

# ACOUSTIC NOISE REDUCTION IN PD- AND T1-WEIGHTED TSE-IMAGING

Martin Ott<sup>1</sup>, Martin Blaimer<sup>1</sup>, Felix Breuer<sup>1</sup>, David Grodzki<sup>2</sup>, and Peter Jakob<sup>1,3</sup>

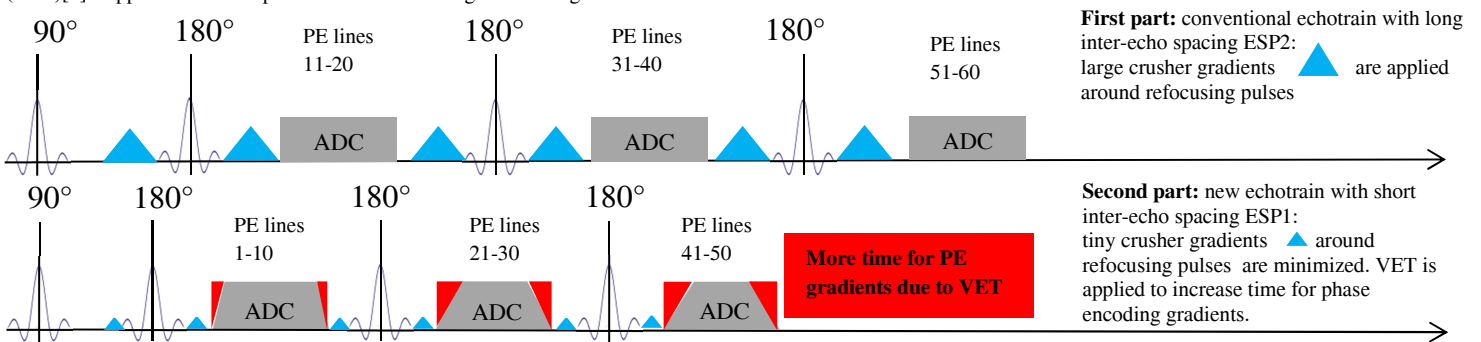
<sup>1</sup>MRB Forschungszentrum für Magnet-Resonanz-Bayern e.V., Würzburg, Bavaria, Germany, <sup>2</sup>Siemens AG, Erlangen, Bavaria, Germany, <sup>3</sup>Department of Experimental Physics 5, University of Würzburg, Würzburg, Bavaria, Germany

**Target audience:** This work aims for people who are interested in MR acoustic-noise experiments and 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 addressed for the reduction of acoustic noise. For example, standard TSE sequences (also known as RARE/CPMG/FSE) can reach over 100 dB(A). The purpose of this work is to significantly reduce the noise levels in TSE imaging (qTSE) in a prototype sequence. Recently it has been shown that T2-weighted qTSE imaging (requiring a long TE) with reduced acoustic noise is feasible when the inter-echo spacing can be increased and other gradient optimization is applied [5]. This is not applicable for PD- and T1-weighted images since TE equals the inter-echo spacing and needs to be short. In this work, we describe a novel concept for generation of T1-weighted as well as PD-weighted images, allowing for significant noise reduction by the use of improved k-space reordering in combination with an optimized crushing gradient.

**Methods:** For T1-weighted and PD-weighted image contrast, commonly a short TE <10ms as well as a short echo train length < 5 (i.e. turbofactor TF) is used. Using protocol and sequence optimization, a longer TE might be needed for a significant noise reduction. To overcome this problem, we divide k-space into two interleaved parts and measure with two different inter-echo spacings which are constant within each shot:

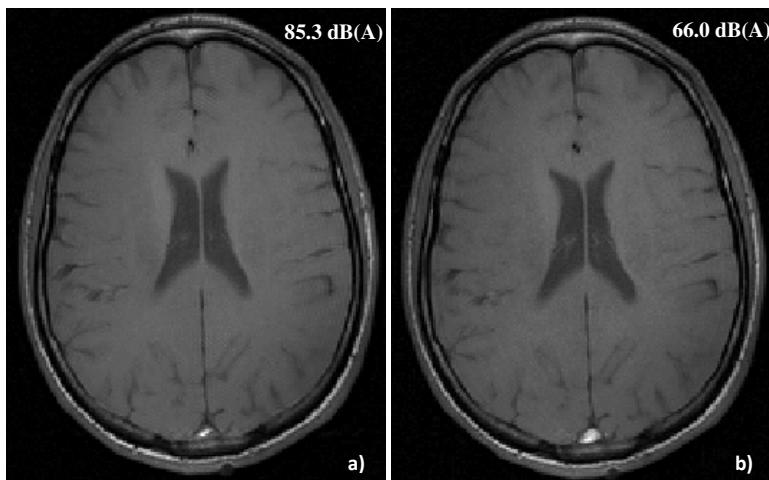
The first part concerns the peripheral region of k-space where higher echo spacings are unproblematic. This can be measured with a longer inter-echo spacing of e.g. 12ms. This part of the sequence can be implemented to be very quiet since enough time is available. This is depicted in the first sequence diagram in Figure 1. The second part concerns the center part where a short TE and hence a short inter-echo spacing is compulsory. To keep the slewrate and acoustic noise as low as possible we apply the following modifications. To avoid spurious FID-echoes of the 180° pulses, the k-space part is measured twice with phase-cycling technique [7] instead of applying crusher gradients which require fast-switching gradients. To increase time for phase-encoding gradients (PE lines), Variable Encoding Time (VET)[6] is applied. This is depicted in the second diagram in Figure 1.



**Figure 1: Noise management** using two temporally interleaved TSE readouts, where each TSE shot is independently noise reduced. The readout ADC bandwidth is constant for every readout. The depicted PE lines are exemplary. Overall echo time distribution is smoother due to the low change of TE within k-space from segment to segment.

Using both sequences within one measurement, all PE lines can be filled with very low gradient activity and therefore very quietly. Due to the second sequence type measurement time increases by 50%. Experiments were performed on clinical 3T scanner (Magnetom Skyra, SIEMENS, Erlangen, Germany) and compared to the standard TSE sequence using the parameters provided in Table 1. Target subjects were phantoms as well as healthy volunteers. The acoustic noise was analyzed using a Brüel&Kjaer Mediator 2238 Noise Meter with an applied dB(A)-weighting. The noise was measured during a phantom measurement using the same imaging parameters.

**Results:** All measured dB(A) values are shown in the Table 1. Significant noise reduction of up to 19 dB(A) was achieved. In-vivo results are shown in Figure 2. PD-weighted images with a longer TR lead to the same acoustic noise level.



sequence	ESP1	ESP2	Acquisition time	Acoustic noise level
TSE	-	9 ms	59 s	85,3 dB(A)
qTSE	9 ms	12 ms	89 s	66,0 dB(A)

**Table 1: Imaging parameters** for the performed experiments. Slice thickness: 5mm, Matrix: 256x252, FOV: 250mmx250mm, TF: 3, TE: 9 ms, TR: 700 ms, readout bandwidth TSE 227 Hz/px, readout bandwidth qTSE 260 Hz/px

**Figure 2: comparison of reference and new proposed method**

- T1-weighted image from a healthy volunteer acquired with a conventional TSE sequence
- the same image acquired with the new proposed qTSE sequence. The conventional image visually does not differ from the new proposed method

**Discussion:** The proposed method allows for a significant noise reduction without loss of image quality at an increase of acquisition time. Parallel imaging techniques like SENSE or GRAPPA could be applied for reducing the extended measurement time to the standard level.

**Conclusion:** We showed a new concept for reducing acoustic noise by a factor of over 3.5 in terms of loudness even with short-echo-time imaging. This promises higher patient comfort and less imaging artifacts while having no need for hardware modification.

**Acknowledgements:** Siemens, Healthcare Sector, Erlangen, Germany, for financial and technical support and Bavarian Ministry of Economic Affairs, Infrastructure, Transport and Technology (BayStMWiVT), for financial support.

**References:**[1] Schmitter et al, MRM 21:317-325 (2008), [2] Hennel et al, MRM 42:6-10 (1999), [3] Hedeem, Edelstein, MRM 37:7-10 (1997), [4] Hennel, JMIRI 13:960-966 (2001), [5] Pierre et al. ISMRM 2012#0253 [6] Feinberg, D. A. MRM 38: 7-14 (1997) [7] Klarhöfer et al. ISMRM 2006# 3024