MEG auditory evoked gamma phase locking correlates with 1H-MRS determined temporal lobe GABA levels

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INTRODUCTION

Magnetoencephalography (MEG) recording of neural oscillations of the gamma band (~40 Hz) have proven to be a useful tool in neuroscience. Along with measurements of the amplitude and frequency, another powerful metric is the phase locking factor (PLF), a number which measures how well the response coincides with the stimulus in time and whose value ranges from near zero for random phase trials to one for completely synchronized trials[1]. Previous studies have suggested MEG determined auditory evoked gamma band phase locking may index neocortical GABAergic inhibitory interneuronal activity. No previous studies have correlated MRS determined GABA concentration with auditory MEG phase locking metrics.

METHODS

In this pilot study we measured MRS determined temporal lobe GABA levels and MEG evoked phase locking in 7 normal adult subjects (4 males, mean age = 35.33) in good physical health. MRS GABA levels were determined for both left and right temporal lobes using a MEGA-PRESS sequence[2], with edit-on and edit-off frames interleaved, for a total of 512 acquisitions (256 edit-on and 256 edit-off frames) on a GE 3T HDx scanner with TR/TE= 2500ms/70ms. Edit-on and edit-off frames for each acquisition were separated, reconstructed, and fitted using SAGE (GE Healthcare). The processed edit-off spectra were subtracted from the edit-on spectra to produce the GABA spectra. The GABA peak area was divided by the area of the creatine peak in the edit-off spectra to produced the GABA/Cr ratio.

Auditory gamma band responses were produced using 500 ms duration 60 db HL 1 kHz sine waves amplitude modulated by 40 Hz sine waves. Stimuli were repeated every 3.5 seconds for 200 or more trials at each ear (monaural presentation) using foam insert earpieces. Magnetic evoked fields were recorded in the supine position using a whole head neuromagnetometer (Magnes 3600 WH) while subjects watched a silent video. Details of recording and data analytic methods have been previously described[3]. For statistical purposes we extracted the mean phase locking factor in the transient portion of the response from 20 to 150 ms post stimulus onset from the contralateral hemispheres.

RESULTS

Plots of the PLF versus GABA/Cr ratio for each subject for left and right temporal cortex are shown in Figure 1. Note that the GABA/Cr ratios are coincidentally numerically similar to the PLF values. Right hemisphere transient gamma (40 Hz) phase locking factor was correlated with the right hemisphere temporal lobe GABA/creatine ratio with r = 0.62 and the left hemisphere measures correlated with r =.67.

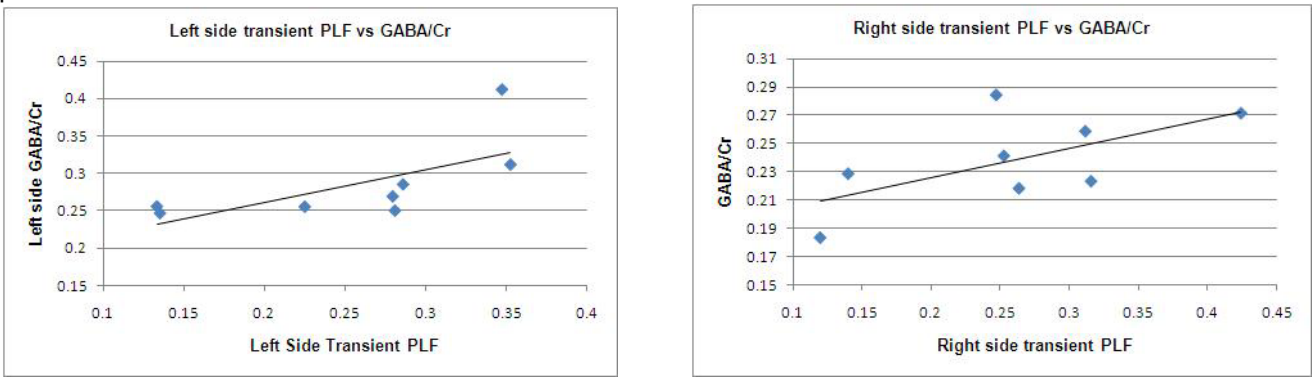

Fig. 1: Plots of the PLF vs GABA/Cr for left (r =.67) and right (r =.62) hemisphere temporal lobes.

DISCUSSION

While previous studies of the visual cortex[4,5] have explored the relationship of GABA levels measures via MRS and the frequency and amplitude of MEG gamma band response, to our knowledge this is the first examination of the MEG PLF and MRS-measured GABA levels in a temporal lobe voxel including auditory cortex.

CONCLUSIONS

This data, while quite preliminary, is supportive of MEG auditory evoked phase locking as an index of neocortical GABAergic inhibitory interneuronal activity at least as indexed by GABA concentration.

REFERENCES: 1. Tallon-Baudry C et al., J. Neurosci 16:4240-4249(1996). 2. Mescher M et al, NMR Biomed 11(6):266-272 (1998). 3. Teale P et al., Neuroimage 42:1481-1489(2008). 4. Edden RA et al. J. Neurosci 29(50):15721-15726 (2009). 5. Muthukumaraswamy SD et al. PNAS 106(20):8356-8361(2009).

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