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Rosette spectroscopic imaging for whole-brain metabolite mapping at 7T: acceleration potential and reproducibility

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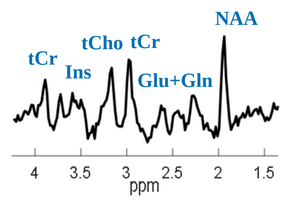
BACKGROUND

Proton-Free-induction-decay (^{1}H-FID) magnetic resonance spectroscopic imaging (MRSI) enables the measurement of brain metabolite distributions:

- Ultra-short TE ➔ SNR;
- short TR → acquisition time

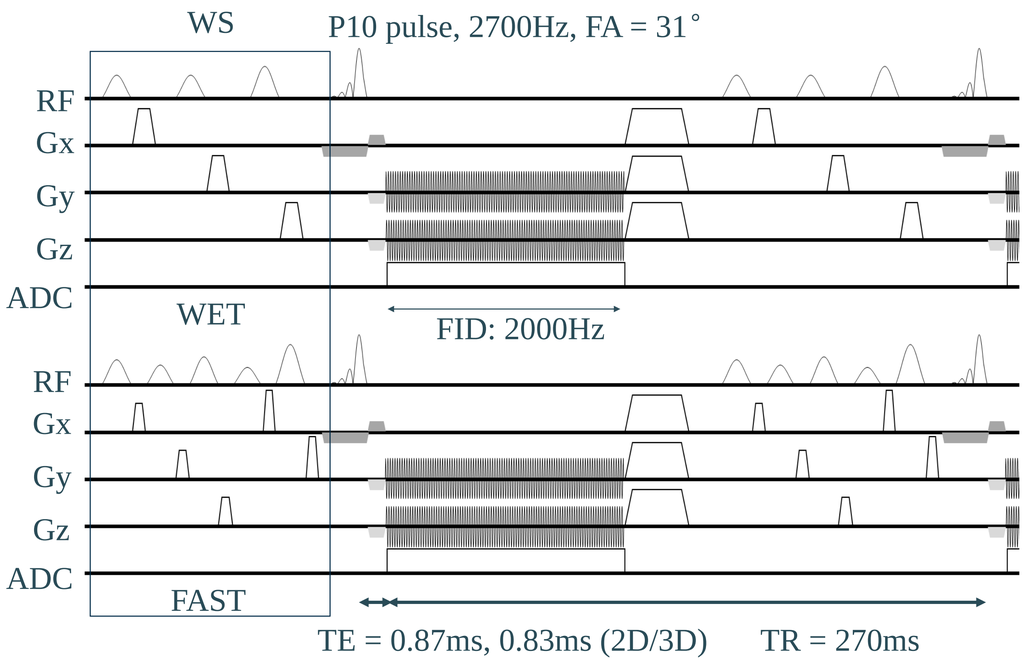
GOAL

- Long acquisition time ➔ rosette trajectory[1, 2] + compressed sensing (CS)
- Signal contamination ➔ water: FAST water suppression (WS) scheme (Five variable Angle gaussian pulse with ShorT duration) + Lipid: pixel-wise L_2 regularization method
- Reproducibility: Intersession coefficients of variance (CV)



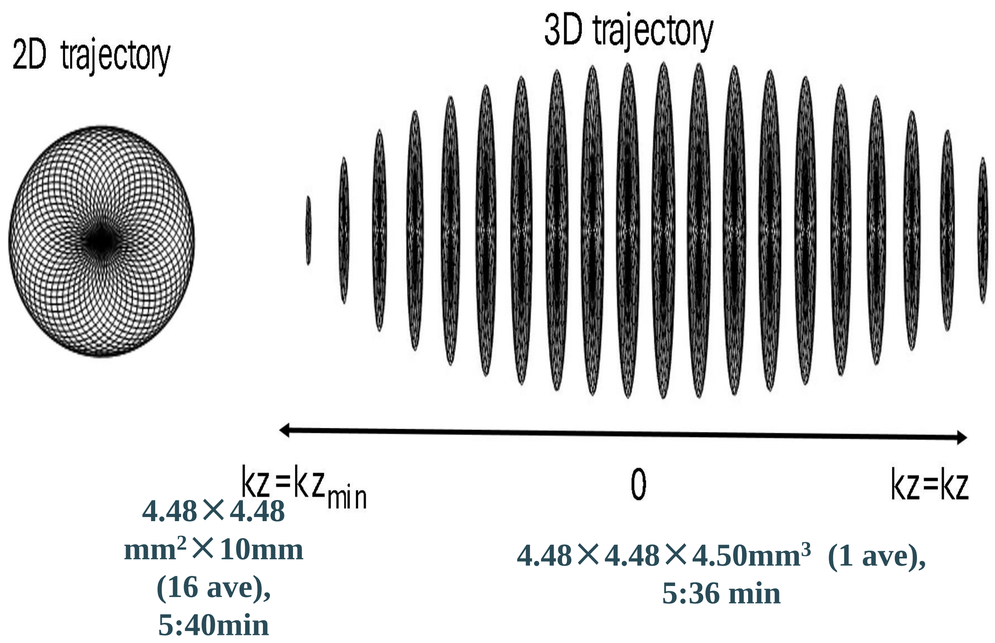
METHODS

Sequence



Trajectory

$$k(t) = k_{\max}\sin(\omega_1 t)e^{-i\omega_2 t}, \omega_1 = \omega_2 = 2000\pi$$



Data acquisition

3 subjects (1 female, 28-40 yrs) 7T Terra. X MR scanner
8-channel transmit/ 32-channel receive headcoil (Matlab)

Reconstruction & Post-processing :

- NUFFT[3] reconstruction with adaptive coil combination[4]
- HLSVD (residual water)
- Pixel-wise L_2 regularization[5] (lipid)

$$LSS = \sum_{i\in[0.7,1.8]ppm} abs(S_i)\,;\ \frac{LSS(reg_{i+1}) - LSS(reg_i)}{LSS(reg_i)} \leq threshold$$

$$LSS_{peripheral} \leqq mean(LSS_{center}) + std(LSS_{center})$$

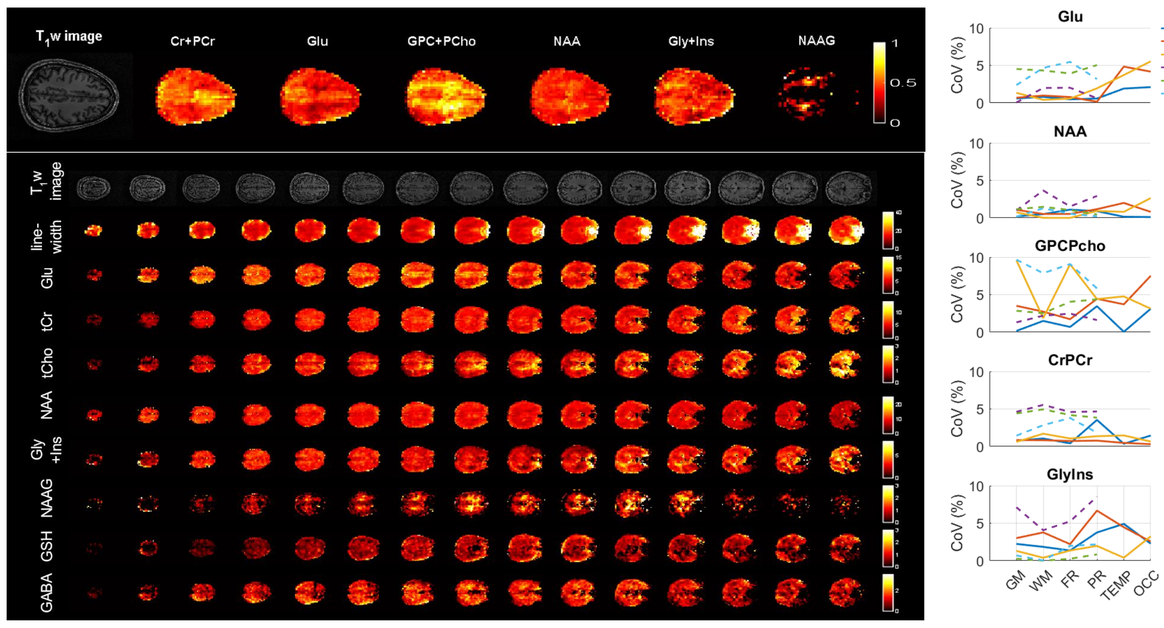
$$\min_x \left|\left|F_u x - y\right|\right|_2 + \lambda_1 \left|\left|TV(x)\right|\right|_1$$

- LCModel quantification (CRLB 100%), Water content correction[6], T_1 relaxation correction[7]
- Retrospective compressed sensing (CS) with BART[8] (3D):

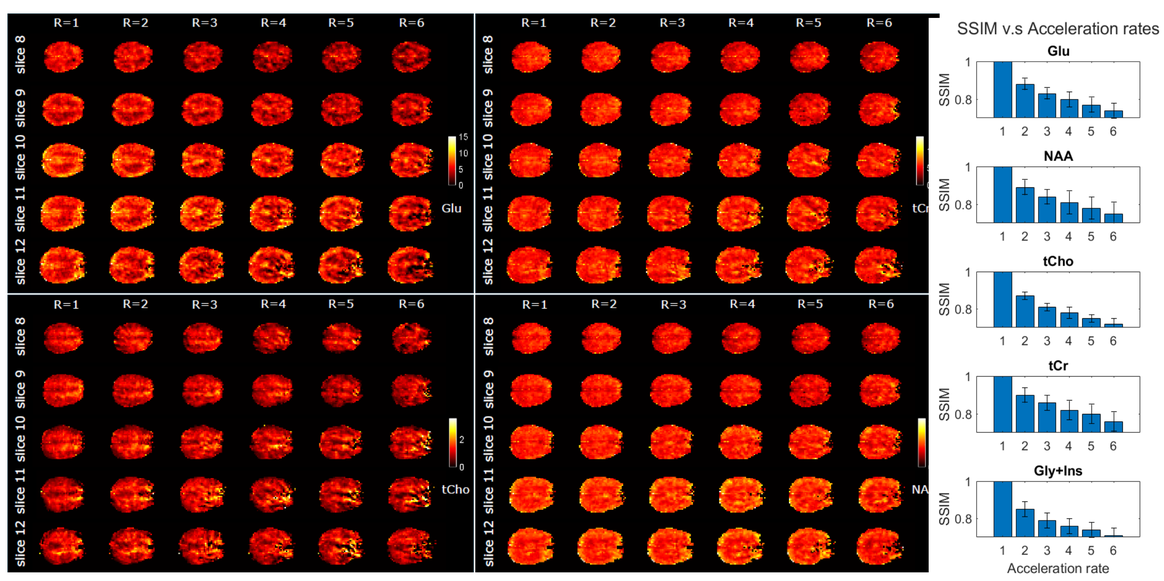
RESULTS

Reproducibility coefficients of variance (CV):

2D: NAA, tCho, tCr, Gly+Ins, Glu < 6%; NAAG, GSH, Tau < 10%;
3D: NAA, tCho, tCr, Gly+Ins, Glu < 5%; NAAG, GSH, Tau < 10%



Compressed Sensing: Acceleration rates↑, SNR↓, SSIM↓, CRLB↑;
average SSIM > 0.8: R=3 for NAA, Glu, tCho, tCr, R=2 for Ins+Gly



CONCLUSION

- Whole-brain non-lipid-suppression ultra-short-TE ^{1}H-MRSI acquisition scheme with rosette: 1) optimized WS scheme; 2) pixel-wise L_2 lipid removal method.
- Excellent inter-session reproducibility, with major metabolites' CVs below 5%
- Potential time reduction by 2-3 times with CS ➔ 3D dataset with matrix size 50x50x20 for 2-3min

The fast and reproducible measurement of the spatial metabolic distribution in the human brain paves the way for a better understanding of brain functions and pathology.

Want to know more?

References:
1. Noll, Douglas C. et al., (1997). 2. Schirda, Claudiu V., et al., (2009); 3. Fessler, J. A., et al., (2003); 4. Walsh, D. O., et al., (2000); 5. Bilgic, B. et al., (2014); 6. Bluestein, K. T., et al., (2012); 7. Xin L, et al., (2013); 8. Uecker, Martin, et al. (2013).

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