Method of transforming brain spectroscopic waterline data into standard brain space (analyzing functional MRS in FSL)

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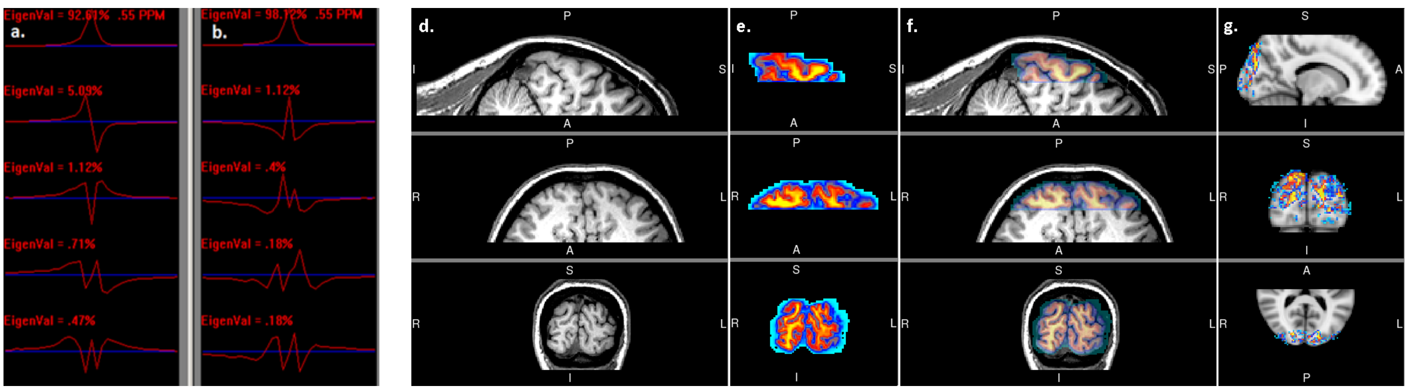
Purpose: To study waterline shape in the brain and perform inter-subject analysis, we introduce a method to transform spectroscopic data to a standard brain space. Waterline shape in the brain may be studied using high spatial resolution 3-dimensional echo planar chemical shift imaging (3D-EPSI) [1,2] during a cognitive task. Typical echo planar imaging in fMRI study can optionally be acquired in the same region for comparison.

Methods: The 3D-EPSI sequence was implemented on a 3T MR scanner (Achieva, Philips Healthcare, The Netherlands) as described before.[3] Non-water suppressed EPSI data was acquired in conjunction with an inversion recovery pulse to suppress the CSF in brain using an 8-channel sensitivity encoding (SENSE) head coil operating in quadrature mode with the following parameters: FOV=128×128×20 mm^3, matrix=64×64×10, voxel size=2×2×2 mm^3, TR=1500 ms, TE~1 ms, spectral bandwidth=500 Hz, samples=128, averages=1, CSF suppression=180° pulse with duration of 5 ms and delay prior to excitation RF pulse of 660.7 ms, scan duration=16:06 min. Oblique 3D MPRAGE anatomical images were acquired for localization purposes with 1×1×1 mm^3 voxel sizes and 4:51 min scan duration. Principal Component Analysis was performed on the spectroscopic data using 3DiCSI.[4] First five principal components (PCs), before and after frequency and phase corrections, as previously reported, [5] were calculated (Fig 1.a and 1.b). The 1st PC score map originally stored in a text file was converted to nifti format using MTLAB (Mathworks, Natick, MA, USA) and was then registered to MPRAGE using FSL's FEAT (v 5.0.1, www.fmrib.ox.ac.uk/fsl). The registration's transformation matrix (xfm1) was applied to the 2nd PC score map. MPRAGE was registered to a standard MNI brain (MNI152-T1-1mm-brain) in FSL (transformation matrix is called xfm2). Xfm2 was then applied to the 2nd PC score map already in Highres space. This in effect would transform the 2nd PC score map into the Standard MNI brain space. Similarly, 1st PC score map could also be transformed into the standard space by applying the xfm2 transformation matrix to the 1st PC score map in Highres space.



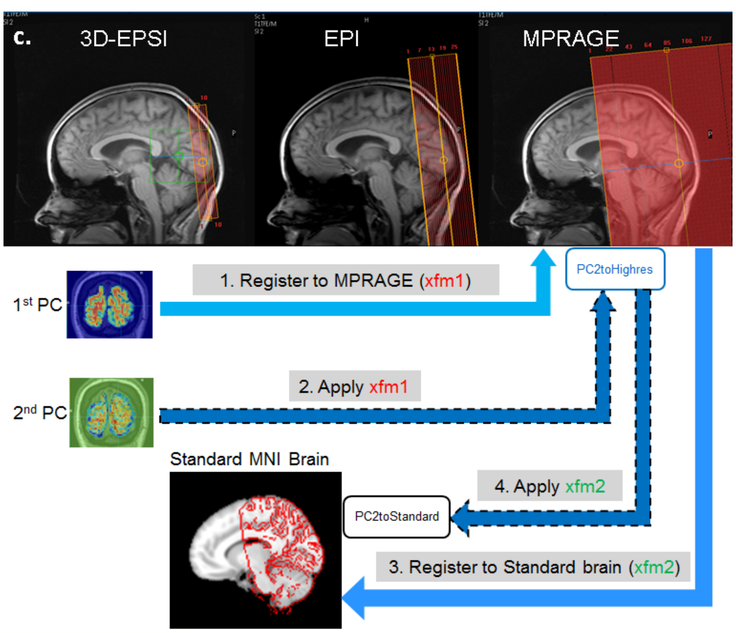


Figure 1. *a, b: First five PC of non-water suppressed 3D-EPSI acquired from visual cortex during a flickering checkerboard experiment with 8 Hz frequency shown before and after frequency and phase corrections. c: Transformation of water line-width spectroscopic data (2nd PC score map of 3D-EPSI) to standard MNI brain space, for inter-subject analysis is shown in 4-steps. d-f: Displays anatomical MPRAGE, 1st PC score map registered to MPRAGE, and overlaid 1st PC score map on MPRAGE. g: 2nd PC score map overlaid on Standard brain (PC2toStandard).*

Results: The 1st PC after frequency and phase corrections (Fig 1.b top) corresponds to amplitude of water signal in the brain data.[5] The 2nd PC (Fig 1.b 2nd from top) corresponds to the water line-width.[5] Following the steps shown in Fig1.c, registering the spectroscopic data (1st PC score map of 3D-EPSI data) to high resolution anatomical image using typical analysis tools such as MATLAB and FSL was successfully performed (Fig 1.f). The line-width characteristic of the water in the brain presented by the 2nd PC score map was transformed to the MNI standard brain for potential inter-subject analysis (Fig 1.g).

Conclusion: Functional MR imaging and spectroscopy may be compared in standard brain space using our method in typical fMRI software. More sophisticated features of waterline shape presented as 3rd to 5th PCs (Fig 1.b bottom three) could be studied further, using inter-subject analytical methods in standard space.

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References: **1.** Mansfield P. Spatial mapping of the chemical shift in NMR. Magn Reson Med. 1984;1(3):370-386. **2.** Posse S et al. High speed 1H spectroscopic imaging in human brain by echo planar spatial-spectral encoding. Magn Reson Med. 1995;33(1):34-40. **3.** Mojahed H et al. 3D Zero J-Modulation Echo Planar Chemical Shift Imaging (3D ZJ-EPSI), ISMRM Electronic Poster #3969, Salt Lake City, UT 2013. **4.** Zhao Q PP et al. An interactive software for 3D chemical shift imaging data analysis and real time spectral localization and quantification. Proc Intl Soc Magn Res Med 2005;13:2465. **5.** Stoyanova R et al. NMR spectral quantitation by principal component analysis. NMR Biomed, 2001. 14(4): p. 271-7.