3D Zero J-Modulation Echo Planar Chemical Shift Imaging (3D ZJ-EPSI)

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Purpose: MR spectroscopic imaging (MRS) is one of the best non-invasive, safe, and rich diagnostic procedures available. However, routine acquisition of MRS especially in three dimensions is still limited by long scan times. Here we introduce 3-dimentional zero J-modulation echo planar chemical shift imaging (3D ZJ-EPSI) sequence that is reducing the acquisition time by N (in M×N×P matrix) with near zero echo time that allows us to acquire proton spectra with zero J-modulation.

Methods: 3D ZJ-EPSI is based on an echo planar chemical shift imaging that was first introduced by Mansfield and Posse. [1,2] The sequence was implemented according to Fig 1 on a 3T MR scanner (Achieva, Philips Healthcare, the Netherlands). In every TR, a 3D slab is excited with an RF-90 pulse and an excitation gradient after which the phase encoding is achieved in two directions (PEy and PEz gradients in Fig 1.a) while a rapidly switching gradients in the other direction encodes the phase in the third direction (x) while simultaneously sampling the FID. The k-space trajectory during each ascending and descending readout gradient is shown in Fig 1.a (top). The sampled data from even and odd acquisition periods are collected and analyzed separately so the effective spectral bandwidth is halved. A CHESS water suppression pulse with a RF 80°-80°-145° was used to cancel the water signal (Fig 1.b). The MRS was acquired using a 8-channel SENSE head coil operating in quadrature mode with the following parameters: FOV=240×240×60 mm^3, matrix=32×32×10, voxel size=7.5×7.5×6 mm^3, TR=1500 ms, TE<1 ms, spectral bandwidth=1350 Hz, samples=512, averages=1, slice oversampling factor =1.28, water suppression=Simulated CHESS pulse with RF 80°-80°-145°, duration=10:28 min. Axial T_2W and 3D MPRAGE anatomical images were acquired for localization purposes with 0.58×0.58×5 mm^3 and 1×1×1 mm^3 voxel sizes and 1:48 min and 4:51 min scan durations respectively.

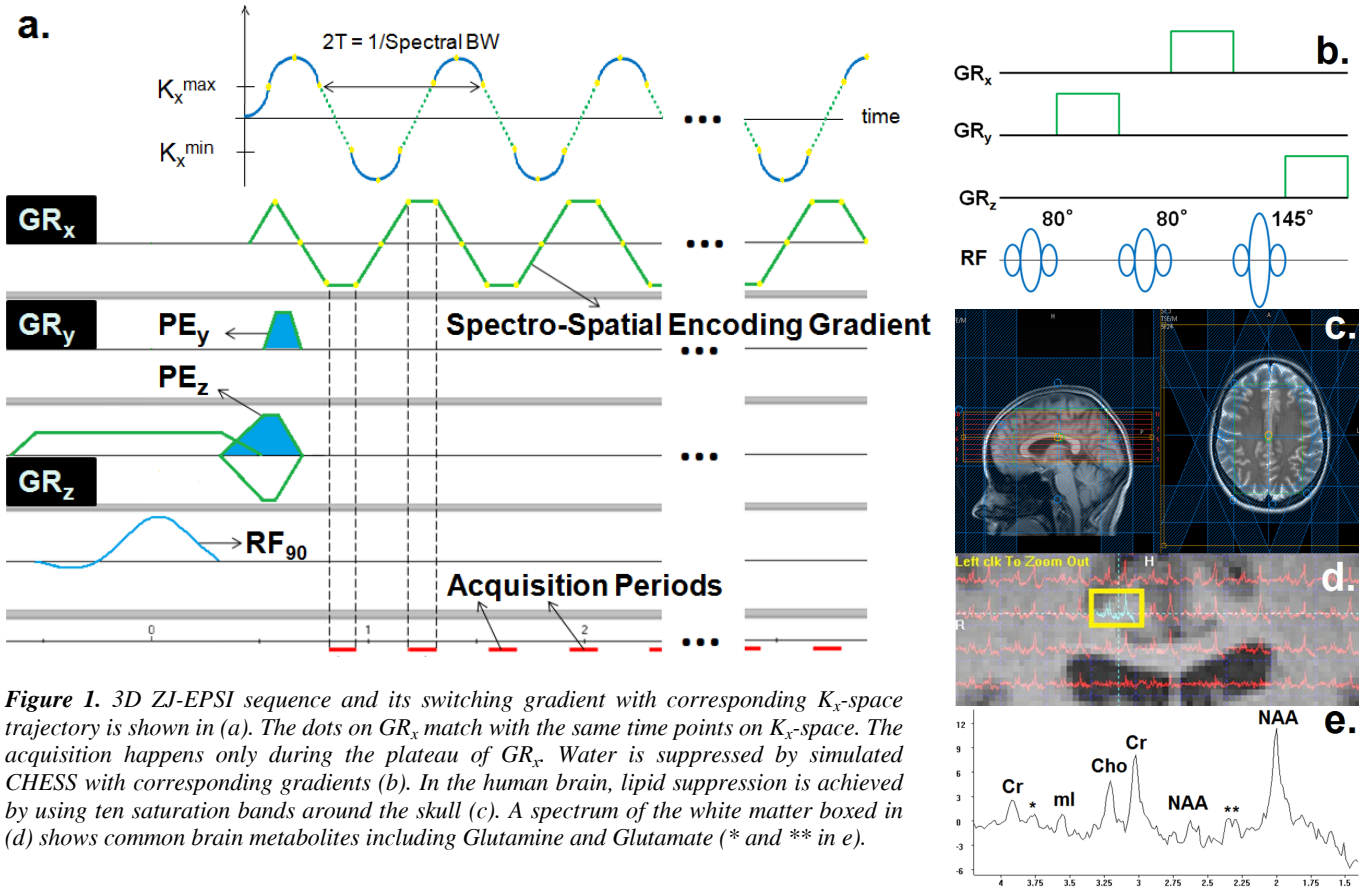

Figure 1. *3D ZJ-EPSI sequence and its switching gradient with corresponding K_x-space trajectory is shown in (a). The dots on GR_x match with the same time points on K_x-space. The acquisition happens only during the plateau of GR_x. Water is suppressed by simulated CHESS with corresponding gradients (b). In the human brain, lipid suppression is achieved by using ten saturation bands around the skull (c). A spectrum of the white matter boxed in (d) shows common brain metabolites including Glutamine and Glutamate (* and ** in e).*

Results: The 3D ZJ-EPSI sequence was developed on a 3T scanner and applied on human brain. Water signal was also removed in the post processing (Sodano, Gaussian) and a 4 Hz Lorentzian filter was applied on the spectra (Fig 1.e)

Conclusion: The 3D ZJ-EPSI pulse sequence allows for rapid MR spectroscopy acquisition. Near zero echo time and no J-modulation allows for a higher SNR, better T_2*, an easier to model line shape, and thus an overall better metabolic quantification method than other high speed 3D spectroscopy techniques.[3]

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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. Bonekamp D et al. Quantitative SENSE-MRSI of the human brain. *Magn Reson Imaging*. 2010;28(3):305-313.