Spectroscopic Imaging Using Concentrically Circular Echo-Planar Trajectories

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Introduction – Echo-Planar Spectroscopic Imaging (EPSI) [1] is generally the technique of choice for the acceleration of Chemical Shift Imaging [2] due to its ability to reduce scan times by over an order of magnitude. Despite the speed advantages of the EPSI sequence, the physically demanding nature of the bipolar trapezoidal readout-gradient trains places significant restrictions on spectral bandwidth that limit its usage, especially at higher magnetic field strengths. We propose a novel Spectroscopic Imaging using CONcentrically Circular Echo-Planar Trajectories (SI-CONCEPT) sequence, which, due to the sinusoidal nature of the readout gradients, is much gentler on hardware requirements, allowing for the acquisition of higher spectral bandwidths than the traditional EPSI sequence. We demonstrate the feasibility of using concentric *k*-space trajectories *in vivo* in the brain of a healthy male volunteer.

Methods – To demonstrate the feasibility, the standard trapezoidal EPSI readout gradients were replaced with sinusoids to trace out the concentric *k*-space trajectories as shown in Fig. 1. The concentric nature of the acquisition requires that the data be processed with re-gridding algorithms so that the resulting *k*-space data can be processed with ordinary two-dimensional fast Fourier Transform (2D FFT). A 24x24cm^2 field of view (FOV) was used with a 24x24 imaging grid and a slice thickness of 2cm, resulting in an individual voxel volume of 2cm^3. The following experimental parameters were used: TR/TE/avgs = 1500ms/30ms/16 with 4 preparation scans, resulting in a scan time of 4 minutes 54 seconds. All scans were performed on a Siemens 3T Trio-TIM scanner with a 12 channel head receive coil. The results were fit using the LC-Model software package.

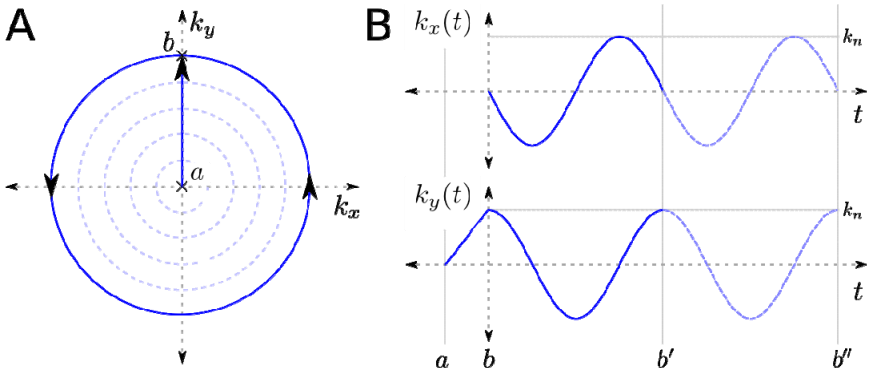

Fig. 1 – Circular echo-planar *k*-space trajectory used for simultaneous spectral and spatial encoding.

Results and Discussion – Figure 2 shows the fitted spectra from a select voxel (yellow box), indicating a quality fit for the major metabolites, N-Acetyl Aspartate (NAA), Creatine (Cr), Choline (Cho), Glutamate+Glutamine (Glx) and myo-Inositol (mI). The individual spectrum looks comparable to those obtained using the ordinary EPSI sequence yielding expected metabolite concentrations (not shown), indicating proper spectral encoding by means of the repeated sinusoidal gradients required for the concentric *k*-space sampling. Since the concentric circles encode both sides of *k*-space in a single TR, the SI-CONCEPT sequence requires only half the number of excitations as EPSI, effectively cutting experimental time in half for a given imaging grid. Further optimization is still needed to maximize the sensitivity of the SI-CONCEPT sequence.

Conclusions – We have shown that concentrically sampled *k*-space trajectories can be used to properly encode both spatial and spectral information. The sinusoidal nature of the SI-CONCEPT gradient waveforms has significantly lower slew rates than the traditional EPSI sequence, which can effectively allow for higher spectral bandwidths, opening the door for EPSI-like spectra to be obtained, without introducing severe aliasing, at higher magnetic fields.

References

[1] Mansfield P. Magn Reson Med 1984;1:370– 386.
[2] Brown T, Kincaid B, Ugurbil K. Proc Natl Acad Sci USA 1982;79:3523–3526.

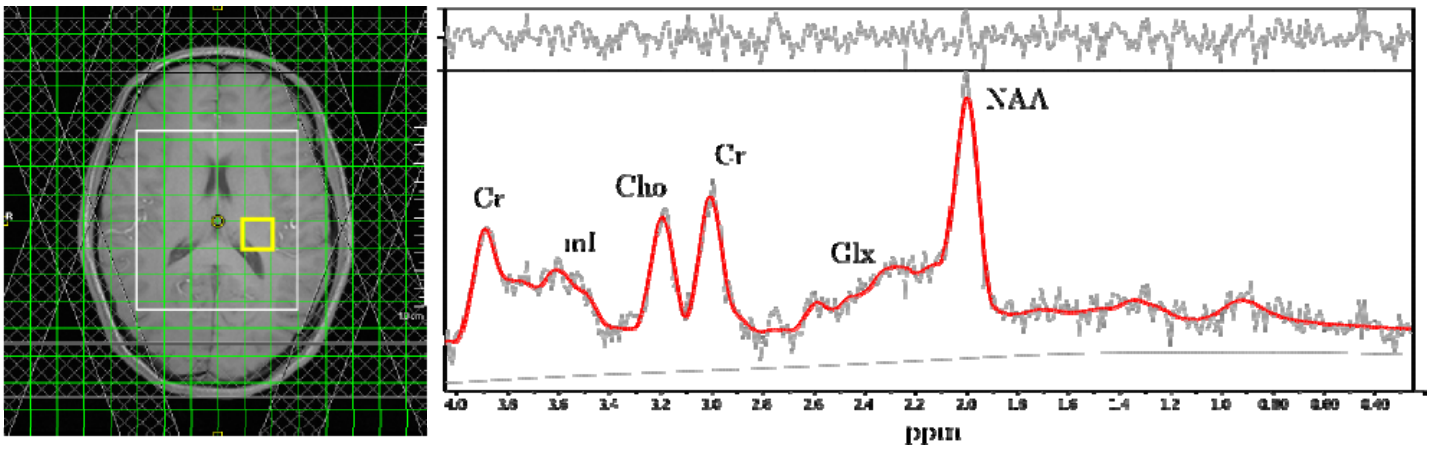

Fig. 2 – Fitted spectra using concentric *k*-space sampling from a select voxel of 2.0mL (yellow box) showing the major metabolites, NAA, Cr, Cho, Glx, and mI.