Chronic Low Back Pain and Sensorimotor Network Changes

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Introduction

- Resting state fMRI data analysis consistently displays a set of stable cortical networks, including the Sensorimotor Network (SMN).[6]
- The SMN can be further divided into dorsal and lateral networks within each hemisphere.[7]
- Chronic low back pain is associated with functional connectivity changes in networks such as the Default Mode and Salience Networks.[1,4]
- Chronic pain, including low back pain, is associated with changes in cortical representation of the body part involved.[2]
- No literature is available specifically assessing changes within the Sensorimotor Network of those experiencing Chronic Low Back Pain.
- Connectivity within the Sensorimotor Cortex was compared between people with chronic low back pain and healthy controls.
- We hypothesized differences in connectivity measures specifically of the dorsal subnetwork including representation of the low back

Methods

Datasets Used:

- A publicly accessible dataset was used (openpain.org)
  - 28 individuals with chronic back pain (ages 21-6, mean= 49.71)
  - 28 healthy controls (ages 21-64, mean= 49.43)
- Data from 32 healthy controls collected previously in the lab was used as an independent dataset to generate the ICA based ROIs.

Region of Interest Generation (Parcellation Analysis):

- Used a 300 region of interest (ROI) parcellation by Seitzman et al 2020
- All ROIs within each Sensorimotor Subnetwork were divided by hemisphere and compiled into a single ROI, for a total of four ROIs
- An additional set of ROIs were generated using Independent Component Analysis of an Independent dataset by spatial correlation to SMN maps generated by Smith et al 2009
- An ROI-to-ROI connectivity analysis was performed using the four parcellation-based ROIs and later repeated for the ICA-based ROIs.

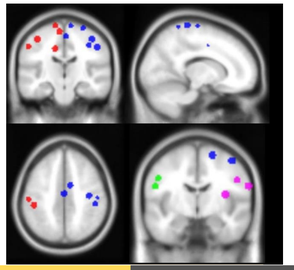


Figure 2: Parcellation Based ROIs

Left lateral:
Right lateral:
Left dorsal:
Right dorsal:

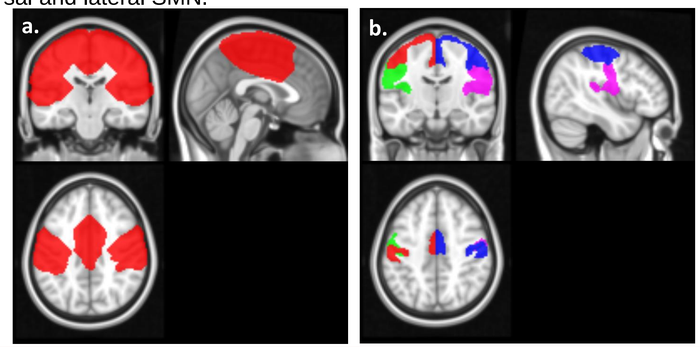
Methods cont.

Regions of Interest (Independent Component Analysis):

- An Independent component analysis (ICA) was performed on the independent data set and results were compared via spatial correlation to component maps generated by Smith et al, 2009 (Figure 2a)
- The resulting component was used as a mask to constrain a second series of ICA to isolate the sub-networks of the SMN. (Figure 2b)
- Multiple ICA were performed to determine the ideal number of components needed to isolate the dorsal and lateral SMN.

Figure 2: Independent Component Analysis Based ROIs

Figure 2b labels SMN subnetworks using the same color convention as Figure 1.



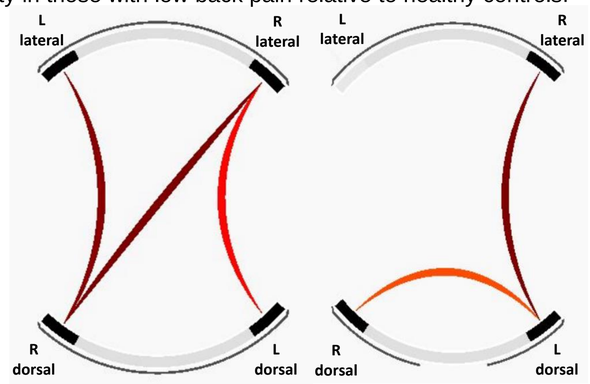
Results

Connectivity Analyses

- An analysis of functional connectivity between each subnetwork region was performed for each set of ROIs using an ROI-to-ROI analysis, which determines how synced activity is in two or more brain regions.
- Pairwise connectivity was determined and is given in Figure 4. Strength of connectivity is given in T-values reported in Tables 1 and 2. Positive values indicate higher levels of connectivity in those with low back pain relative to healthy controls.

Figure 3. Connectivity Maps for Parcellation and ICA Based Connectivity Analysis

Subnetwork labels follow color convention from Figure 2. T and p values for connectivity strengths are given in Tables 1 and 2.



Results cont.

Table 1: Parcellation based Analysis Results

	Statistic	p (uncorrected)
L dorsal ↔ L lateral	1.11	0.272
L dorsal ↔ R lateral	1.08	0.283
R dorsal ↔ L lateral	0.82	0.413

Table 2: ICA based Analysis Results

	Statistic	p (uncorrected)
R dorsal ↔ L lateral	1.13	0.264
R dorsal ↔ L dorsal	0.68	0.501

Discussion

- No significant differences in connectivity within the sensorimotor network were found between those with chronic low back pain and healthy controls, which did not support our hypothesis
- Both approaches yielded similar results.
- Lack of changes in the sensorimotor cortex in those with low back pain is consistent with the multi-dimensional nature of pain and supports use of non-anatomical based therapies for this condition.
- Our findings contrast to that of anther group who found a difference between those with chronic low back pain and healthy controls when sensory representation of the back was isolated,3 as opposed to our analysis which included the entire lateral and dorsal subnetworks.
- This analysis deals only with changes during resting state, we cannot say if there is a difference in cortical activity in the SMN during a task or during stimulation in those with chronic low back pain relative to healthy controls.

References

1. Baliki MN et al. (2014) PLoS ONE, 9(9), e106133.
2. Bowering KJ et al. (2013) , Journal of Pain. 14(1):3-13. doi:10.1016
3. Kim, J et al. (2019). *PAIN*, *160*(7), 1594–1605.
4. Kolesar TA et al. (2017) Scandinavian Journal of Pain 16:10-14. doi:10.1016
5. Seitzman, BA et al. (2020) NeuroImage, 206, 116290
6. Smith SM et al. (2009) Proceedings of the National Academy of Sciences of the United States of America, 106(31), 13040–13045.
7. Yeo BTT et al. (2011). 1125-1165. doi:10.1152

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