Multi-Echo PRESTO: T2* mapping for 3D fMRI

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Purpose

The purpose of this study was to test the applicability of the Multi-Echo PRESTO technique [1] for functional MRI. T2* maps generated from multi-echo data may allow for separation between voxels dominated by gray matter, CSF and blood.

Introduction

Last year the Dual-Echo PRESTO [1] technique was introduced to measure I_0 and T2* simultaneously. This technique is an extension of the PRESTO [2] technique (TE > TR) and allows for the acquisition of two echoes within each TR. The first echo with a short TE (~7 ms) is acquired directly after RF excitation and is immediately followed by an echo with a long TE (~43 ms) which is echo-shifted. Using the echo shifting technique (TE>TR) for the second echo eliminates the 'dead-time' between the two echoes. In this study we extended the technique for multi-echo acquisition. The use of multiple echoes allows a better estimation of T2* and I_0 than the dual-echo method. A motor cortex activation experiment was performed to explore the applicability of Multi-Echo PRESTO.

Methods

Multi-Echo PRESTO was implemented on a PHILIPS 1.5 Tesla ACS-NT Compact Plus scanner, equipped with a PT6000 gradient set (gradient strength 22 mT/m, slew rate 105 mT/m/s). Scan parameters used in a six echo experiment were: TR=67 ms, TE1=8 ms, TE2=85 ms, TE3=28 ms, TE4=105 ms, TE5=48 ms, TE6=125 ms Flip angle 18, EPI-factor (echo train)=13 echoes, 4 interleaves, matrix 64*64*22, voxelsize 4 mm isotropic, scantime 7.5 for a volume of 22 slices. Echo-shifting technique (TE>TR) was used for the even echoes.

In this (on-going) study a motor cortex experiment was performed with four healthy volunteers. Motor activation entailed pressing a button with the right-hand thumb, at 1 Hz. Four periods of button pressing (30 seconds, i.e. 4 scans, each) were alternated with five rest periods. A total of 112 volumes were acquired in four blocks of 28 scans. All volumes were registered prior to analysis. I_0 and T2* were obtained by fitting a mono-exponential to the six echoes. Multiple regression was used for generating functional maps at each TE and for the calculated I0 and T2* data sets. Data analysis was done in PV-WAVE with custom written software. The threshold for activity was $p<0.05$, Bonferroni corrected for all brainvoxels (i.e. $T_{critical}=4.5$)

Results

Each of the six TE images together with the calculated I_0 and T2* images are shown in figure 1 for a single slice. Figure 2 shows a slice of an activation map for the TE=48 ms data (the 'standard' BOLD T-map) and for the calculated T2* data. The active voxels in the functional map based on the T2* data are subdivided in two T2* ranges: 55 ms <T2*< 90 ms (gray matter dominated voxels) and T2*>90 ms (CSF dominated voxels).

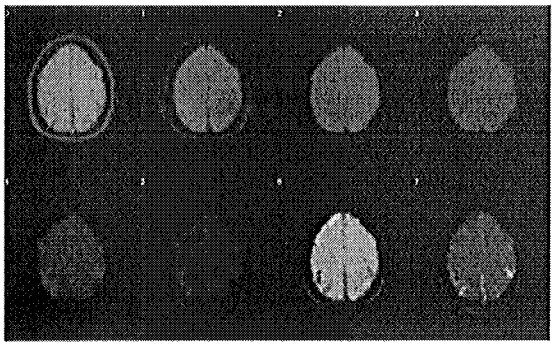

Figure 1. A slice from the brain of one of the subjects. Starting upper left the echo-times are: 8, 28, 48, 85, 105 and 125 ms. The last two figures in the lower right corner are the fit results for I_0 and T2* respectively.

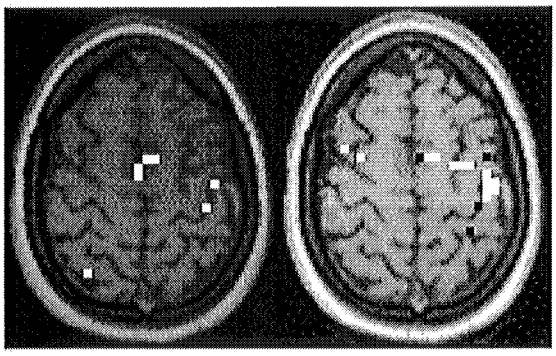

Figure 2. Left: The standard BOLD T-map based on the TE=48 ms data. Right: The T-map based on the calculated T2* data. The active voxels on the right are subdivided in two T2* ranges: white 55 ms <T2*< 90 ms (gray matter dominated voxels) and black T2*>90 ms (CSF dominated voxels).

Conclusions

The preliminary results indicate that Multi-Echo PRESTO is capable of generating functional maps. The T-map based on the calculated T2* data yields functional brain activity that matches the BOLD T-map based on the TE=48 ms data. In principle the calculated T2* data can provide useful additional information on the tissue contents of the activated voxels.

References

1. Hoogduin J.M. et al. *Abstract ISMRM Philadelphia* (1999)
2. Van Gelderen P. et al. *Proc. Natl Acad. Sci USA* **92**:6906-6910 (1995).