Intrinsic rsfMRI connectivity networks in the human spinal cord

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Target Audience spinal cord and rsfMRI

Purpose The spinal cord is the main pathway for information connecting the brain and peripheral nervous system. The gray matter, in the center of the cord, consists of cell bodies of interneurons and motor neurons. The white matter is located outside of the gray matter and consists almost totally of myelinated motor and sensory axons. "Columns" of white matter carry information either up or down the spinal cord. The goal of this study was to use rsfMRI to investigate the intrinsic connectivity network in the human spinal cord. We focused on mapping functional connectivity of cervical spinal cord from C1-C4.

Methods Four self-declared normal volunteers were studied. For each subject, 4 repeated BOLD rsfMRIs were performed at 3T using a neck RF coil, covering the bottom of C1 to C4. rsfMRI parameters were: axial gradient echo EPI, FOV=128x128mm, matrix=128x128, TR=2s, TE=26ms, Thk=3mm, 23 slices, 300 time points (10 mins). Anatomical T2 turbo spin echo images were also obtained with TR=6.9s, TE=70ms, flip angle 150^{o}, NT=2, and 1x1x3 mm. rsfMRI was analyzed on the masked spinal cord using independent component analysis (ICA). Co-registration was done semi-manually. A neck brace was used to reduce motion artifacts and facilitated co-registration.

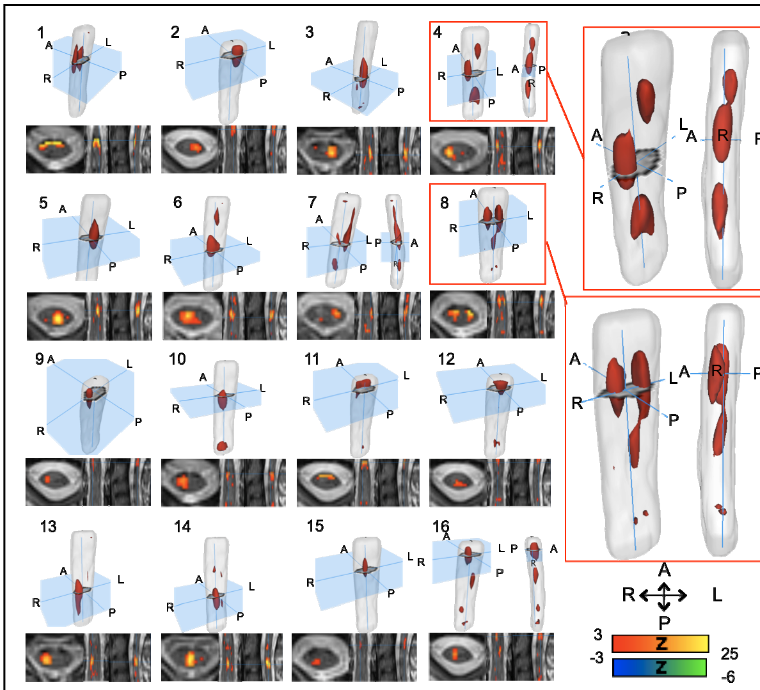

Figure 1. ICA rsfMRI components of the spinal cord. A 3D rendering and the 3 views are shown for each component. Expanded views are shown for two components.

Results Figure 1 shows 16 ICA rsfMRI components. rsfMRI components found within C1-C4 segments were highly reproducible, suggesting a robust network of connectivity exists in the spinal cord. The majority of the rsfMRI patterns were localized to gray matter albeit some partial volume effects. Some components are bilateral, some are unilateral, and some are in the rostro-caudal direction. We also found unilateral and bilateral connectivity along the length of the spinal cord (3D rendering insets in Figure 1). 3D rendering of 5 components (#1, 2, 4-6, 7, 9, 10) are shown in **Figure 2**.

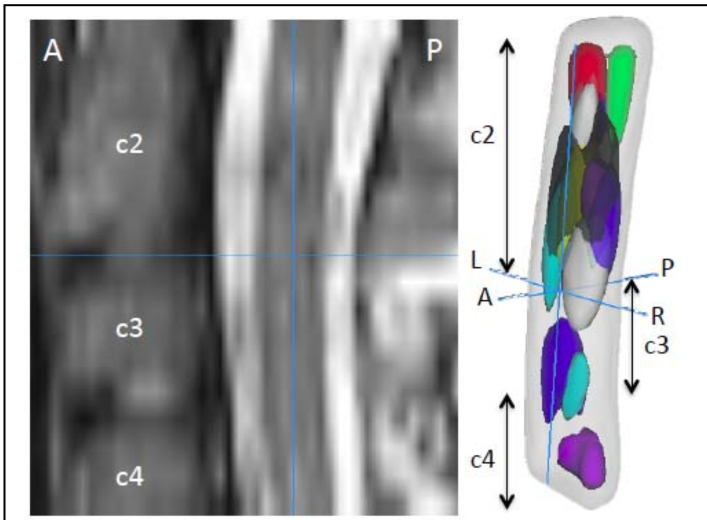

Figure 2. Anatomical image shows level of activation of 5 components in a single 3D rendering surface.

Discussion and Conclusions Previous studies have investigated rsfMRI of the spinal cord at 1.5 T and 7T on single subjects with limited successes.[1, 2] To our knowledge this study is the first to report rsfMRI connectivity networks as a group sample and demonstrated reproducibility. We found it helpful to first mask spinal cord before co-registration and rsfMRI ICA analysis. A similar approach has been applied to mask rsfMRI of the brainstem.[5] Detailed interpretations of the intrinsic connectivity network will likely benefit from improved spatial resolution. Nonetheless, this study demonstrates a novel rsfMRI application to investigate the spinal cord. We detected an elaborate functional network in the spinal C1-C4, and they included unilateral, bilateral and rostro-caudal functional connectivity. Future studies will improve spatial resolution to distinguish different functional structures and to map connectivity of the entire spinal cord to the brain. This approach set the stage for exploring clinical applications (such as post-traumatic injuries and neurodegenerative conditions).

REFRENCES (1) Wei et al. Eur J Appl Physiol 2010;108:265. (2) Barry et al. ISMRM 2013;p2237. (3) Yoshizawa et al. Neuroimage 1996;4:174. (4) Cadotte et al. J Neurosurg Spine 2012;17:102. (5) Beissner et al. Neuroimage 2013 in press.