Frequency-Dependent Changes in Lactate Concentration during Activation of Human Visual Cortex

A-L. Lin[1], J. Hardies[1], J-H. Gao[2], C. S. Gregory[1], and P. T. Fox[1]

[1]Research Imaging Center, University of Texas Health Science Center at San Antonio, San Antonio, TX, United States, [2]Brain Research Imaging Center, University of Chicago, Chicago, IL, United States

Introduction: In a previous fMRI study, we reported that the changes in cerebral metabolic rate of oxygen consumption ($\Delta CMRO_2$) during visual stimulation is frequency-dependent, the $\Delta CMRO_2$ reaches a peak at 4 Hz and declines at higher frequencies (1). It has been hypothesized that the energy demand at 4 Hz or lower was mainly supplied by oxidative metabolism, and by non-oxidative metabolism at frequencies higher than 4 Hz due to the relatively slow rate of oxygen delivery (2). To test this hypothesis, we measured lactate concentration (the end product of non-oxidative metabolism) using ^{1}H NMR spectroscopy with graded photic stimulation at three different frequencies (4, 8, and 16 Hz).

Method: Seven normal volunteers were recruited for this study. The localized ^{1}H NMR spectra were obtained with a Siemens Trio 3T MR scanner with a phase array coil using PRESS sequence (TR/TE, 2000/30 ms). A voxel was positioned within the primary visual cortex (V1) centered on the calcarine fissure. The voxel size was 25×21×30 mm for a volume of 15.8 cc. Visual stimulation was performed using a black-white checkerboard reversing contrast at 4, 8, and 16 Hz. The paradigm consisted of 4-min (120 averages) visual stimulus at each frequency alternating with 4-min baseline (eyes closed) condition. Data was analyzed using Nut_04 software (Acorn NMR Inc., Livermore, CA, USA). Lactate concentrations ([Lactate]) during resting and activation states were estimated from the ratio of the integrated intensities centered at 1.33 ppm and the NAA resonance at 2.02 ppm. Relative [Lactate] (Δ[Lactate] (%)) was estimated by comparing the activation states to the resting state.

Results and Discussion: Fig. 1 shows the spectra representing inter-subject averages for four minutes of stimulation. It is apparent that the [Lactate] at 4 Hz is slight larger then that at resting state; while those at 8 and 16 Hz are well above that of resting state. The data is reported quantitatively in Fig. 2. The Δ[Lactate] (%) measured at 8 and 16 Hz are consistent with the results reported in previous ^{1}H NMR studies (3-5). Our results support the hypothesis that the energy demand at 4 Hz is mainly supplied by oxidative metabolism; while by non-oxidative metabolism at 8 and 16 Hz. The results of the present study will be preliminary data for further investigation and understanding of human brain functions and neurodegenerative disorders.

References: (1) Lin et al., *Proc Int Soc Magn Reson Med*. 2006, 14:539. (2) Lin et al., in review. (3) Chen et al., *Proc Natl Acad Sci USA* 1993, 90:9896-9900. (4) Jenkins et al., *Soc Magn Reson Med Abstr* 1992, 11:2145. (5) Prichard et al., *Proc Natl Acad Sci USA*. 1991, 88:5829-5831.

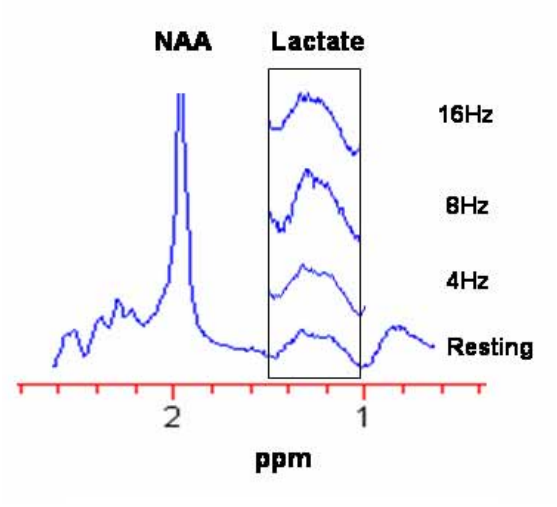

Fig.1 The inter-subjects- averaging ^{1}H spectra of [Lactate] during resting state, 4, 8, and 16 Hz visual stimulation

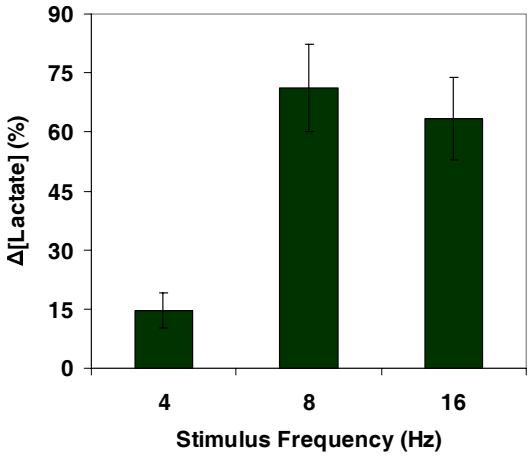

Fig.2 The percent changes of [Lactate] at 4, 8, and 16 Hz.