Dynamic Whole Brain Spectroscopic Imaging using Multiple Spin Echoes at 3T

U. Dydak[1], J. M. Tyszka[2], D. Meier[1], M. Cadiolo[3], H. Rowley[4], T. P. Roberts[5], P. Boesiger[1]

[1]Institute for Biomedical Engineering, University and ETH Zuerich, Zuerich, Switzerland, [2]Division of Biology, Caltech, Pasadena, CA, United States, [3]Department of Neuroradiology, Scientific Institute San Raffaele Hospital, Milan, Italy, [4]Department of Radiology, University of Wisconsin, Madison, WI, United States, [5]Medical Imaging, University of Toronto, Toronto, ON, Canada

Introduction

An important feature of the ^{1}H spectrum at 3T, compared to 1.5T, is the doubling of the absolute frequency band containing the most commonly observed cerebral metabolites. This increase (from about 250 Hz to 500 Hz) can be exploited in a multiple spin-echo spectroscopic imaging sequence (TSI, turbo spectroscopic imaging) (1) to reduce the minimum acquisition time. The shorter echo spacings and longer echo trains possible at 3T allow dynamic whole brain MRSI data acquisition with high spatial resolution and a temporal resolution of the order of ten minutes. As an initial application test, TSI with an echo train length of six and an echo spacing of 144 ms ("TSI6") was used to follow the dynamics of ethanol uptake in six slices of a healthy adult volunteer. Contrary to a previous dynamic MRSI study by Hetherington *et al.*, which was limited to single slices (2), we show in this study that the TSI6 methodology extends the coverage of dynamic MRSI measurements to a large fraction of the adult human brain.

Methods

All MRSI data were acquired using a 3T Philips Intera whole body system. Following an initial baseline data acquisition, the subject drank a 1% bodyweight dose of ethanol (40% vodka diluted to 250ml with cordial). Blood alcohol content was monitored between data acquisitions using a breath analyzer fitted with an extension tube to reach the subject within the magnet bore. MRSI data were acquired five times: before the alcohol intake (t = 0 min) and at t = 29 min, t = 56 min, t = 86 min and t = 126 min after intake. Six slices covering both cerebellum and cortex were acquired with a multi-slice TSI sequence using an echo train length of six (20x20 voxels per slice, FOV = 220 mm, slice thickness = 11 mm, TR = 7 s, TE = echo spacing = 144 ms, nominal spectral resolution = 8.8 Hz, isotropic voxel size of 1.1 x 1.1 x 1.1 cm^3). Second order shimming was used to attain good field homogeneity over all six slices and outer volume suppression pulses were used to suppress signal from subcutaneous fat. Postprocessing included exponential filtering of the echo signals, cosine filtering in spatial k-space and B0 correction. All MRSI spectra were analyzed using both naïve peak integration and a four-resonance model with an adaptive baseline (3).

Results and Discussion

TSI6 allows the acquisition of six MRSI slices with high resolution within only 11 minutes and thus provides sufficient spatiotemporal resolution to image metabolic dynamics, such as alcohol uptake, across a large fraction of the adult brain. Figure 1 shows ethanol maps over time from three out of six TSI slices, showing a clear increase in visible ethanol in the ventricles. For comparison the NAA map from slice 3 remains constant over time.

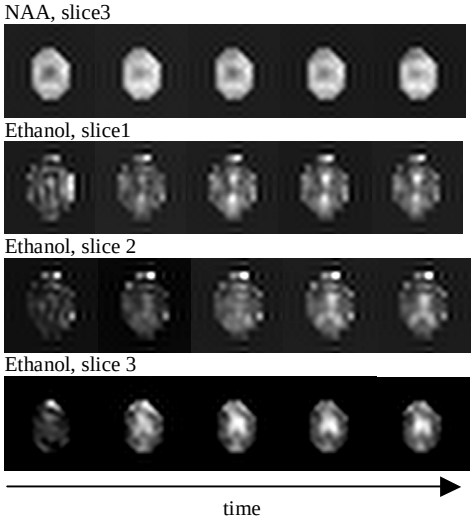

Figure 1: Integrated maps for NAA (slice 3) and ethanol in three out of six slices over time, demonstrating the ability of TSI6 to track metabolite dynamics over an extended volume.

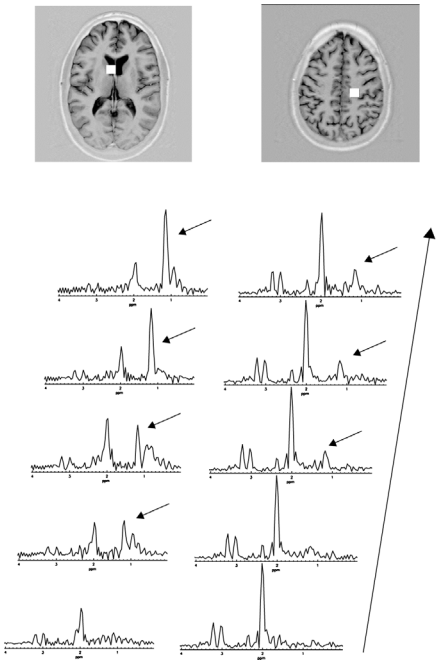

Figure 2: Dynamic spectra from a voxel containing manily CSF (left) and a voxel in white matter (right). Note the change in the EtOH methyl triplet (1.22ppm) over time (increasing from bottom to top)

Figure 2 shows the time courses of the spectra from the highlighted voxels, demonstrating the larger increase of the ethanol peak at 1.22 ppm in voxels containing CSF (slice 2) compared to a voxel in white matter of slice 5. While quantitative interpretation of the apparent differential ethanol accumulation in differing brain regions is subject to analysis of voxel tissue content and consideration of intracellular fraction, it is nonetheless apparent that the TSI6 methodology allows dynamic monitoring of spatial and temporal variations in ethanol content with relatively high resolution in both domains. By extension dynamic spatiotemporal studies of metabolite alterations and / or pharmaceutical accumulations appear to be enabled by such a multi-echo MRSI strategy, which in turn benefits from the increased absolute ^{1}H spectral bandwidth available at 3T.

References

1. Duyn JH et al., Magn Reson Med 30, 409, 1993.
2. Hetherington HP et al., Magn Reson Med 42, 1019, 1999.
3. Tyszka JM et al., Magn Reson Med 46, 219, 2001.