Topographical Individualized Neuromarkers in the Analysis of the Brain Functioning of Social-Emotional Development

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Abstract

Topographical Individualized Neuromarkers (TIN) are spatially arranged patterns of brain function used to develop novel brain markers of social-emotional functioning and development.The current study focuses on developing markers of risk for psychological problems in children. We are expanding on previous research that indicates the brains of shy children differ from the brains of non-shy children, where shy children present with a topographical pattern of brain function that may be considered an internally hypervigilant neuromarker (Taber-Thomas et al., 2016). Using the online software, Neurosynth, we will extend our research into neuromarkers for other disorders using publicly available data. This program allows for the examination of internally hypervigilant neuromarkers in several regions of the brain. The regions we will be specifically examining are the insula, cingulate gyrus, hippocampus, and amygdala. This model will be explored further by calculating topographical maps from fMRI data and examining how differences in the maps are related to social-emotional functioning and development.

Introduction

Children with the behavioral inhibition phenotype, experience hypervigilance for threat and therefore experience high levels of social anxiety. Past research on altered topography of intrinsic functional connectivity (Taber-Thomas et al. 2016) found that these children have higher activation in the amygdala and attention control areas that are connected to increased fear and emotion centers to maintain vigilance. This past study used functional magnetic resonance imaging to analyze children's brains while they performed goal-directed tasks. While children rested in the scanner, baseline levels of connectivity were examined within the salience network. This network filters a stream of incoming internal and external stimuli to focus on attention or motivationally relevant information. Specifically, the regions examined were the lateral prefrontal cortex or anterior insula and medial prefrontal cortex or the anterior cingulate gyrus. The current study will extend the research to other insula subregions. Using publicly available data, we will look at how topographical individualized neuromarkers in these other subregions may differ from the regions previously studied.

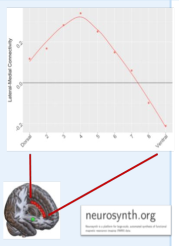


Figure 1. Topographical pattern of connectivity between a lateral region (right anterior insula; green) and a contiguous spatial sequence of medial regions (following a dorsal to ventral path along the anterior cingulate gyrus; red). Data displayed here were extracted from Functional Connectivity 1000 dataset on Neurosynth.org, which contains average connectivity values for 1000 subjects.

Insula Sub-Regions

1) "Three Systems of Insular Functional Connectivity Identified with Cluster Analysis" (Deen et al. 2010)

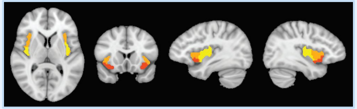


Figure 2. Three subregions of the right insula identified with cluster analysis. Ventral anterior insula (red), dorsal anterior to middle insula (orange), and posterior insula (yellow). Showing slices x 5 36, x 5 36, y 5 14, z 5 9. Images are in radiological convention. (Deen et al. 2010)

Table 1
Mean coordinates of insular subregions, in MNI152 space

Regions	Mean coordinates (mm) x	y	z
Left ventral anterior insula	- 33	13	- 7
Right ventral anterior insula	32	10	- 6
Left dorsal anterior insula	- 38	6	2
Right dorsal anterior insula	35	7	3
Left posterior insula	- 38	- 6	5
Right posterior insula	35	- 11	6

2) "Evidence for rostro-caudal functional organization in multiple brain areas related to goal-directed behavior" (Dixon et al. 2014)

ROI	x	y	z
Insula			
Anterior Insula	±36	23	0
Mid insula	±39	7	6
Posterior Insula	±40	10	12

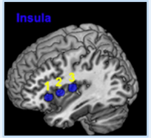


Fig. 3: Insula: 1.anterior insula, 2.mid-insula, 3.posterior insula. (Deen et al. 2014)

3) "Attentional Modulation of Primary Interoceptive and Exteroceptive Cortices" (Farb et al. 2012)

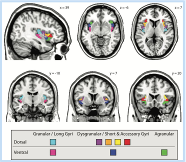
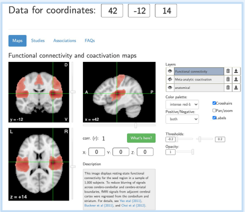


Figure 4. ROI locations along the insula cortex. ROIs were drawn to fit each visible gyrus of the template brain, yielding 8 anatomically defined regions (Farb et al. 2012)

ROI	x	y	z
Light Blue	42	-12	14
Purple	42	0	10
Orange	42	12	0
Yellow	42	20	-2
Red	40	20	-4
Pink	42	-14	0
Dark Blue	40	8	-18
Green	40	20	-12

Methods

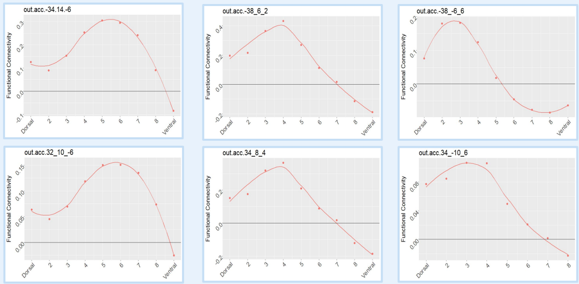
- Functional Connectivity Maps were downloaded via www.neurosynth.org
  - Enter MNI seed coordinates
  - Change color palette to "intense red/blue"
  - Change positive/negative to "both"
- Open in the software NeuroDebian to extract data for TIN curve for each insula sub-region



Results (Deen et al., 2010)

Ventral Anterior | Dorsal Anterior | Posterior

Left insula / Right insula



Conclusion

The main focus of this study is to analyze fMRI data in order to develop neuromarkers for potential psychological risks in children. Using the software systems, Neurosynth and Neurodebian, we extended the previous findings on insula connectivity with medial prefrontal cortex by looking at multiple subregions of the insula. The results show evidence of the rostro-caudal organization of insula connectivity that may relate to goal-directed behavior and suggests hierarchical organization.

The aims of the future study are to examine these TIN patterns in individuals with psychological disorders. Our future study will also expand upon different regions of the medial prefrontal cortex, rather than limiting our analysis to the anterior sector.

References

Deen et al. (2010). Three Systems of Insular Functional Connectivity Identified With Cluster Analysis. *Cerebral Cortex*, *21*(7), 1498–1506. Doi:10.1093/cercor/bhq186

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