T2-prepared combined acquisition technique (CAT) for SAR reduced neuroimaging

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Introduction: Fast Spin Echo MRI such as RARE [1] (Turbo Spin Echo, TSE) at high field strengths is challenging due to the increased SAR especially when long echo train lengths (ETL) are needed. Currently Hyperecho-RARE [2] imaging and GRASE [3] are the most versatile sequences with reduced SAR for T2-weighted imaging.
The TSE-EPI-CAT hybrid approach (Combined Acquisition Technique) [4, 5], which essentially integrates TSE and EPI modules in a sequential fashion, is also an interesting candidate for high-field MRI. However, so far, the free choice of the λ-factor, which defines the percentage of echoes acquired in the TSE module, was limited for arbitrary T2-contrast imaging.
The proposed technique overcomes the aforementioned limitation with the additional potential of significantly reduced λ-factors and thus SAR. The TSE-EPI-CAT used here acquires the TSE-echoes for the center of k-space and the EPI-echoes for the periphery of the k-space as shown in figure 1. As demonstrated in this work, the combination of TSE-EPI-CAT with T2-preparation [6] and centric reordering allows for (1) an increased flexibility, (2) higher SAR reduction, (3) flexible T2-weighting and (4) further flexibility in the choice of λ in particular for large matrix sizes.

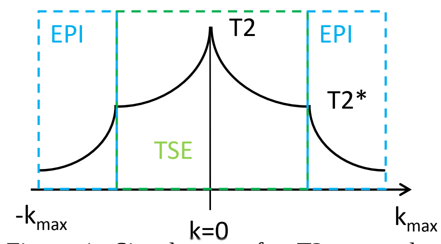

Figure 1: Signal curve for T2-prepared TSE-EPI-CAT imaging.

Materials and Methods: Figure 2 shows a diagram of a T2 prepared TSE-EPI-CAT sequence. The T2-preparation module allows for a flexible choice of the echo time (TE) and thus a flexible choice of λ. Imaging experiments were performed on healthy volunteers using a clinical 1.5 T scanner. The parameters of the T2 prepared TSE-EPI-CAT sequence were: TE_{prep} = 80 ms and TR = 4000 ms and an ETL of 15 was used to achieve an appropriate T2 contrast. The λ-factor was varied between 0.3 (5 SE and 10 GE) and 1.0 (15 SE and 0 GE). For an echo spacing (ESP) of 10 ms a BW of 220 Hz/Px was chosen for the TSE module. A higher BW of 610 Hz/Px was used for the EPI module in order to keep the ESP as short as possible. The FOV was 230x194 mm^2 with a Matrix size of 256x240.

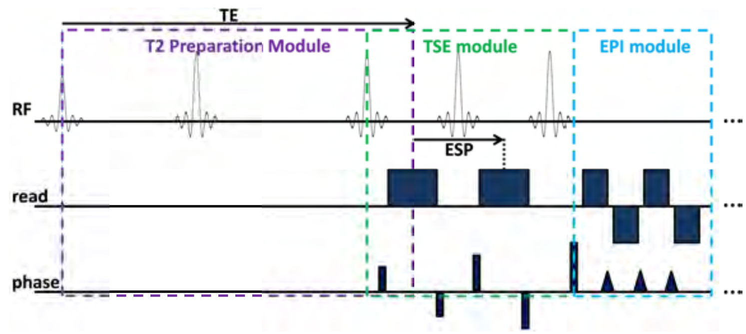

Figure 2: Diagram of T2 prepared TSE-EPI-CAT sequence with T2 preparation module, a TSE module with two echoes and an EPI module with four echoes. The λ-factor in this example is 0.3.

Results: Figure 3 a shows a pure T2 prepared TSE in which only TSE echoes (TF=15, **λ=1.0**) were acquired. Fig. 3 b shows a TSE-EPI CAT with **λ=0.5** which means that 8 TSE-echoes and 7 EPI-echoes were measured. A SAR reduction about 40% was achieved. Fig. 3 c shows a TSE-EPI CAT with **λ=0.3** (5 TSE-echoes and 10 EPI-echoes). Here a SAR reduction of 55% has been achieved with almost no loss in image quality.

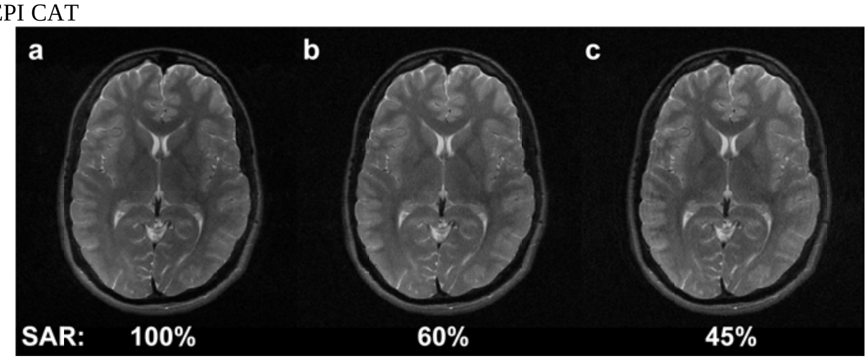

Figure 3: T2 prepared TSE-EPI-CAT. In (a) the λ-factor in was 1.0 (only TSE-echoes were acquired). In (b) a TSE-EPI-CAT with λ=0.5 is shown. The SAR reduction was 40%. In (c) a TSE-EPI-CAT with λ=0.3 is shown in which a SAR reduction of 55% was achieved.

Discussion: In this work we have demonstrated the applicability of the CAT approach with T2 preparation module in order to significantly reduce SAR up to 55 % in T2 weighted images. As shown in Figure 3 the sequence is now ready for use in neuroimaging. Since no fat saturation is required an even further SAR reduction compared to a standard TSE was achieved. For future applications, larger matrix sizes for high field MRI and further reduction of λ is possible.

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References:
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