Temporal Dynamic Analysis

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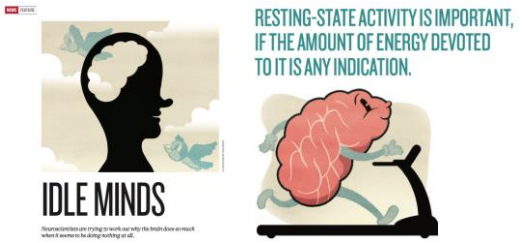
Introduction



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Smith , 2012. Nature

Introduction

Computational Methods

- Regional characteristics of a single voxel
- Relational characteristics among multiple voxels

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Zuo and Xing, 2014. Neurosci Biobehav Rev

Introduction

Regional characteristics of a single voxel

Amplitude measures. For a given frequency:

- RMS: root mean square (Biswal et al., 1995)
- RSFA: standard deviation (Kannurpatti et al. 2008)
- ALFF: amplitude of low-frequency fluctuations (Zang et al., 2007)
- fALFF: fractinal ALFF (Zou et al., 2008)

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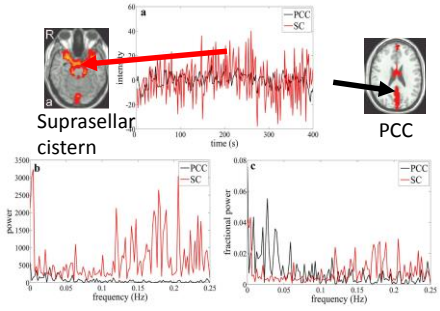
Zuo and Xing, 2014. Neurosci Biobehav Rev

Introduction

Improvement: fractional ALFF



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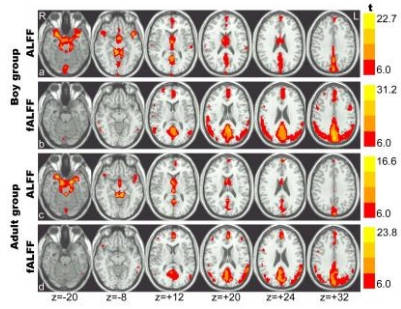
Zou et al., 2008. J Neurosci Methods

Introduction

ALFF vs. fALFF



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Zou et al., 2008. J Neurosci Methods

Introduction

Regional characteristics of a single voxel

- Degree of power-law fitting (Kiviniemi et al., 2000)
- Fractal dimension or Hurst exponent (Maxim et al., 2005; Wink et al., 2008)
- Multi-scale or approximate entropy (Smith et al., 2014; Liu et al., 2013a)
- Lyapunov exponent (Xie et al., 2008)

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Zuo and Xing, 2014. Neurosci Biobehav Rev

Introduction

Relational characteristics among multiple voxels

- Functional Connectivity
- Effective Connectivity

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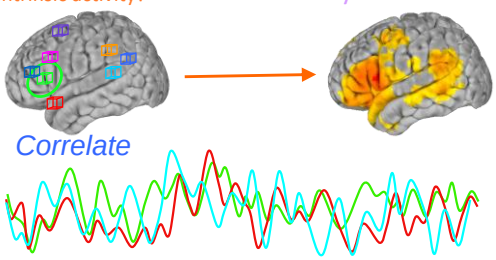
Introduction

How do we detect organized patterns of intrinsic activity?

Resting State Functional Connectivity



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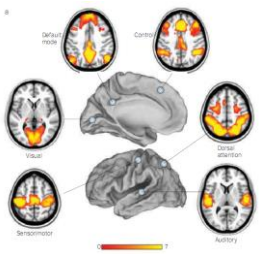
Introduction

- **Correlation**



Zhang and Raichle, 2010. Nat Rev Neurol

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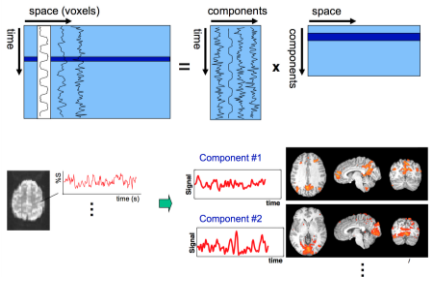
Introduction

- **ICA**



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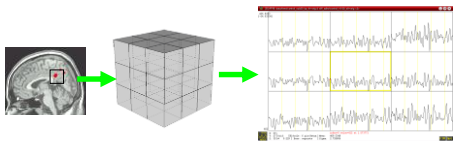
Beckmann et al., 2005; Birn, 2015

Introduction

Regional Homogeneity (ReHo)

Similarity or coherence of the time courses within a functional cluster



$$W = \frac{\Sigma(R_i)^2 - n(\bar{R})^2}{\frac{1}{12}K^2(n^3 - n)}$$

Zang et al., 2004, Neuroimage

Or COSLOF, Li et al., 2002

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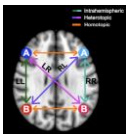
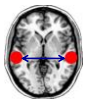
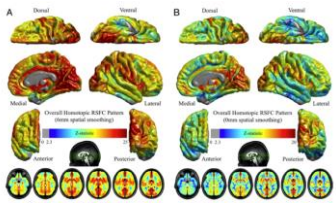
Introduction

Voxel Mirrored Homotopic Connectivity (VMHC)



Gee et al., 2011



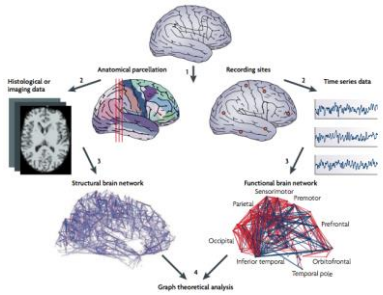


Zuo et al., 2010

Introduction

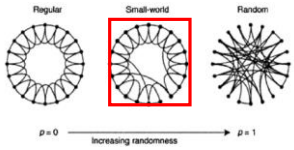
Graph theoretical analysis

Bullmore and Sporns, 2009



Introduction

Graph theoretical analysis



Watts and Strogatz, 1998. Nature

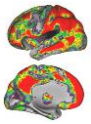
Regular:	Small-world:	Random:
high C_p	high C_p	low C_p
high L_p	low L_p	low L_p

Small-world networks contain many local links and a few long-distance links (so-called "shortcuts").

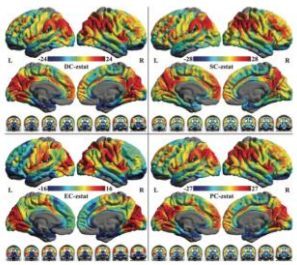
C_p: average clustering of a network
L_p: average shortest path length of a network

Introduction

Voxel-wise network centrality metrics



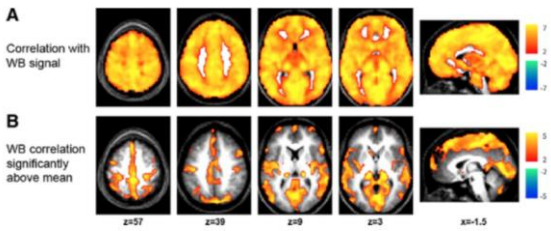
Degree Centrality
Buckner et al., 2009. J Neurosci



Zuo et al., 2011. Cereb Cortex

Introduction

Global Signal Correlation



Fox et al., 2009. J Neurophysiol

Introduction

Voxel strength: ALFF/fALFF

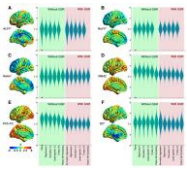
Regional synchronization: ReHo

Homotopic connectivity: VMHC

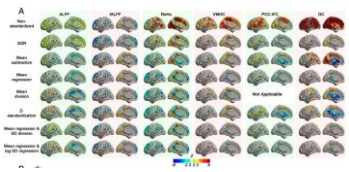
Global connectivity: Degree Centrality

GSCorr

Introduction

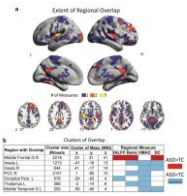


Head motion control
Yan et al., 2013a. Neuroimage

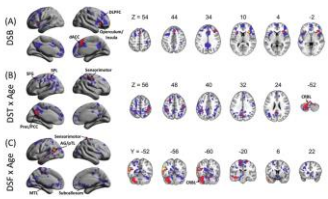


Standardization
Yan et al., 2013b. Neuroimage

Introduction



Intrinsic activity in Autism
Di Martino, Yan et al., 2014. Mol Psychiatry



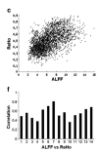
Intrinsic brain indices of verbal working memory capacity
Yang, , Yan et al., 2015. Dev Cogn Neurosci

Introduction

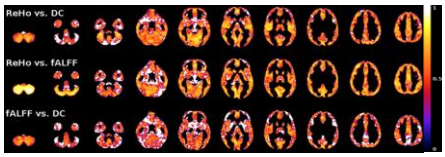
Interdependencies among different intrinsic brain function measures

- **How concordant differing indices are with respect to their variation across voxels**
- **How concordant different indices are with respect to their variation from one individual to the next**
- **How concordant differing indices are with respect to their variation over time**

Introduction

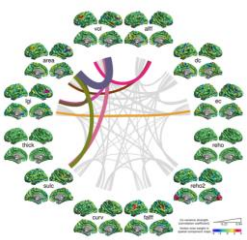


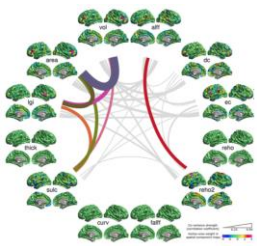
Yuan et a., 2013.
Magn Reson Imaging



Aiello et a., 2015.
Neuroimage

Introduction

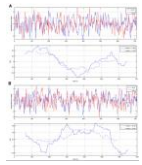




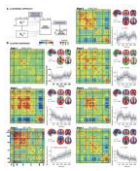
Yang et al., 2016. Brain Struct Funct

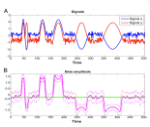
Introduction

Temporal Dynamic Perspective

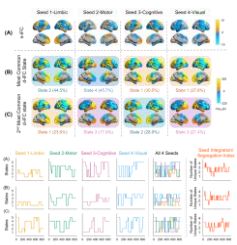


Chang and Glover, 2010.
Neuroimage





Allen et al., 2013.
Cereb Cortex



Yang, , Yan, et al., 2014. Neuroimage.

Kang , Yan et al., 2011.
Neuroimage

Introduction

The goal of the present work is to provide a comprehensive understanding of interdependencies among different intrinsic brain activity measures within and across individuals.

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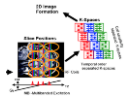
Materials and Methods

Enhanced Nathan Kline Institute - Rockland Sample

173 neurotypical individuals ages between ages 8 and 86 with quality pass datasets (mean age: 44.5; 117 females)



MultiBand EPI
TR = 0.645s

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Nooner et al., 2012

Materials and Methods

Preprocessing

Yan et al., 2016. Neuroinformatics

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Materials and Methods

R-fMRI Indices

Voxel strength: ALFF/fALFF

Regional synchronization: ReHo

Homotopic connectivity: VMHC

Global connectivity: Degree Centrality

GSCorr

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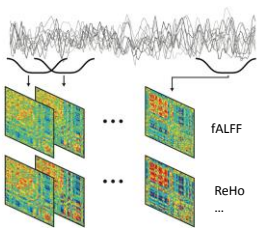
Materials and Methods

Dynamic R-fMRI Indices



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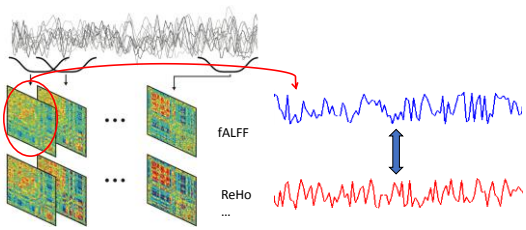
Materials and Methods

Correlation between Global Mean of R-fMRI Indices



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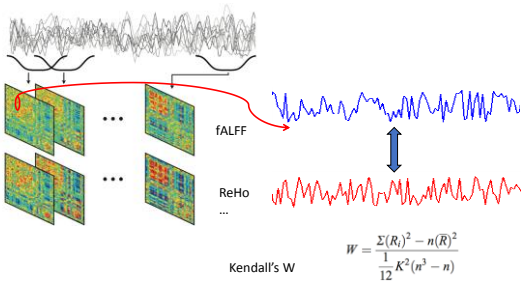
Materials and Methods

Voxel-wise Concordance Index



Kendall's W $W = \frac{\Sigma(R_i)^2 - n(\bar{R})^2}{\frac{1}{12}K^2(n^3 - n)}$

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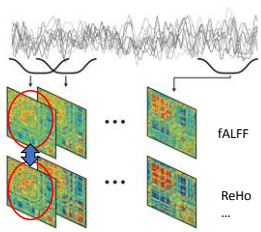
Materials and Methods

Volume-wise Concordance Index



Kendall's W $W = \frac{\Sigma(R_i)^2 - n(\bar{R})^2}{\frac{1}{12}K^2(n^3 - n)}$

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Materials and Methods

Age Effects

A given measure = b0 + b1×Age + b2×Sex + b3×meanFD + error

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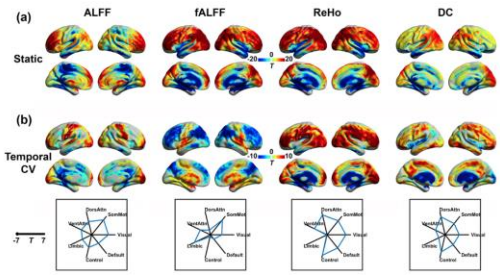
Results and Discussion

Static and Dynamic R-fMRI Indices



Yan et al., 2017. Science Bulletin

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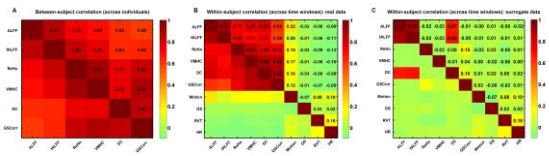
Results and Discussion

Evaluating Concordance among R-fMRI Indices: Global-Level Analyses



Yan et al., 2017. Science Bulletin

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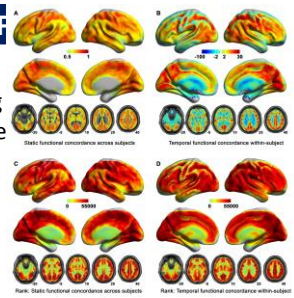
Evaluating Indices: Voxel-wise



Yan et al., 2017. Science Bulletin

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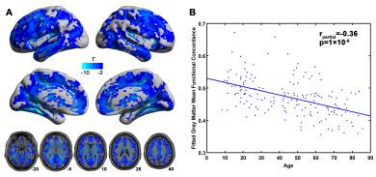
Results and Discussion

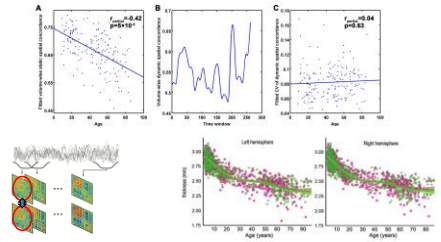
Evaluating Concordance among R-fMRI Indices: Voxel-wise Analyses



Yan et al., 2017. Science Bulletin

Results and Discussion

Evaluating Spatial Concordance among R-fMRI Indices: Volume-wise Analysis

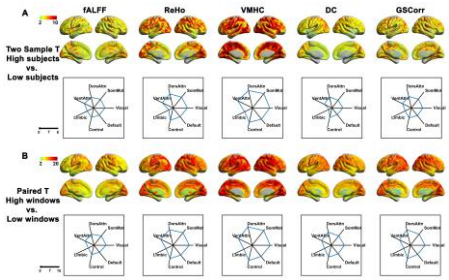


Yan et al., 2017. Science Bulletin

Fjell et al., 2015. PNAS

Results and Discussion

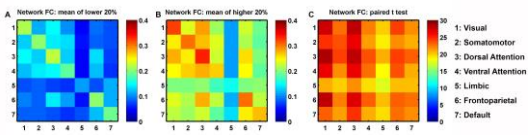
Understanding Low/High Concordance



Yan et al., 2017. Science Bulletin

Results and Discussion

Understanding Low/High Concordance



Yan et al., 2017. Science Bulletin

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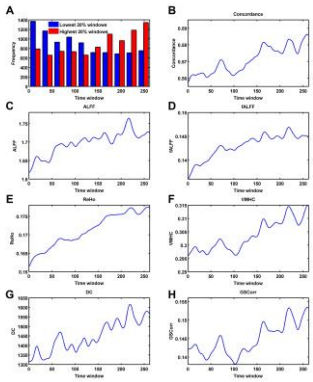
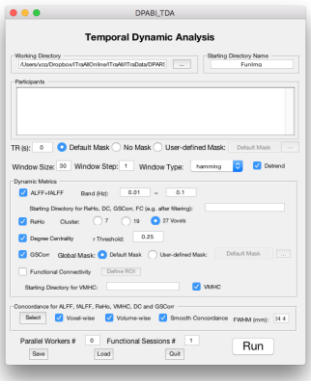


Yan et al., 2017. Science Bulletin

DPABI_TDA



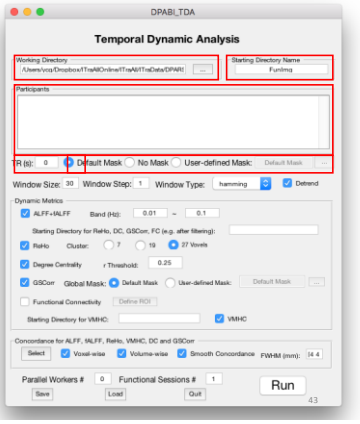
Based on DPARSF Preprocessed Data

Starting Directory Name

Participants

TR

Mask



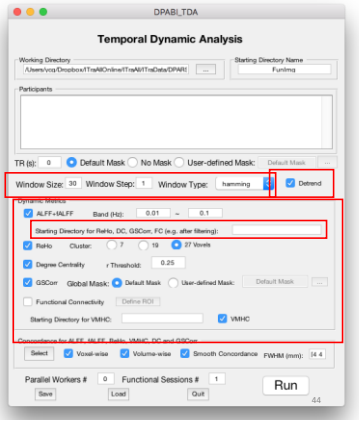
Based on DPARSF Preprocessed Data

Window Setup

Detrend

Dynamic Indices

If need filtering



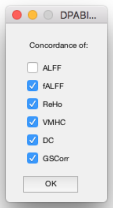
Based on DPARSF Preprocessed Data

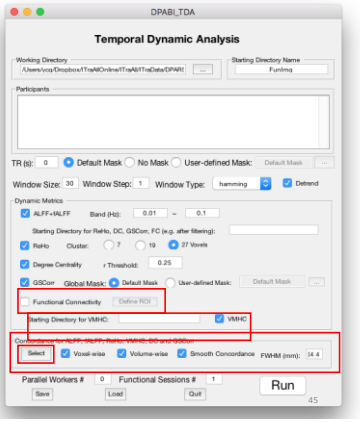
Functional Connectivity

Symmetric for VMHC

Concordance

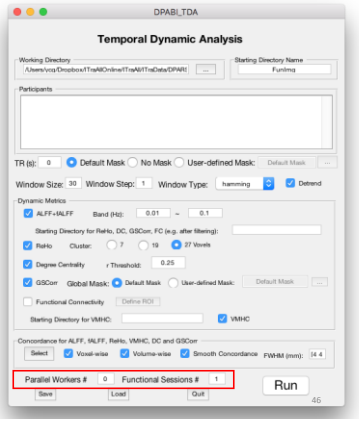
Concordance Settings



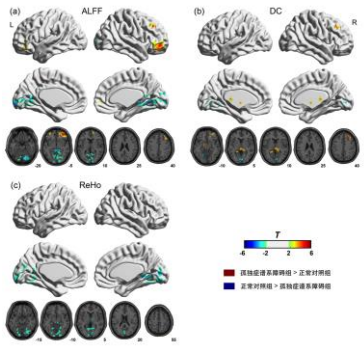


Based on DPARSF Preprocessed Data

Parallel Settings

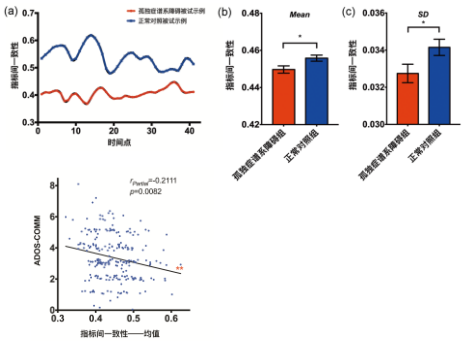


孤独症脑自发活动动态性及其整合的异常机制



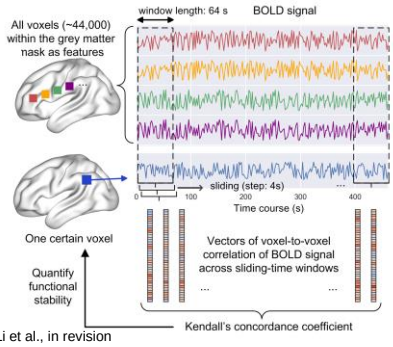
鲁彬, , 严超赣*, 2018. 科学通报.

孤独症脑自发活动动态性及其整合的异常机制



鲁彬, , 严超赣*, 2018. 科学通报.

Definition of stability of functional architecture



The temporal stability of functional architecture of brain voxel was defined as the Kendall's coefficient of concordance (KCC, also known as Kendall's W) of dynamic functional connectivity (DFC) over time between that voxel with other regions in the brain.

The analyses were conducted in a voxel-to-voxel approach, in which the KCC of a voxel was computed based on the features of its voxel-level DFC maps.

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Profile of stability of intrinsic functional architecture

- Resting-state fMRI data of 216 young adults from the CoRR (Consortium for Reliability and Reproducibility) release (Zuo, et al., 2014) was used. The data contained two scanning sessions acquired at different days, and the two sessions were analyzed separately.
- The derived KCC for each subject was z-standardized across a grey matter mask, to increase comparability across participants and conditions.
- One-sample T-tests with zero

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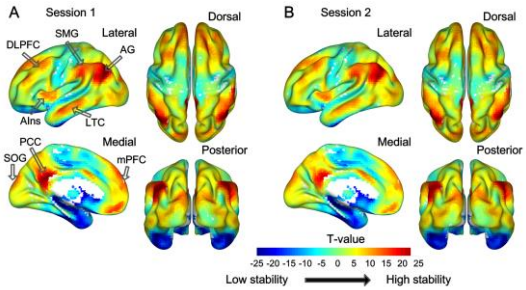
Profile of stability of intrinsic functional architecture

- Result of one-sample T-tests



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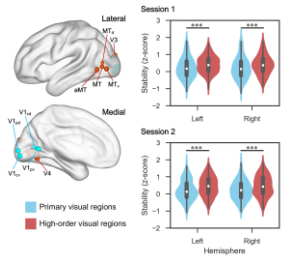
Profile of stability of intrinsic functional architecture

- Comparison of functional stability between high-order associative and primary visual regions.



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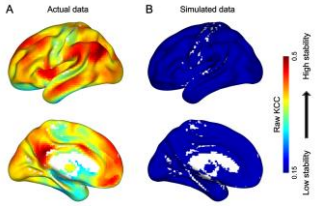
Profile of stability of intrinsic functional architecture

- Was the stability of functional architecture above random level?
- Simulated data was created by randomizing the phases while keeping the amplitude of the resting-state signals.



- All $p < E\text{-}10$ in paired-sample T-tests
- grand mean KCC = 0.376 for the actual data
- grand mean KCC = 0.163 for the simulated data

The stability of functional architecture doesn't exist in simulated random data, while distributed across the brain in a biological meaningful way.

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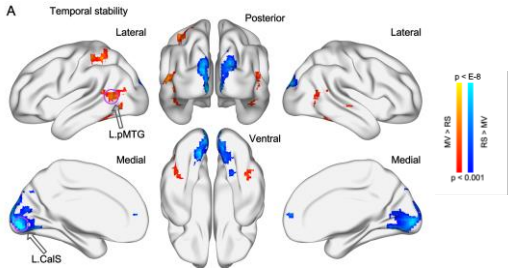
Stability during natural viewing

- A movie-watching task was employed, during which viewers had to constantly integrate changing audiovisual stimuli over time, in order to comprehend the movie.
- The dataset from the HBN (Healthy Brain Network) release (Alexander, et al., 2017) was analyzed. The fMRI data was acquired from 32 children and adolescents, and there were two runs of resting-state scanning, followed by another run of movie watching.
- The movie was a 10-min clip of an animated film named "Despicable Me".

Stability during natural viewing

- Result of pair-sample T-tests



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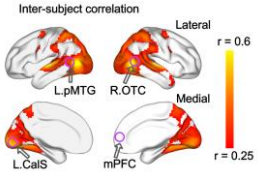
Stability during natural viewing

- Inter-subject correlation (ISC) of neural activity (Hasson, et al., 2010), which can reveal which brain region was engaged when the subjects watched the movie.
- Threshold: $r > 0.25$ in average and $p < 0.001$ in one-sample T-test with 0



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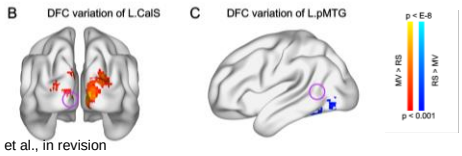
Stability during natural viewing

- The stability of functional architecture of a certain region was measured based on the whole-brain DFC for that region. A further step is to probe which connections specifically contributed to the difference in stability observed between states.
- ROI: left pMTG, left Calcarine sulcus
- DFC variation for each ROI was calculated as standard deviation of DFC across sliding-time windows. At the group-level analyses, the DFC variation was compared between the two states.



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Thanks for your attention!