




## Resting-State fMRI: Applications

Chao-Gan YAN, Ph.D.  
严超赣  
ycg.yan@gmail.com  
http://rfmri.org  
Institute of Psychology, Chinese Academy of Sciences

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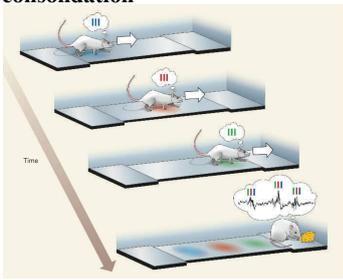
## Outline

- ➔ Applications to Cognitive Science
- Applications to Brain Disorders

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### Applications to Cognitive Science

#### Off-line spontaneous brain activity and memory consolidation



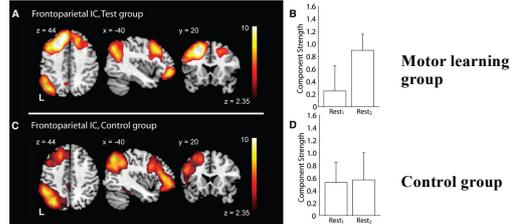
**Reverse replay of behavioral sequences in hippocampal place cells during the awake state.**

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

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### Applications to Cognitive Science

#### Resting-state fMRI and memory consolidation



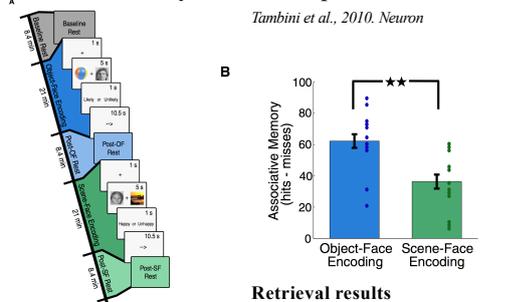
**Motor learning but not motor performance modulated subsequent frontal-parietal resting-state network**

*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

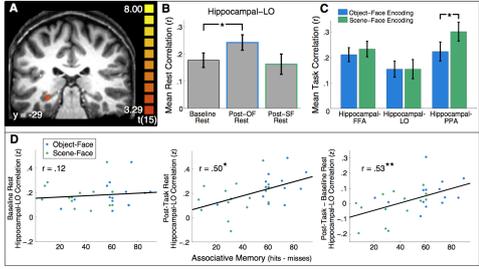


*Tambini et al., 2010. Neuron*

**Retrieval results**

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### Applications to Cognitive Science



*Tambini et al., 2010. Neuron*

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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?

```

graph TD
    A[Encoding] --> B[Consolidation]
    B --> C[Retrieval]
    
```

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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

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### 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

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### 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

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### Applications to Cognitive Science

**Hippocampus**

**A** ReHo ratio APOE ε3/ε4 > ε2/ε3

**B** ReHo ratio APOE ε2/ε3 vs ε3/ε4

**C** ReHo ratio REST1 vs REST2

**D** Correlation in APOE ε3/ε4

**E** Correlation in APOE ε3/ε4

**F** Correlation in APOE ε2/ε3

(P < 0.05, SVC)

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

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## Applications to Brain Disorders

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

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## Applications to Brain Disorders

ALFF in AD

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## Applications to Brain Disorders

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

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## Applications to Brain Disorders

### Degree centrality in AD

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

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### Applications to Brain Disorders

Classification of AD

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

Lateral view: MOGL, HES.L, IOG.R, INS.R, ORBsup.B

Medial view: POG.L, FFG.L, HIP.L, ORBsupmed.R, HIP.R, PHG.R, FFG.R

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

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### Applications to Brain Disorders

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### 广泛应用于脑疾病中

#### 抑郁症

Yan et al., 2017, Transl Psychiatry

#### 孤独症

Di Martino, Yan et al., 2014, Mol Psychiatry

#### 注意缺陷多动障碍

Zhu, Yan et al., 2008, Neuroimage

#### 进食症

Wang, Yan\* et al., 2017, J Psychiatry Neurosci

#### 阿尔茨海默病

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

#### 术前定位

Qiu, Yan, et al., 2014, Acta Neurosci

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### MDD疾病负担重, 诊断缺乏生物学客观标准

Figure 3: Disability-adjusted life years (DALYs) for each mental and substance use disorder in 2010, by age

Whiteford et al., 2013, Lancet

抑郁症 (重性抑郁障碍, MDD) 疾病负担居于首位

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### Depressive-like behavior in rat model of caregiver maltreatment

**a Methods**

Treatment: Pups Born (PN1), Raising with a control mother or low-bedding mother (PN8), Forced swim test (PN12), Sucrose preference test (PN45-55), Social interaction test (PN60-80)

**b Maternal behavior**

Maternal Behaviors	Control	Maltreated
Stop or jump on	1.10%	3.00%
Rough handling	0.92%	4.26%
Chew pup	0.19%	3.95%
Naming	82.38%	43.35%
Mother's time in the nest	84.15%	48.79%
Pup vocalization	1.27%	4.08%

Yan et al., 2017, Transl Psychiatry

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**c** Latency to immobility (s)

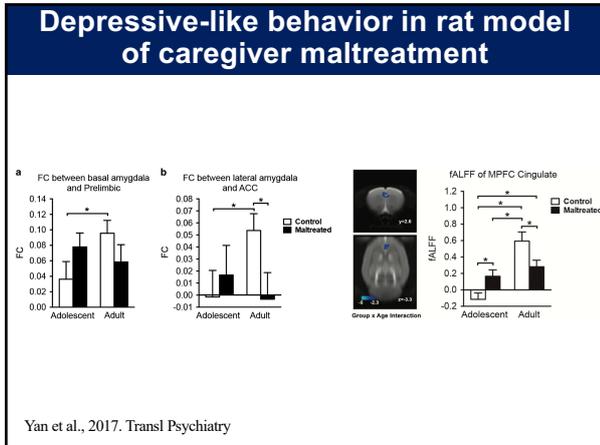
**d** Sucrose consumption (g)

**e** Time spent in social stimulus chamber (s)

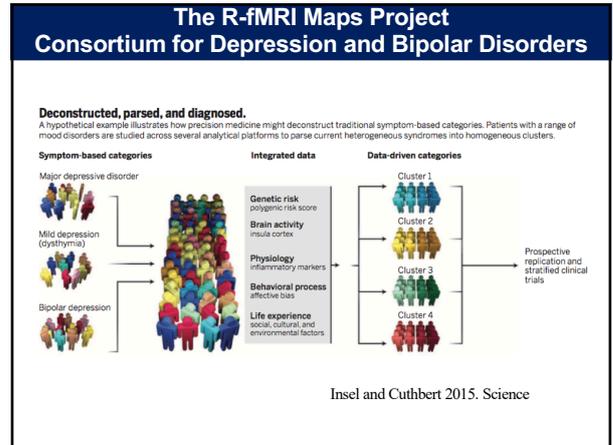
**f** Number of crossings between chambers

Yan et al., 2017, Transl Psychiatry

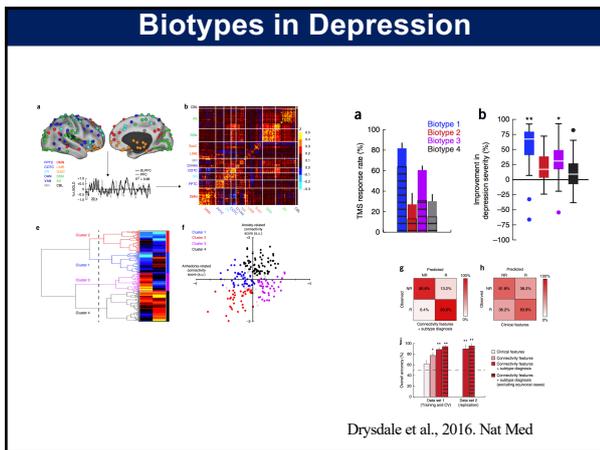
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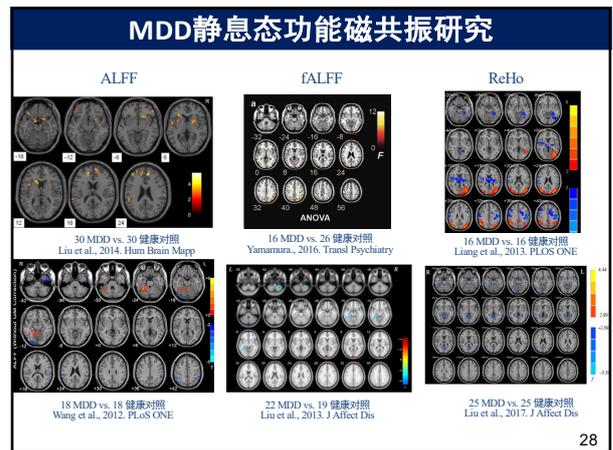
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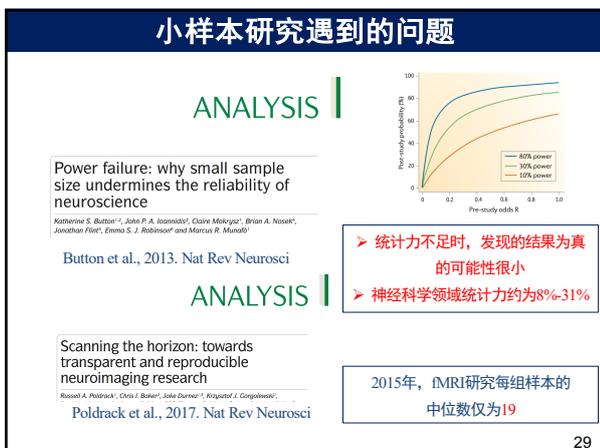
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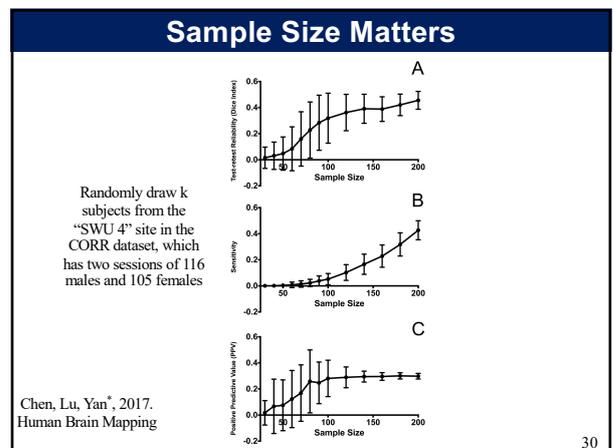
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### REST-meta-MDD

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

25 MDD research groups over China

组号	参与研究单位	研究负责人	样本量	
			MDD	NC
1	北京大学第六医院	陆林	74	54
2	首都医科大学	曹树基	30	30
3	中山大学附属第一医院	曹树基	27	27
4	中南大学湘雅二医院	段文斌	24	24
5	上海交通大学医学院附属精神卫生中心	马勒妮/张洪	15	15
6	上海交通大学医学院附属精神卫生中心	马勒妮/张洪	15	15
7	浙江大学医学院附属嘉善医院	曹树基	38	48
8	中国医科大学附属第一医院	王敏	75	75
9	首都医科大学	曹树基	30	30
10	中南大学湘雅二医院	曹树基	30	30
11	重庆医科大学附属第一医院	曹树基	32	28
12	重庆医科大学附属第一医院	曹树基	32	4
13	西安中心医院	曹树基	25	17
14	中南大学湘雅二医院	曹树基	66	32
15	中南大学湘雅二医院	曹树基	56	56
16	四川大学华西医院	曹树基	31	31
17	重庆医科大学附属第一医院	曹树基	47	44
18	中南大学湘雅二医院	曹树基	21	20
19	重庆医科大学附属第一医院	曹树基	15	30
20	中南大学湘雅二医院	曹树基	262	251
21	中南大学湘雅二医院	曹树基	46	50
22	中南大学湘雅二医院	曹树基	30	20
23	中南大学湘雅二医院	曹树基	32	30
24	中南大学湘雅二医院	曹树基	32	31
25	中南大学湘雅二医院	曹树基	89	83

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

Sample size, Sex, Age, HAMSD

Yan et al., 2019, PNAS.

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### REST-meta-MDD

Illness Duration Effect, Medication Effect

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

All MDDs vs. NCs, FEDN MDDs vs. NCs, Recurrent MDDs vs. NCs

Yan et al., 2019, PNAS.

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### REST-meta-MDD

All MDDs vs. NCs, FEDN MDDs vs. NCs, Recurrent MDDs vs. NCs

ReHo

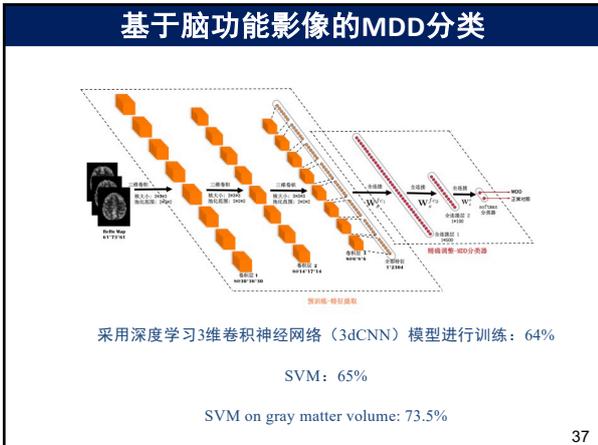
Yan et al., 2019, PNAS.

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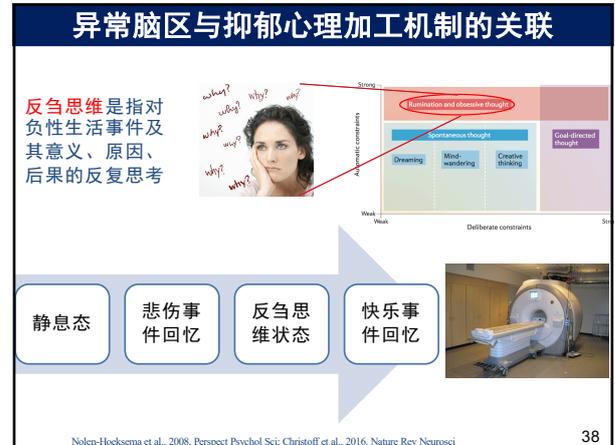
### 合作情况

1	用静息功能磁共振研究抑郁症小世界属性的异常	浙江大学医学院附属第一医院
2	抑郁症大脑功能连接量化研究	湘雅二医院
3	严重抑郁症内前额叶-纹状体-基底节-丘脑连接变化	杭州师范大学 华西医院; 浙江大学
4	抑郁症症状学特征与功能异常研究: 基于HAMD的亚型分析	四川大学心理学部
5	基于静息态影像和深度学习方法的抑郁症预测研究	西南大学心理学部
7	抑郁症患者注意网络结构和功能连接的研究	首都医科大学附属北京安定医院
8	抑郁症功能连接异常型的研究: 基于多中心静息态功能磁共振数据分析	四川大学华西医院
9	Abnormal interhemispheric connectivity in major depressive disorder: an voxel mirrored homotopic connectivity analysis of 2428 individuals from REST-meta-MDD working group	上海市精神卫生中心
10	不同性别抑郁患者静息态功能连接研究	苏州大学二院
11	抑郁症动态功能网络连接模式研究	中南大学湘雅二医院
12	抑郁症基于静息态功能网络的静息态功能影像研究	重庆医科大学附属第一医院
14	不同年龄发病的抑郁患者的脑功能影像学研究	昆明医科大学第一附属医院
15	抑郁症自杀倾向的神经环路	中南大学湘雅二医院
16	MDD的脑网络异常机制研究	北京大学第六医院
17	基于图谱的时间序列网络有连接分析	西安交通大学第一附属医院
18	抑郁症与静息态功能网络: 基于HAMD的亚型	中南大学湘雅二医院
19	髓鞘调节通路在首发未用药抑郁症患者中的静息态功能影像学研究: 基于独立样本验证	山西医科大学第一医院
20	基于网络控制论的抑郁症与正常网络区分	中国医科大学附属第一医院
21	Integrating graphic measures and deep learning technology to detect MDD at the individual level	四川大学华西医院-华西MDD研究中心
22	Changes in local brain activity and functional connectivity in major depressive disorder patients with insomnia	首都医科大学附属北京安定医院
23	The structural and functional alterations of brain in MDD with gastrointestinal symptoms	山西医科大学第一医院
24	Evolution of Brain Network in Depression: An Age and Illness Duration-associated Cross-sectional Study	四川大学华西医院
25	Abnormal resting-state functional connectivity of nucleus accumbens in patients with major depressive disorder	湘雅二医院
26	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
29	Baseline time variability and co-activation pattern based evaluation of severity in patient with MDD	东南大学附属中大医院
30	Common and different patterns of altered functional activities in drug-naive and treated first-episode depressive patients	苏州大学附属第一医院
31	Relationship of brain structure of MDD patients and metabolome expression in classical rodent models of MDD	重庆医科大学

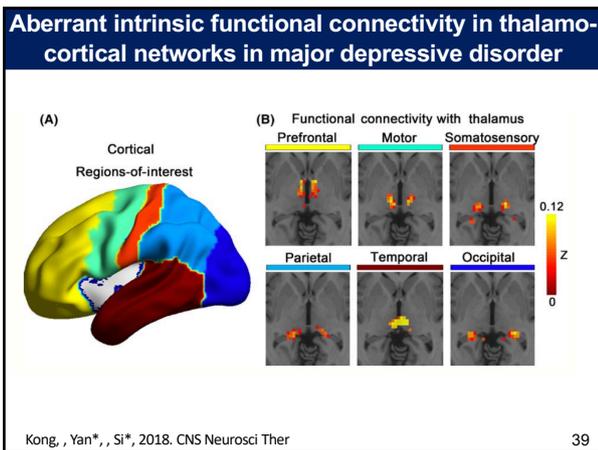
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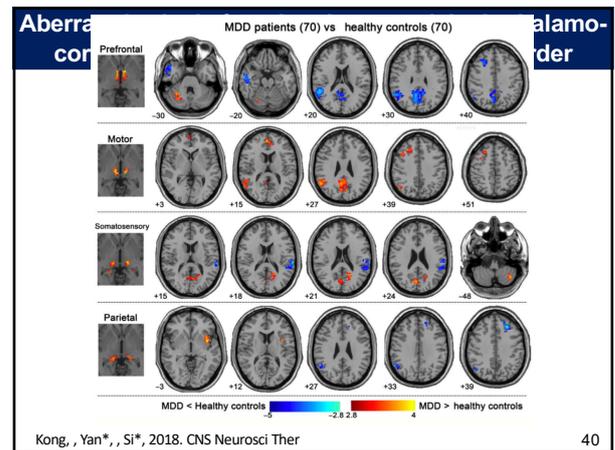
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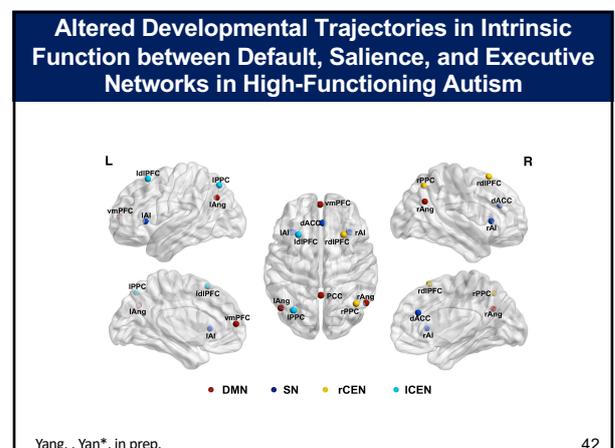
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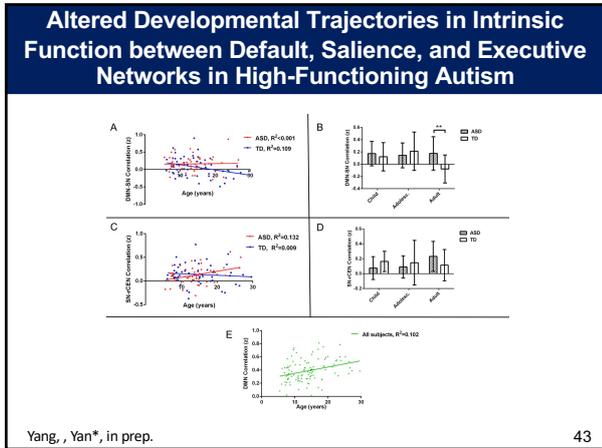
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- ### Applications to Brain Disorders
- Alzheimer's Dementia (AD)
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  - Autism Spectrum Disorder (ASD)
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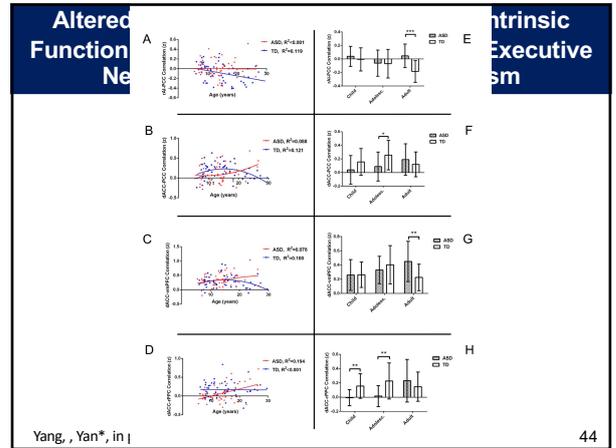
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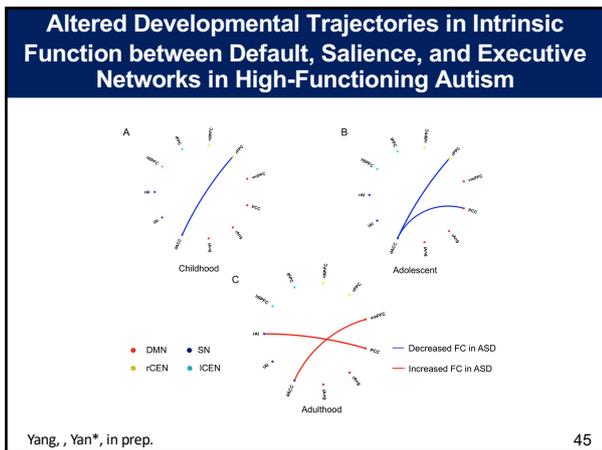
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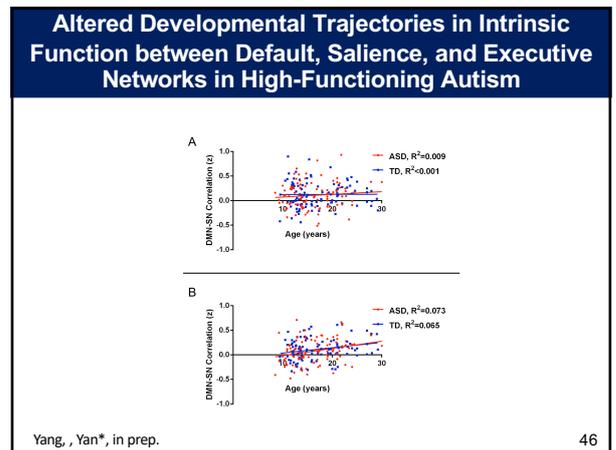
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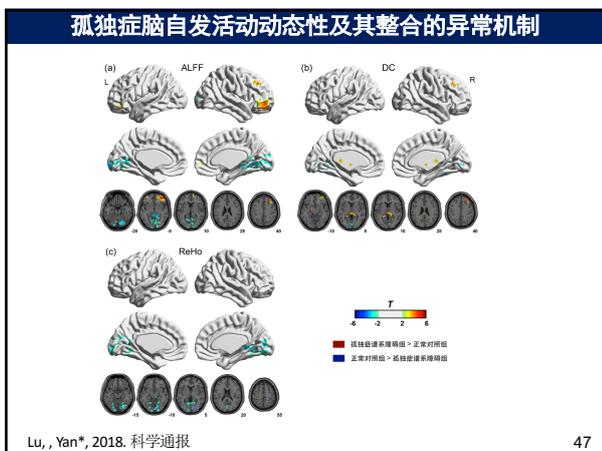
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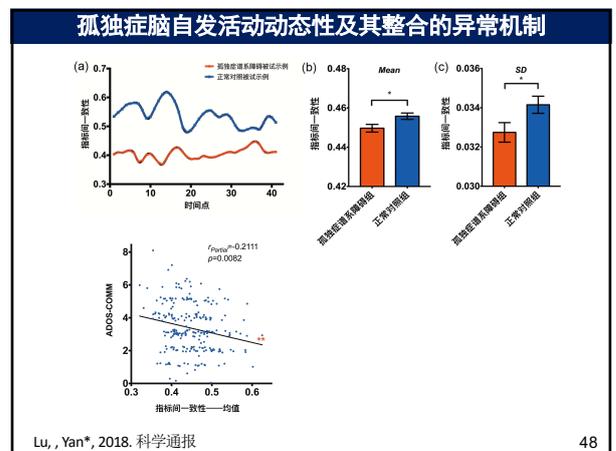
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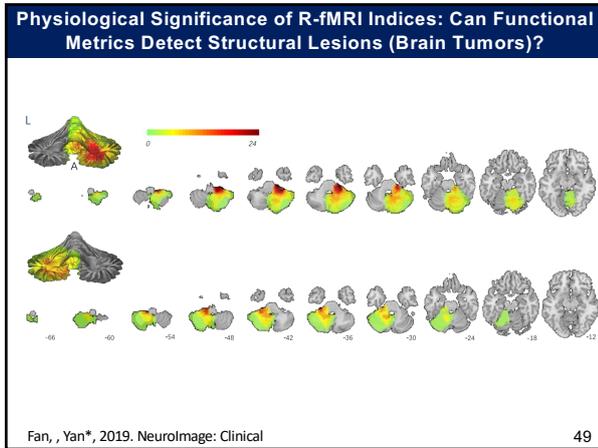
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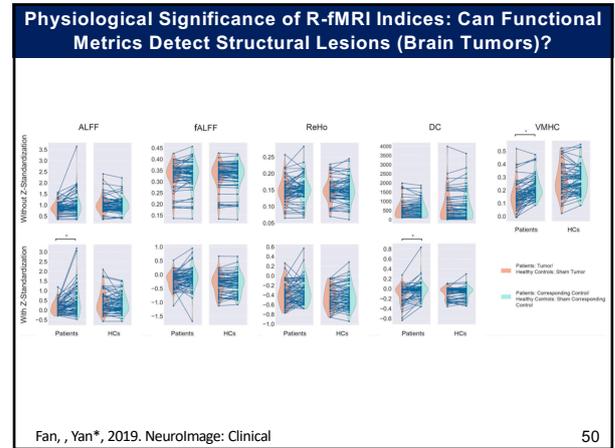
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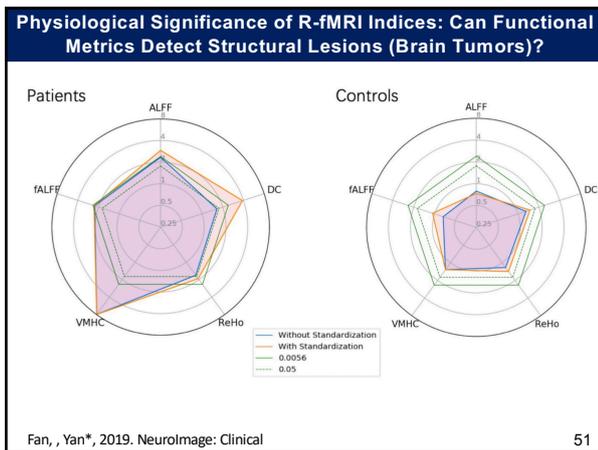
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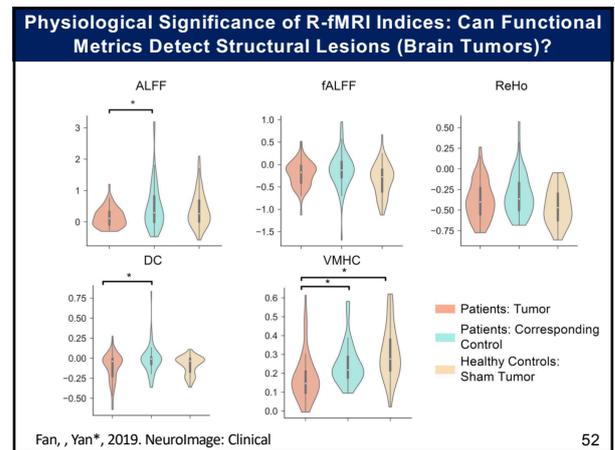
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### Further Help

<http://wiki.rfmri.org>

The R-fMRI Journal Club

Official Account: RfMRI Lab

<http://rfmri.org/Course>

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