

Repeatability of 2D Magnetic Resonance Spectroscopic Imaging

L. Kenning¹, M. Lowry¹, D. J. Manton¹, and L. W. Turnbull¹

¹Centre for MR Investigations, University of Hull, Hull, United Kingdom

Introduction

Magnetic resonance spectroscopic imaging can be used for characterising both focal and non focal diseases throughout the brain as well as other areas of the body. 2D-MRSI can potentially help evaluate diseases such as Alzheimer's, tumour growth and epilepsy [1]. It is therefore important to determine the repeatability of MRSI, both at short and long term, as well as under differing clinical acquisition conditions. This study attempts to compare the repeatability between differing field strengths, echo times, pulse sequences and time points (short/long term).

Methods

Spectroscopic data were acquired from ten healthy volunteers at three separate time points. Baseline scans were conducted with repeat scans after two hours and at 6 weeks. Volunteers were scanned on a 3.0T GE 750 Discovery and a 1.5T GE Signa Echospeed using eight channel phased array coils. PRESS and STEAM spectroscopic acquisition sequences were used at both short (TE=35ms) and long (TE=144ms) echo times for comparison purposes. A FOV of 16x16 cm was used with a phase encoding matrix of 16x16x1 for a nominal voxel size of 1cm³. NEX = 1 with a 1s TR for an acquisition time of 4'20min. The 2D MRSI selection box was positioned onto AC PC oriented axial T₂ images. An additional half voxel buffer gap was allowed around the entire edge of the VOI to boost the SNR in edge voxels. Additional saturation bands were placed over the sinuses and skull base to reduce signal from outside of the VOI. N-Acetyl Aspartate (NAA), creatine (CRE) and choline (CHO) concentrations were quantified using LCModel [2]. Repeatability values were calculated from voxels with Cramer-Rao bounds of less than 20%.

Results

The first table shows results for long term repeatability in order of decreasing theoretical SNR (short term repeatability was very similar [not shown]). Data acquired at 3.0T using a 35ms PRESS sequence were the most repeatable for both concentrations and ratios, however 35ms PRESS at 1.5T was unexpectedly the least repeatable of all the conditions. Transition to higher field strengths lead to the greater SNR, and the improved chemical shift dispersion (resolution) expected, as well as a subsequent improvement in repeatability values. The number of voxels suitable for analysis appears to share a strong relationship with the theoretical SNR of the acquisition. 35ms PRESS at 3.0T for metabolite ratios, kept on average a total of (62/63) voxels where as 144ms STEAM at 1.5T was the poorest for number of voxels, with only 10 paired voxels with Cramer-Rao lower bounds of 20% or less remaining from the 63 acquired. The second table shows the 'robustness' of each acquisition, which is a ratio of the percentage repeatability and the percentage of voxels remaining following Cramer-Rao filtering. There appears to be a correlation between robustness and the theoretical SNR of the acquisition with higher values being more robust.

	FIELD	3.0T	3.0T	1.5T	1.5T	1.5T	1.5T
	SEQUENCE	PRESS	PRESS	PRESS	PRESS	STEAM	STEAM
	TE (ms)	35	144	35	144	35	144
Metabolite RPT %	CRE	48 ± 12	54 ± 10	75 ± 19	59 ± 11	82 ± 17	61 ± 13
	CHO	43 ± 9	47 ± 7	73 ± 16	64 ± 8	65 ± 15	68 ± 16
	NAA	39 ± 7	45 ± 8	61 ± 11	56 ± 4	52 ± 14	59 ± 22
	NAA/CRE	47 ± 13	56 ± 13	67 ± 12	60 ± 11	64 ± 9	73 ± 17
	CHO/CRE	50 ± 9	63 ± 17	81 ± 23	70 ± 11	80 ± 28	64 ± 26
	NAA/CHO	45 ± 7	50 ± 8	71 ± 18	64 ± 8	62 ± 21	61 ± 21
	MEAN RPT	45	53	71	62	68	64
% Voxels Remaining	CRE	98 ± 4	87 ± 13	67 ± 16	53 ± 10	54 ± 16	24 ± 9
	CHO	98 ± 3	87 ± 8	60 ± 21	69 ± 16	40 ± 19	29 ± 17
	NAA	98 ± 3	95 ± 5	70 ± 19	77 ± 10	25 ± 8	24 ± 11
	NAA/CRE	97 ± 5	85 ± 12	59 ± 20	46 ± 11	18 ± 8	11 ± 8
	CHO/CRE	97 ± 4	81 ± 14	51 ± 21	38 ± 13	27 ± 16	10 ± 8
	NAA/CHO	97 ± 4	86 ± 9	51 ± 24	57 ± 14	14 ± 9	10 ± 8
	MEAN % V	98	87	60	57	30	18
Short Term	MEAN RPT %	41	53	68	60	69	64
	MEAN % V	98	84	66	63	31	19
	ROBUSTNESS	2.36	1.59	0.96	1.04	0.45	0.29
Long Term	MEAN RPT %	45	53	71	62	68	64
	MEAN % V	98	87	60	57	30	18
	ROBUSTNESS	2.16	1.65	0.84	0.91	0.44	0.28

Conclusions

This study shows that MRSI acquired at higher field strengths is, overall, more repeatable; however at lower field strengths longer echo times are more favourable than short echo times. PRESS in general looked the more favourable sequence with the exception of 35ms PRESS at 1.5T. It is documented that PRESS has approximately double the SNR of STEAM and this is reflected in percentage of voxels with sufficient spectral quality as shown in this study. The poorer chemical shift dispersion at 1.5T may have prevented discrimination between NAA and glutamine and glutamate and their underlying baseline by LCModel. This may explain the poor repeatability for short echo times at low field. 35ms PRESS at 1.5T appears to have the highest number of voxels remaining at 1.5T despite having the worst repeatability which supports the chemical shift dispersion explanation. The short echo PRESS sequence at 3.0T was both the most repeatable, and robust set of acquisition parameters since shorter echo times produce more relative SNR due to T₂ relaxation combined with the higher field strength. Due to the apparent relationship between SNR and repeatability, it would seem repeatability is limited by hardware rather than by physiology.

References

1. Soares D.P. & Law M. (2009) Magnetic resonance spectroscopy of the brain: review of metabolites and clinical applications. Clinical Radiology 64. 12-21.
2. Provencher S.W. (1993) Estimation of metabolite concentrations from localized in vivo proton NMR spectra. Magnetic Resonance in Medicine 30. 672-679.