Influence of TR and TE on the Signal-to-Noise Ratio in DTI

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Introduction

In many clinical and research settings, reducing the acquisition time is crucial to minimize discomfort for the patient, reduce motion artifacts, and increase throughput of imaging studies. Diffusion-weighted images are prone to high noise levels, and there is a trade-off between data acquisition time and signal-to-noise ratio (SNR). Generally, it is assumed that longer TR (repetition time) and shorter TE (echo time) increase the signal in MR images [1]. Here, we test whether this holds true for a time-consuming multi-shell DTI protocol.

Methods

Participant

- 28-year-old neurotypical male subject

MRI data acquisition

- 3T Prisma Fit, 64 channel head coil
- 10 b = 0 images
- 2 shells a 98 diffusion-weighted images b = 1000 s/mm^2, b = 2000 s/mm^2)
- Resolution = (1.7 mm)^3

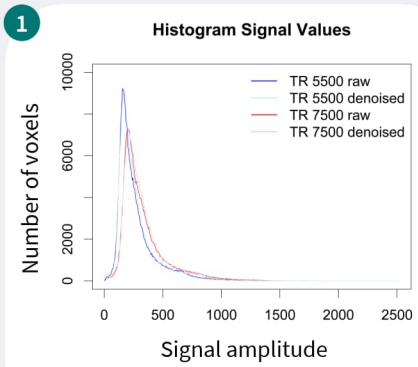
Analysis

- SNR = Signal amplitude/ Standard deviation of noise [2]
- SNR comparison for raw and denoised B0 images
- Tract-based [3] SNR comparison for raw and denoised B0 images

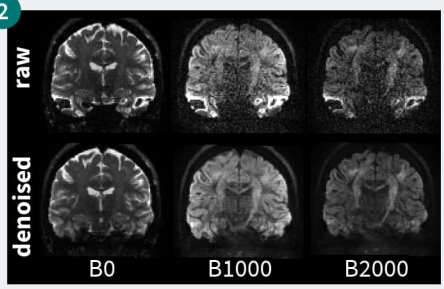
Experiment	TE/TR	Partial Fourier	Acquisition time
Exp. 1	98/5500ms	8/8	19:33min
Exp. 2	91/7500ms	7/8	26:21min

Results

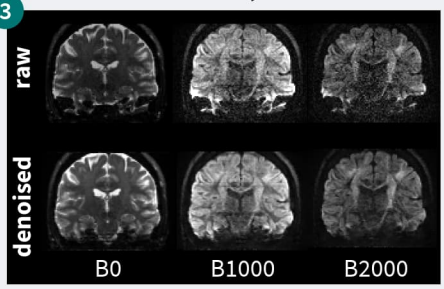
1



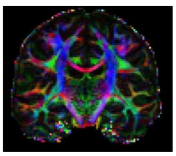
2 **TR 5500 ms, TE 98 ms**



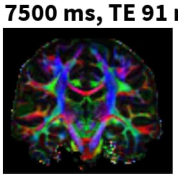
3 **TR 7500 ms, TE 91 ms**



4 **TR 5500 ms, TE 98 ms**

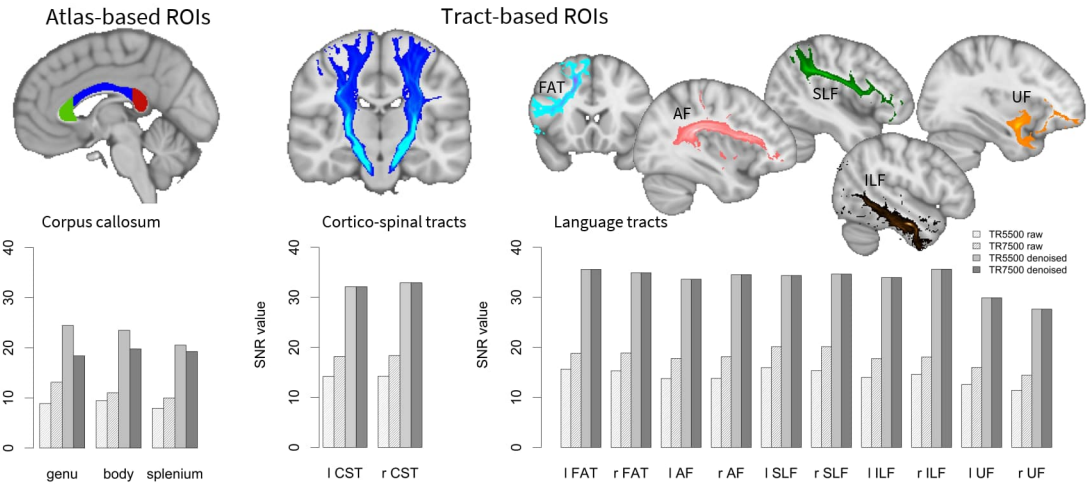


TR 7500 ms, TE 91 ms



Fiber orientation maps

5 **SNR comparison for raw and denoised B0 images**



No differences occurred for cortico-spinal tracts and language tracts when comparing denoised data

Conclusion

- While the longer TR resulted in increased SNR for the raw data, the SNR after denoising was not influenced by TR and TE, contrary to prior expectations.
- Denoising dramatically increased SNR.
- This result highlights the effectiveness of modern denoising protocols. Moreover, the finding suggests that the less time-consuming sequence can adequately acquire DTI data with sufficient SNR.
- However, as this study is a case study, a more comprehensive group study might be needed to obtain conclusive evidence.

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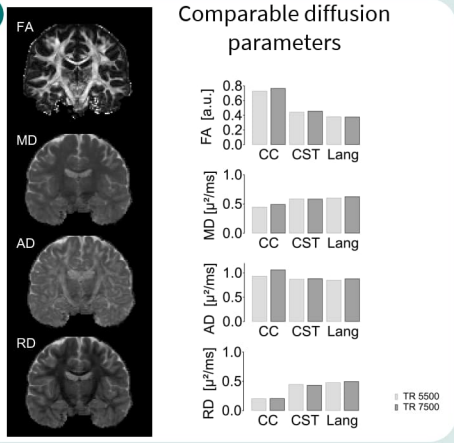

References

[1] Weishaupt D, Köchli VD, Marincek B (2014) Wie funktioniert MRI? Eine Einführung in Physik und Funktionsweise der Magnetresonanz-bildgebung. Springer Verlag, Berlin und Heidelberg.

[2] Firbank, M. J., Coulthard, A., Harrison, R. M., & Williams, E. D. (1999). A comparison of two methods for measuring the signal to noise ratio on MR images. Physics in Medicine & Biology, 44(12), N261–N264.

[3] Warrington, S., Bryant, K. L., Khrapitchev, A. A., Sallet, J., Charquero-Ballester, M., Douaud, G., Jbabdi, S., Mars, R. B., & Sotiropoulos, S. N. (2020). XTRACT - Standardised protocols for automated tractography in the human and macaque brain. Neuroimage, 217, 116923.