

BOLD responses in 7T fMRI of the human spinal cord on a single-subject level

Ulrike Horn¹, Nicolas Gross-Wege^{1,2}, Johanna Vannesjo³, Merve Kaptan¹, Alice Dabbagh¹, Robert Trampel¹, Harald Möller¹, Nikolaus Weiskopf^{1,4}, Falk Eippert¹

¹Max Planck Institute for Human Cognitive and Brain Sciences, Leipzig, Germany,

²Siemens Healthcare GmbH, Erlangen, Germany,

³Department of Physics, Norwegian University of Science and Technology, Trondheim, Norway,

⁴Felix Block Institute for Solid State Physics, University of Leipzig, Leipzig, Germany

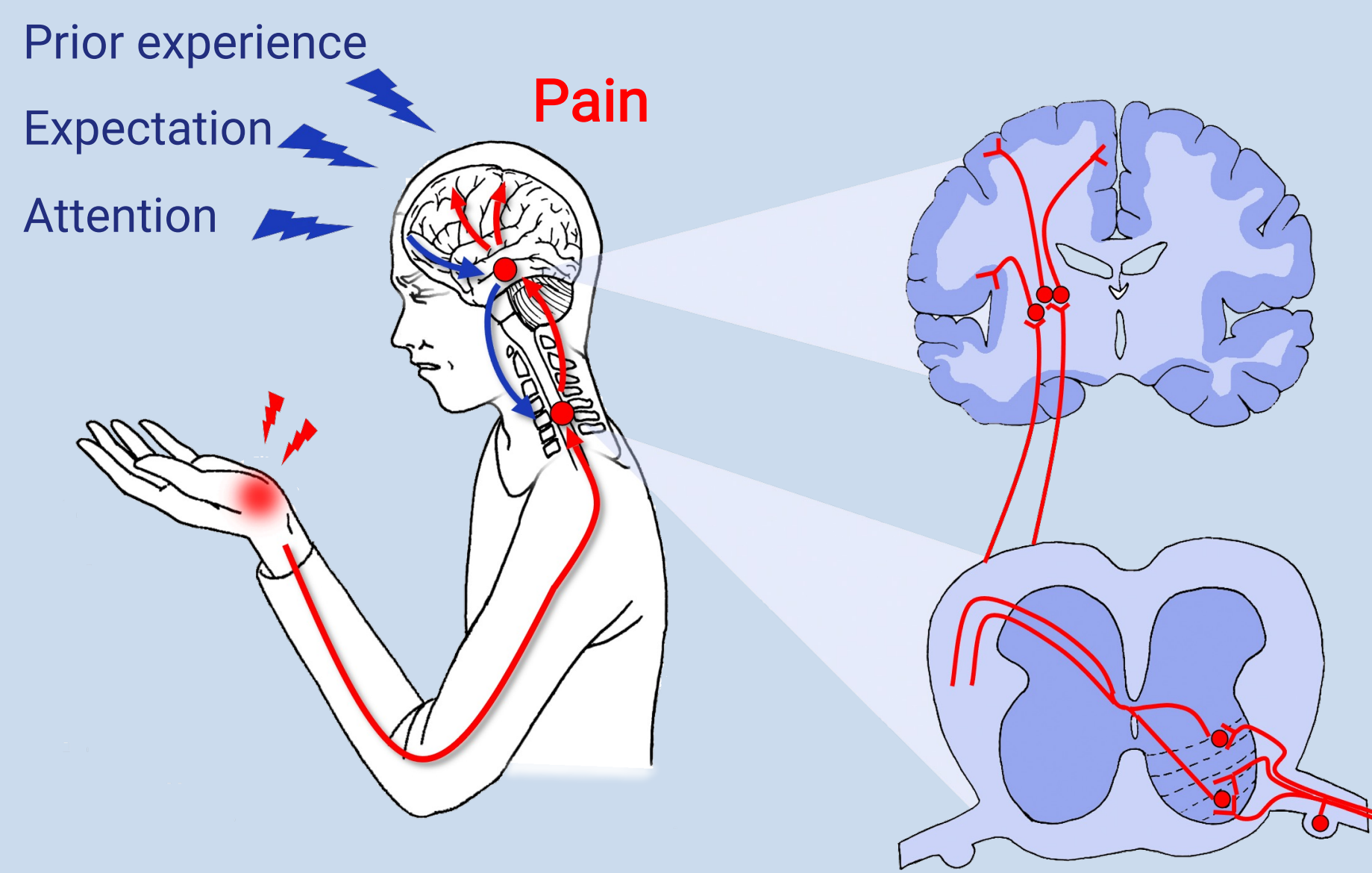
@ulrike_horn

uhorn@cbs.mpg.de



Why spinal cord?

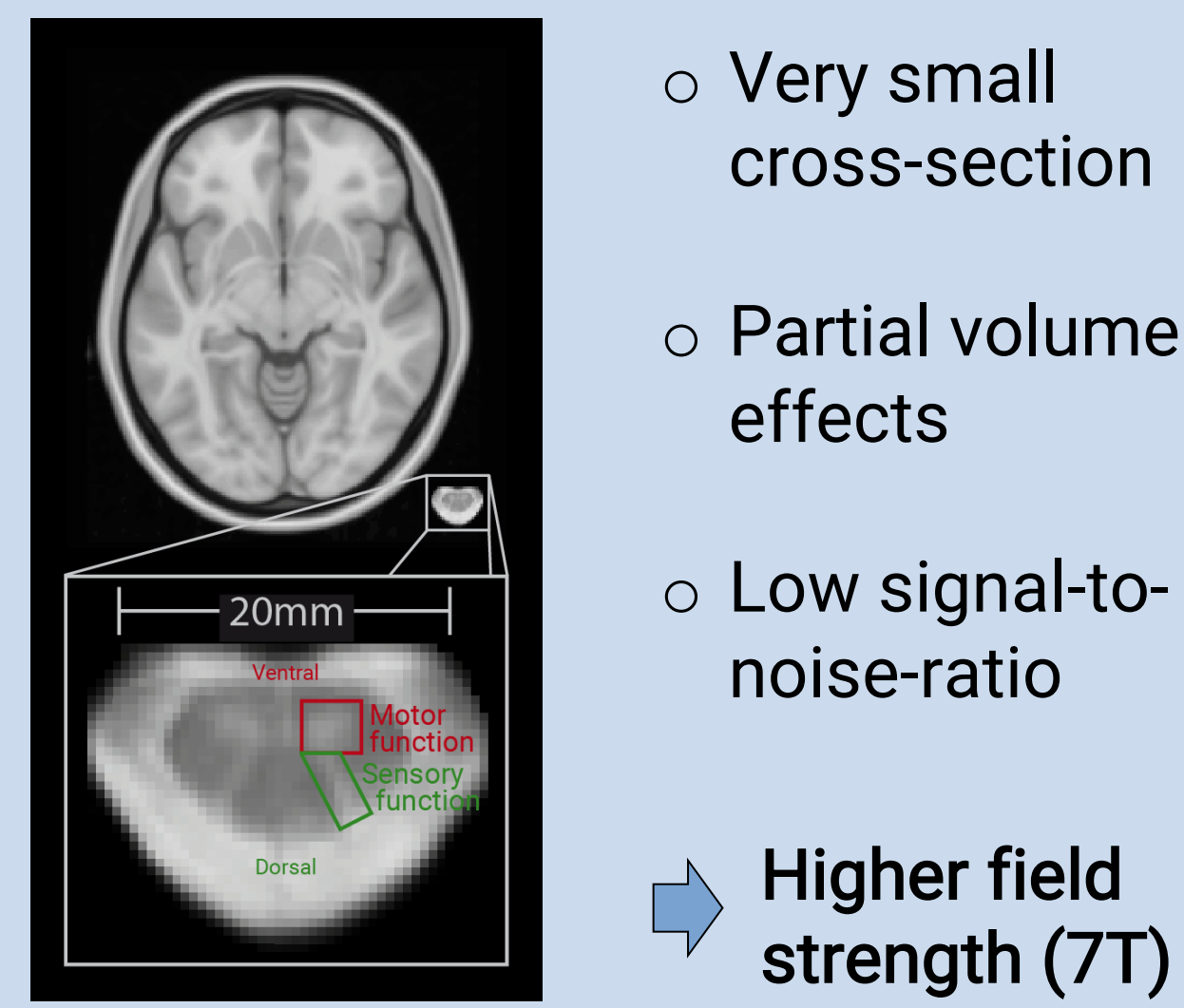
Pain signals arise from the nociceptors and are transmitted via the spinal cord to the brain. Pain is an important warning signal, but the perception of pain does not always exhibit a one-to-one relationship with tissue damage. Instead the perception of pain can be modulated by many different factors.



One way how these factors can influence pain perception is via descending pathways that influence earlier stages of the processing hierarchy.

This means the very first modulation of nociceptive signals can already take place in the spinal cord. But despite its importance and potential clinical relevance, our knowledge of the human spinal cord in light of pain perception is still limited.

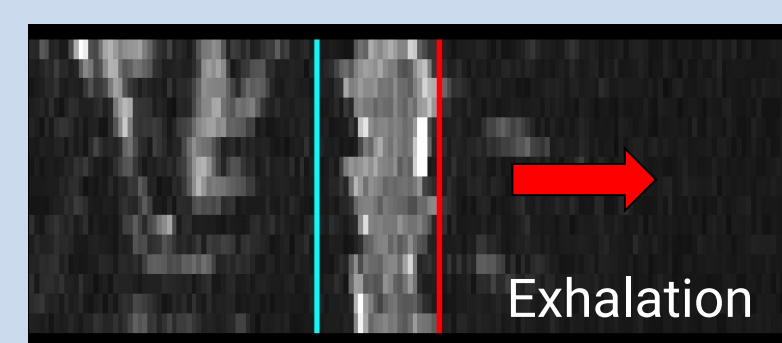
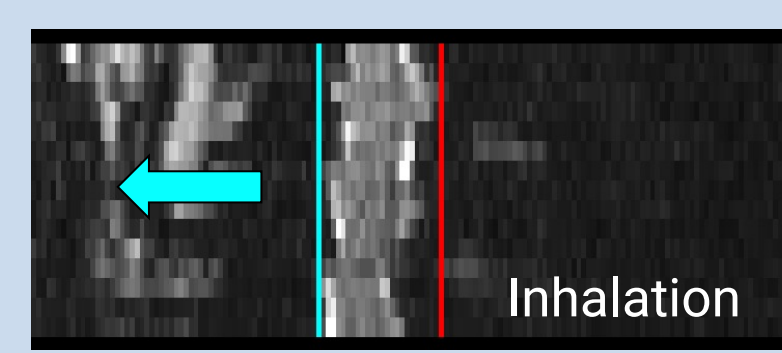
Challenges of spinal cord fMRI



- Very small cross-section
 - Partial volume effects
 - Low signal-to-noise-ratio
- ➔ Higher field strength (7T)

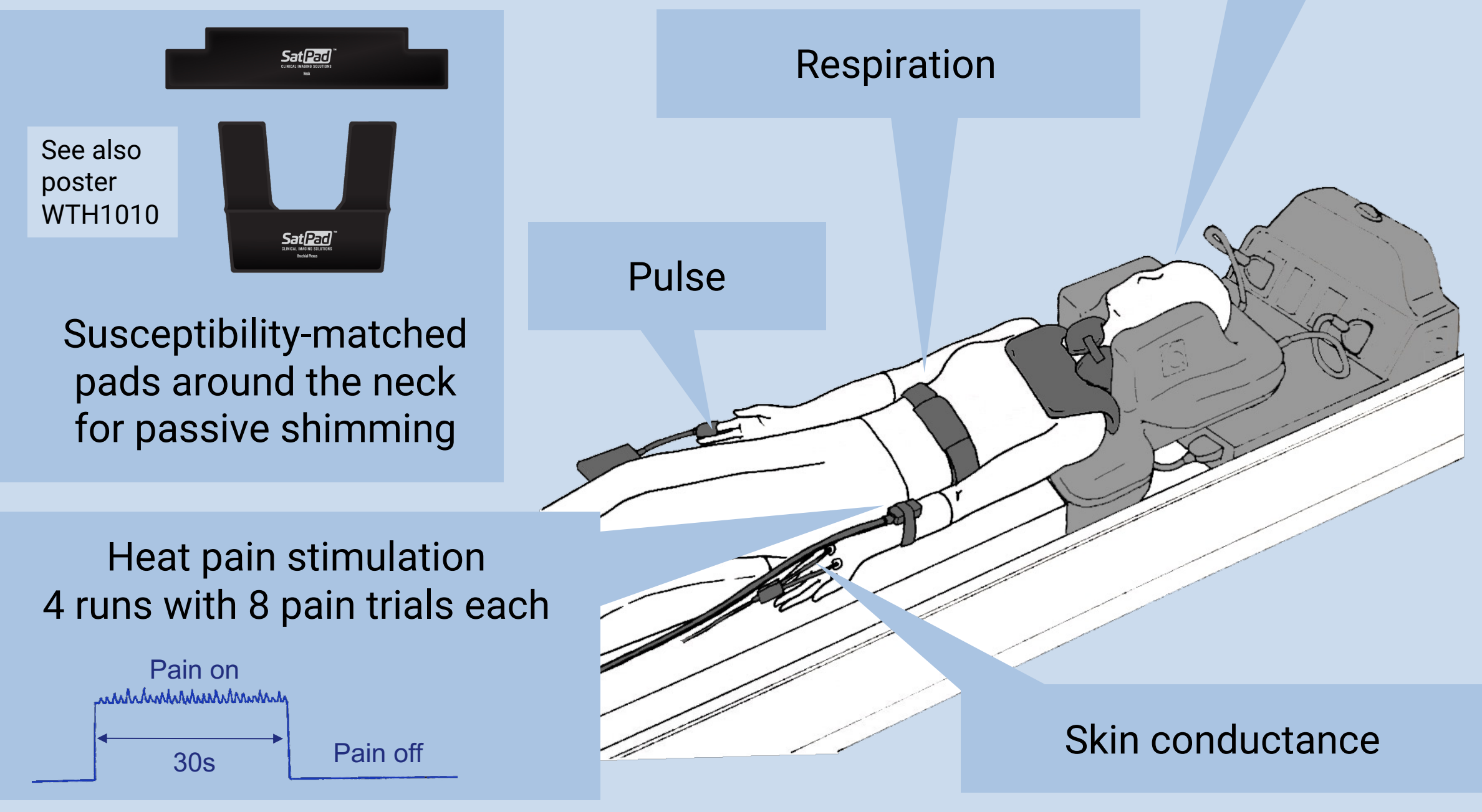
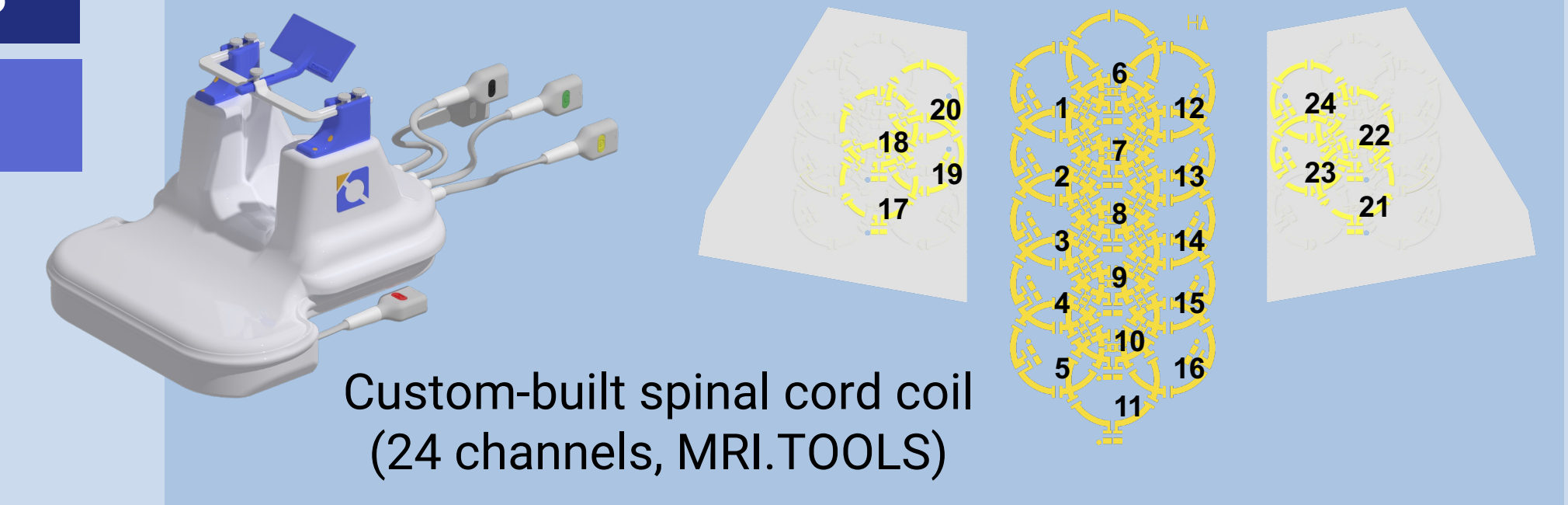
but:

- Only a few custom-built coils exist
- Field inhomogeneities present a significant problem
- Impact of physiological noise



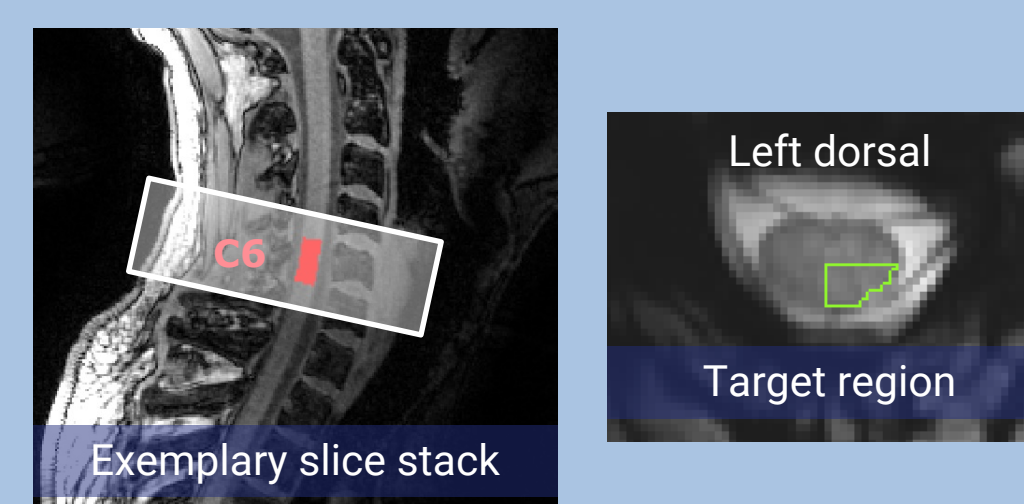
Methods

Setup



Imaging

EPI, 0.75mm in-plane, 3 mm slice thickness, TR 1.12s, TE 23ms, GRAPPA acceleration factor 3



Preprocessing

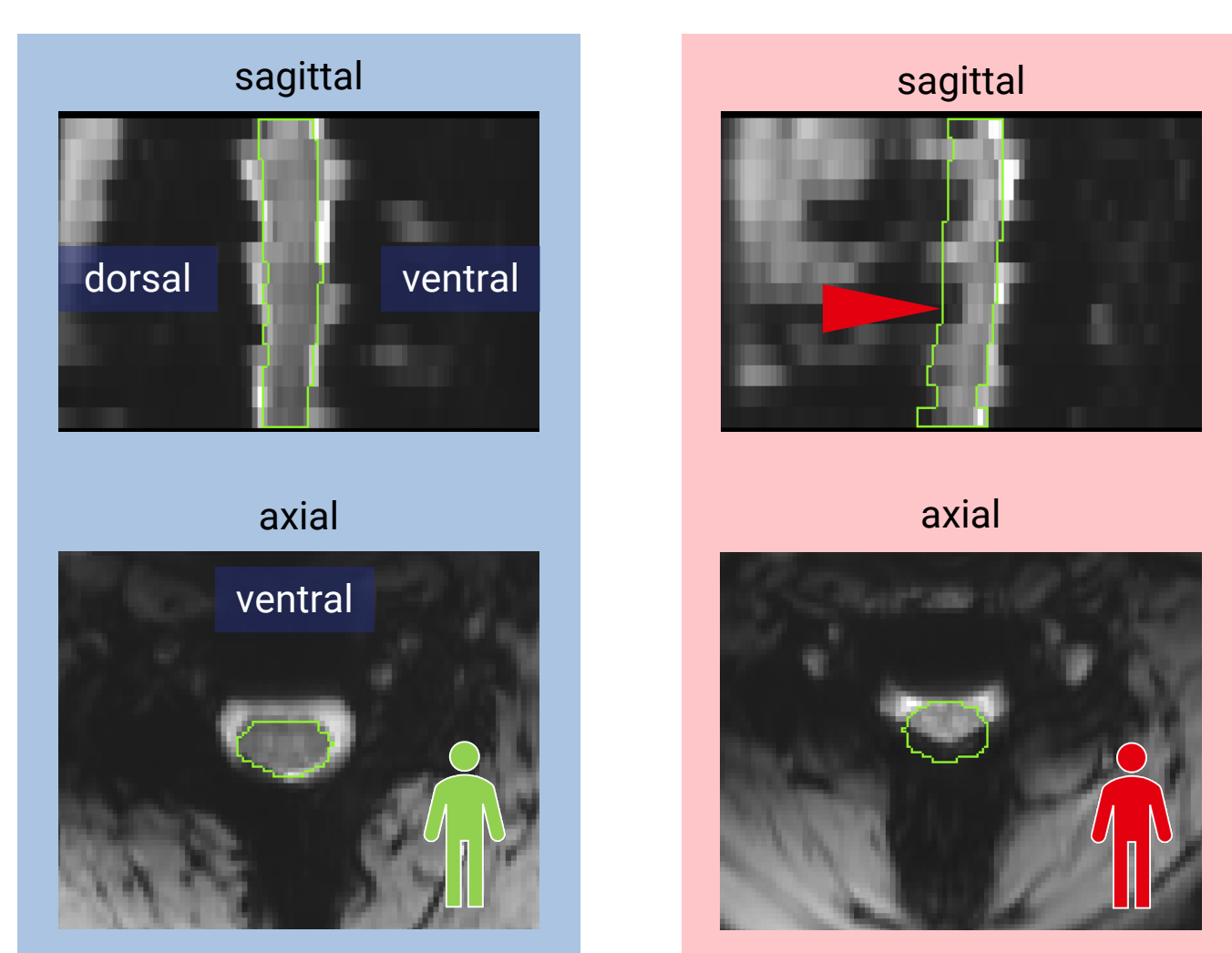
- Slice-wise motion correction (SCT)
- Motion-correction parameters included in GLM
- Automated censoring of outlier volumes
- Multi-step non-linear warping to template space

Statistical analysis

- FSL FEAT
- Slice-wise physiological noise modelling (PNM)
 - Cardiac noise
 - Respiratory noise
 - CSF fluctuations

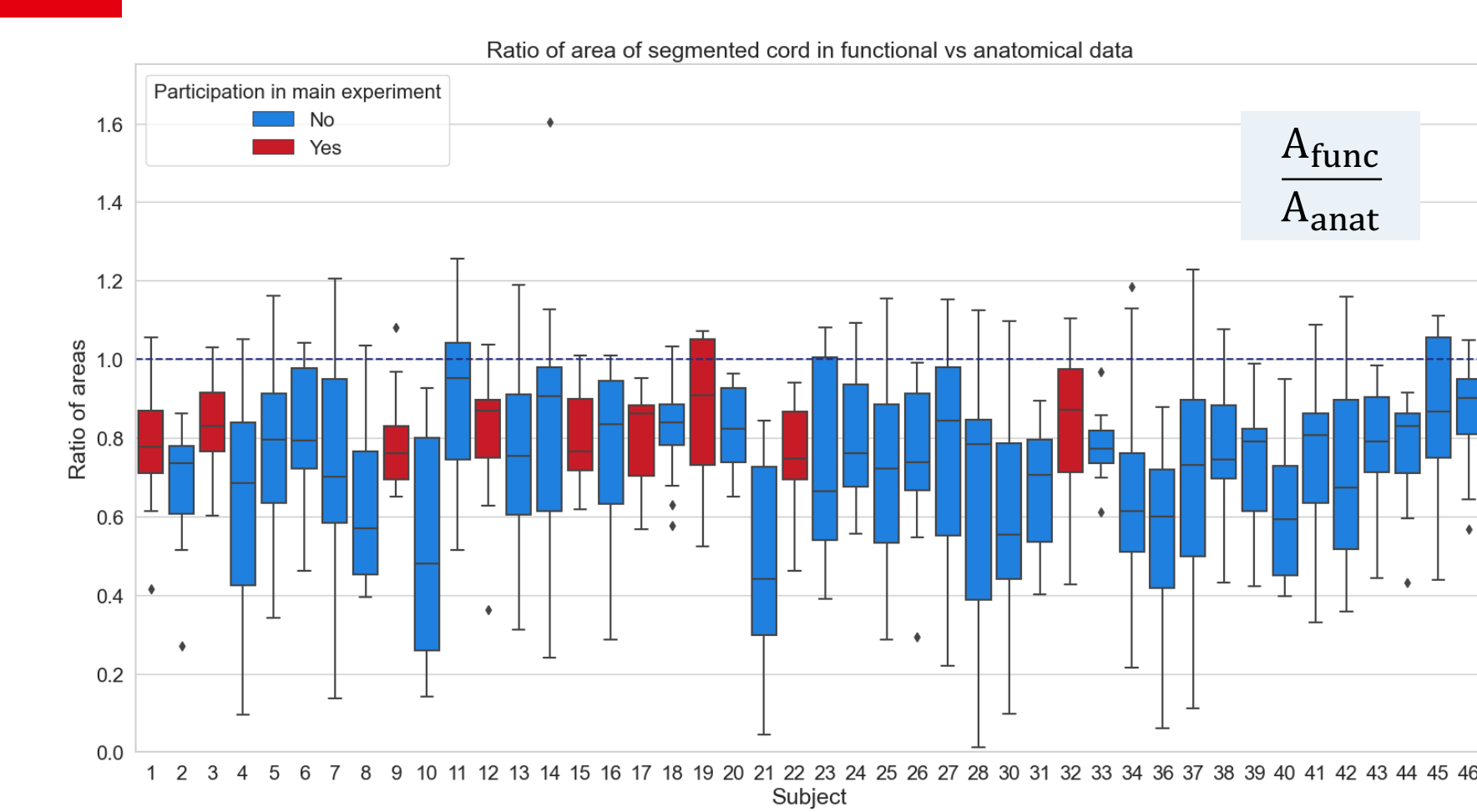
Results

1 Data quality differs across participants ...

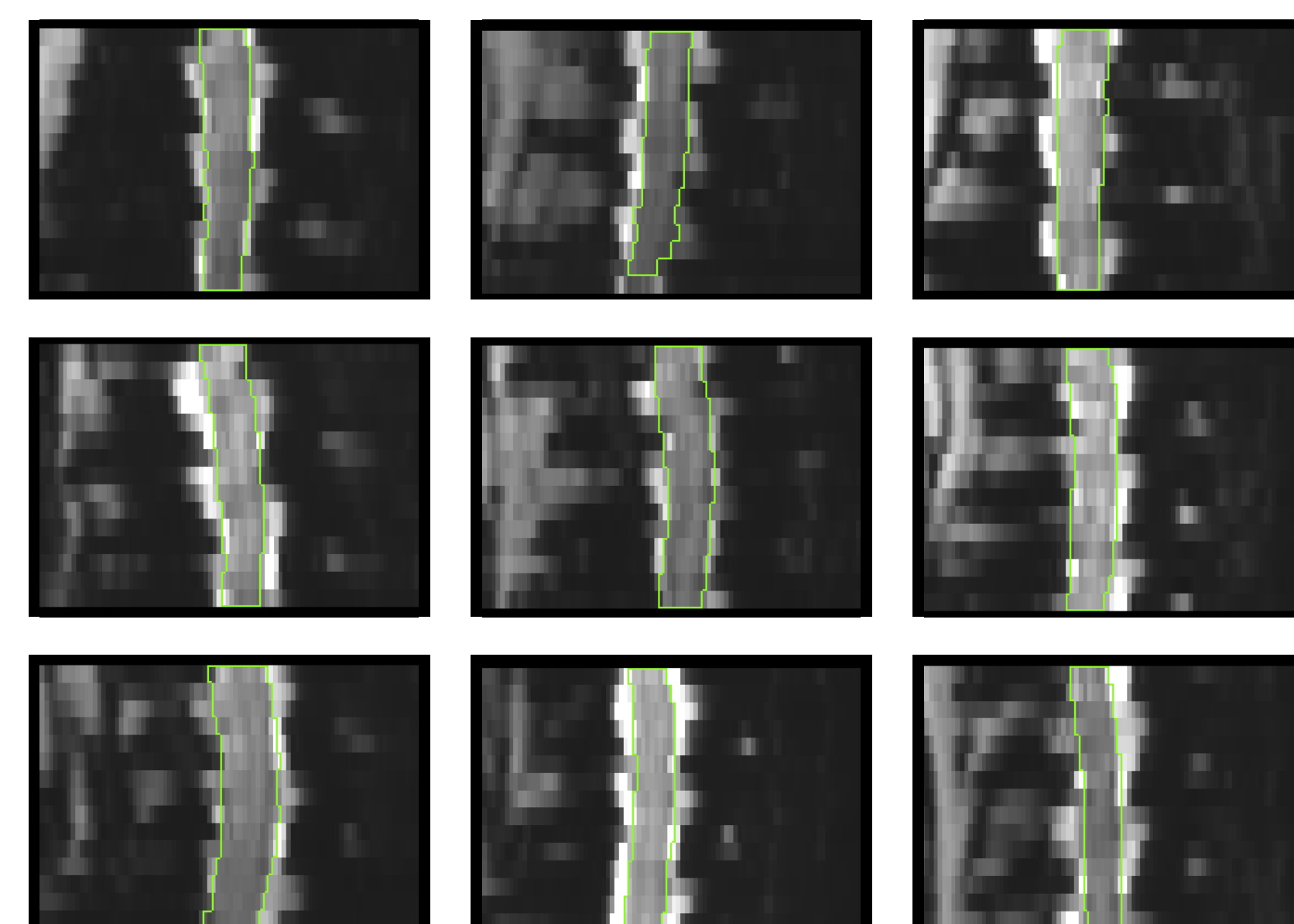


Cord segmentations based on anatomical scans overlaid on functional scans show where distortions and signal drop-outs occur.

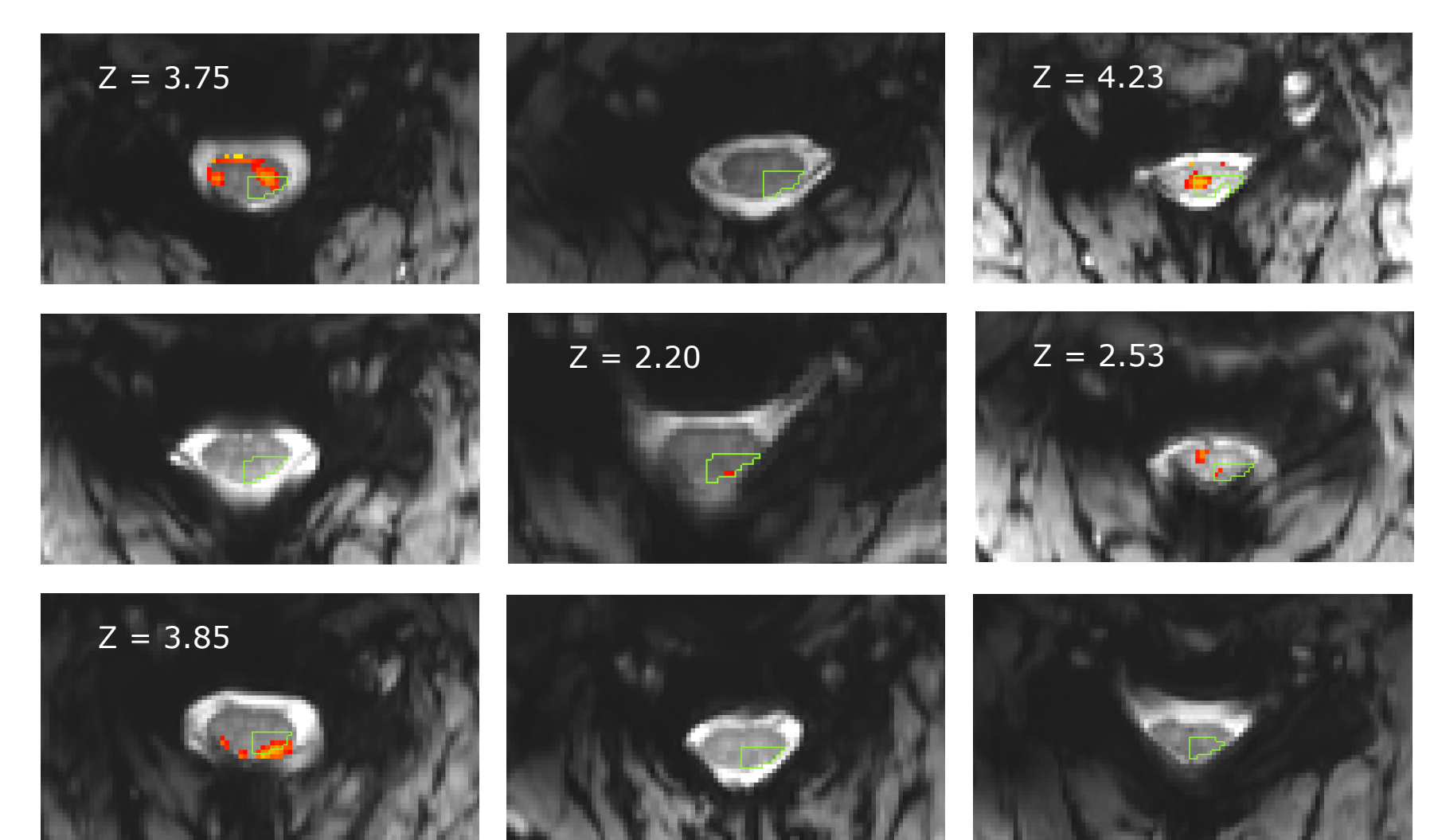
3 We select participants based on criteria...



4 ... that ensure good data quality.

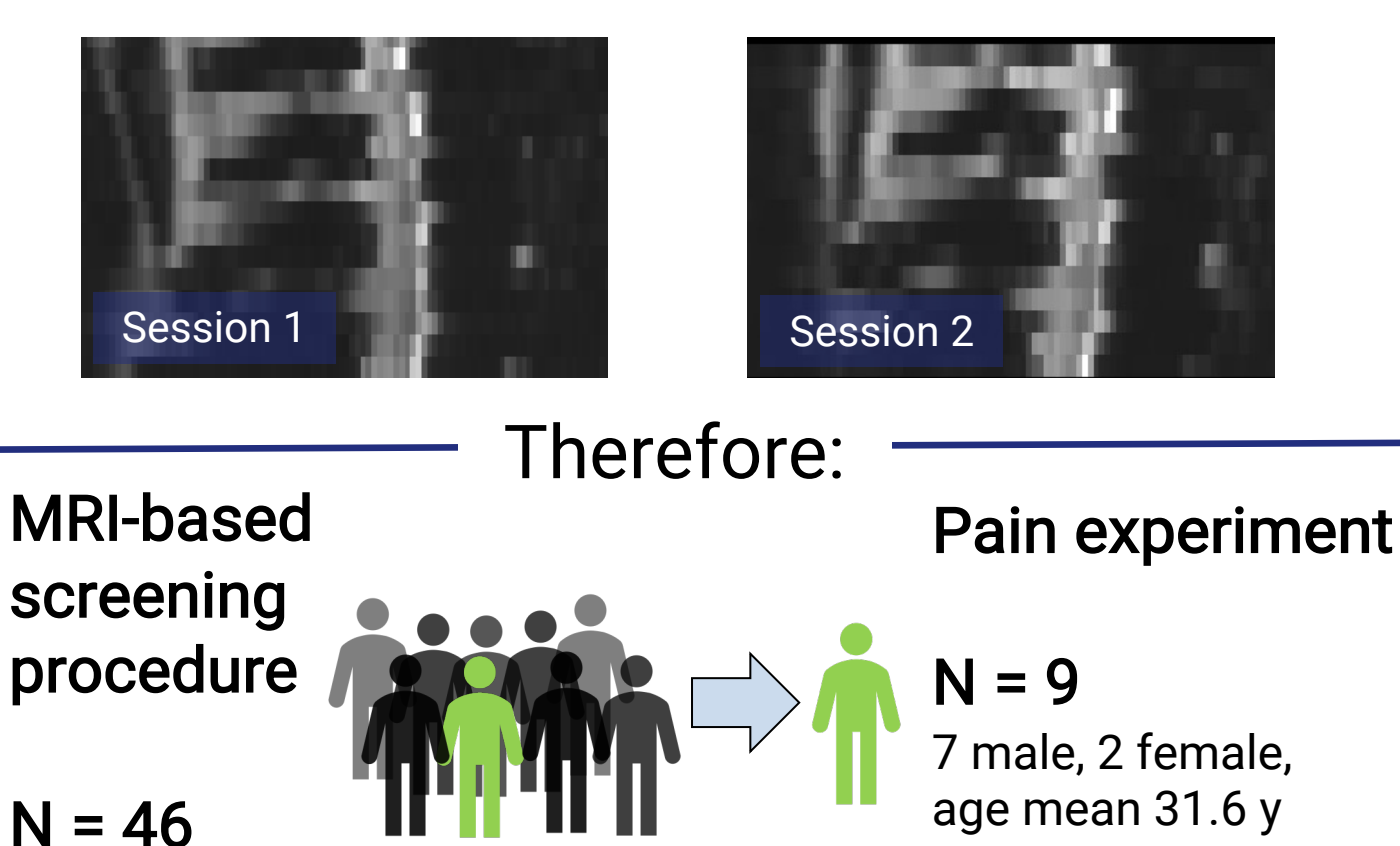


5 We observe BOLD responses to painful heat...

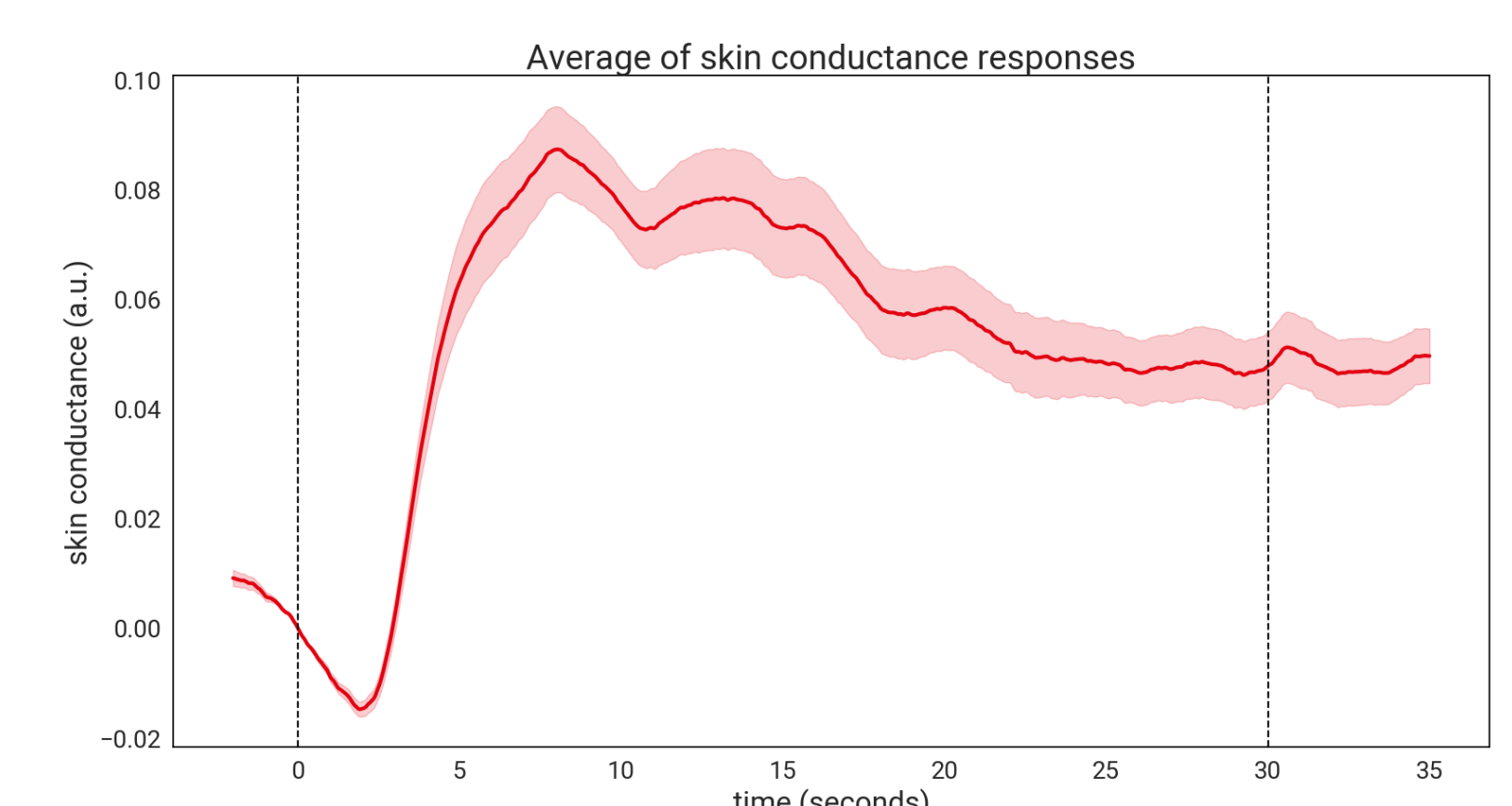


In 5 out of our 9 participants we observe activation in the expected location, suggesting that task-based functional MRI in spinal cord is indeed feasible at 7T.

2 ... but is reproducible.



6 ... and accompanying autonomous responses.



Summary

- fMRI of the human spinal cord at 7T faces many technical challenges
- Single-subject spinal cord BOLD responses to painful heat stimulation in expected region, but consistency of responses across participants currently unclear

- Next step: evaluating distortion correction of EPI data to allow more fine-grained response delineation in grey matter
- Ultimate goal: sufficient data quality to investigate interplay of bottom-up and top-down factors in pain perception in different layers of dorsal horn

Funding sources



European Research Council
Established by the European Commission
STG: GA ID: 758974