Association between microarchitecture and functional topology of cerebral cortex and its behavioral relevance

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Introduction

- Microarchitecture of the cerebral cortex has been believed to reflect its underlying functions [Huntenburg, 2017].
- Based on sophisticated descriptors of neurite-architectures and functional topology, we examined the structure-function relationship.
- Furthermore, We also studied whether this association is relevant to impulsive behaviors and binge drinking.

Methods

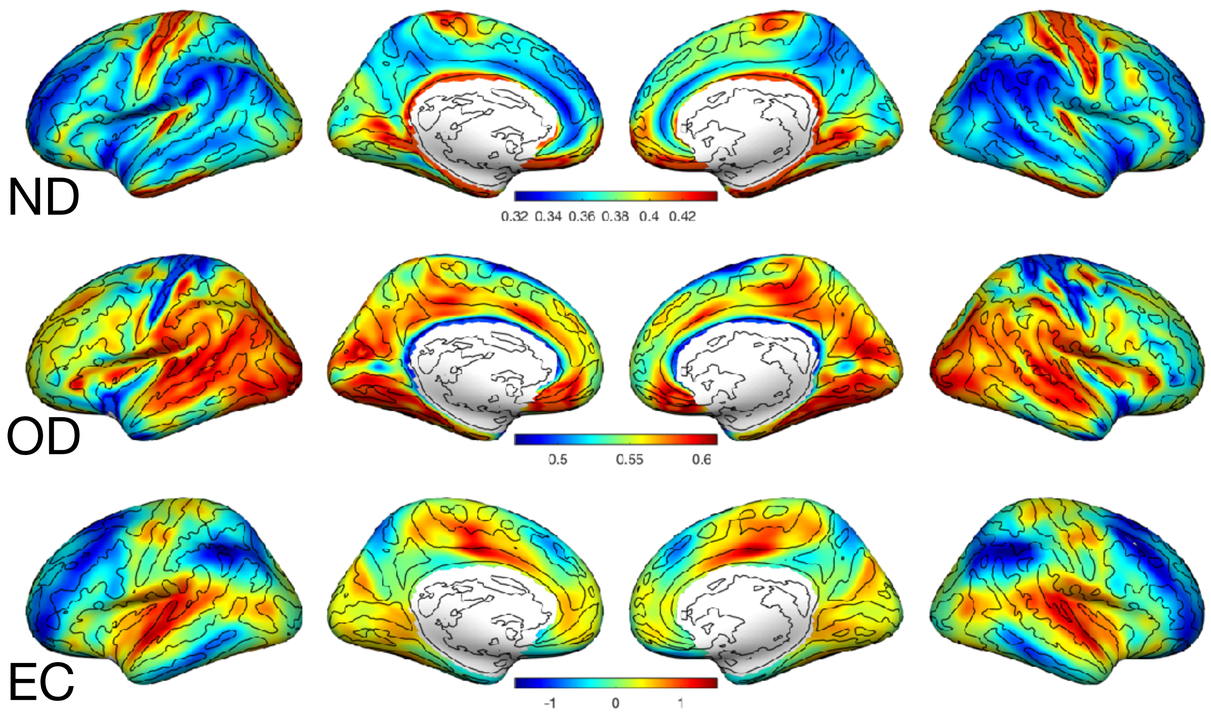
- Subjects: 24 binge drinkers (BD; age = 23.7 ± 3.9 years, 21 females) and 35 healthy volunteers (HV; age = 21.5 ± 2.7 years, 9 females) [Morris, 2017]
- Diffusion-weighted imaging: neurite orientation dispersion and density imaging (NODDI) [Zhang, 2012] models diffusion within the neurites (dendrites & axons; hindered diffusion) separately and computes neurite density (**ND**) and orientation dispersion (**OD**) of neurites [two-shell HARDI, 2-mm isovoxel].
- Resting-state functional imaging: multi-echo independent component analysis (MEICA) [Kundu, 2013] decomposes BOLD series acquired at multiple TEs, discards components that are insensitive to TE (i.e., non-BOLD sources), then reconstructs it [TR = 2.48 s, 9.8 min, 3.75-mm isovoxel].
- Functional connectivity measure: eigenvector centrality (EC) of 1+corr
- Common space: Freesurfer average5, fwhm = 9 mm
- Structure-function correlation: corr(ND, EC) and corr(OD, EC) within a given area over multiple spatial scales:

  (1) All: whole-cortex
  (2) Lobes: 4 lobes and the cingulate cortex
  (3) RSNs: 17 resting-state network derived from 1,000 healthy subjects [Yeo, 2011]

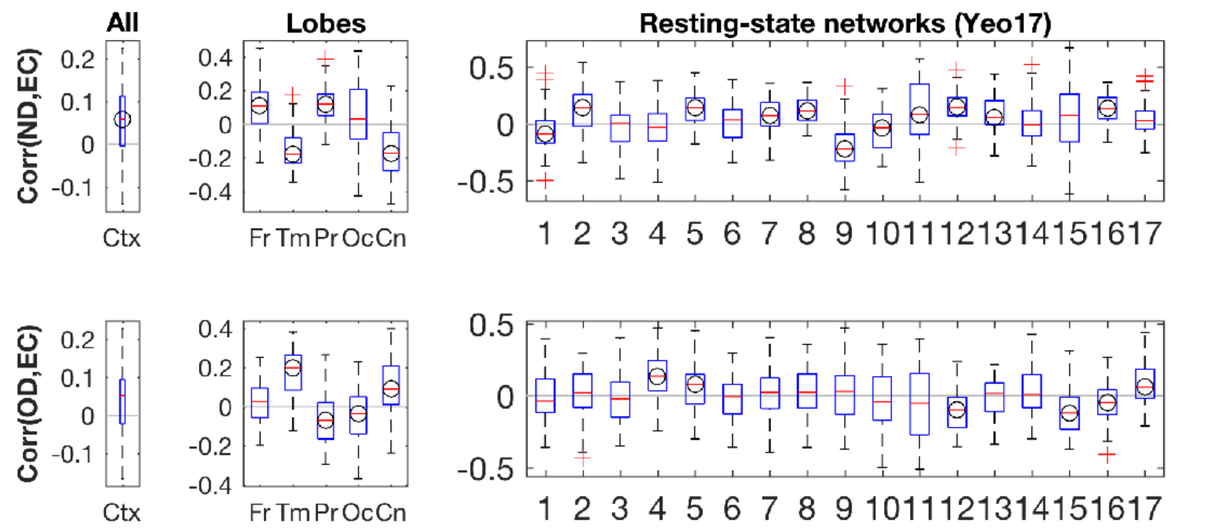
  with false-discovery rate (FDR) adjustment for the number of areas at each scale
- Behavioral measures: (1) binge-drinking (2) UPPS-P Impulsive Behavior Scale with 5 subscores (negative urgency, lack of premeditation, lack of perseverance, sensation seeking, positive urgency), correlated with the age and sex covaried

Structure-function relationship

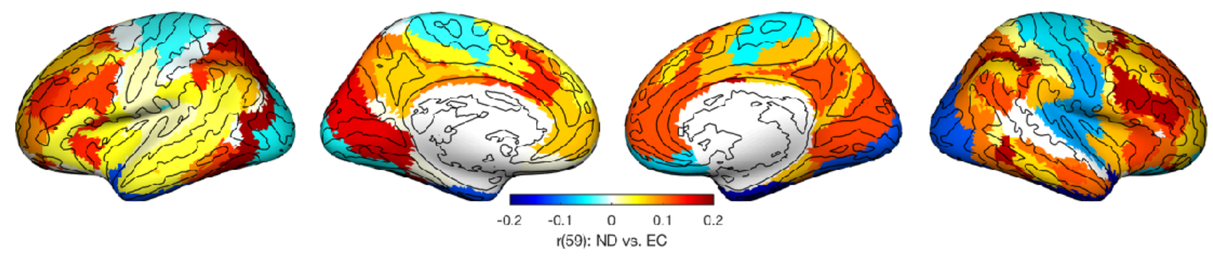
- Overall (n = 59) average of ND, OD, and EC



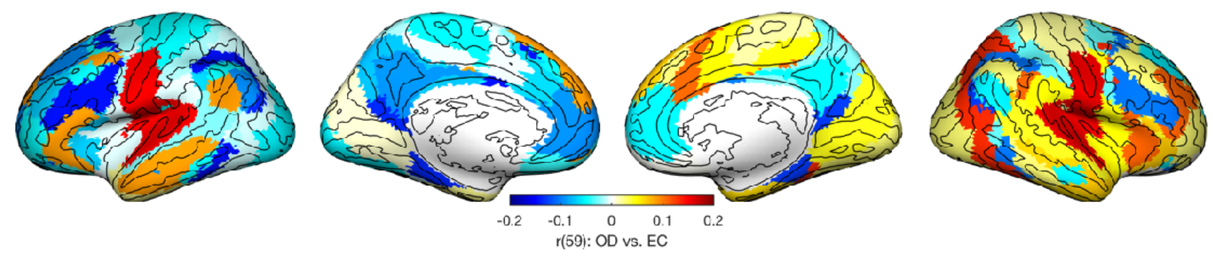
- Significant correlation between ND (or OD) and EC over multiple scales from the whole-cortex to RSNs



- Corr(ND,EC) was positive in RSNs including DMN and executive networks

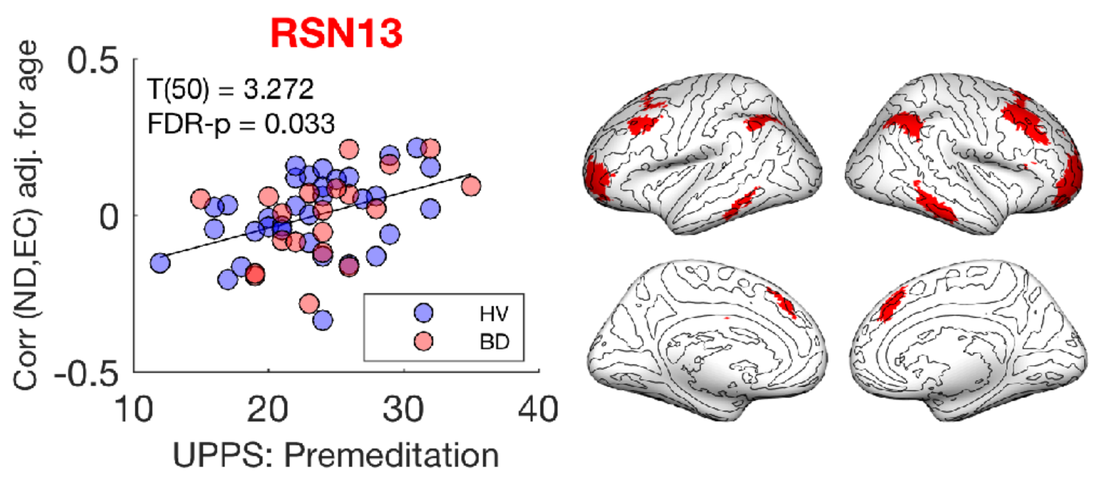


- Corr(OD,EC) was positive in RSNs over sensory-motor areas



Behavioral relevance

- No group difference between HV and BD (min FDR-p = 0.18)
- Positive correlation between corr (ND, ED) and "Lack of Premeditation" subscore of UPPS-P (FDR-p = 0.03) in the RSN #13 (related to executive functions and impulsivity control)
- Underlying physiology of the findings need to be further investigated.



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