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Comparing the SPIJN algorithm with conventional NNLS for myelin water fraction mapping

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Session	**AI in Action**
Date	**01 October 2020**
Time	**14:30**
Program #	**S03.07**
Abstract ID	A-1118

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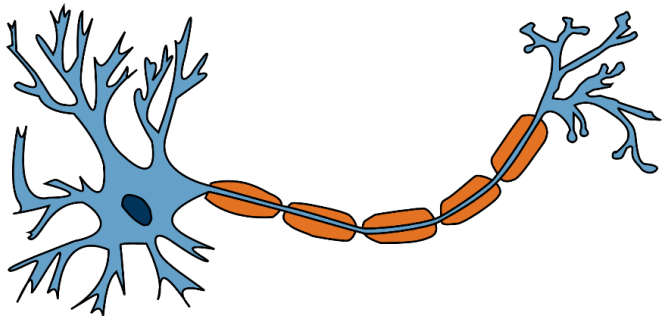
Introduction

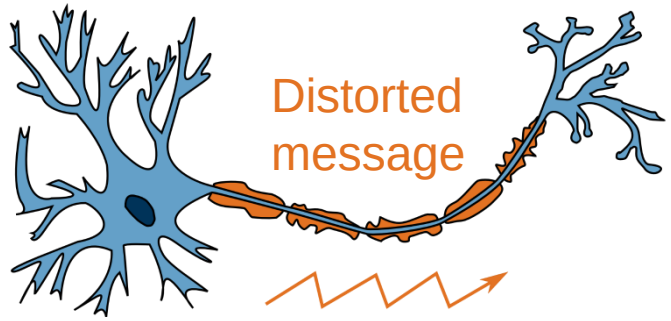
Myelin



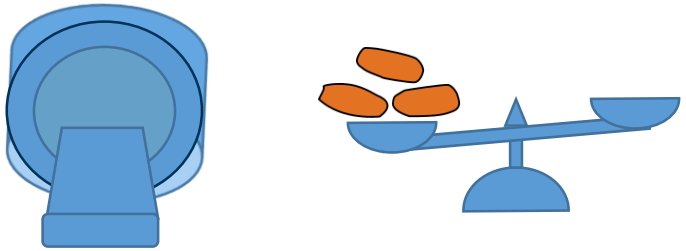
- Insulation
- Fast signal conduction

Demyelination

MS



Myelin imaging

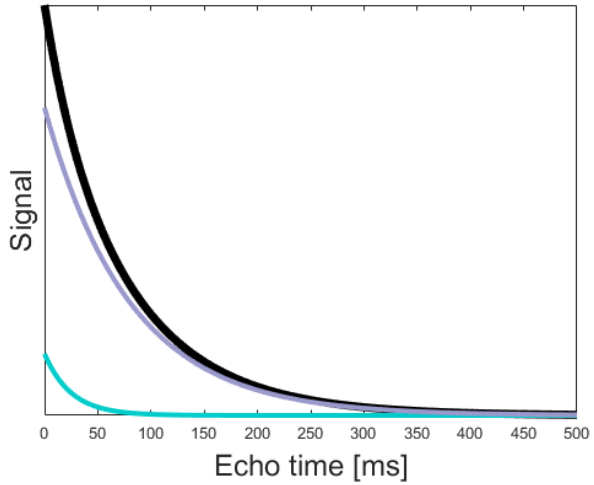


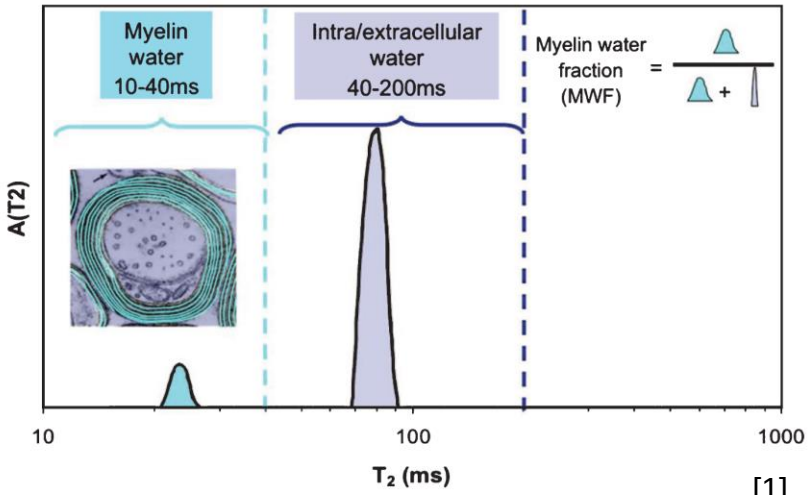
- Integrity of nerve tissue
- Monitor demyelinating diseases

MS nerve fiber: modified from https://commons.wikimedia.org/wiki/File:Neuron.jpg

Theory

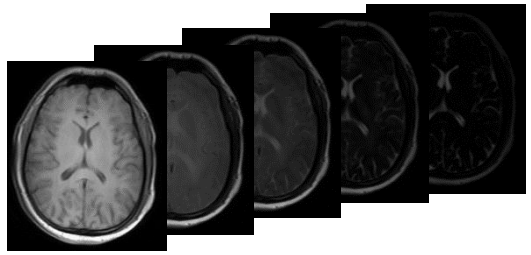
Myelin Water Imaging





[1]

Calculating T2 distributions



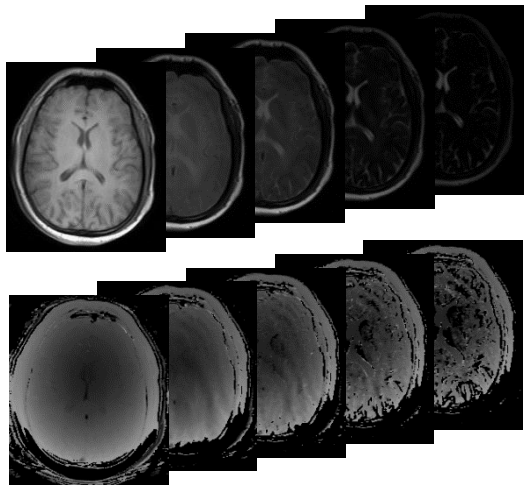
- Magnitude data

NNLS [2]

- Non-Negative Least Squares

SPIJN magn-based [3]

- Sparsity Promoting Iterative Joint NNLS
- MR Fingerprinting based
- Joint sparsity constraint
- New and faster method



- Complex data

SPIJN comp-based [3]

- SPIJN can be improved by including complex data

Aim

Compare NNLS and SPIJN (based on magnitude and complex data) for MWF mapping

[1] MacKay, A.L., & Laule, C. (2016). Brain plasticity, 2(1), 71-91. [2] MacKay, A., …, Mädler, B. (2006). MRM, 24(4), 515-525. [3] Nagtegaal, M., …, Doneva, M. (2019). ISMRM 2019, Abstract #4401.

Methods

Cohort

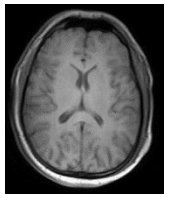
- n = 8 (3♀ / 5♂)
- Ø 33 years (29-49)
- healthy

Sequence

- 3D GRASE
- TE1/ΔTE = 8/8 ms
- TR = 1120 ms
- 48 echoes
- 1x2x5mm³
- 20 slices
- α = 90°
- Philips Engenia Elition 3T

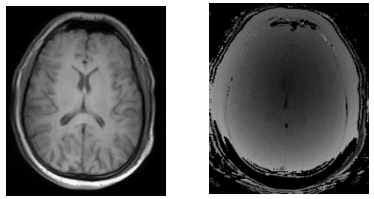
Comparing NNLS & SPIJN

NNLS | SPIJN magn



- Only magnitude data
- n = 8 (3♀ / 5♂)

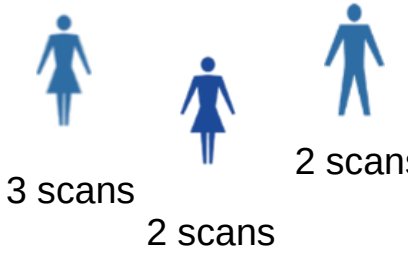
NNLS | SPIJN magn | SPIJN comp



- Complex data available
- n = 4 (2♀ / 2♂)

Reproducibility analysis

- Rescanning same subjects
- n = 3



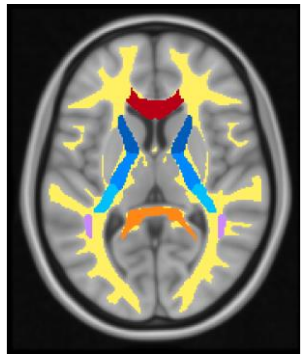
NNLS

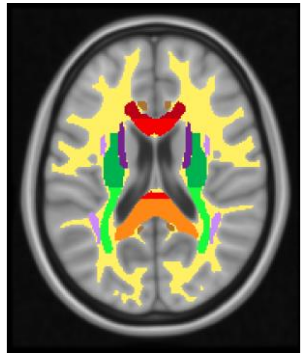
SPIJN magn

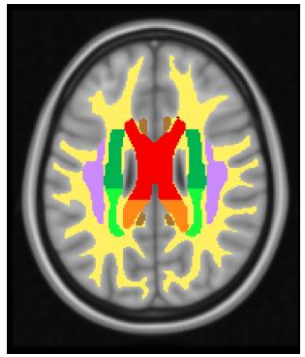
Quantitative analysis

12 WM regions:

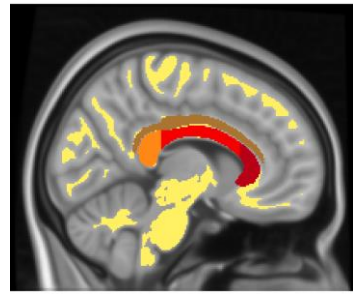
Whole brain WM







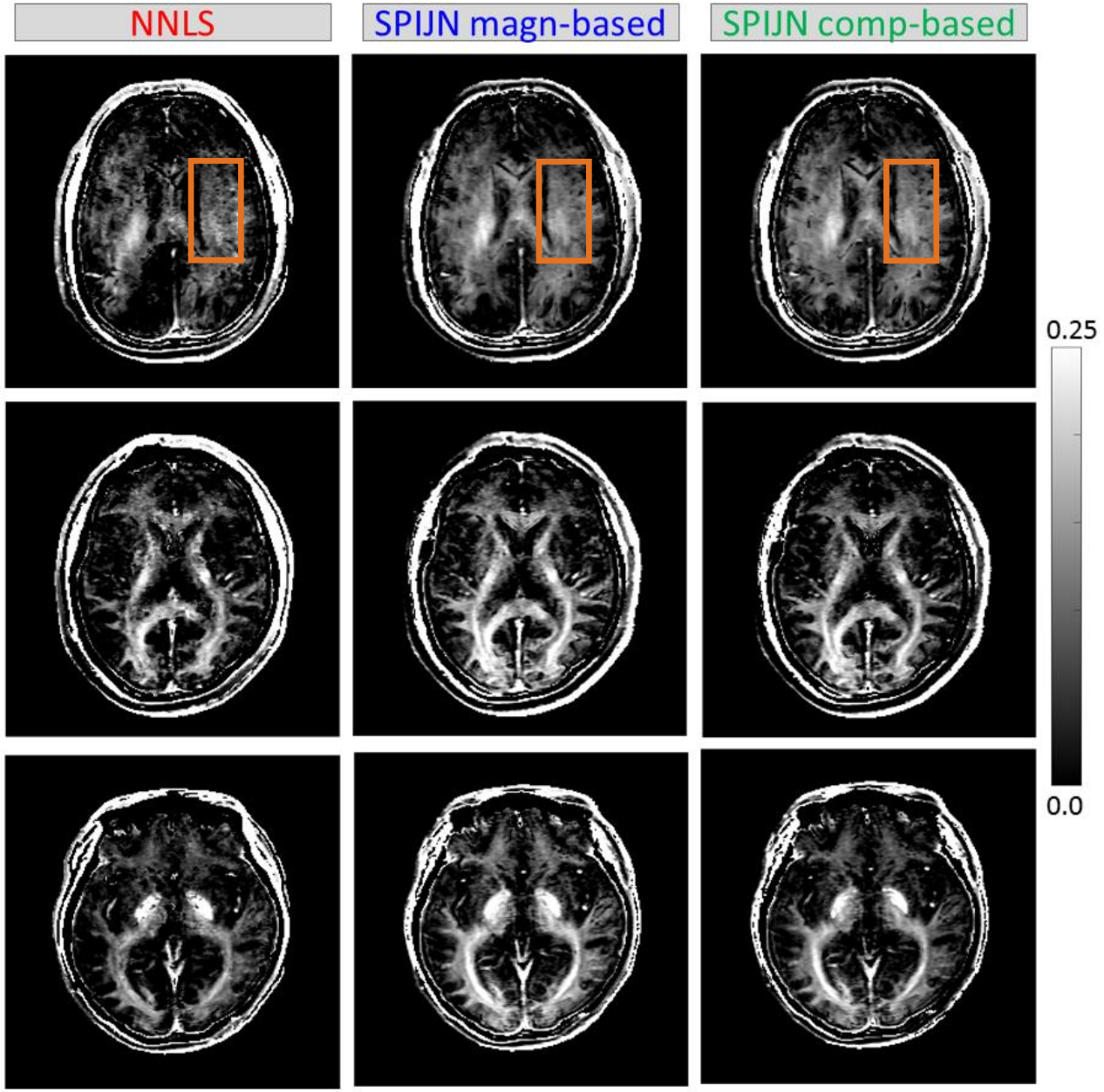
11 labels from the JHU ICBM-DTI-81 White-Matter Atlas



Genu of CC
Body of CC
Splenium of CC
Ant. limb of IC
Post. limb of IC
Retrolent. of IC
Sup. corona rad.
Post. corona rad
Cingulate gyrus
Sup. long. fasc.
Sup. fronto-occ. facs.

JHU atlas: Mori, S., et al., MRI atlas of human WM, 2005.

Visual comparison

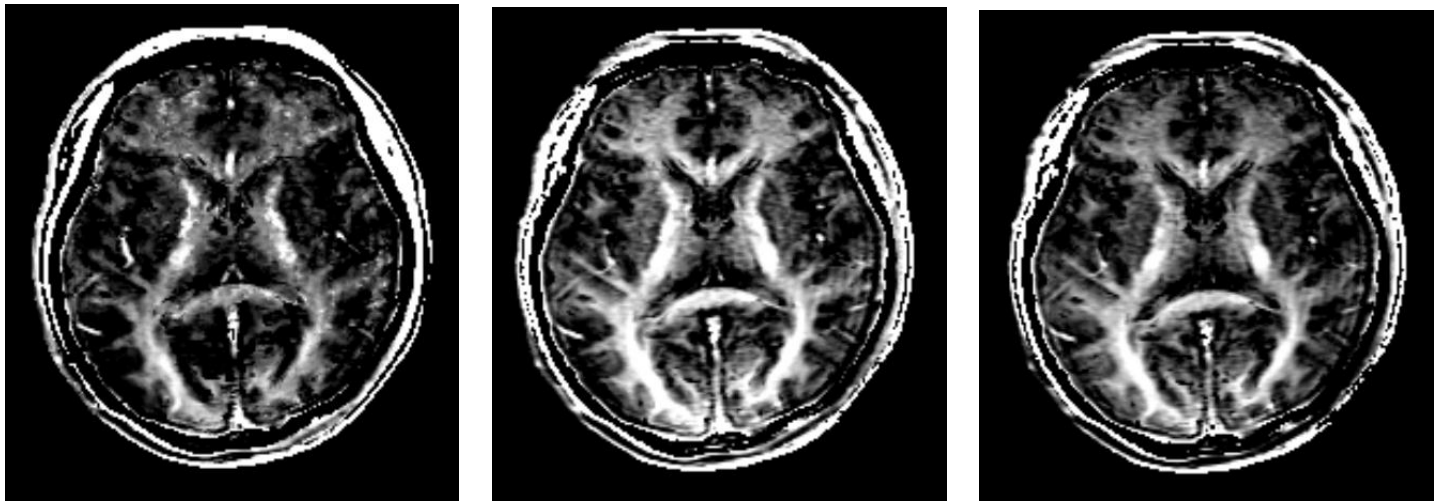


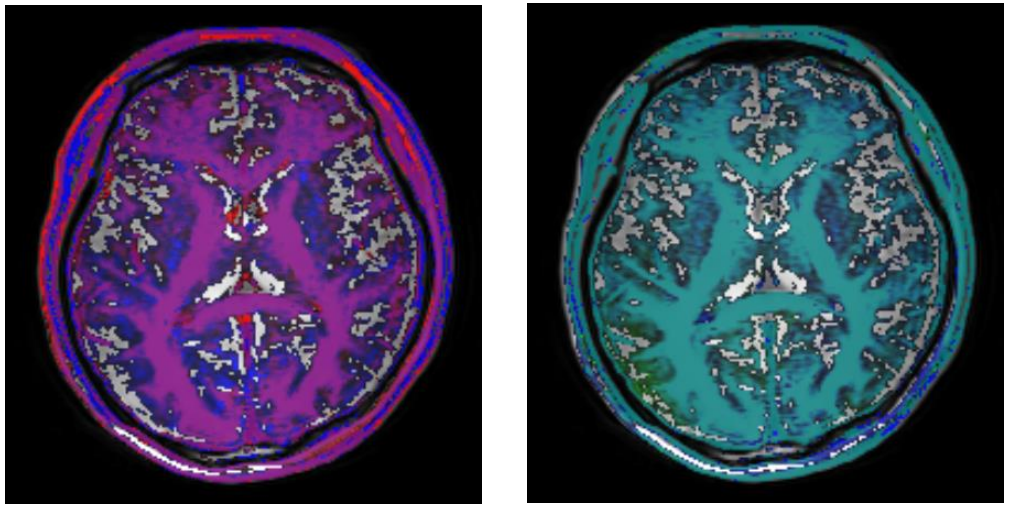
- Good agreement of areas with high MWF
- NNLS MWF maps appear a bit more noisy and porous
- SPIJN MWF maps appear relatively smooth

  → probably due to stronger regularization

Visual comparison

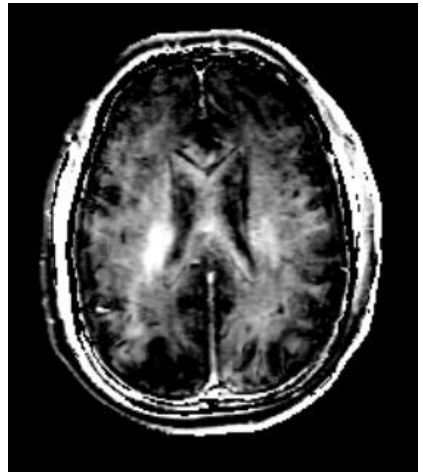
NNLS | SPIJN magn-based | SPIJN comp-based

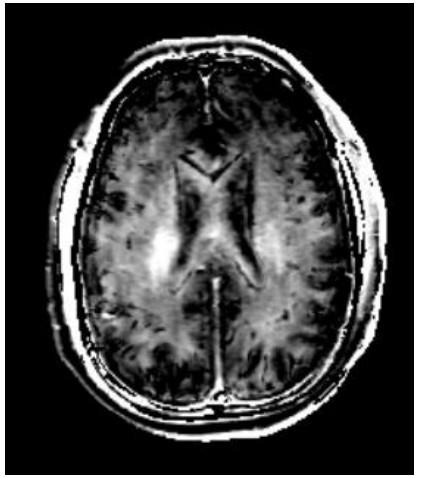




NNLS  SPIJN magn  SPIJN comp

SPIJN magn-based | SPIJN comp-based





0.2

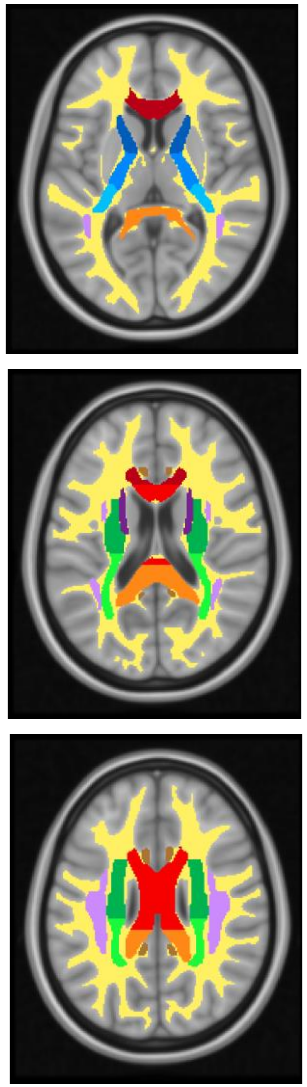
0.0

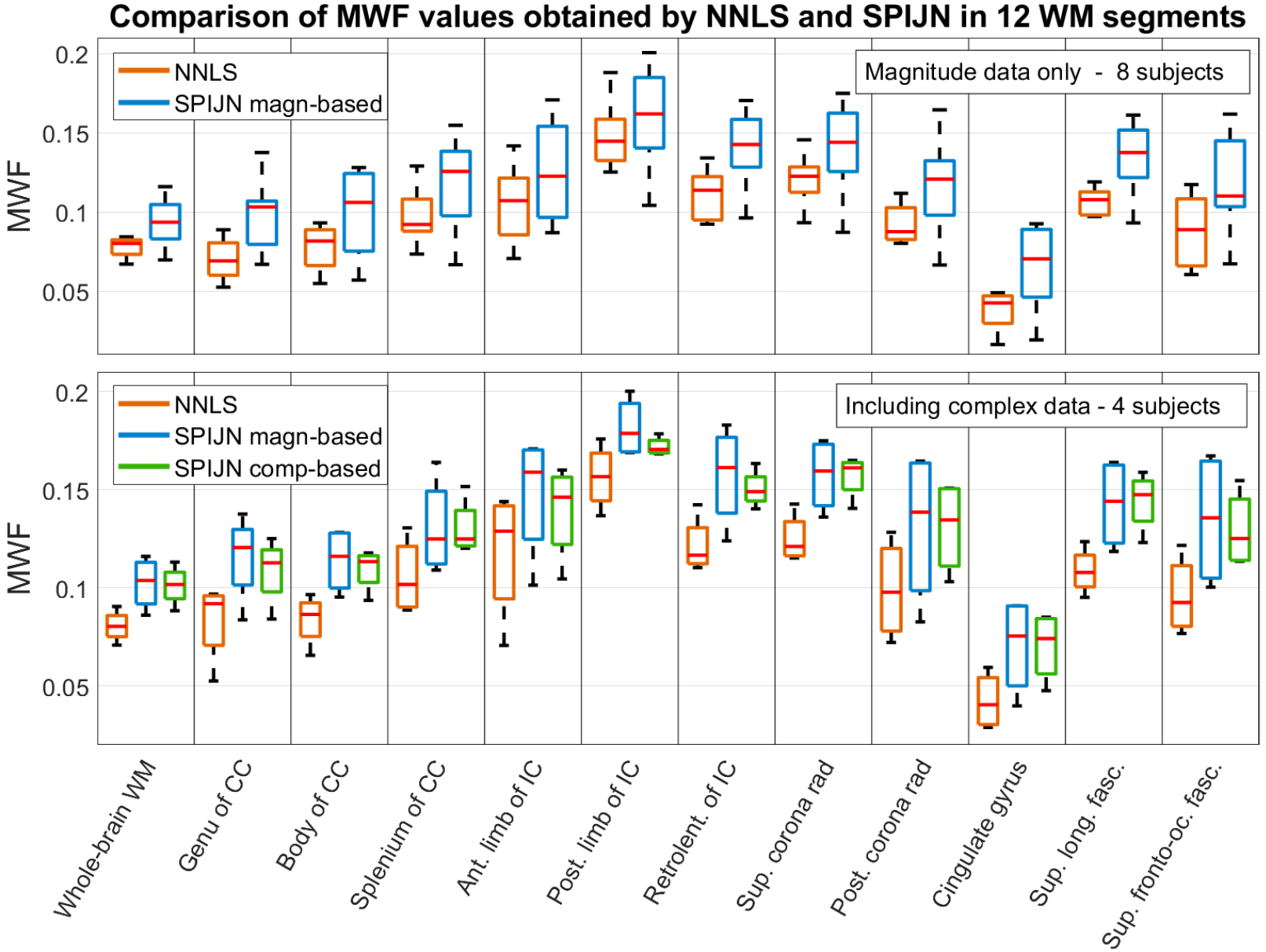
SPIJN magn – SPIJN comp

-0.05  0.05

- SPIJN magn and SPIJN comp very comparable
- Small phase-like patterns in the subtraction image

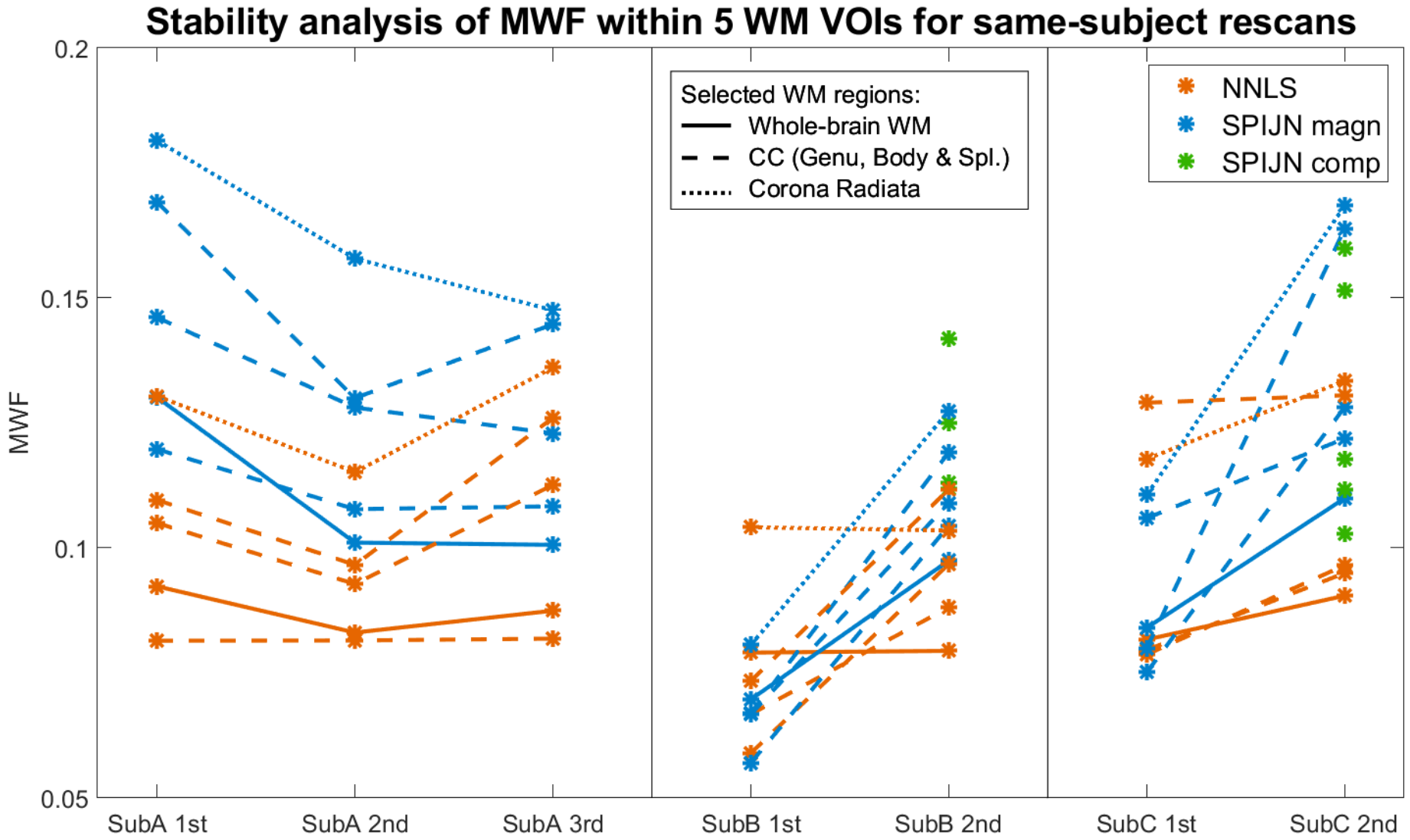
Quantitative analysis





- Similar mean MWF values of NNLS and SPIJN
- SPIJN systematically higher and varies more strongly between subjects
- Slightly lower MWF and smaller variance of mean MWF across subjects with complex-data based SPIJN

Reproducibility analysis



- Rescanning of the same subjects
- Complex data only for 2nd scan of Sub B & C
- Comparison of several WM regions
- NNLS MWF values tend to be more stable

Conclusion

- SPIJN yielded visually smoother MWF maps
- NNLS algorithm seemed to provide more stable MWF values
- Complex-data based SPIJN processing provided better agreement with NNLS MWF
- Future studies:
    - Reproducibility analysis for complex-data based SPIJN
    - Effect of SPIJN regularization

Thank you for your attention!

We highly appreciate support by the Friedrich-Ebert-Stiftung (FES) providing a PhD grant for Ronja Berg