



Resting-State fMRI: Applications

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<http://rfmri.org>

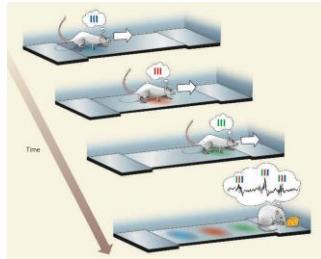
Institute of Psychology, Chinese Academy of Sciences

Outline

- ▶ • Applications to Cognitive Science
- Applications to Brain Disorders

Applications to Cognitive Science

Off-line spontaneous brain activity and memory consolidation

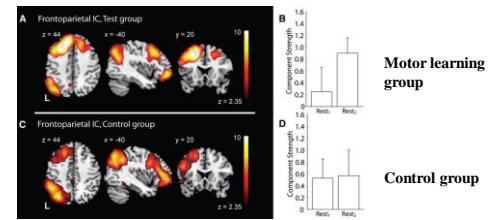


Foster and Wilson, 2006. *Nature*; Colgin and Moser, 2006. *Nature*

Reverse replay of behavioral sequences in hippocampal place cells during the awake state.

Applications to Cognitive Science

Resting-state fMRI and memory consolidation



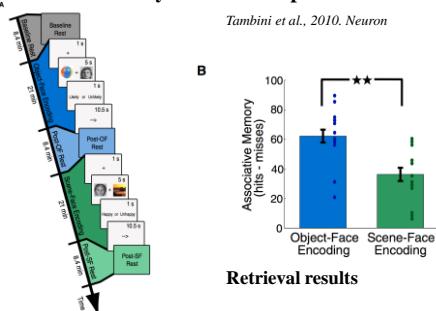
Motor learning but not motor performance modulated subsequent frontal-parietal resting-state network

Albert et al., 2009. *Curr Biol*

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Applications to Cognitive Science

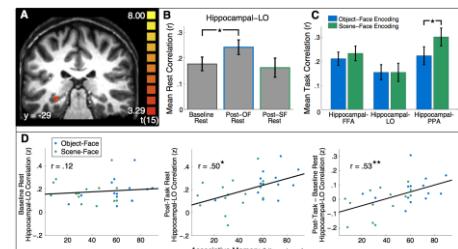
Enhanced brain correlations during rest are related to memory for recent experiences



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Applications to Cognitive Science

Tambini et al., 2010. *Neuron*



Tambini et al., 2010. *Neuron*

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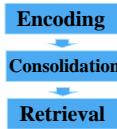
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Applications to Cognitive Science

Episodic memory and Alzheimer disease:

- Subtle change of episodic memory is the earliest cognitive deficit in AD (Schwindt & Black, 1999, *NeuroImage*)
- Consistently decreased activation in AD patients during both encoding and retrieval stages of episodic memory (Schwindt & Black, 2009, *NeuroImage*)
- Mechanism of episodic memory consolidation after encoding?



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Applications to Cognitive Science

Resting-state fMRI, memory consolidation, APOE ε4

- Question-1: Resting-state fMRI, hippocampus activity, and APOE ε4 healthy carriers?
- Question-2: Spontaneous activity modulation by episodic memory task in the brain regions for encoding?

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Applications to Cognitive Science

Participants:

- 917 students
2/2 2/3 2/4 3/3 3/4 4/4
1 52 13 799 51 1
- Two groups of healthy APOE carriers: ε4/3 vs. ε2/3, n = 20 vs 19, (half males), 18 – 23 yrs from BNU, match for IQ and education

Wang, , Yan et al., 2012. PLoS ONE 9

Applications to Cognitive Science

Behavior result: retrieval performance

	d' mean	SD	t	p
2/3	2.46	0.68	-0.387	0.7
3/4	2.54	0.63		

No significant difference between the two groups

Wang, , Yan et al., 2012. PLoS ONE 11

Applications to Cognitive Science

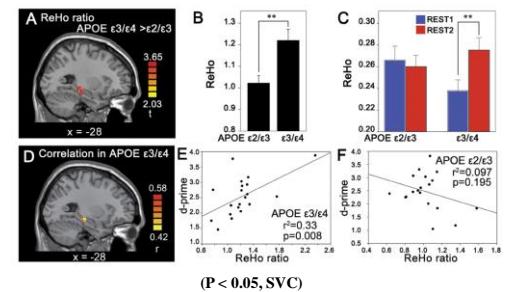
Design

- Scanning sessions (3T Siemens):
 - S1 Resting-state (Rest1) 8 min
 - S2 Pictures (indoor or outdoor) (encoding) 5 min
 - S3 3D structure 8 min
 - S4 Resting-state (Rest2) 8 min
 - S5 Retrieval: old or new (2 runs) 10 min
- Rest2/Rest1: spontaneous brain activity modulation by task

Wang, , Yan et al., 2012. PLoS ONE 10

Applications to Cognitive Science

Hippocampus



(P < 0.05, SVC)

Wang, , Yan et al., 2012. PLoS ONE 12

Applications to Brain Disorders

Outline

- Applications to Cognitive Science
- ➡ • Applications to Brain Disorders

- Alzheimer's Dementia (AD)
- Depression
- Autism Spectrum Disorder (ASD)
- ...

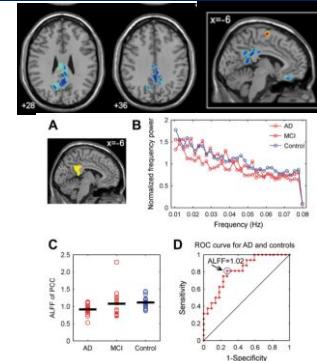
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Applications to Brain Disorders

ALFF in AD



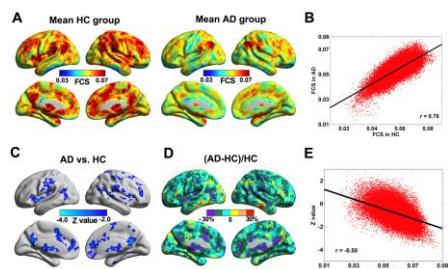
Applications to Brain Disorders



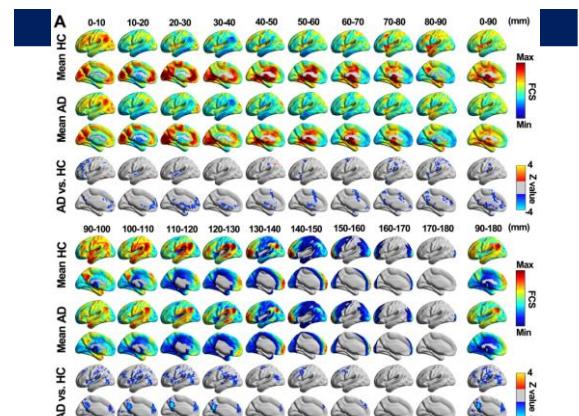
Wang*, Yan* et al., 2011,
Hum Brain Mapp

Applications to Brain Disorders

Degree centrality in AD



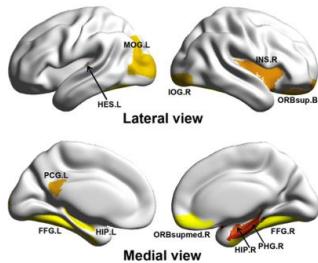
Dai, Yan et al., 2014. Cerebral Cortex.



Applications to Brain Disorders

Classification

- Multi-modal
- characterizes
- Features
- ALFF
- ReHo
- Region
- Gray matter
- Accuracy: 89.47%

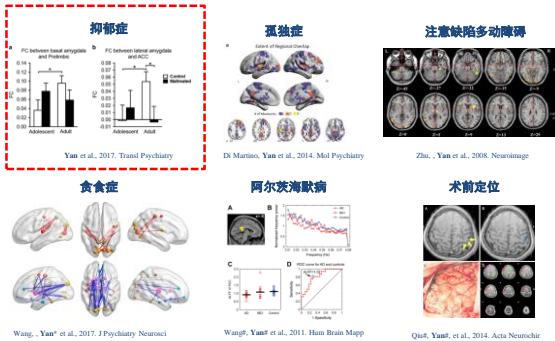


Dai[#], Yan[#] et al., 2012, NeuroImage

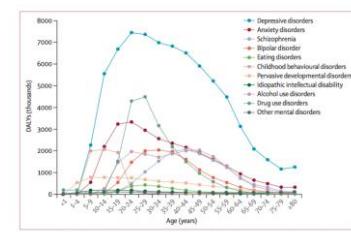
Applications to Brain Disorders

- Alzheimer's Dementia (AD)
- Depression
- Autism Spectrum Disorder (ASD)
- ...

广泛应用于脑疾病中



MDD疾病负担重，诊断缺乏生物学客观标准

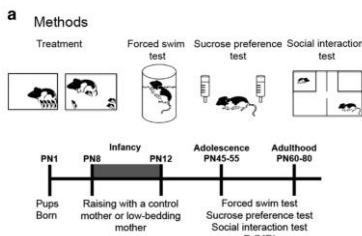


抑郁症（重性抑郁障碍，MDD）疾病负担居于首位

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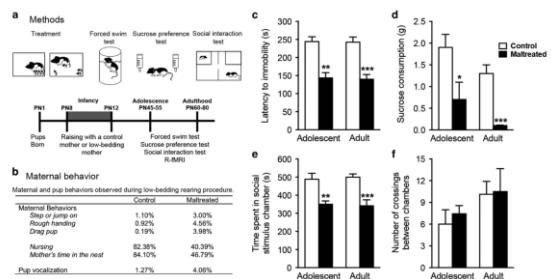
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Depressive-like behavior in rat model of caregiver maltreatment



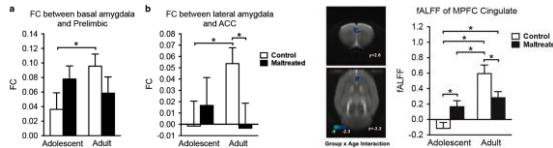
Yan et al., 2017, Transl Psychiatry

Depressive-like behavior in rat model of caregiver maltreatment



Yan et al., 2017, Transl Psychiatry

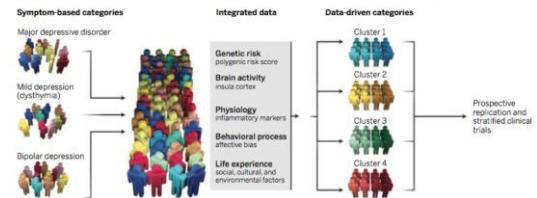
Depressive-like behavior in rat model of caregiver maltreatment



Yan et al., 2017. Transl Psychiatry

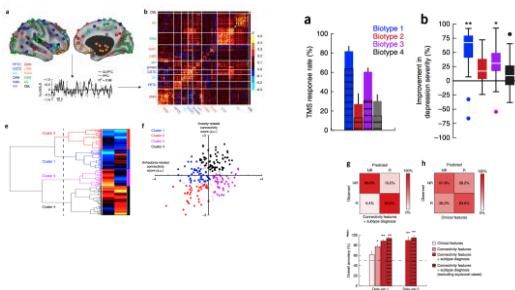
The R-fMRI Maps Project Consortium for Depression and Bipolar Disorders

Deconstructed, parsed, and diagnosed.
A hypothetical example illustrates how precision medicine might deconstruct traditional symptom-based categories. Patients with a range of mood disorders are studied across several analytical platforms to parse current heterogeneous syndromes into homogeneous clusters.



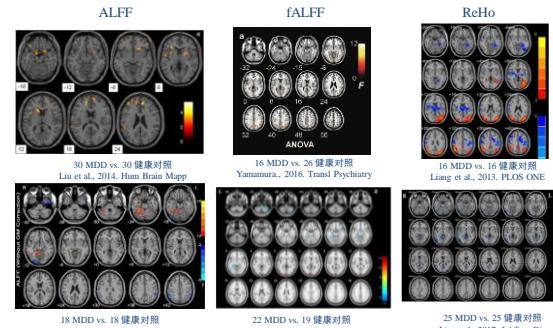
Insel and Cuthbert 2015, Science

Biotypes in Depression



Drysdale et al., 2016. Nat Med

MDD静息态功能磁共振研究



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小样本研究遇到的问题

ANALYSIS

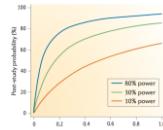
Power failure: why small sample size undermines the reliability of neuroscience

Katherine S. Button¹, John P. A. Ioannidis², Claire Majerus³, Brian A. Nosek⁴,

Jessica Pfeffer⁵, Emma S. J. Robinson⁶ and Marcus R. Munafò⁷

Button et al., 2013. Nat Rev Neurosci

ANALYSIS



- 统计力不足时，发现的结果为真的可能性很小
- 神经科学领域统计力约为8%-31%

Scanning the horizon: towards transparent and reproducible neuroimaging research

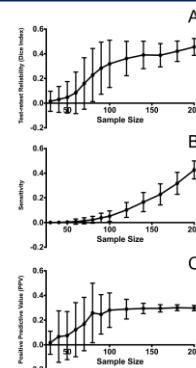
Russell A. Poldrack¹, Davis J. Binder², John D'Esposito³, Krystal J. Gorgolewski¹, ...

Poldrack et al., 2017. Nat Rev Neurosci

2015年, fMRI研究每组样本的中位数仅为19

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Sample Size Matters



Chen, Lu, Yan*, 2017.
Human Brain Mapping

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REST-meta-MDD

Started a consortium for big data sharing on MDD. Connected by the preprocessing pipeline, DBARSE cited for over 1500 times.



表 1 REST-muta-MDD 计划参与研究组以及数据构成情况

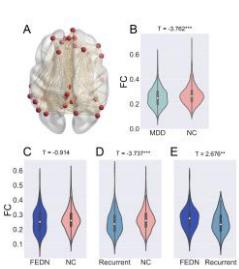
参与研究单位	研究的白蚁种类	参考文献
1. 北京农业大学	拟黑多刺白蚁	何积海等 74
2. 中国科学院植物研究所	拟黑多刺白蚁	王金海等 75
3. 中科院植物所-农药局	拟黑多刺白蚁	周树森 27
4. 中科院植物所-农药局	拟黑多刺白蚁	董文光 28
5. 中国科学院植物研究所	拟黑多刺白蚁	董文光 29
6. 中国科学院植物研究所和中国科学院微生物研究所	拟黑多刺白蚁	董文光等 30
7. 中国科学院植物研究所和中国科学院微生物研究所	拟黑多刺白蚁	董文光等 31
8. 中国科学院植物研究所和中国科学院微生物研究所	拟黑多刺白蚁	董文光等 32
9. 中国科学院植物研究所和中国科学院微生物研究所	拟黑多刺白蚁	董文光等 33
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32. 中国科学院植物研究所和中国科学院微生物研究所	拟黑多刺白蚁	董文光等 56
33. 中国科学院植物研究所和中国科学院微生物研究所	拟黑多刺白蚁	董文光等 57
34. MDD、中科院植物所、NCI、健康所	拟黑多刺白蚁	董文光等 58

25 MDD research groups over China

REST-meta-MDD consortium contains neuroimaging data of 1,300 depressed patients and 1,128 normal controls from 25 research groups in China, forming the world's largest MDD R-fMRI dataset

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REST-meta-MDD

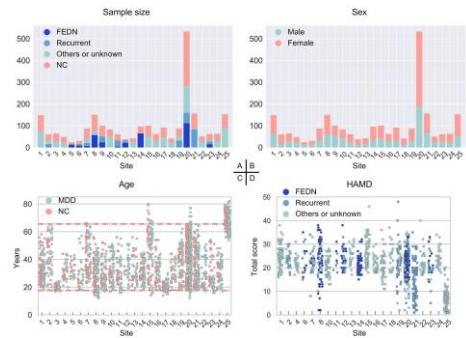


By addressing the inconsistency of FC pattern in DMN for MDD, we suggest that DMN FC remains a prime target for understanding the pathophysiology of depression, with particular relevance to revealing mechanisms of effective treatments

Yan et al., 2019, PNAS.

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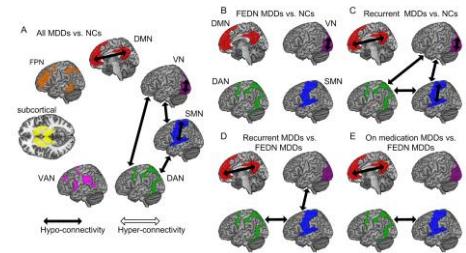
REST-meta-MDD



Yan et al., 2019, PNAS

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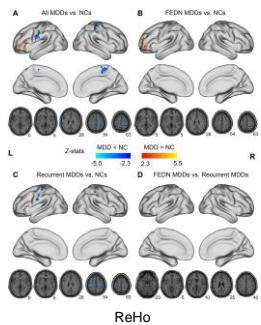
REST-meta-MDD



Yan et al., 2019, PNAS

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REST-meta-MDD



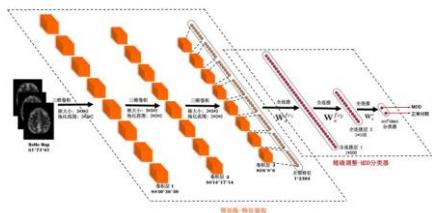
Yan et al., 2019, PNAS.

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合作情况

- | | |
|--|--------------------|
| 1 用静息态功能连接研究抑郁障碍神经生物学的异常 | 浙江大学医学院附属第一医院 |
| 2 抑郁症的脑成像机制研究 | 湘雅二医院 |
| 3 基于静息态功能连接的抑郁症自动识别及演化研究 | 浙江大学医学院附属第一医院;浙江大学 |
| 4 抑郁症症状量表的静息态功能连接模式研究 | 西南大学心理学院 |
| 5 基于信息论和深度学习方法的抑郁症脑图谱研究 | 西南大学心理学院 |
| 6 抑郁障碍突变易感性结构和功能的神经机制 | 首都医科大学附属北京安定医院 |
| 7 静息态功能连接与抑郁症的脑影像学特征 | 四川大学华西医院 |
| 8 静息态功能连接与抑郁症的脑影像学特征分析 | 上海精神卫生中心 |
| 9 连接性分析对2428个个体从REST至MDD MDD working group | 西南大学心理学院 |
| 10 不同性别抑郁症患者脑功能连接研究 | 中南大学湘雅三医院 |
| 11 抑郁症功能连接网络的连接模式研究 | 重庆医科大学附属第一医院 |
| 12 不同程度抑郁症患者静息态功能影像学研究 | 重庆医科大学附属第一医院 |
| 13 不同年龄抑郁症患者静息态功能影像学研究 | 东南大学附属中大医院 |
| 14 抑郁症自杀风险神经环路 | 北京大学第三医院 |
| 15 MDD的脑网络异常研究 | 北京大学第三医院 |
| 16 基于图论的空间序列连接度统计分析 | 西安交通大学第一附属医院 |
| 17 抑郁症内致炎炎症因子与抑郁的关系 | 中南大学湘雅二医院 |
| 18 维生素D代谢在首阳末梢免疫器官脾脏发育的脑影像学机制研究:基于独立样本验证 | 山西医科大学第一医院 |
| 19 基于图论的抑郁症静息态功能连接特征分析 | 中国科学院大学附属第一医院 |
| 20 Integrating graphic measures and deep learning technology to detect MDD at the individual level | 四川大学华西医院华西MRI研究中心 |
| Change as brain activity and functional connectivity in major depressive disorder patients with insomnia | |
| 21 The structural and functional alterations of brain in MDD with gastrointestinal symptoms | 首都医科大学附属北京安定医院 |
| Evolution of Brain Network: An Age and Illness Duration Associated Cross- sectional Study | 山西医科大学第一医院 |
| 22 Atrial resting-state functional connectivity of nucleus accumbens in patients with major depressive disorder | 中国科学院大学附属第一医院 |
| Resting-State Functional Connectivity of the Habenula in Depressive Disorder Patients With and Without Suicide-Related Behaviors | 重庆医科大学附属第一医院 |
| 24 Common and different patterns of co-activation pattern based evaluation of severity in patient with MDD | 东南大学附属中大医院 |
| Common and different patterns of altered functional activities in drug-naïve and treated first-episode depression patients | 苏州广济医院 |
| Relationship of brain structure of MDD patients and metabolism expression in classical rodent models of MDD | 重庆医科大学 |

基于脑功能影像的MDD分类



采用深度学习3维卷积神经网络（3dCNN）模型进行训练：64%

SVM: 65%

SVM on gray matter volume: 73.5%

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异常脑区与抑郁心理加工机制的关联

反刍思维是指对负性生活事件及其意义、原因、后果的反复思考



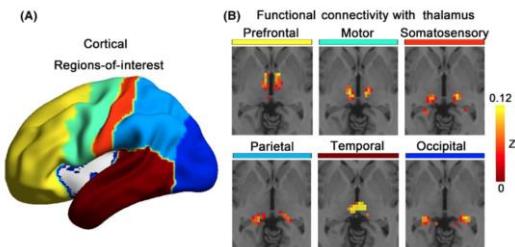
静息态 悲伤事件回忆 反刍思维状态 快乐事件回忆



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Nolen-Hoeksema et al., 2008. Perspect Psychol Sci; Christoff et al., 2016. Nature Rev Neurosci

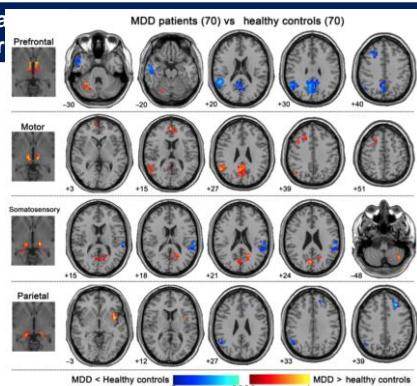
Aberrant intrinsic functional connectivity in thalamo-cortical networks in major depressive disorder



Kong, , Yan*, , Si*, 2018. CNS Neurosci Ther

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Aberrant intrinsic functional connectivity in thalamo-cortical networks in major depressive disorder



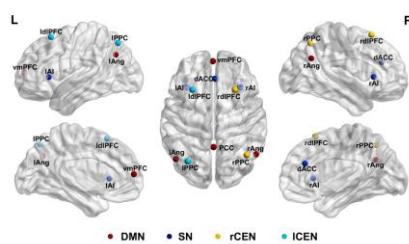
Kong, , Yan*, , Si*, 2018. CNS Neurosci Ther

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Applications to Brain Disorders

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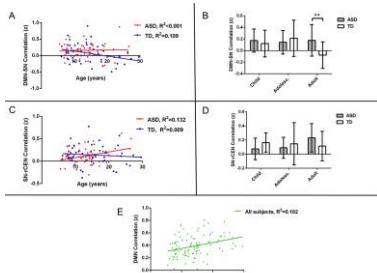
Altered Developmental Trajectories in Intrinsic Function between Default, Salience, and Executive Networks in High-Functioning Autism



Yang, , Yan*, in prep.

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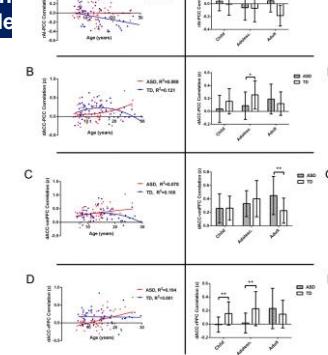
Altered Developmental Trajectories in Intrinsic Function between Default, Salience, and Executive Networks in High-Functioning Autism



Yang, , Yan*, in prep.

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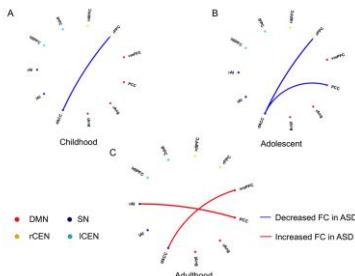
Altered Function in Executive Network in High-Functioning Autism



Yang, , Yan*, in prep.

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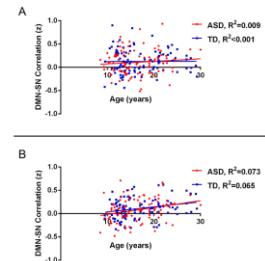
Altered Developmental Trajectories in Intrinsic Function between Default, Salience, and Executive Networks in High-Functioning Autism



Yang, , Yan*, in prep.

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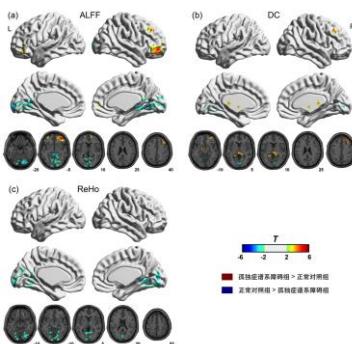
Altered Developmental Trajectories in Intrinsic Function between Default, Salience, and Executive Networks in High-Functioning Autism



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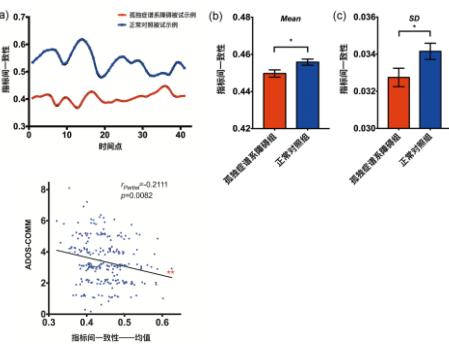
孤独症脑自发活动动态性及其整合的异常机制



Lu, , Yan*, 2018. 科学通报

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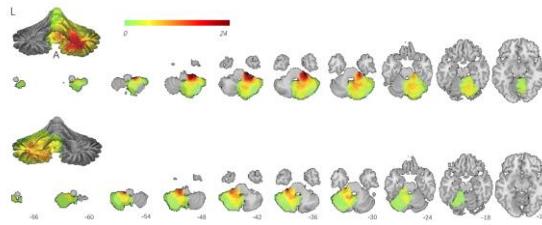
孤独症脑自发活动动态性及其整合的异常机制



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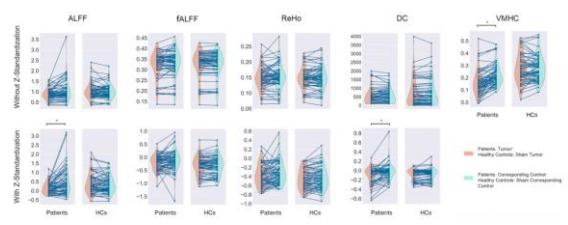
Physiological Significance of R-fMRI Indices: Can Functional Metrics Detect Structural Lesions (Brain Tumors)?



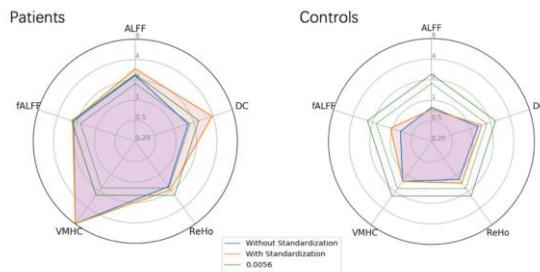
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Physiological Significance of R-fMRI Indices: Can Functional Metrics Detect Structural Lesions (Brain Tumors)?



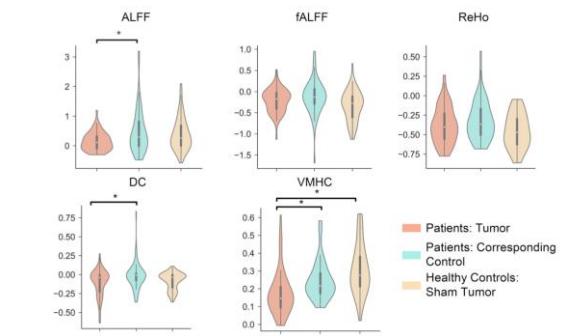
Physiological Significance of R-fMRI Indices: Can Functional Metrics Detect Structural Lesions (Brain Tumors)?



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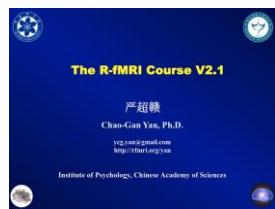
Physiological Significance of R-fMRI Indices: Can Functional Metrics Detect Structural Lesions (Brain Tumors)?



Fan, , Yan*, 2019. NeuroImage: Clinical

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Further Help

<http://rfmri.org/Course><http://wiki.rfmri.org>

The R-fMRI Journal Club



Official Account: RFMRI Lab

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Acknowledgments

Chinese Academy of Sciences
Xi-Nian Zuo

NYU Child Study Center
F. Xavier Castellanos

Hangzhou Normal University
Yu-Feng Zang

Child Mind Institute
Michael P. Milham

Beijing Normal University
Yong He
Xin-Di Wang

Peking University
Jia-Hong Gao
Wei-Wei Men

Funding

- National Natural Science Foundation of China
- Chinese Academy of Sciences

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Thanks for your attention!