Combined Gradient - Echo and Asymmetric Spin - Echo (GREASE): Functional MRI Comparisons and Uses

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PURPOSE:

A new fMRI technique that allows collection of three equally T2´ - weighted echo planar images with a single excitation is introduced. Its uses are demonstrated and discussed.

INTRODUCTION:

T2* - weighting can be achieved by collection of a gradient - echo (GRE) image with TE ≈ T2* or by collection of an asymmetric spin echo (ASE) image, in which collection of the center of k-space is offset from the spin-echo by a time tau ≈ T2*(1). If GRE TE = ASE tau, then similar T2´ weighting is obtained. Since: 1/T2* = 1/T2´ + 1/T2, the images do not have identical T2* weighting because they are differentially T2 -weighted. If the echo planar imaging (EPI) readout window is sufficiently short, then three similarly T2´ - weighted images can be obtained within ≈ 150 ms. The first image is collected during the FID, the second prior to the spin-echo (offset by -tau), and the third after the spin - echo (offset by +tau). Prior studies have demonstrated that gradient - echo and spin-echo image pairs can be collected with a single excitation (2). The sequence introduced, named "gradient–echo and asymmetric spin–echo" (GREASE), is an extension of that method.

METHODS:

Scanning was carried out on a Bruker Biospec 3T/60. Single shot EPI was performed using a three axis balanced torque head gradient coil and a whole brain quadrature endcapped birdcage transmit - receive RF coil. To demonstrate GREASE, a time series of 200 axial image triplets was collected. In - plane voxel dimension = 3.8 x 3.8 mm, slice thickness = 7 mm. TR = 1 ms. The first TE = 27.1 ms. The spin-echo occurred at 109.6 ms. Two tau offsets = ±27.1 ms. During collection of the time series, self - paced bilateral finger tapping was performed in a cyclic manner (20 sec on / 20 sec off). Functional images were produced by voxel - wise correlation with an averaged and smoothed reference waveform obtained from the data.

RESULTS and DISCUSSION:

Figure 1 shows the first anatomical images (TR = ∞) and functional images obtained using GREASE. Figure 2 shows time series from the same voxels in the motor cortex. Because of T2 decay, the signal to noise in each image decreases, and correspondingly, the contrast to noise in the functional images decreases. The functional contrast to noise ratios in the same motor cortex region were 4.9, 2.0, and 1.6 for the three functional data sets respectively.

If TE = ± tau, then a measure of T2 can be simultaneously obtained by fitting the three points to an exponential. In this study, the T2 from the motor cortex region was 74.2 ± 1 ms. The time series can also be averaged to increase the functional contrast to noise ratio.

If one of the two tau offsets is varied, then two other uses of these time series are possible. First, a two point T2* and a two point T2´ measurement may be made at each time point – a single shot *shufflebutt* (3). Second, Bo - field mapping, requiring two gradient-echo images at different TE's, is possible at every time point. Real time Bo - field mapping may allow correction, at each time point, of artifacts caused by speaking, swallowing, and breathing.

Because of the long readout window duration of EPI, a two or three echo T2* measurement on the first FID would require varying the TE across separate excitations (4). If the tau 1 ≠ - tau 2 ≠ GRE TE, then a three point T2´ measurement can be made in one excitation.

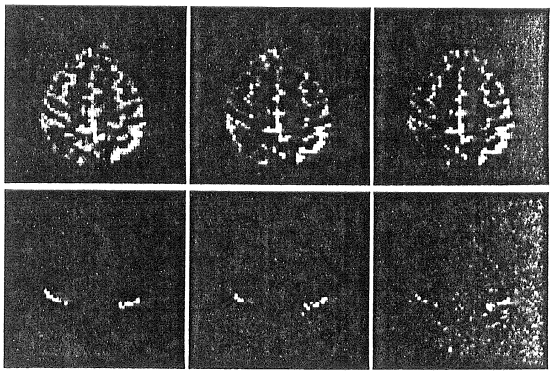

Figure 1: Anatomical and functional images obtained from the same time series. **A.** GRE (TE = 27.1 ms). **B.** ASE, Spin-echo occurs at 109.6 ms: (tau = -27.1 ms), **C.** ASE, (tau = + 27.1 ms).

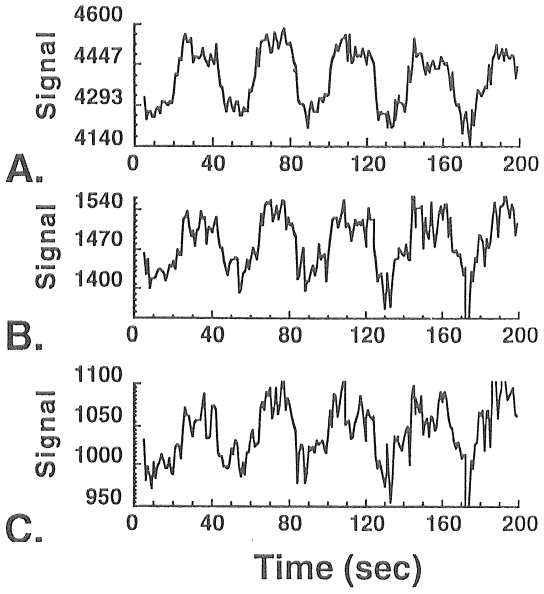

Figure 2: Time course plots from the same motor cortex region. Plots **A, B,** and **C** correspond to images **A, B,** and **C** in Figure 1.

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