephasing gradients equal to duration of the phase-encoding gradients. Consequently a wedge shaped k-space part is not sampled as shown in Figure 2.

However, the sampling of peripheral k-space allows for accurate estimation of the object phase. The missing data was reconstructed using a Margosian [5, 6] algorithm.

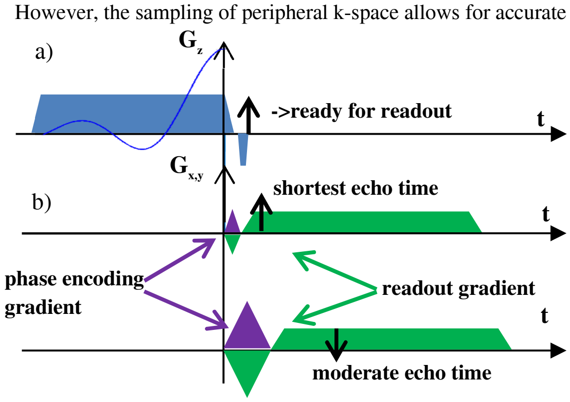
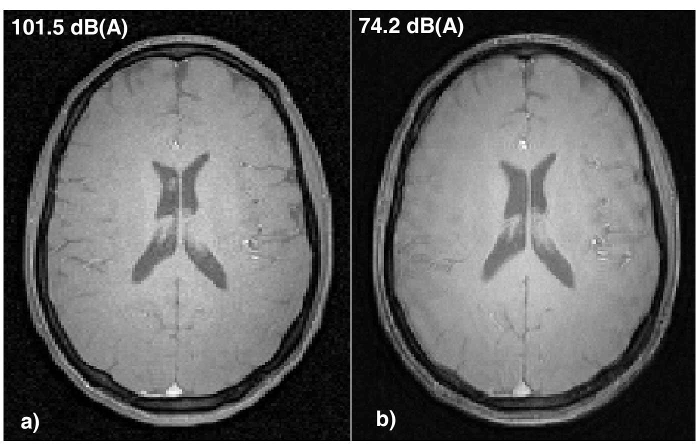


Figure 1: schematic sequence diagram

a) the slice-direction gradient is depicted as well as a rf-half-pulse: the excitation-scheme is always the same except for gradient polarity changes due to averaging. The excitation is ready for readout only a short time after the end of the rf-pulse. See method 1

b) the read- and phase-direction is depicted as well as positions of possible first echo times; the dephasing moment is equal to phase-encoding moment, this results in a variable asymmetric echo. The upper scheme corresponds to central k-space, the lower scheme to peripheral k-space. See method 2 and 3

Exemplary in-vivo experiments were performed on a 3T MAGNETOM Skyra system (Siemens Healthcare, Erlangen, Germany), equipped with a 20-channel head/neck coil. A standard GRE-sequence with asymmetric echo was used with the following parameters: TR = 15ms, FoV= 350x350mm², base resolution = 256, TE = 1.92 ms, slice-thickness = 3mm, BW = 610Hz/px .The developed sequence used identical parameters, but the readout band-width (BW) was constantly at 200Hz/px. The acoustic-noise was analyzed using a Brüel&Kjaer Mediator 2238 Noise-Meter in a separate measurement.



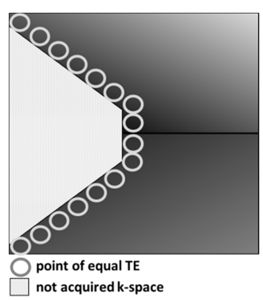


Figure 2: k-space sampling-scheme

Data is acquired with a low TE in the most contrast relevant k-space center. This is on the cost of a wedgelike non acquired k-space in the peripheral part.

Figure 3: image results

a) image acquired with a standard GRE-sequence with asymmetric echo
b) image acquired the new proposed method with post processing Margosian algorithm

Results: Figure 3a shows a image with a standard GRE-sequence and Figure 3b the quiet acquired image. Acoustic noise levels dropped from 101.5 dB(A) to 74.2 dB(A). Hence, we obtained a noise level reduction of over 25 dB(A) compared to the standard sequence. Only 2/3 of the k-space was acquired, nevertheless the obtained image shows better SNR than the standard GRE-sequence due to low bandwidth acquisition, which is technically not feasible in standard GRE sequences having a low TE.

Discussion: We have demonstrated that significant acoustic-noise reductions can be achieved in GRE imaging even at small TEs, thin slice thickness and high spatial in-plane resolution with some visible degradation of image quality. Acoustic-noise measurements revealed a significant reduction of noise level by 25dB to a permanently tolerable level. The additional measurement time can be reduced by applying parallel imaging techniques or the use of asymmetric pulses in the outer k-space-region instead of averaged half-pulses. Other k-space reconstructions algorithms like POCS could be applied.

Conclusion: The proposed sequence design allows for fast GRE imaging with significantly reduced acoustic noise.

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References: [1] Schmitter et al, MRM 21:317–325 (2008), [2] Hennel et al, MRM 42:6–10 (1999), [3] Hedeen, Edelstein, MRM 37:7-10 (1997), [4] Hennel, JMRI 13:960 –966 (2001) , [5] Pauly et al, JMRI 81:43 –56 (1989), [6] Margosian et al MRM (2007)