Zoomed Spin-Echo Echo Volumar Imaging of the mouse brain *in vivo* using Adiabatic Pulses

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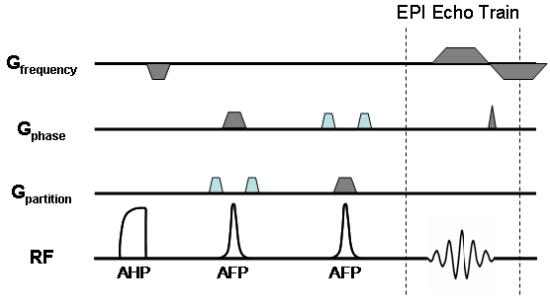

Fig.1. Zoomed Spin-Echo EVI sequence (ZEVIA). An AHP pulse is used for excitation while the volume is selected by two orthogonal adiabatic slice-selective HS1 pulses.

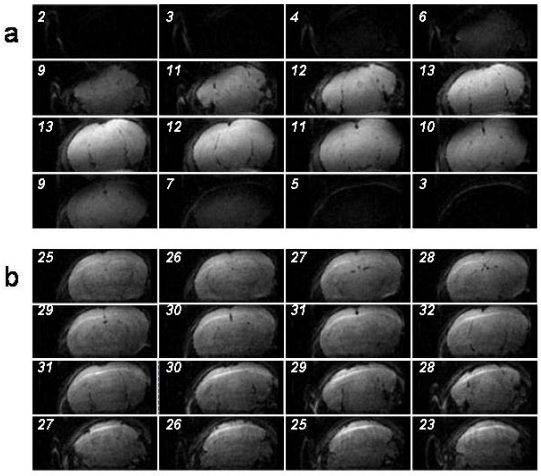

Fig.2. Comparison of signal homogeneity between EVI (a) and ZEVIA (b) sequences with the same FOV and acquisition parameters. For each image, normalized SNR is given in the upper-left corners (in $\mu mol^{-1}.min^{-1/2}$).

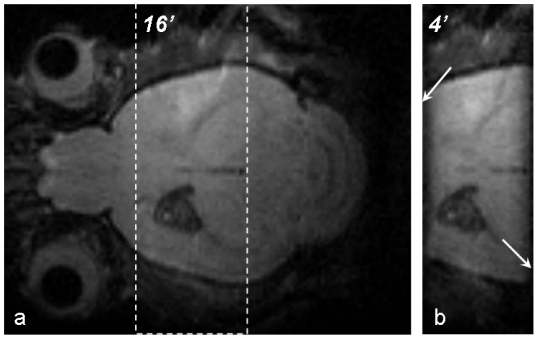

Fig.3. Images acquired without (a) and with (b) a factor-4-zoom in the z-direction. The darkening at the edges of the zoomed FOV (white arrows) corresponds to the transition bandwidth of the slice-selective AFP pulse.

Introduction

In recent years, there have been many developments in the field of fast preclinical imaging based on EPI sequences whether to study brain function with BOLD-fMRI [1], brain anatomy with DWI [2] or image the accumulation of contrast media in tissue with DCE-MRI [3]. Echo Volumar Imaging (EVI) is a 3D extension of EPI that possess the same advantages (elevated signal-to-noise ratio, rapid brain mapping) and adds several advantages for dynamic MRI such as reducing the risk of intra-volume motion and vascular inflow effects [4]. We propose here an optimized protocol designed for preclinical *in vivo* imaging combining a quadrature surface coil with a zoomed Spin Echo EVI sequence using two orthogonal slice-selective adiabatic pulses (designated as ZEVIA) for volume selection. We expect a more homogenous and extended sensitivity and a higher temporal resolution.

Material and Methods

ZEVIA sequence. Figure 1 shows the chronogram of the sequence, consisting in a non-selective 90° adiabatic half-passage (AHP, 4ms) excitation pulse followed by two orthogonal adiabatic slice-selective full-passage pulses (HS1, R=20, 3ms) for volume selection in the phase encoding directions. A traditional k-space cartesian EPI trajectory was used for encoding.

MRI acquisition. High resolution images were acquired on a 7T small animal MRI scanner (Bruker, Germany) using a home-made quadrature surface ^1H coil (loops diameter =12mm, Q_{loaded}=110) using either a Spin-Echo EVI or our ZEVIA sequence. A segmented multishot approach (n=4) was adopted in order to reduce distortions. For comparison, most of the acquisition parameters were the same (BW=200kHz, TR=2000ms, resolution=150µm isotropic, acquisition time ~16') except for the TE (TE=21ms, doubled for ZEVIA) and the matrix sizes (EVI: matrix=150x40x128, ZEVIA: matrix=150x40x128 or matrix=150x40x32). Besides, an outer-volume suppression band was added to the EVI sequence in order to select the volume in the second direction of encoding. Setup included global shimming and B_0 compensation.

Animal. *In vivo* experiments were performed on C57BL/6 mice (male, ~30g) anesthetized with a mixture of isoflurane (1-2%), O_2 and Air (50/50).

Results

Improved brain coverage. Figures 2a and 2b show respectively a subset of images acquired using either EVI or ZEVIA. The use of adiabatic pulses for excitation and refocusing allow an improved homogeneity over the mouse brain (see figure 2b). Besides, the ZEVIA sequence yields a substantially increased SNR (from 13 to 32 $\mu mol^{-1}.min^{-1/2}$ at the center of the FOV; and from 2 to 23 $\mu mol^{-1}.min^{-1/2}$ at the edge).

Improved time resolution. As shown in figure 3a and 3b, images acquired respectively without and with zoom (reduction of the FOV by a factor 4 in the z direction) are similar and exhibit similar normalized SNR (30 vs. 27 $\mu mol^{-1}.min^{-1/2}$). Consequently, the acquisition time can be reduced by the same factor (for the same resolution, acquisition time goes from 16' to 4'). One can notice (white arrows on figure 3b) a slight darkening at the edges of the FOV corresponding to the transition bandwidth of the AFP pulse.

Conclusion

With the addition of adiabatic pulses for excitation and refocusing to a conventional SE-EVI (respectively SE-EPI) sequence, we have shown that brain coverage and time resolution can be improved substantially without any drawbacks. In our future works, we are aiming at evaluating the ZEVIA sequence for BOLD-fMRI, DWI, CEST- and ORS-MRI in the mouse brain.

References

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