Towards a Standard Pipeline for the Analysis of Human Spinal Cord fMRI Data

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SANTA LUCIA NEUROSCIENZE E RIABILITAZIONE

SCIENTIFIC PROBLEM

fMRI techniques based on the BOLD signal have already been exploited for the indirect study of the neuronal activity both in the brain and in the spinal cord

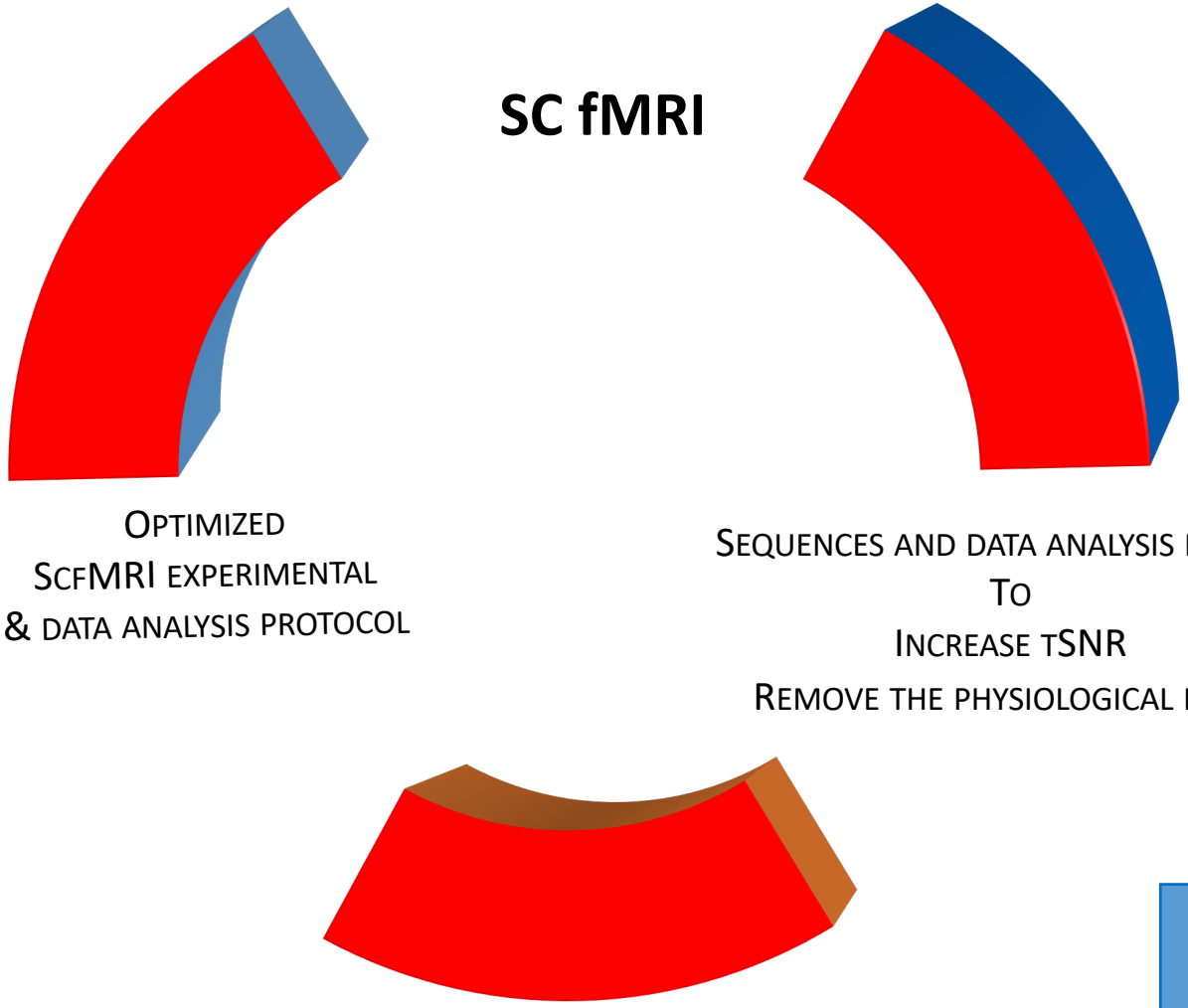
BUT

limited use in the study of the spinal cord function because of:

1. obtaining good functional images of the SC still represents a technical and scientific challenge
2. the exact features –and even the biophysical origins– of the functional response in the SC are still unclear.

If these challenges can be overcome, **ScfMRI** may be of immediate application for the assessment and follow-up of spinal injuries, pain, and neurodegenerative diseases.

Multimodal Approach



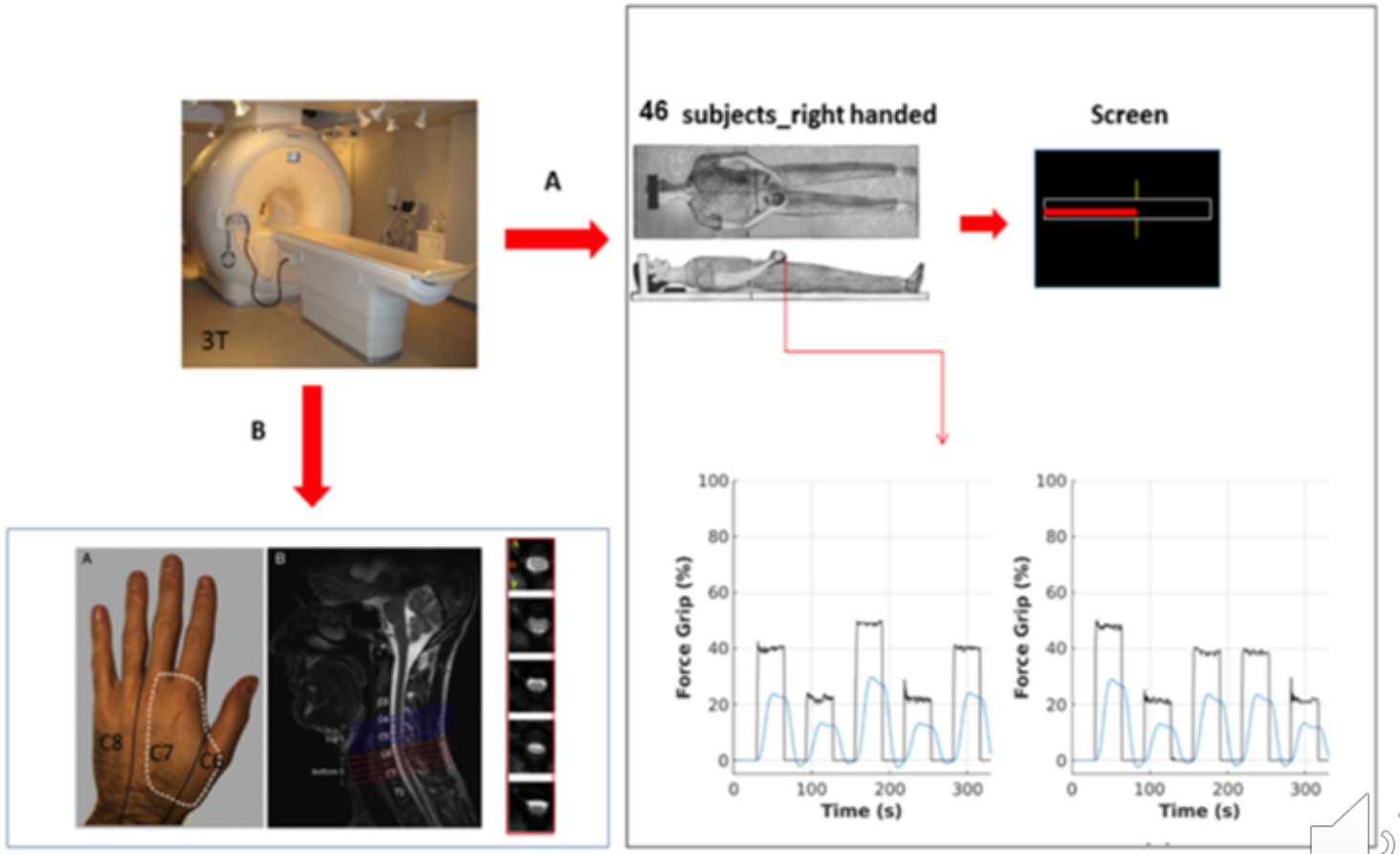
MATERIALS AND METHODS

We acquired axial and sagittal functional images at 3T from the spinal cord of 46 healthy subjects (all right-handed with a mean age of 35 years) while performing a block-design isometric motor task consisting of 5 cycles of 30s/30s rest/task epochs.

Technical conditions to provide the best NMR-image quality

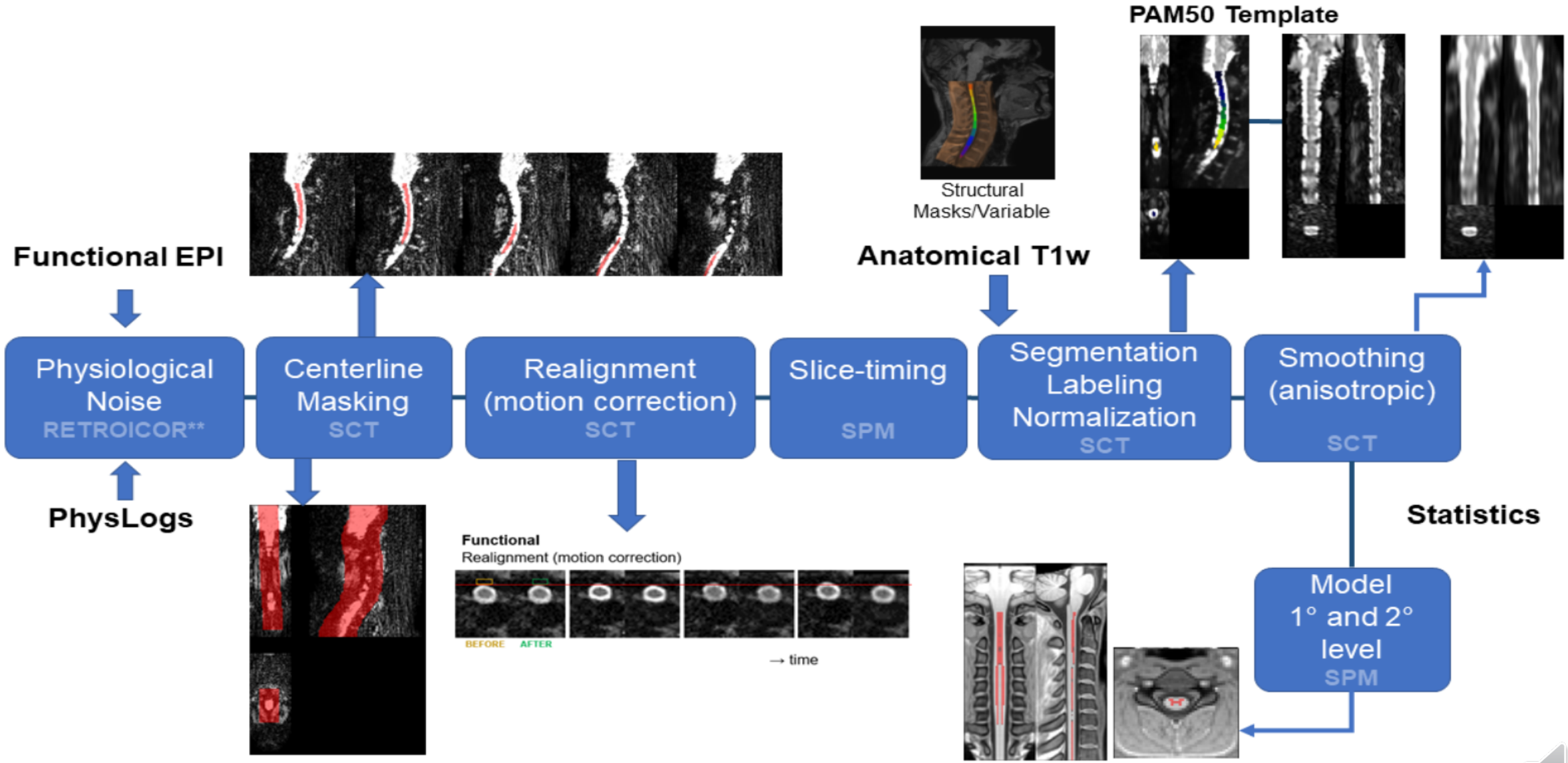
GE-EPI	
TE/TR	25/3000 ms
Flip angle	80°
Acquisition matrix	
(sagittal) (axial)	128x128x35 96x96x34
Resolution	
(sagittal) (axial)	3x1.5x2 mm 1.5x1.5x3 mm
FO V	
(sagittal) (axial)	192x144x104 mm 140x140x143 mm
T1-weighted GE	
TE/TR flip angle FOV Resolution	5.89/9.59 ms 9° 240x240x192 cm 0.75x0.75x1.5mm

Experimental design: isometric task force



P. Summers et al. NeuroImage 50, Issue 4,1415, 2010

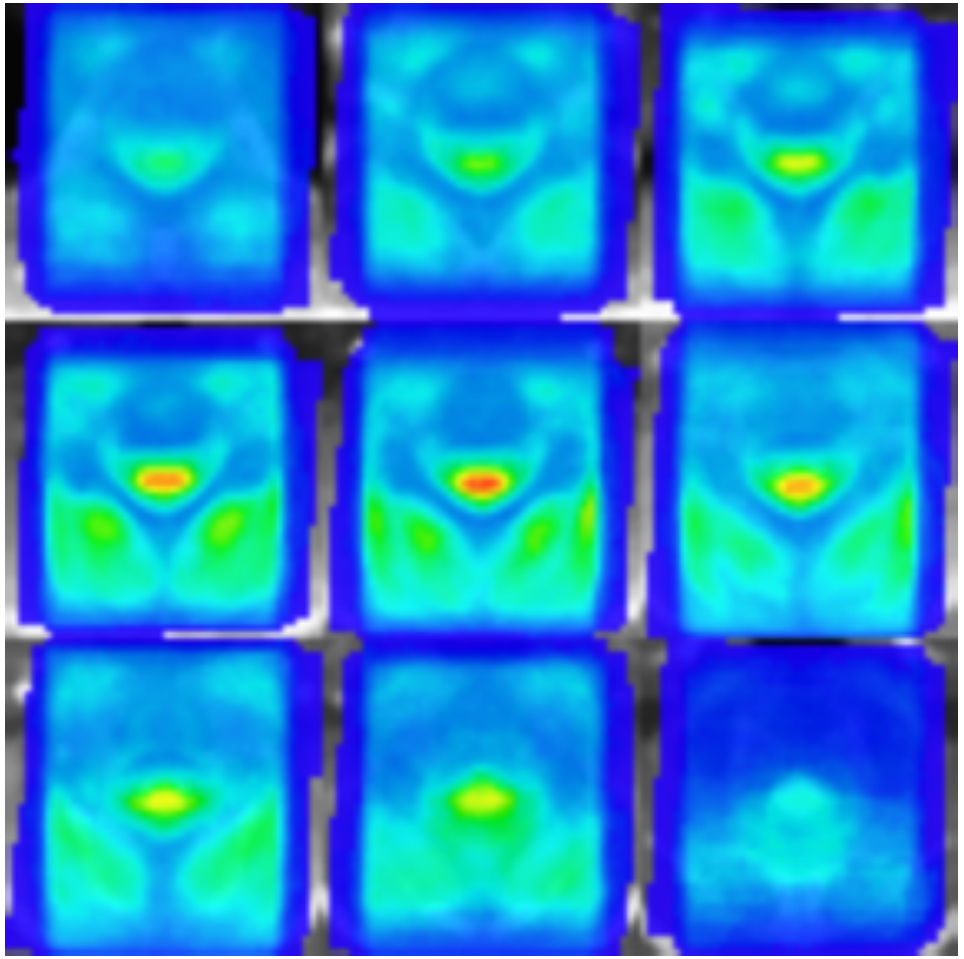
METHODS: SCfMRI DATA ANALYSIS PIPELINE

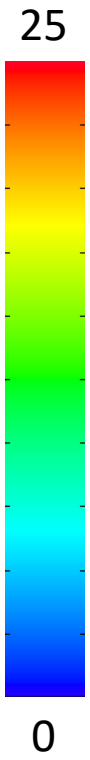


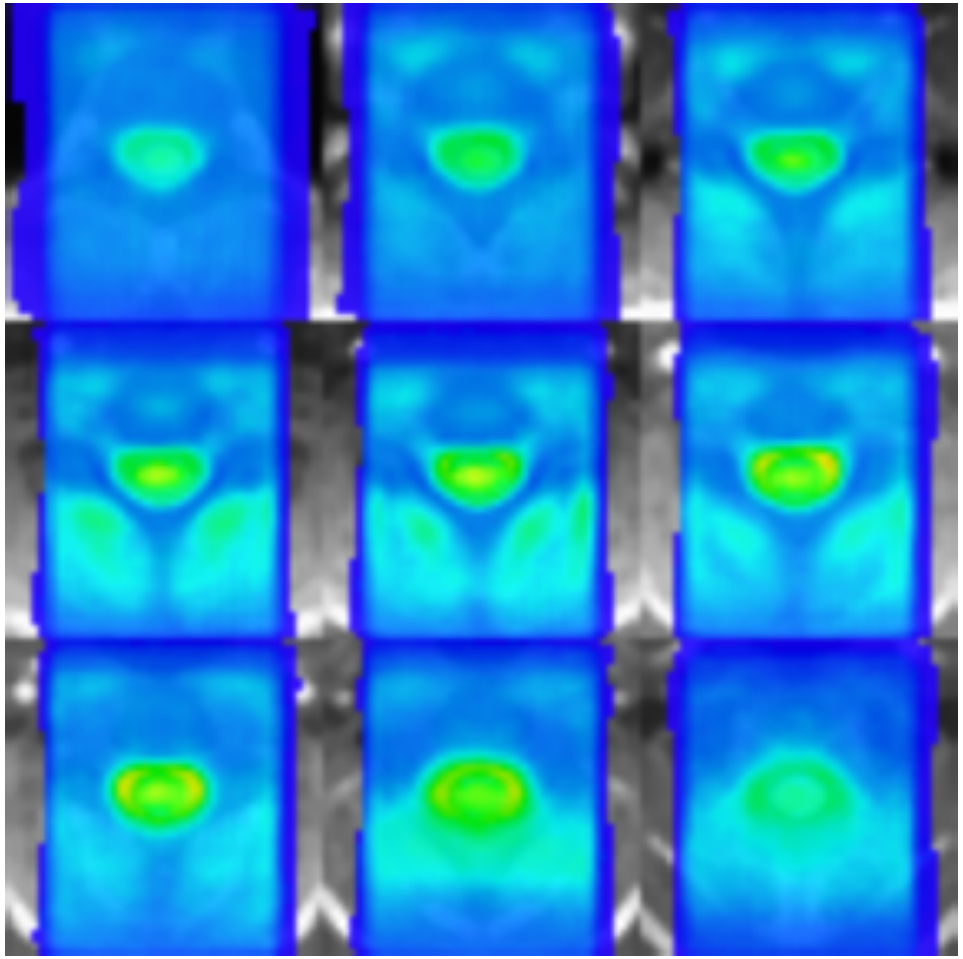
RESULTS RELATIVES TO :

OPTIMIZED SCFMRI EXPERIMENTAL & DATA ANALISIS PROTOCOL

tSNR







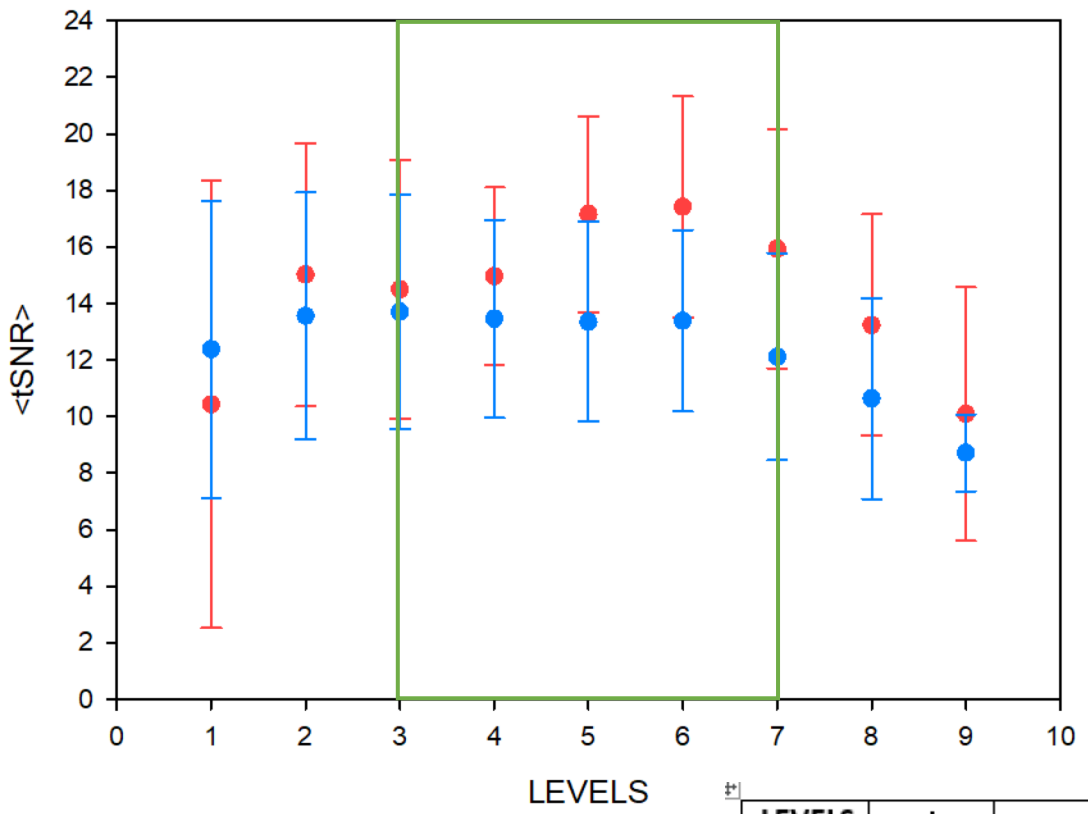
Mean tSNR Map for Ax

Mean tSNR Map for Sag

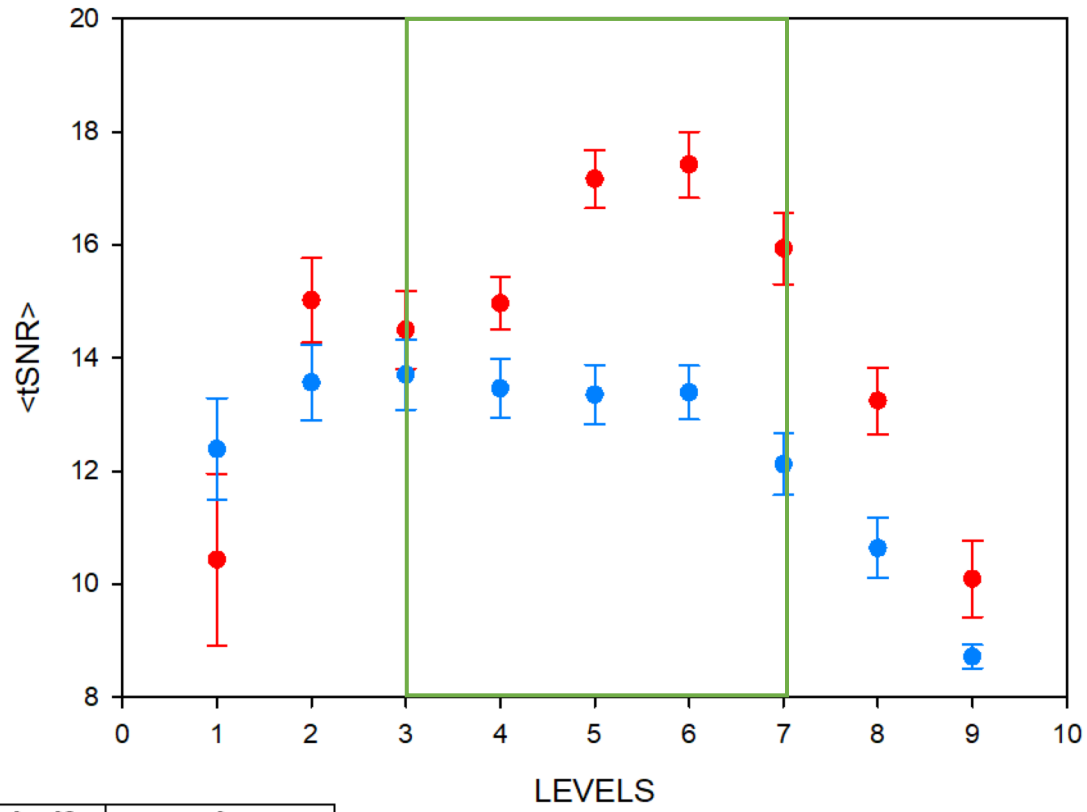
TSNR

Ax Red – Sag Blu

SD

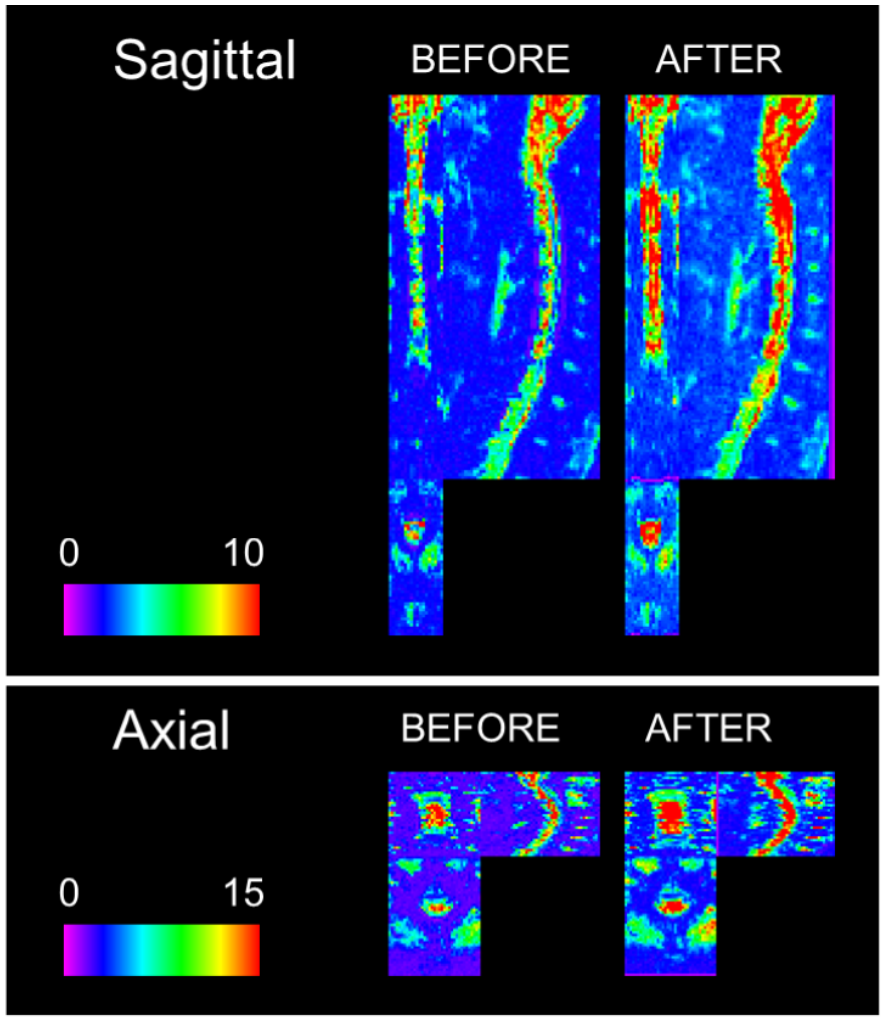


SEM



LEVELS	t	p	N	Power of test with alfa	Normality test
1	-1.956	0.0638	22	0.050: 0.463	passed
2	1.639	0.110	38	0.050: 0.358	passed
3	0.0965	0.924	45	0.050: 0.051	passed
4	2.385	0.021*	45	0.050: 0.645	passed
5	6.037	<0.001*	45	0.050: 1.000	passed
6	5.644	<0.001*	45	0.050: 1.000	failed
7	5.446	<0.001*	45	0.050: 1.000	passed
8	3.558	<0.001*	45	0.050: 0.936	passed
9	2.044	0.0471*	44	0.050: 0.515	passed

RESULTS: SCT fMRI MOCO vs AFNI 3dWarpDrive



Representative tSNR maps from a healthy subject before and after SCT fMRI MoCo (left)

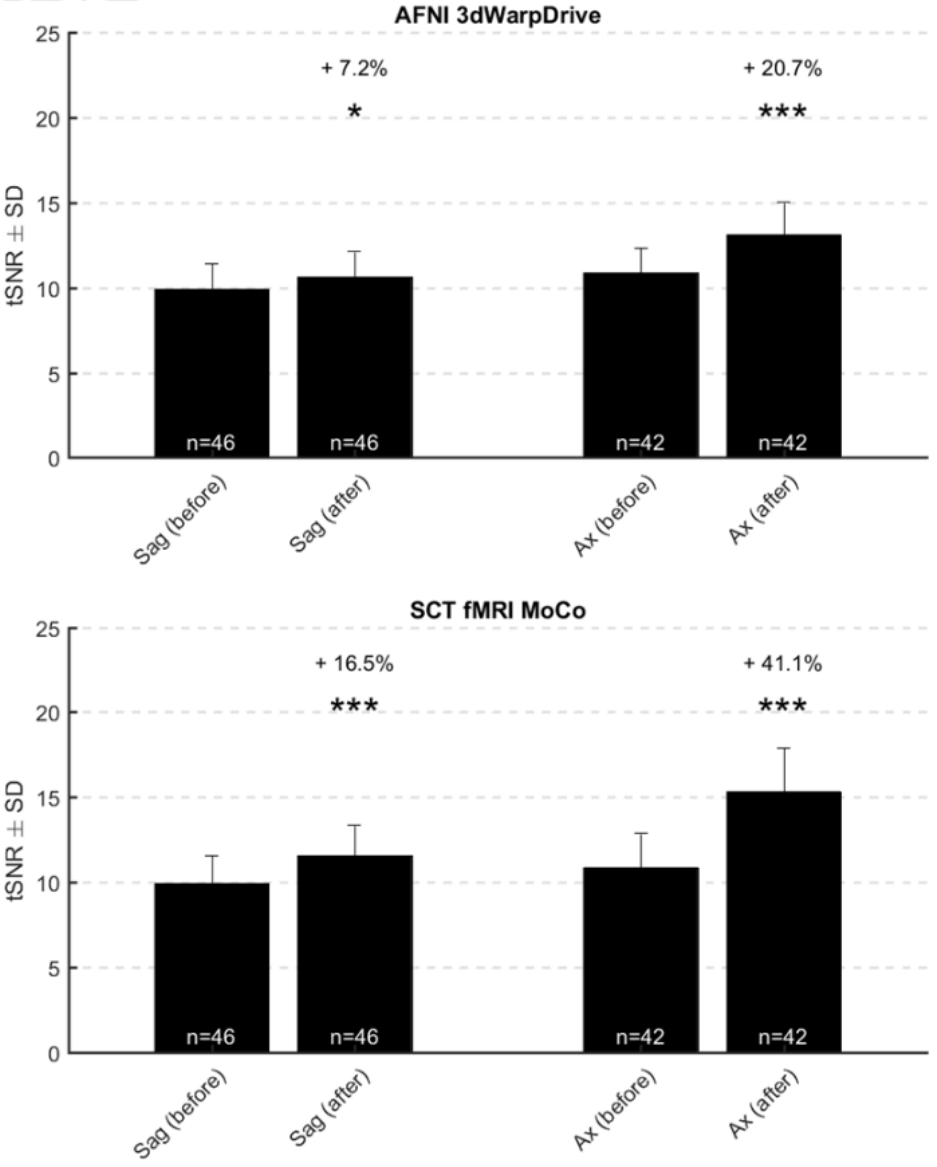
CV's for AFNI 3dWarpDrive and SCT fMRI MoCo were :

59% and 44% for sagittal images, respectively

43% and 36% for axial images, respectively.

The increase in tSNR is statistically significant.

* p<0.05, *** p<0.001.



Group statistics for tSNR after motion correction performed either with AFNI or SCT (right).

CONCLUSIONS

- We implemented and optimized a scfMRI data analysis pipeline built around the Spinal Cord Toolbox (SCT). We acquired axial and sagittal functional images at 3T from the spinal cord of forty-six healthy subjects performing an isometric motor task.
- Using our SCTbased pipeline with an ad hoc experimental setting, we substantially improved motion correction and image registration.
- This result is of great importance for the SC-fMRI application in neuroradiology, and in particular for the assessment and follow-up of spinal injuries, pain, and neurodegenerative diseases (e.g multiple sclerosis), as well as in the development and evaluation of new therapies.

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