Visual stimulation: Proton MRS and fMRI of the human visual pathways

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Purpose Chemical shift imaging (CSI) and MRI of the brain are used to assess changes in lactate content and other metabolites under visual stimulation.

Introduction According to the astrocyte-neuron lactate shuttle hypothesis, lactate is formed in the astrocyte, subsequently transferred to the mitochondria of the neuron and serves there as the main fuel for oxidative metabolism (1). In line with this hypothesis several single-voxel MR spectroscopy (MRS) studies on the effect of visual stimulation on brain metabolism reported that lactate signals increased in the occipital part of the brain upon visual stimulation (2-5). Others did not observe such increased lactate signals at all (6,7) or found only an extremely short-lived increase followed by a decline (8).

Methods Four healthy volunteers were examined by MRI and ^{1}H MRS at 1.5 Tesla using the standard head coil of a Magnetom Sonata system (Siemens AG, Erlangen, Germany). PRESS 2D-CSI measurements with TR/TE 1500/ 135 ms were performed. The T2 weighted MRI series was used as guidance for defining CSI volumes of interest of up to 11x8x2 cm^2 angulated to include (A) optical chiasm as well as occipital brain tissue, (B) the optic dariations and occipital tissue, (C) occipital tissue. At 1 acquisition per phase encode step (16x16 voxel FOV of 16x16 cm2) each CSI measurement took 7 min. Automated localized multiple angle projection (MAP) shimming resulted in a water peak line width of up to 5 Hz in the VOI. Excitation with 2.56 ms sinc-Hanning shaped RF pulses preceded by 25.6 ms Gaussian shaped RF pulses for chemical shift selective excitation (CHESS) and subsequent spoiling of the resultant water signal, was followed by selection of the second spin echo using 1024 data points and a spectral width of 500 Hz Time domain data were multiplied with a Gaussian function (center 0 ms, half width 256 ms), 2D-Fourier transformed, phase and baseline corrected and fitted to Gaussian line shapes (9). Functional MRI was used to confirm the presence of activity in the visual cortex during (flickering dartboard pattern) visual stimulation.

Results Spectral maps of optical chiasm were of poor quality due to field disturbances caused by nearby large blood vessels and/or eye movements. The optic radiations and the occipital lobe did not show any significant MR spectral upon visual stimulation, i.e. the peak areas of inositol, choline, creatine, glutamate and N-acetylaspartate were not affected. Reproducible lactate signals were not observed. fMRI confirmed the presence of strong activations in stimulated visual cortex (Fig 1). Prolonged visual stimulation did not cause significant changes in MR spectra. Evidence was obtained that any signal observed near the 1.33 ppm resonance frequency of the lactate methyl-group was artefactual and originated from lipid signals from outside the VOI (Fig 2).

Discussion Previous claims about changes in lactate levels in the visual cortex upon visual stimulation may have been based on erroneous observations. Out of phase lipid signals due to signal contamination from the fatty areas just outside the brain are easily misinterpreted as lactate, especially where the occipital part of the brain is concerned.

References

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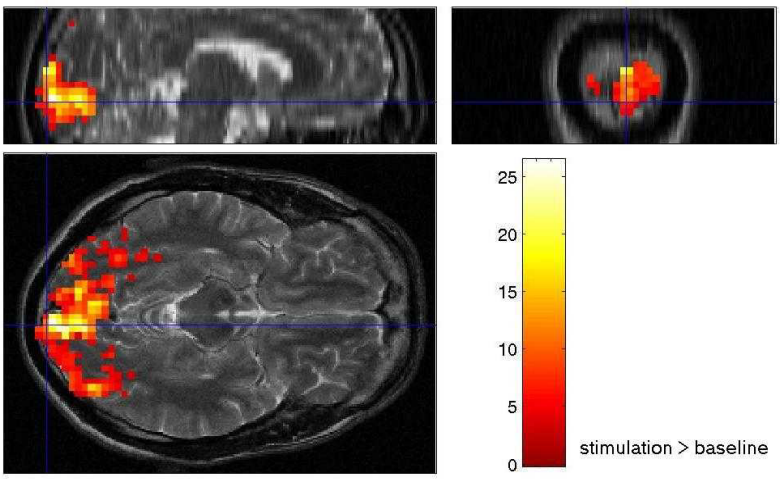

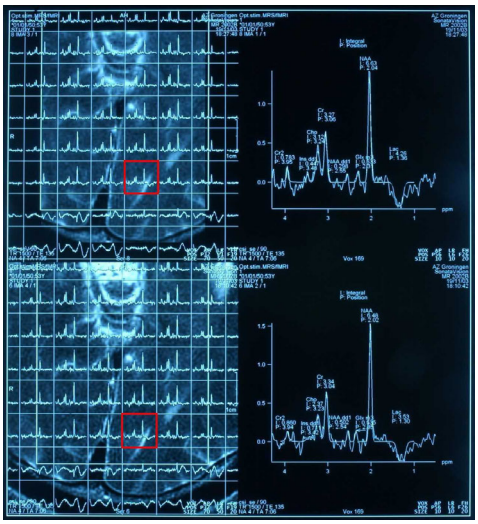

Fig.1. fMRI pattern of activity in visualcortex in the comparison stimulation> basline (P<0.05 corrected).

Fig. 2. The 5x7x2 cm^2 CSI spectral maps of the occipital lobe. In two of 8 maps, once with (upper right) and once without stimulation (lower right) . one voxel shows artefact signal from the adipose tissue between bran and skull that one could easily mistake for lactate signal.