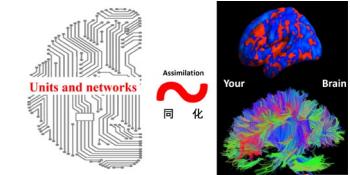


Simulations of DTB and Applications

Jianfeng Feng (冯建峰)

Fudan Univ., China / Warwick Univ., UK



The School of Data Science (SDS)

Faculty

Total: 36

23 faculties, including:
 1 academician
 3 national-level talent program Professors
 5 National Youth Talent Program awarders
 2 Province-level talent program awarders

Students

Graduated Students in past years:

Undergraduate Students: **263**

Graduate Students: **241**

Students in SDS now:

Undergraduate Students: **304**

Graduate Students: **364**

Research Funding and Papers

Research Funding: RMB **32 M** (69 projects)

Industrial Funding: RMB **160 M** (46 projects)

Papers: **> 270**

34 papers in AoS, JASA, JRSS-B

(Top Journals in Statistics)

10 papers in TPAMI

(Top Journal in Machine Learning)

Industrial Collaboration



Signed strategic cooperation memorandums with INESA (Group) Co., Ltd. , UniDT Technology (Shanghai) Co., Ltd., Shanghai Ideal Information Industry (Group) Co., Ltd., State Grid Shanghai Municipal Electric Power Company, Inspur Co., Ltd. et al (**> 10**)
 Established **7** school-enterprise joint laboratories with companies, such as Bank of Communications, China Construction Bank

Institute of Science and Technology for Brain-Inspired Intelligence



Research Team

Total: 301

PIs: 33

Postdocs: 29

Postgraduates: 185

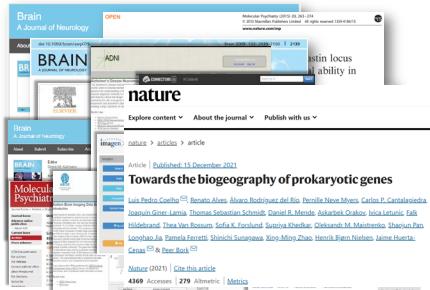
RAs: 27

Technicians: 13

Visitors: 14



>300 Papers



Nature
AMERICAN JOURNAL OF PSYCHIATRY

.....

Research Fields

Computational neuroscience
Cognitive neuroscience
Population Neuroscience
Applied Mathematics
Computer Science
Biomedical Engineering

Research Funding

Research Funding: RMB 1 B

Industrial Funding: RMB 90M

International Collaboration Funding: 28M

Philanthropic Funding: 4M

Research Facilities



MRI
High Performance Computing

.....

International Collaboration



Fudan-Cambridge Brain Health Institute (BHI)
FdU-USyd Brain and Intelligence Science Alliance (BISA)

.....

ZhangJiang International Brain Imaging Centre (**ZIC**, 400M RMB)

You can find a video about this page in the website.

You are welcome to visit us



▼ nature
International journal of science

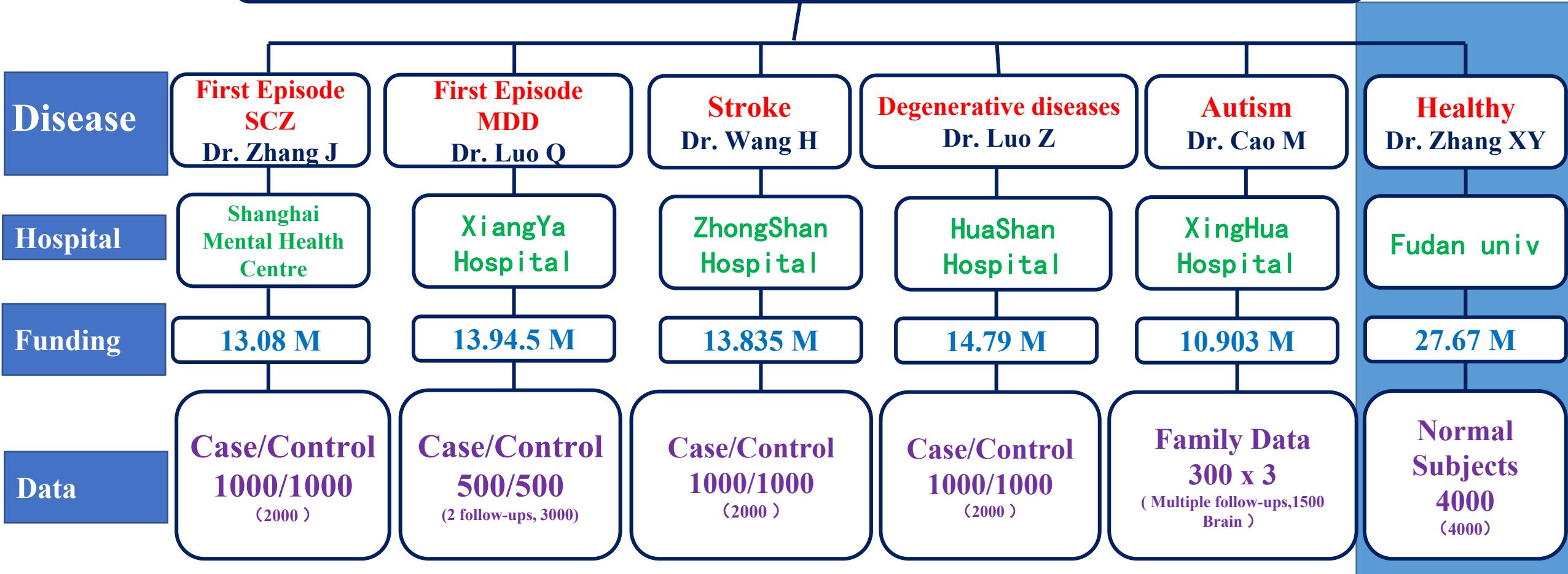


Feng Jianfeng, a computational biologist and head of Fudan University's Institute of Science and Technology for Brain-inspired Intelligence, has been involved in organizing the Shanghai brain projects. He says that one focus will using artificial intelligence (AI) to study brain diseases. Feng adds that, with 190 million Chinese yuan from the university, he is already setting up a brain-imaging facility that will house the largest number of magnetic resonance imaging devices in Asia, and will be based at the southern centre. AI algorithms will screen the images, comparing diseased brains with healthy ones, to form part of the world's largest brain database, he says.

Nature 556, 157-158, 5th April 2018

ZhangJiang International Brain BioBank (ZIB, 100M RMB)

6 Cohorts (15,000 subjects) Prof. Zhao XM and Prof. G. Schumann



International and national datasets Dr. Cheng W

Heathy Cohort: An Example



A total of 4000 university students with

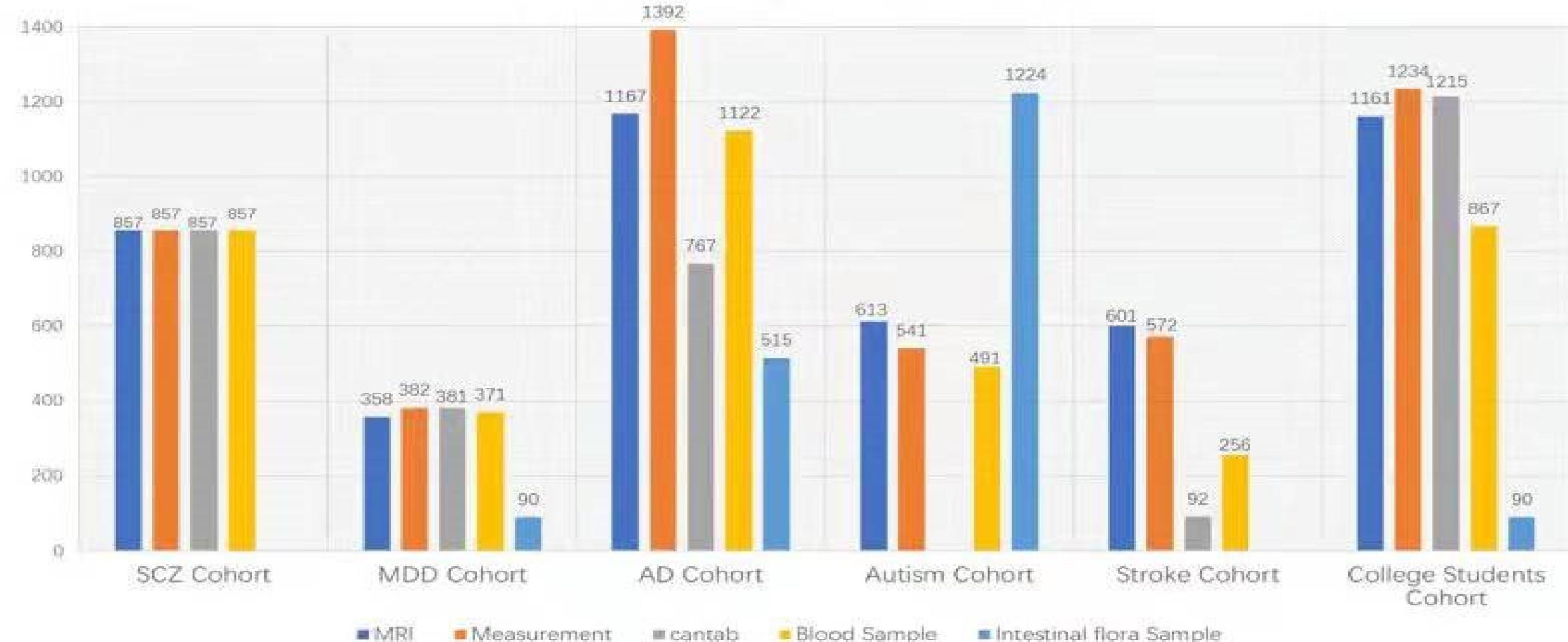
- *genetics*
- *brain images*
- *gut*
- *behaviours*

Year 1 and 4, graduated 5 and 10 years

Assess the impact of university education on your future career

张江国际脑库入组数据(2021.12.31)

ZIB Recruitment Status (2021.12.31)



By Dec 31, 2021, a total of 5,690 volunteers have been successfully recruited by the ZIB project.
In all, 18,930 samples of multimodal data have been collected.

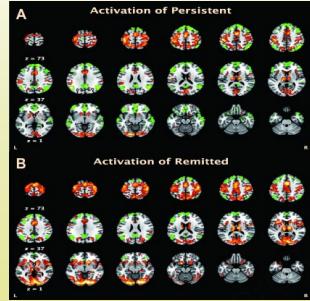
Outcomes from ZIB

1. Resolving heterogeneity in schizophrenia through a novel systems approach to brain structure: Individualized structural covariance network analysis *Molecular Psychiatry*, 2021, July 28
2. The genetic determinants of language network dysconnectivity in drug-naïve early stage schizophrenia, *npj schizophrenia*, 2021 Mar 3;7(1):18. .
3. A global overview of genetically interpretable multimorbidities among common diseases in the UK Biobank. *Genome Med* 13, 110 (2021).
4. Psychiatric disorders in China: strengths and challenges of contemporary research and clinical services. *Psychological Medicine* 2021, 1–14, doi.org/10.1017/S0033291721002816
5. Integration of multi-modal data for deciphering brain disorders, *Annual Review of Biomedical Data Science*, 2021, 4:43-56.
6. Connectivity between the anterior insula and dorsolateral prefrontal cortex links early symptom improvement to treatment response, *J Affect Disord*, 2020 Jan 1;260:490-497.
7. Identifying age-specific gene signatures of the human cerebral cortex with joint analysis of transcriptomes and functional connectomes, *Briefings in Bioinformatics*, 2020 Dec 26:bbaa388.



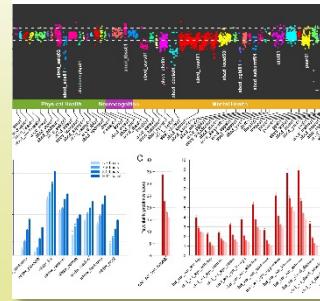
Encyclopaedia for Children Mental Health

ADHD

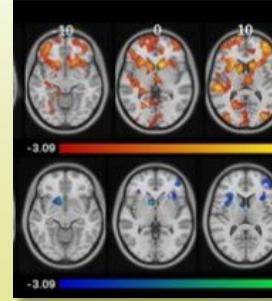


JAACAP, 2022

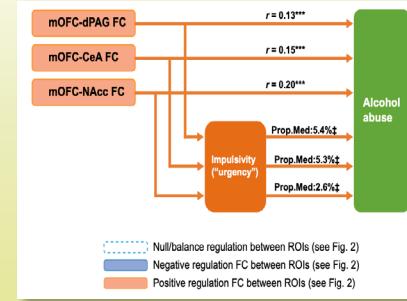
Sleep duration



Sleep & depression

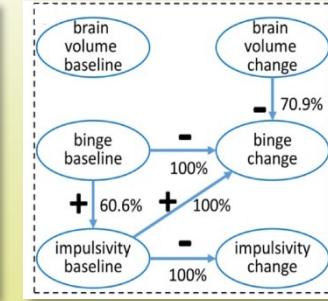


Drug abuse



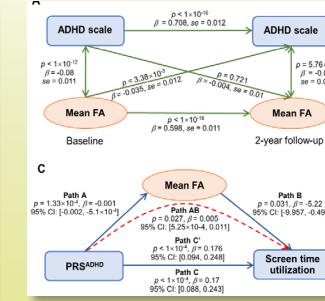
Science Advances, 2021

Drinking



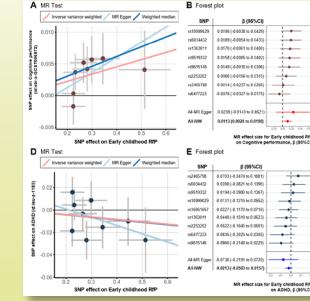
JAMA Psychiatry, 2020

Screen usage



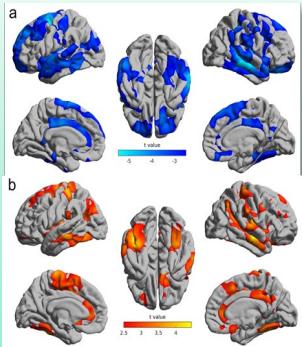
Biol. Psychiatry, Submitted

Reading



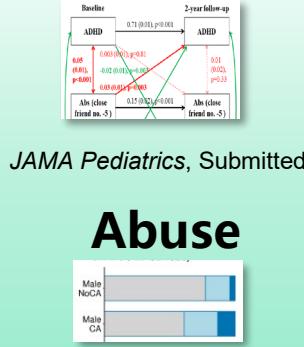
PNAS, Submitted

Family



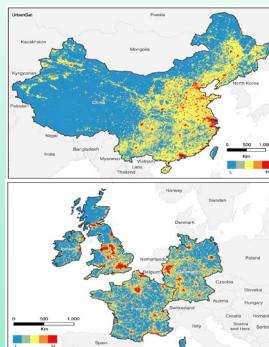
Nat Commun, 2021

Social network



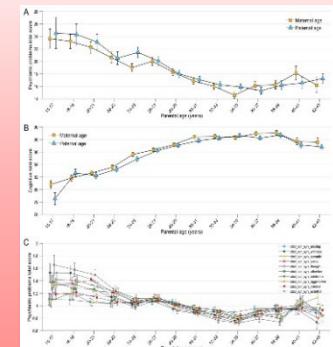
BMC Medicine, 2020

Urbanization



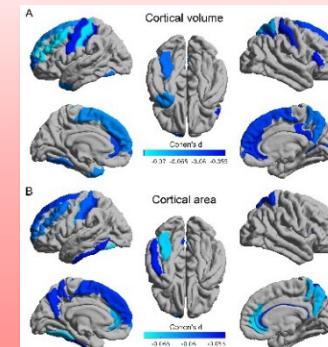
Behaviour
Mental Health
Environment

Birth age



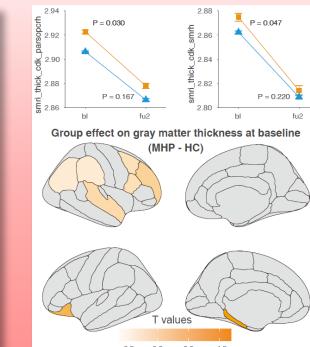
Molecular Psychiatry, 2021

Pregnant I



BMC Medicine, 2020

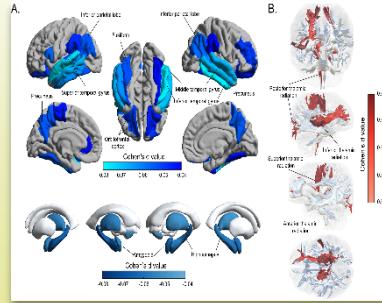
Pregnant II



JAMA Pediatrics, Submitted

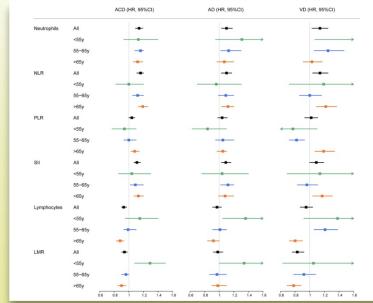
Encyclopaedia for Aging Mental Health

Hearing loss

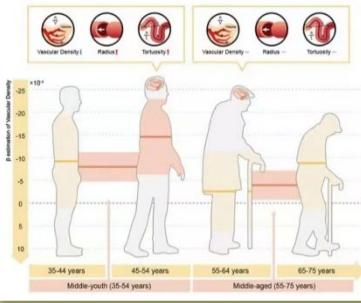


Brain., submitted

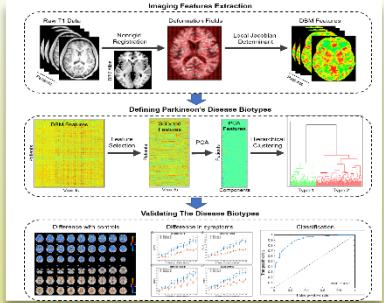
Immune system



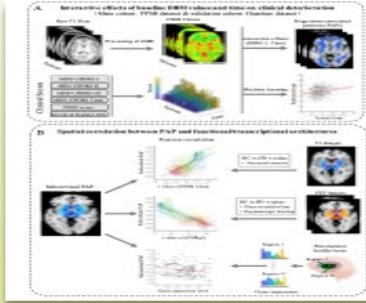
Blood vessel



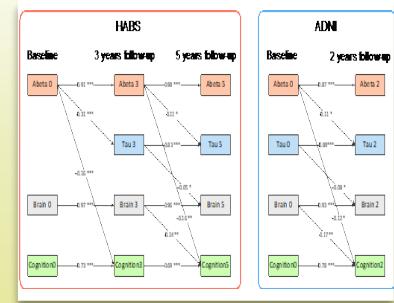
PD subtype



PD development

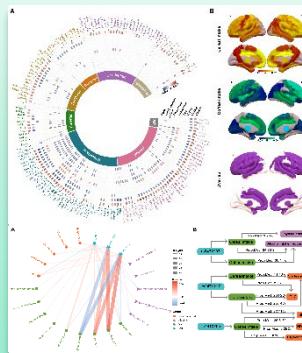


AD development

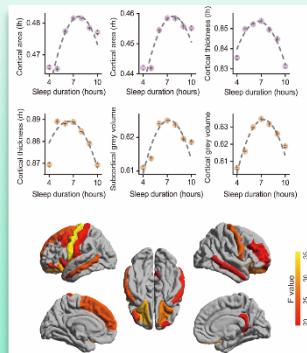


In preparation

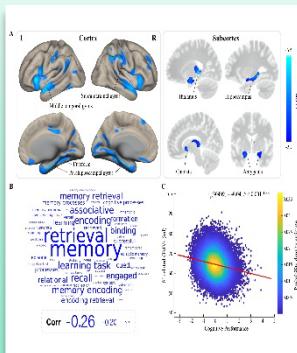
Diet



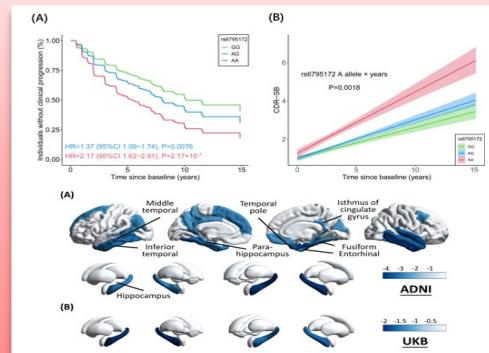
Sleep duration



Social isolation

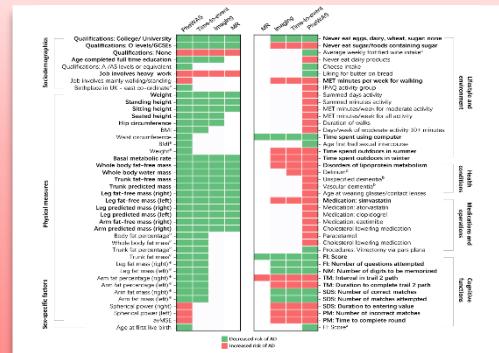


AD genetics



In preparation

AD phenomics



In preparation



460 Million people viewed

#8小时以上睡眠更有利于...

阅读4.6亿 讨论4.7万 详情>

主持人：头条新闻

综合 实时 热门 视频 图片 问答

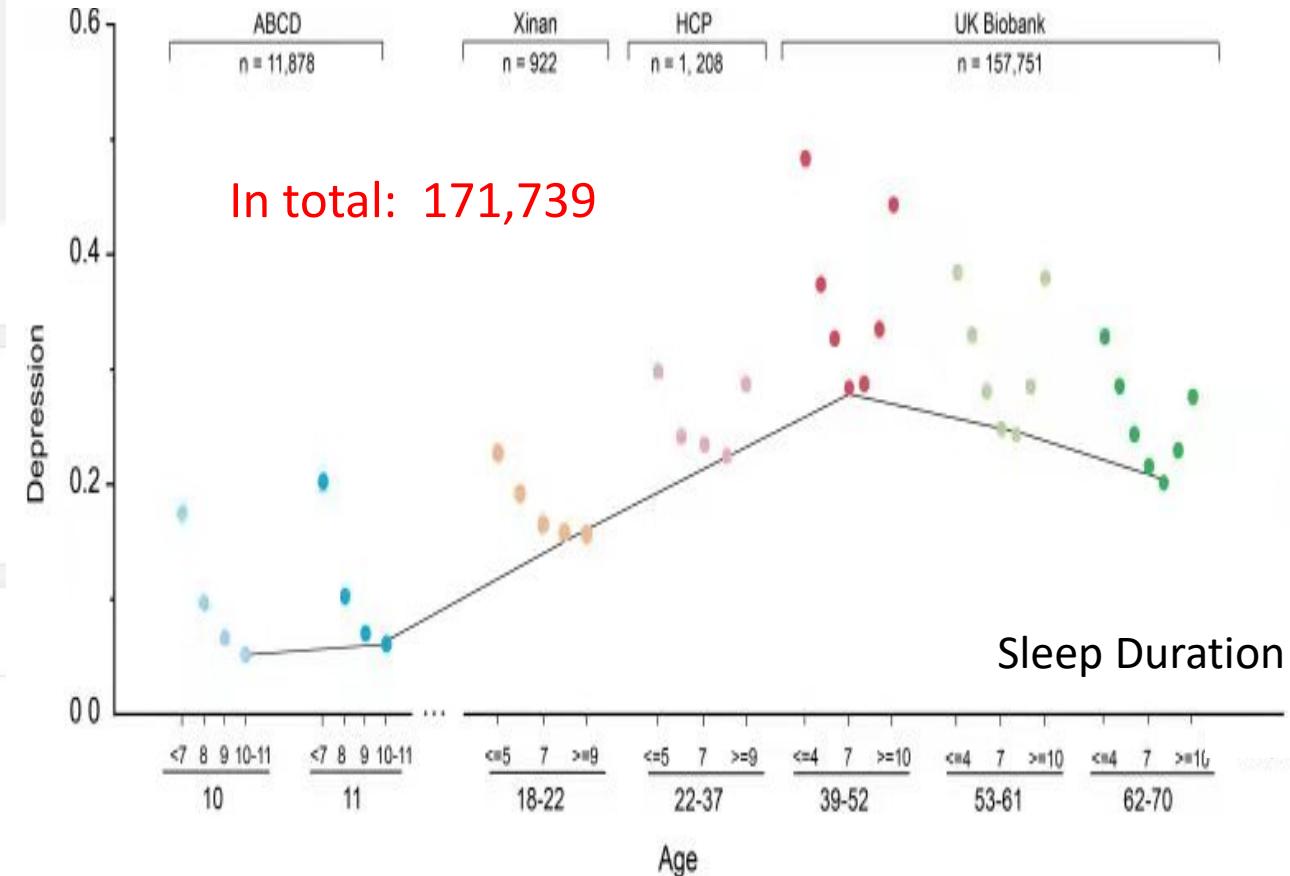
导语：2021世界人工智能大会，青少年人工智能创新发展论坛，复旦大学类脑人工智能科学与技术研究院院长、上海脑科学与类脑研究中心副主任冯建峰指出，...

置顶

头条新闻

昨天 08:54 来自 微博视频号

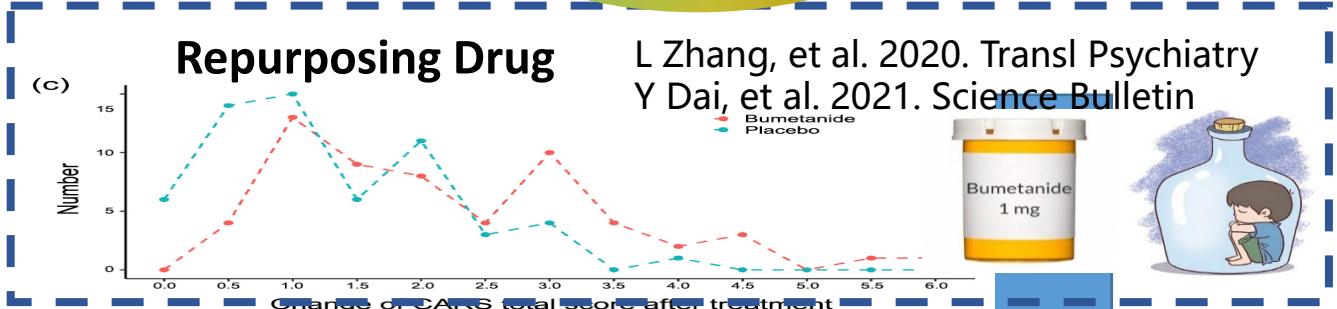
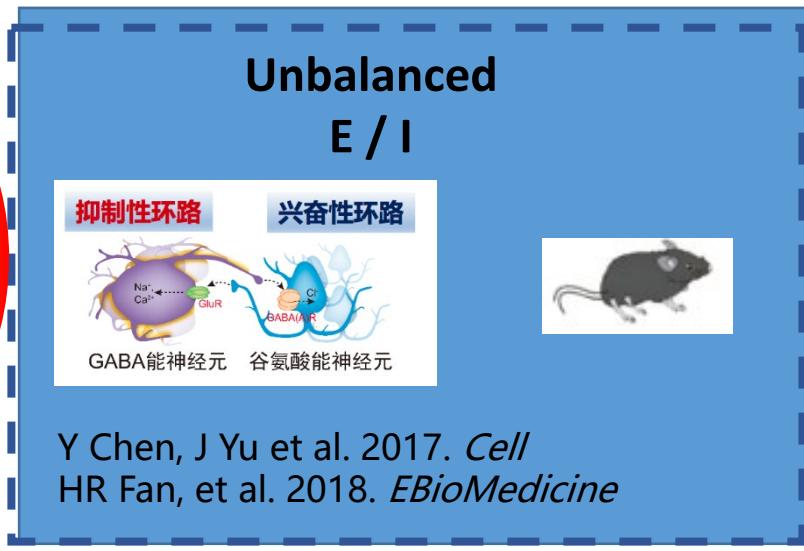
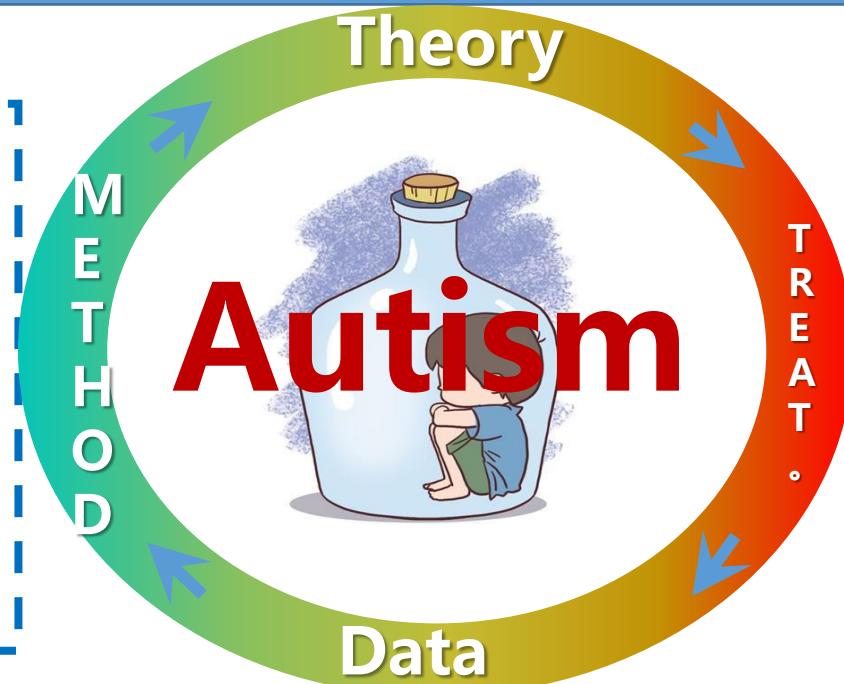
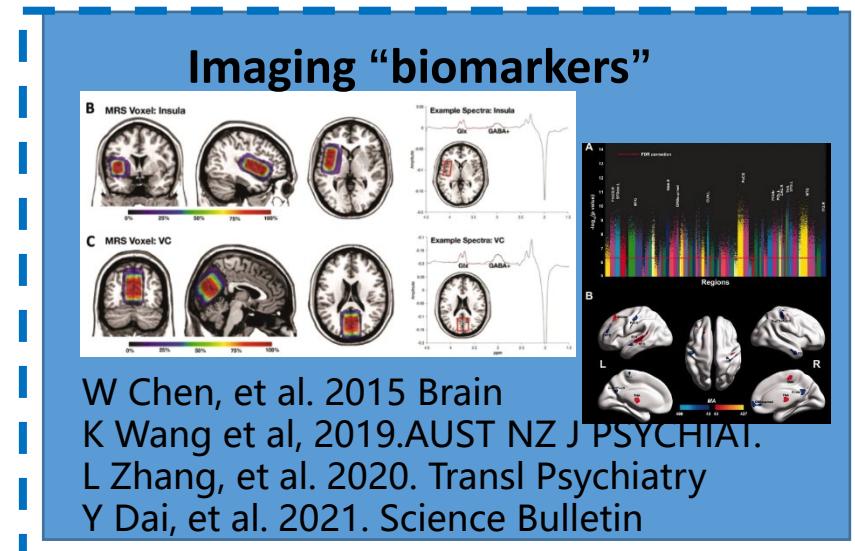
【转给妈妈看！#专家称小孩睡懒觉没坏处#，#8小时以上睡眠更有利于大脑发育#】据@021视频消息：2021世界人工智能大会，青少年人工智能创新发展论坛，复旦大学类脑人工智能科学与技术研究院院长、上海脑科学与类脑研究中心副主任冯建峰指出，对小孩子来说，睡懒觉没坏处，8小时以上睡眠更有利于大脑发 ...全文



Cheng, W., et al. Feng, J. (2020) Sleep duration, brain structure, and psychiatric and cognitive problems in children. *Molecular Psychiatry* doi: 10.1038/s41380-020-0663-2.

Li YZ et al. Feng J. (2022) *Nature Aging*, in press.

Our Approaches



66 Million people viewed



#上海发现低龄自闭症患儿新药#

老药新用！上海发现低龄自闭症患儿新药：或填补...

8519讨论 6690.2万阅读

【老药新用！#上海发现低龄自闭症患儿新药#或填补自闭症药物治疗空白】近日，上海医学院附属新华医院李斐教授领衔的团队与复旦大学类脑智能科学与技术研究院冯建峰教授副研究员团队、英国剑桥大学Barbara J. Sahakian教授团队等合作，在Science Bulletin杂志在线最新研究成果 ... [全文](#)



□ Treatment of ASD by Bumetanide

— Phase I : Open label trial (开盲研究 ChiCTR-OPC-16008336)

— Phase II: placebo-controlled RCT

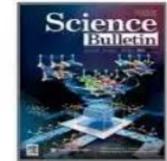
(随机双盲安慰剂对照试验 NCT03156153)



Science Bulletin

Available online 16 January 2021

In Press, Journal Pre-proof



Article

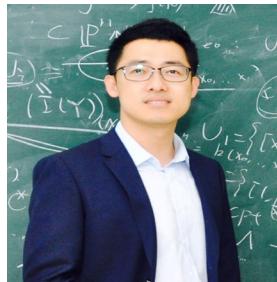
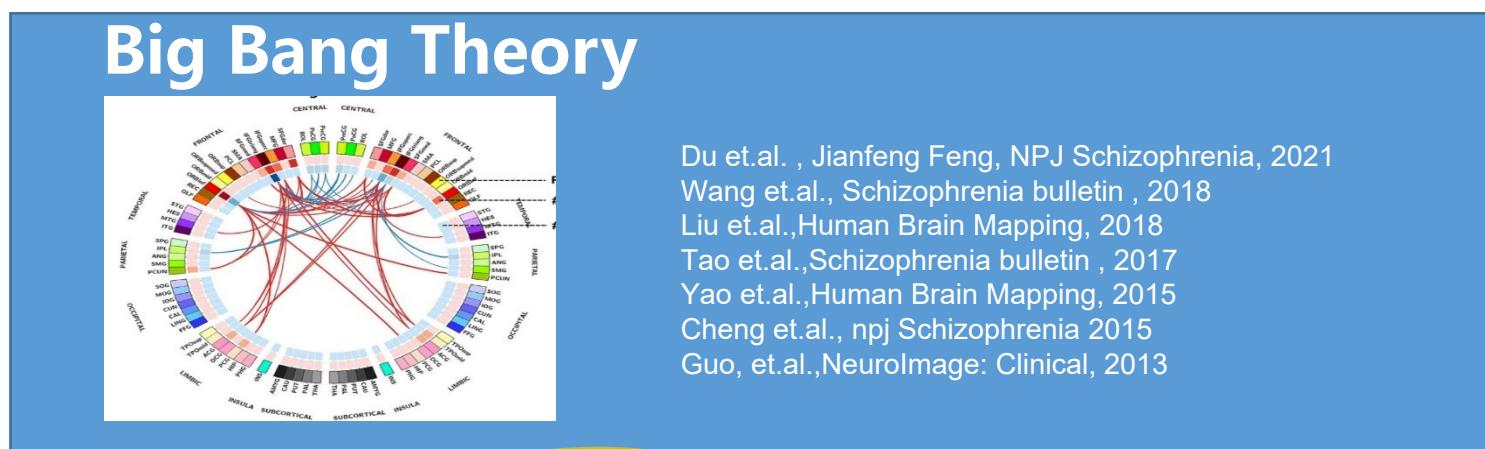
Improved symptoms following bumetanide treatment in children aged 3 to 6 years with autism spectrum disorder: a randomized, double-blind, controlled trial

Yuan Dai ^a, Lingli Zhang ^a, Juehua Yu ^{a, b}, Xin Zhou ^c, Hua He ^a, Yiting Ji ^a, Kai Wang ^a, Xiujuan Du ^a, Xin Liu ^a, Yun Tang ^{a, d}, Shining Deng ^a, Christelle Langley ^e, Wei-Guang Li ^f, Jun Zhang ^a, Jianfeng Feng ^g, Barbara J Sahakian ^{a, e, g}, Qiang Luo ^{g, h}, Fei Li ^a

[1613984498495332.jpg?x-oss-process=style/w10](#)



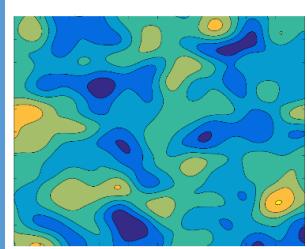
Our Approaches



$$\alpha = P(\max Z(p, q) > z_0) \approx$$

$$\sum_{i=0}^P \sum_{j=0}^Q \mu_i(P) \mu_j(Q) \frac{(2\pi)^{-\frac{i+j+1}{2}} (4\log 2)^{\frac{i+j}{2}}}{FWHM_Z^{i+j}} \times$$

$$e^{-\frac{z_0^2}{2}} \sum_{k=0}^{\lfloor \frac{i+j-1}{2} \rfloor} (-1)^k \frac{(2k)!}{k! 2^k} \left(\frac{i+j-1}{2k} \right) Z_0^{d-1-2k}$$



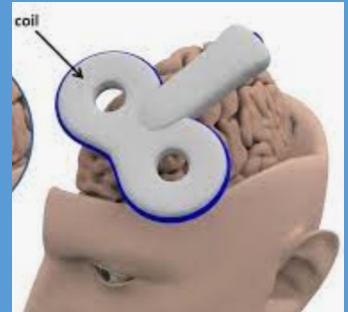
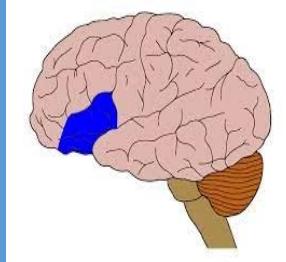
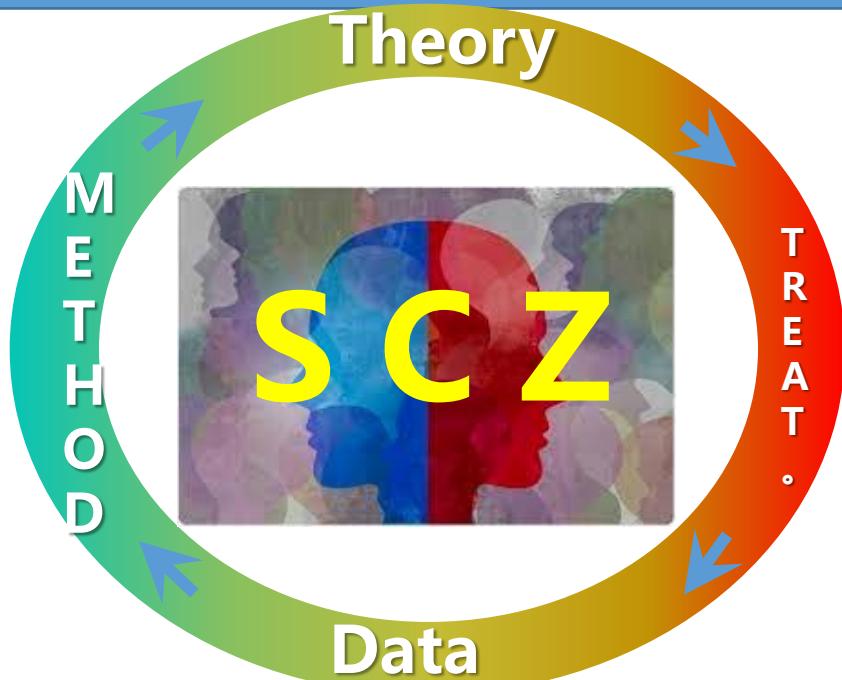
BWAS and related methods

W Cheng, et al, 2015, *Brain*

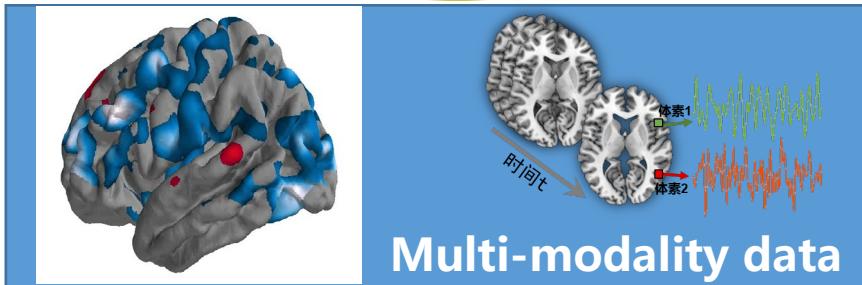
W Cheng, et al, 2016, *Brain*

WK Gong, et al, 2018, *Medical Image Analysis*

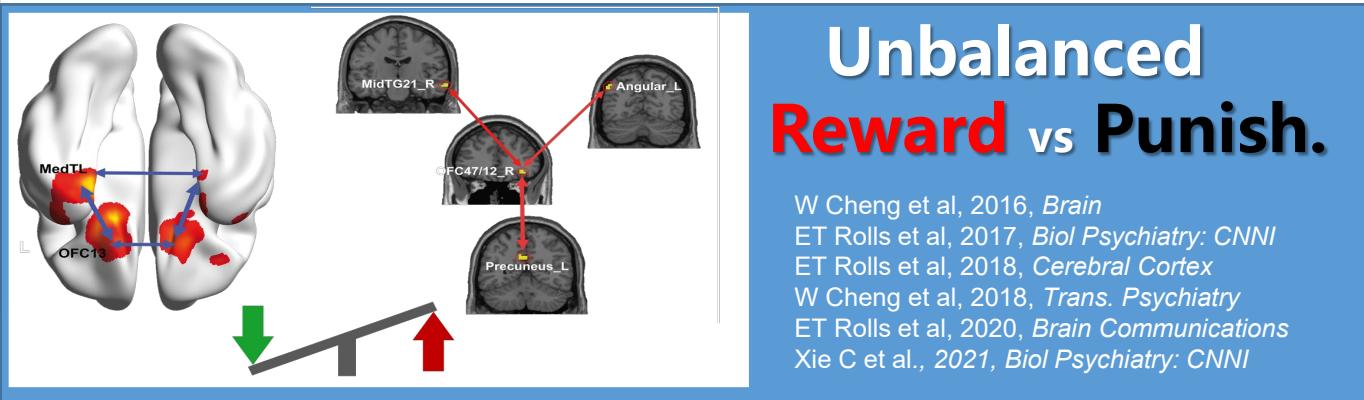
Du et.al. , Jianfeng Feng, NPJ Schizophrenia, 2021



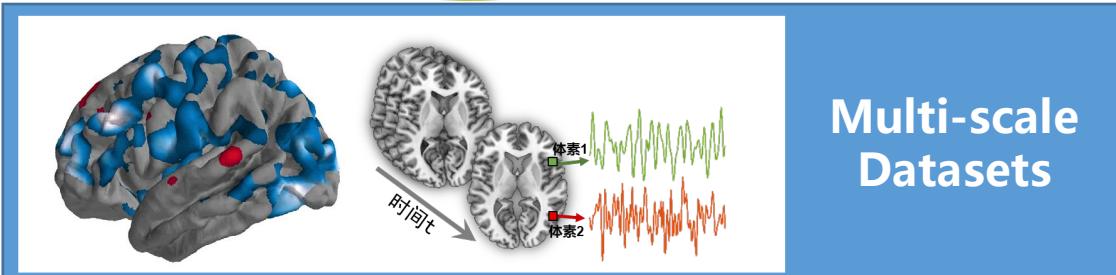
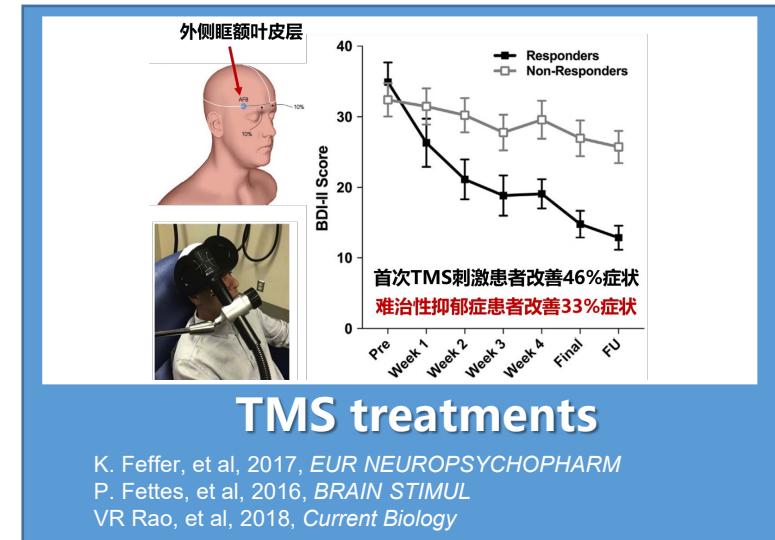
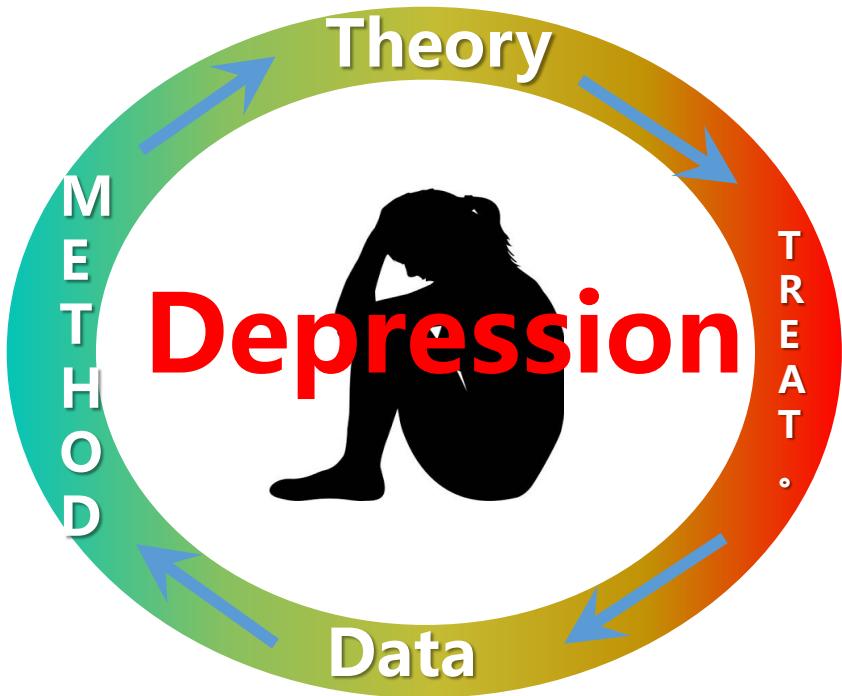
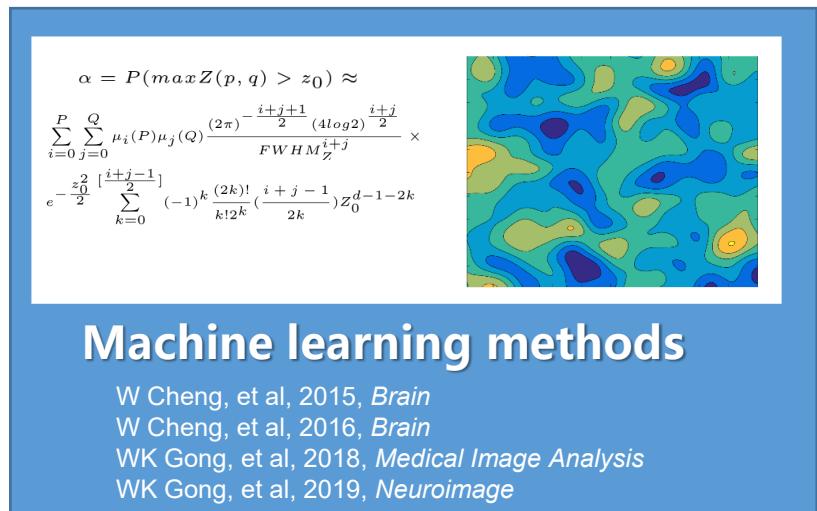
Walther et al. 2020. *Schizophr Bull*



Our Approaches

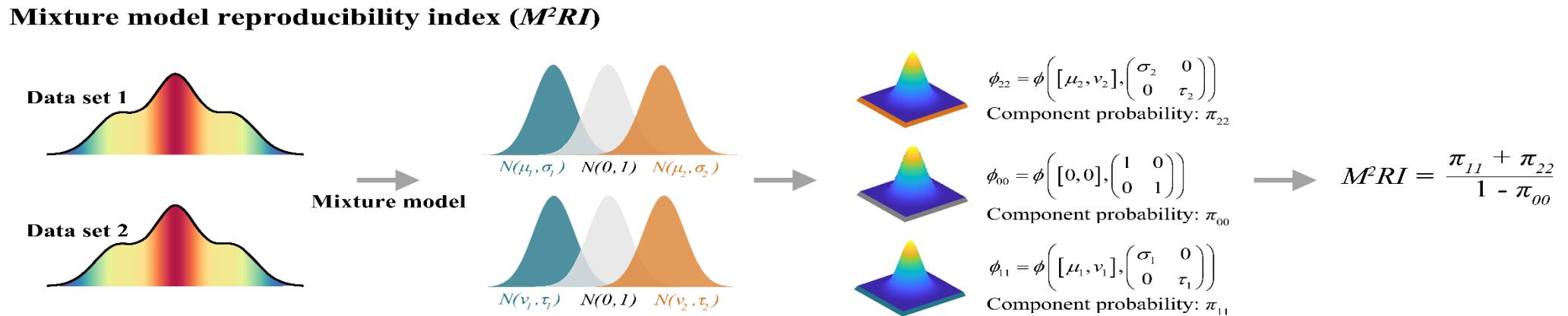


Dr. Cheng W.



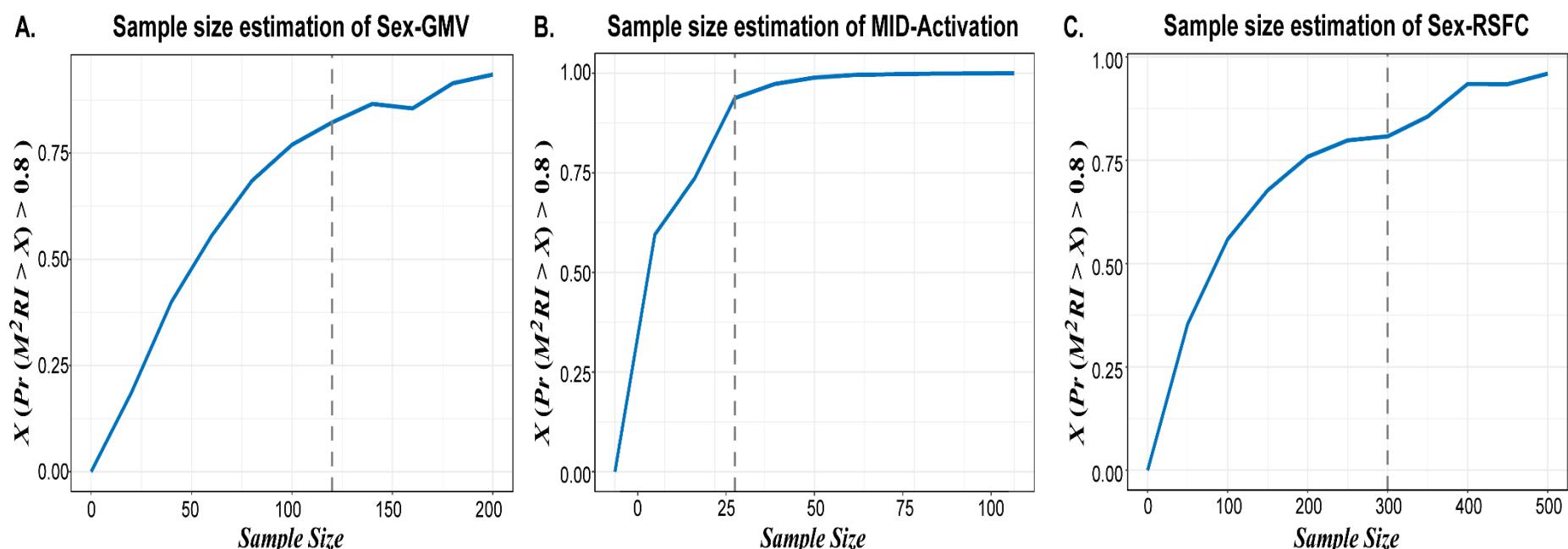
M²RI: Reproducibility

A mixture model approach to assess reproducibility for different MRI-based studies



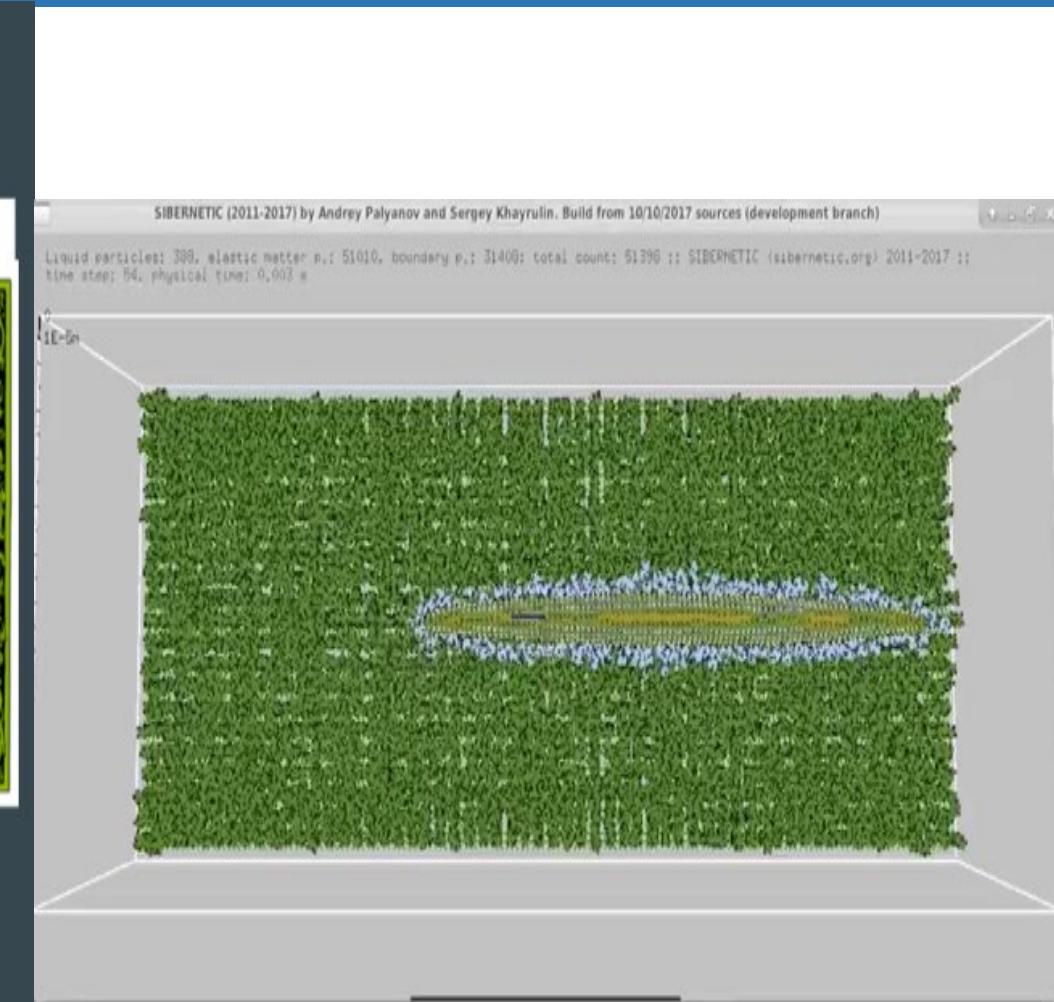
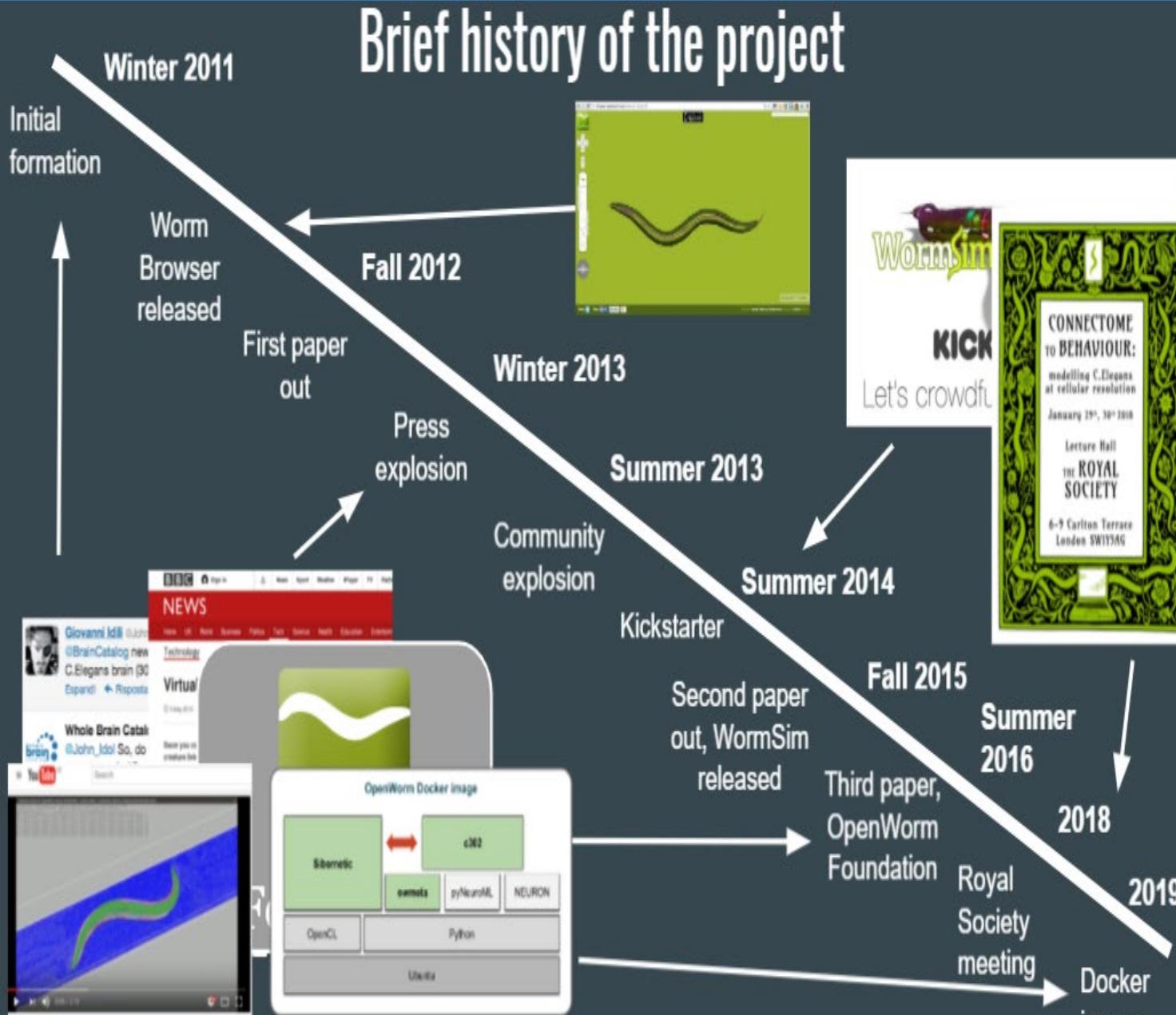
Sample size:

- GMV
70 – 300 samples
- Task activation
20 – 30 samples
- RSFC
200 – 2000 samples



A Ten Years Journey: 302 neurons+ 4 muscles

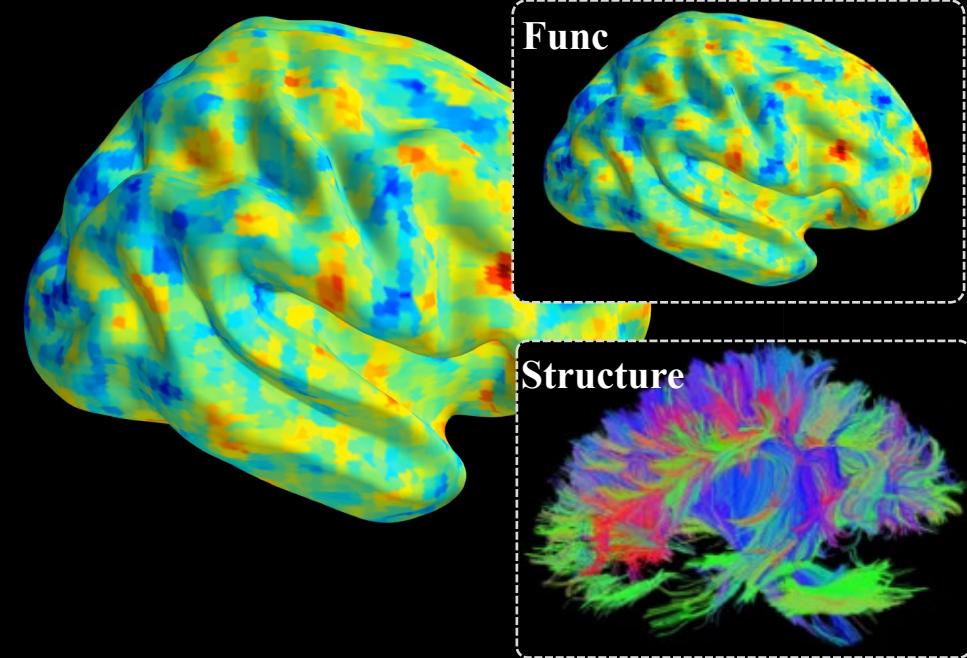
Brief history of the project



Biol.

1

Imaging data



2

Neuronal model

Conductances

$$\frac{ds_j^{\text{AMPA,ext}}(t)}{dt} = -\frac{s_j^{\text{AMPA,ext}}(t)}{\tau_{\text{AMPA}}} + \sum_k \delta(t - t_j^k)$$

Membrane potentials

$$C_m \frac{dV(t)}{dt} = -g_m(V(t) - V_L) - I_{\text{syn}}(t)$$

$$I_{\text{syn}} = I_{\text{AMPA,ext}} + I_{\text{AMPA,rec}} + I_{\text{NMDA,rec}} + I_{\text{GABA}}$$

Synaptic currents

$$I_{\text{AMPA,ext}}(t) = g_{\text{AMPA,ext}}(V(t) - V_E) \sum_{j=1}^{N_{\text{ext}}} s_j^{\text{AMPA,ext}}(t)$$

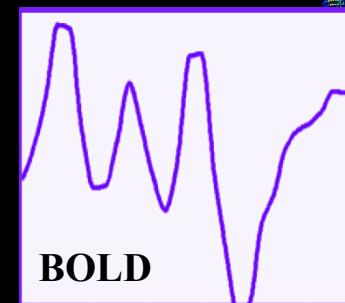
$$I_{\text{AMPA,rec}}(t) = g_{\text{AMPA,rec}}(V(t) - V_E) \sum_{j=1}^{N_E} W_j^{\text{AMPA}} s_j^{\text{AMPA,rec}}(t)$$

$$I_{\text{NMDA,rec}}(t) = \frac{g_{\text{NMDA,rec}}(V(t) - V_E)}{1 + \gamma e^{-\beta V(t)}} \sum_{j=1}^{N_E} W_j^{\text{NMDA}} s_j^{\text{NMDA,rec}}(t)$$

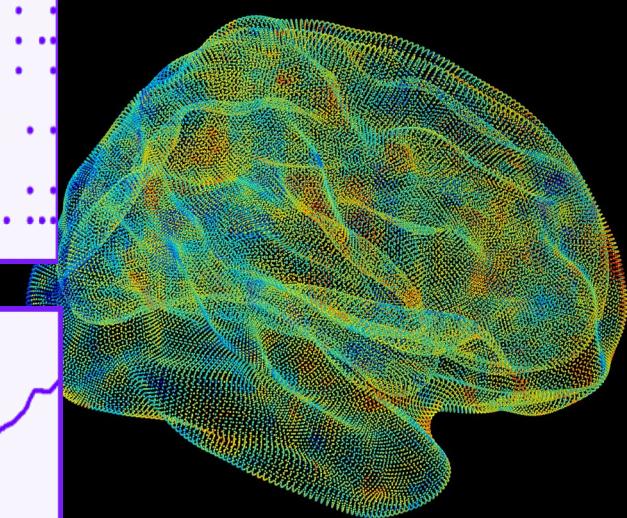
$$I_{\text{GABA}}(t) = g_{\text{GABA}}(V(t) - V_I) \sum_{j=1}^{N_I} W_j^{\text{GABA}} s_j^{\text{GABA}}(t)$$

3

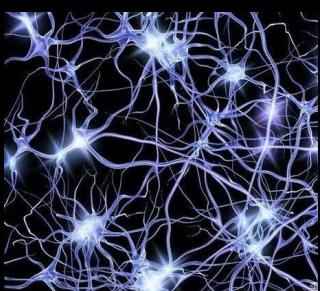
From Spikes to BOLD



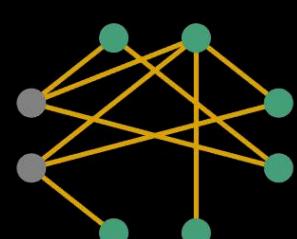
Digital Twin



Neuronal connections



Data assimilation



● ● Excitatory/Inhibitory neuron

Assimilated Brain Signal

V1



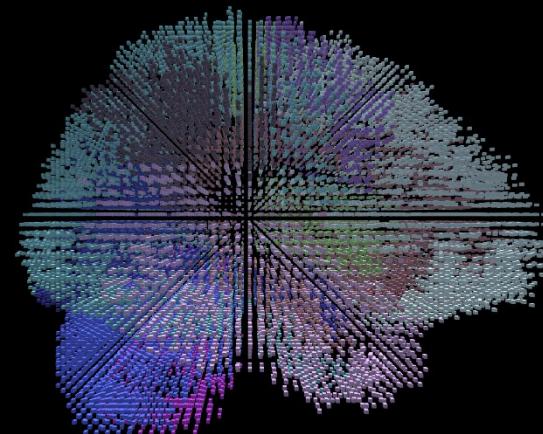
Heschl



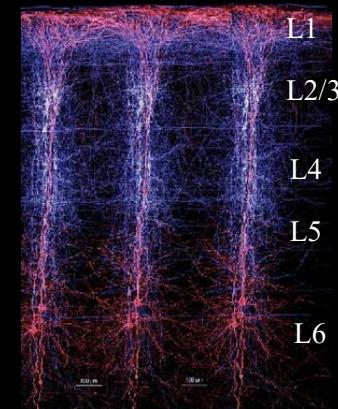
Regions



Voxels



Microcolumns



Versions

92 regions

23094 voxels

23094 voxels * 6 Struc

Neurons

20 B

20 B

86 B

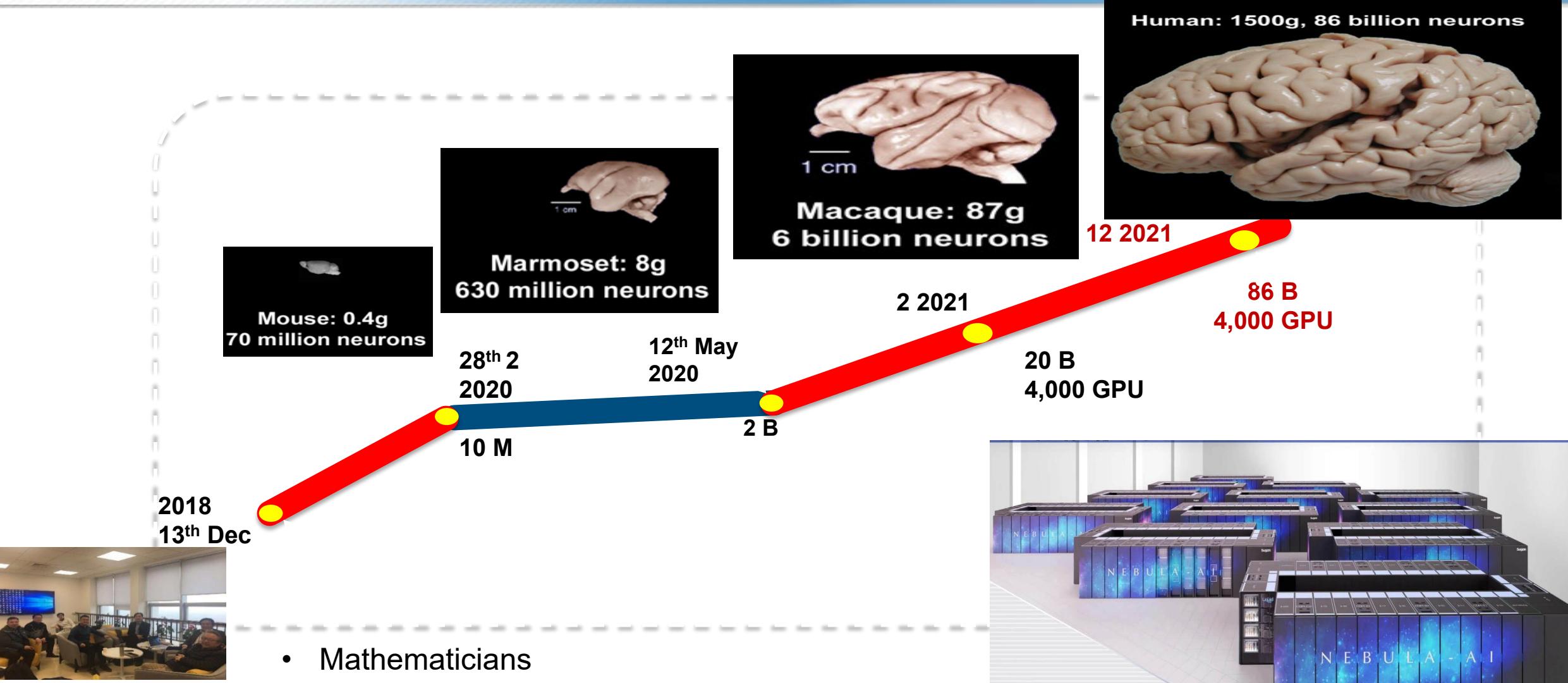
**Computational
Costs**

4000 DCU

4000 DCU

4000 DCU

DTB history

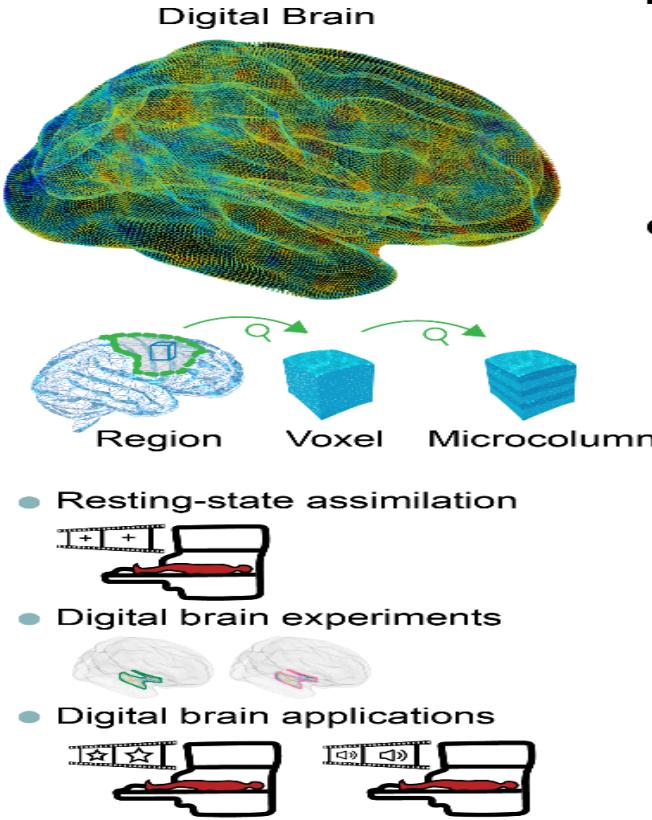
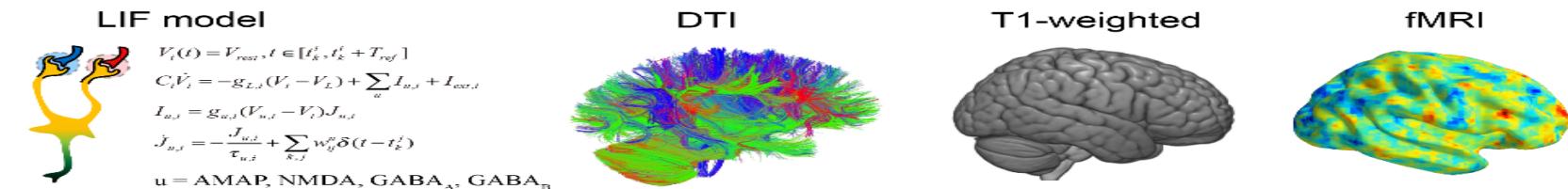
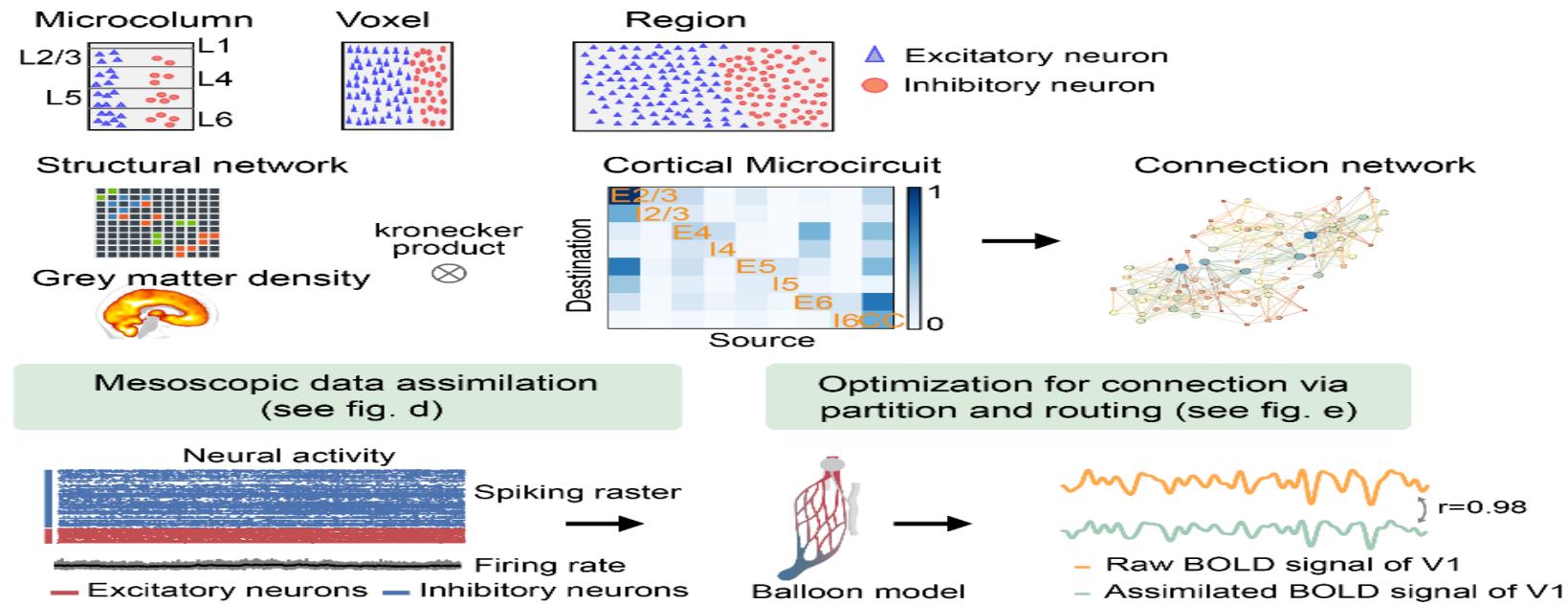


- Mathematicians
- Computer scientists
- Engineers
- Neuroscientists

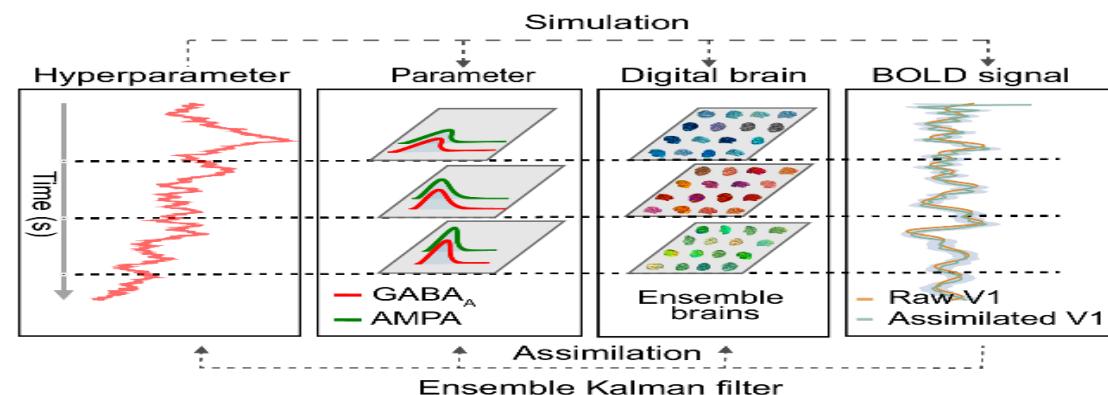


曙光星云超级计算机系统

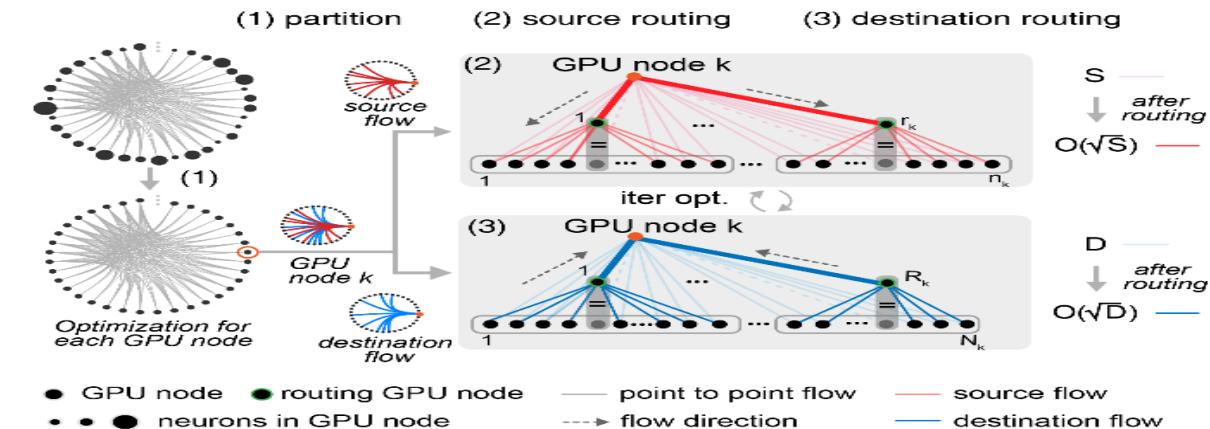
- The largest general purpose computer
- Environment-friendly computer

a**b****c****d**

Mesoscopic data assimilation

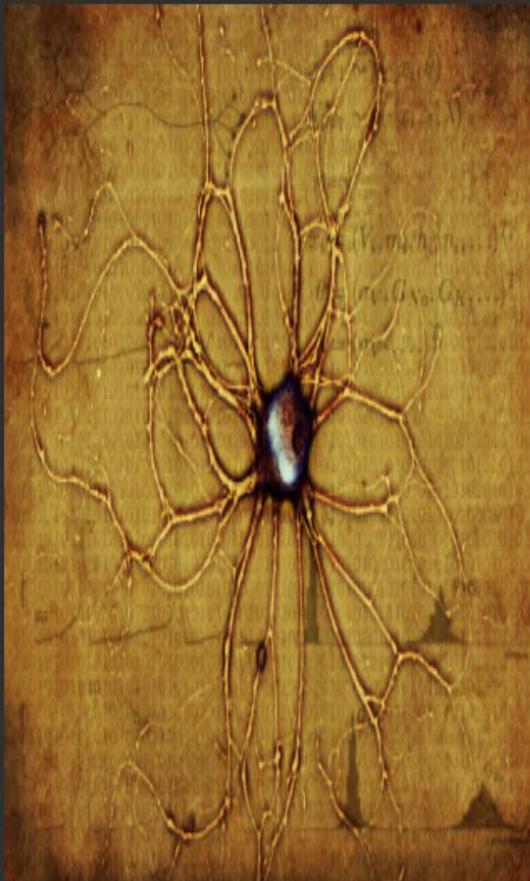
**e**

Optimization for connection via partition and routing



Cover

Nerve cell on worn paper.



This image illustrates a B4 neuron from the mollusk *Lymnaea stagnalis* on a background of mathematical expressions, simulation data, and binary digits, which represent the implicit assumption that nervous systems can be modeled and simulated in a digital computer. In this issue, Vavoulis et al. (10.1371/journal.pcbi.1002401) present a method for estimating dynamic states and parameters in data-driven models of neurons and neural networks based on principles of Bayesian statistics and Sequential Monte Carlo simulation.

Image Credit: Dimitrios V. Vavoulis and Volko A. Straub, the Universities of Warwick and Leicester, United Kingdom, 2012.

Plos Comp Biol, 2012, March.

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数字孪生脑

10月21日下午 14:30-15:00



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上海数学中心首席教授
复旦大学类脑人工智能科学与技术研究院院长
复旦大学大数据学院院长
上海脑科学与类脑研究中心副主任



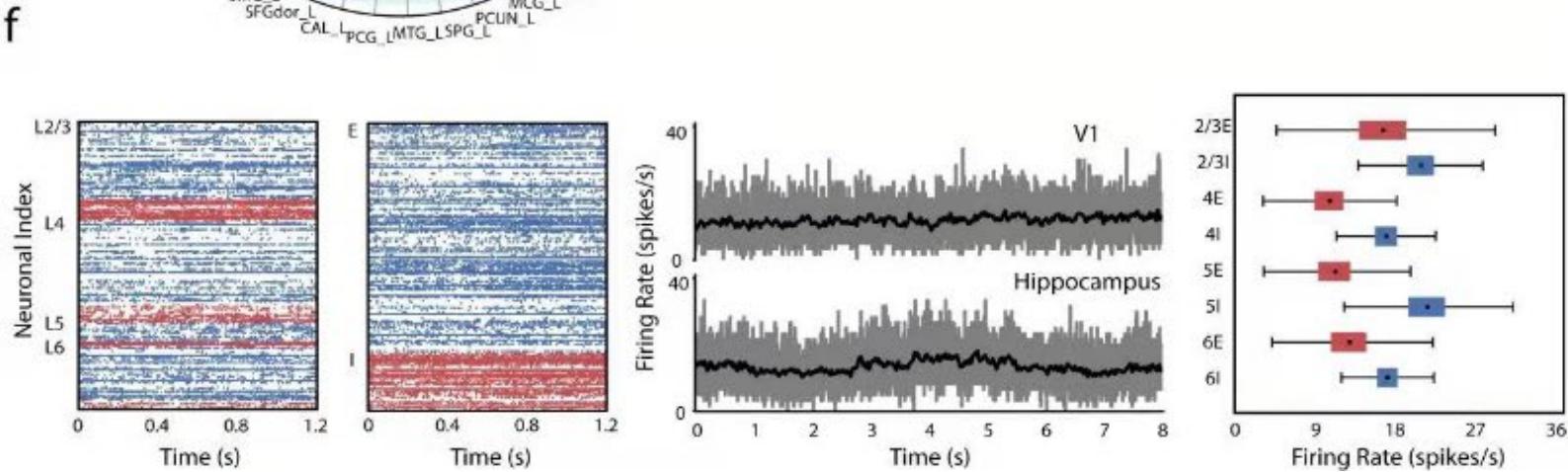
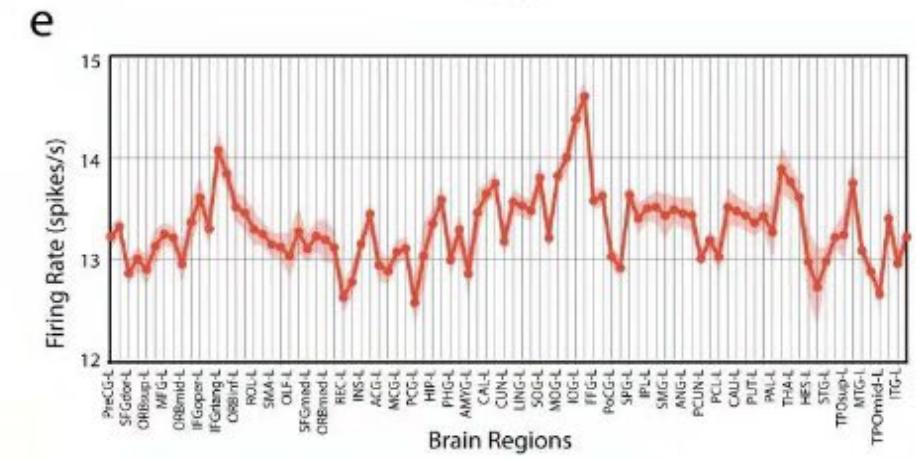
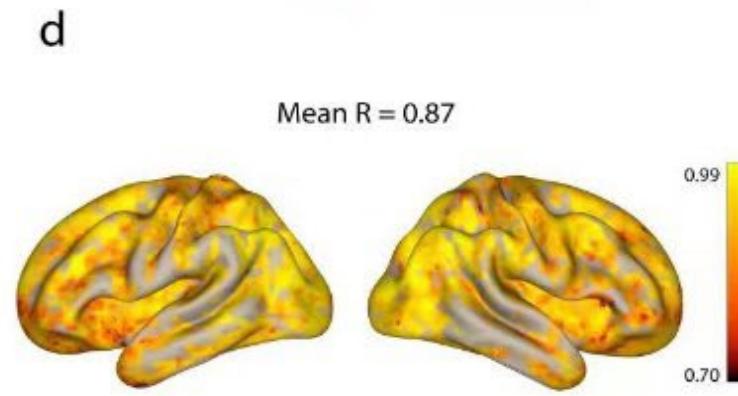
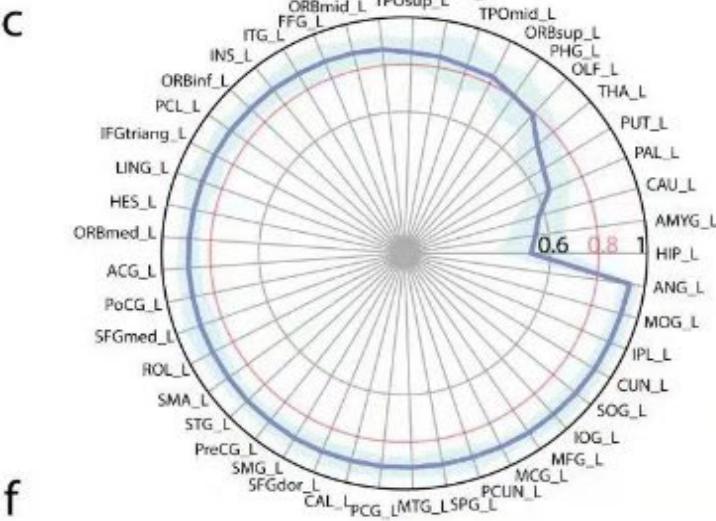
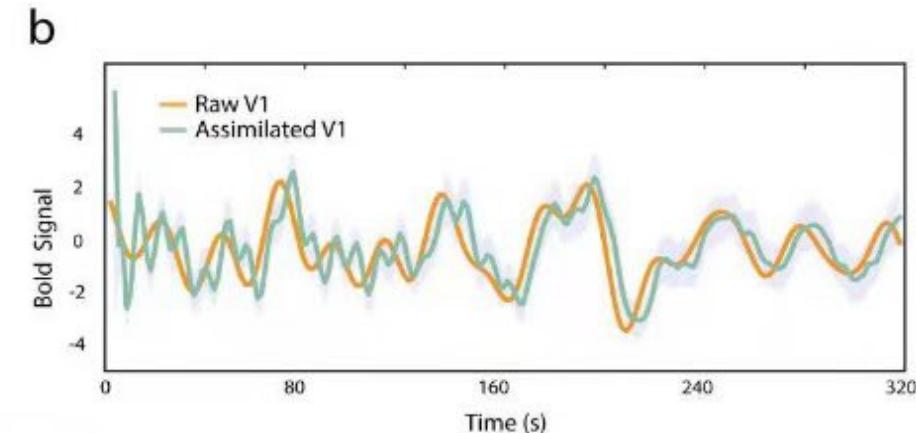
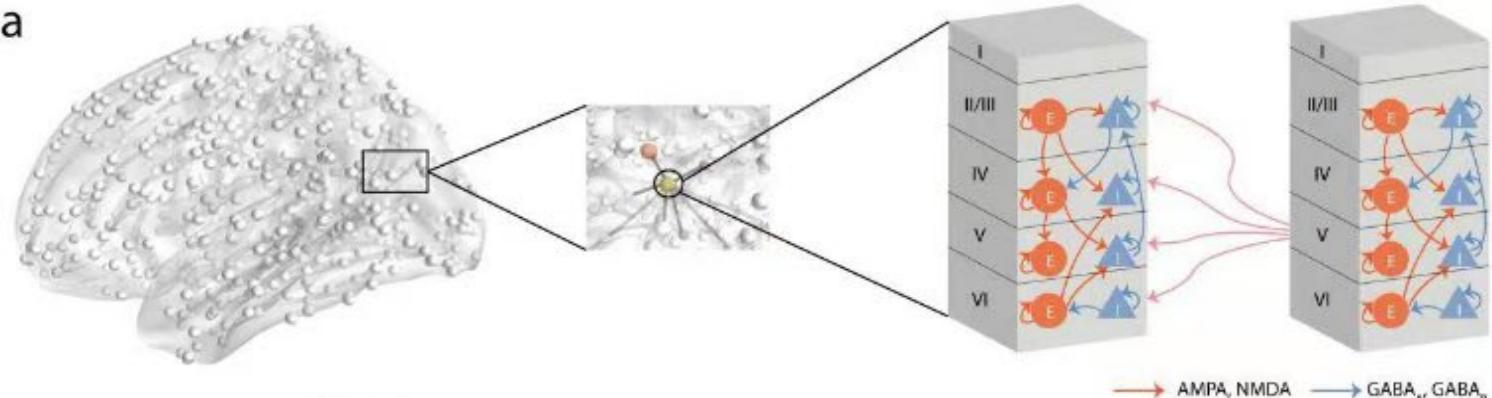
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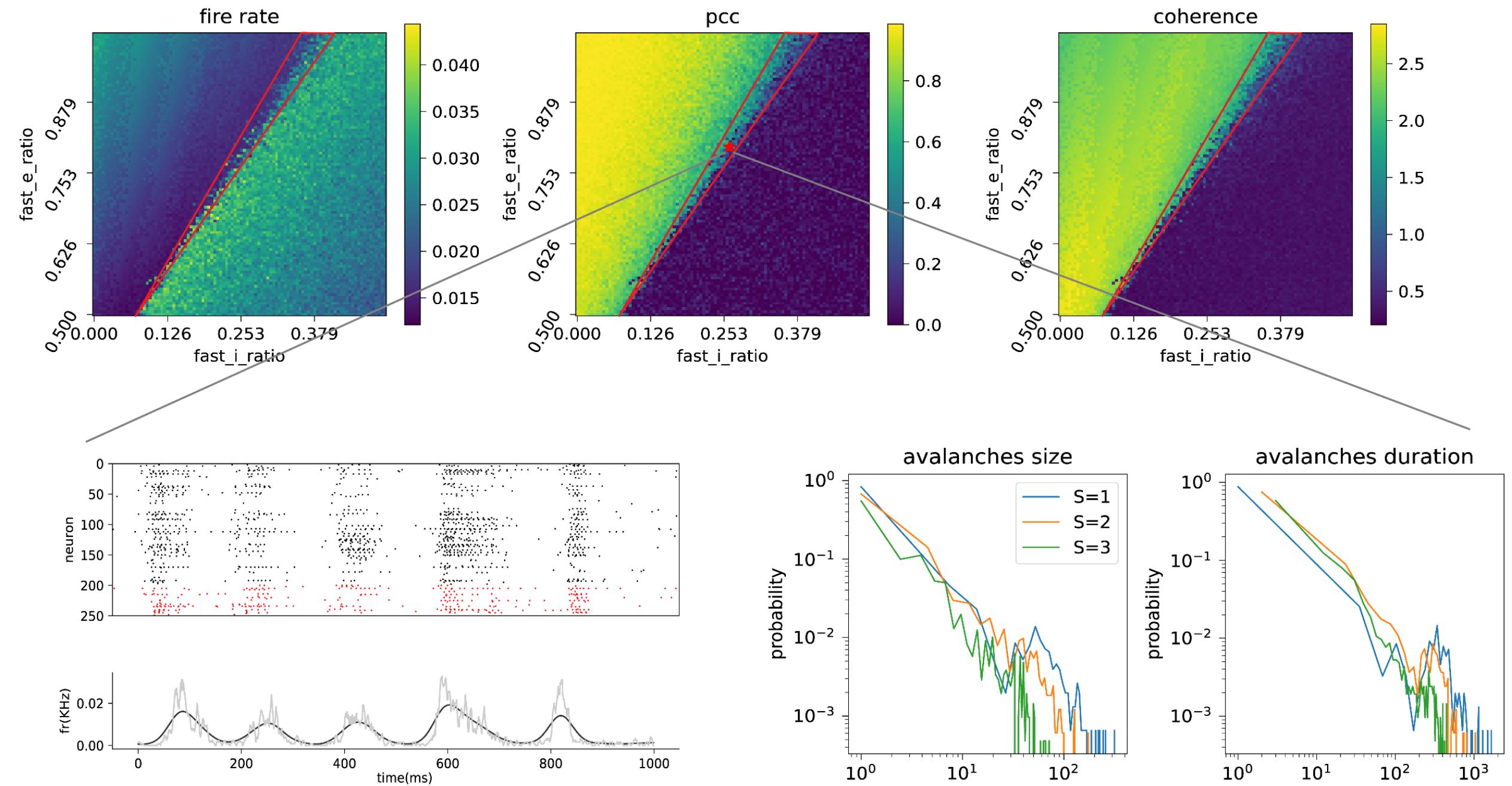
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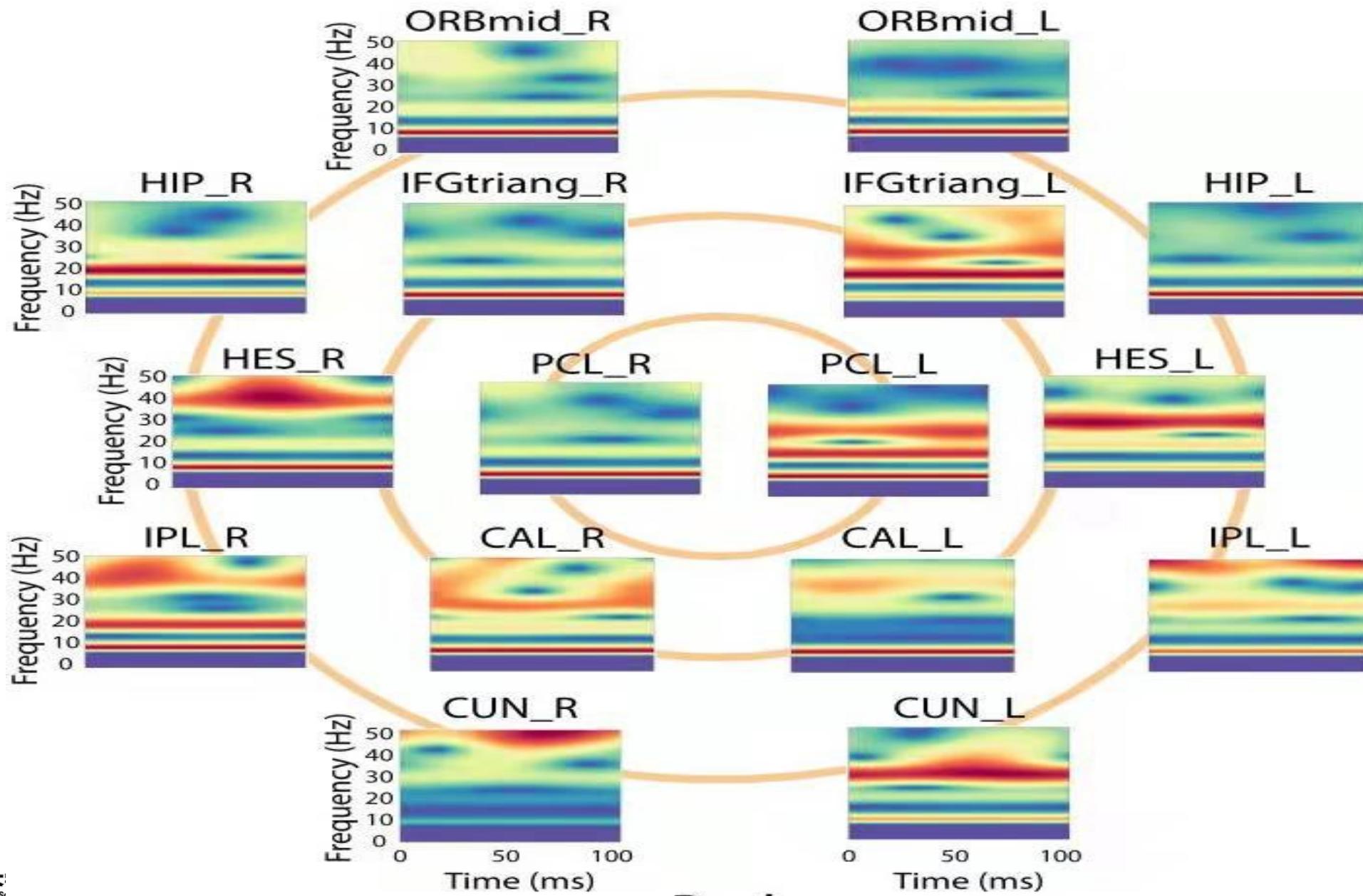
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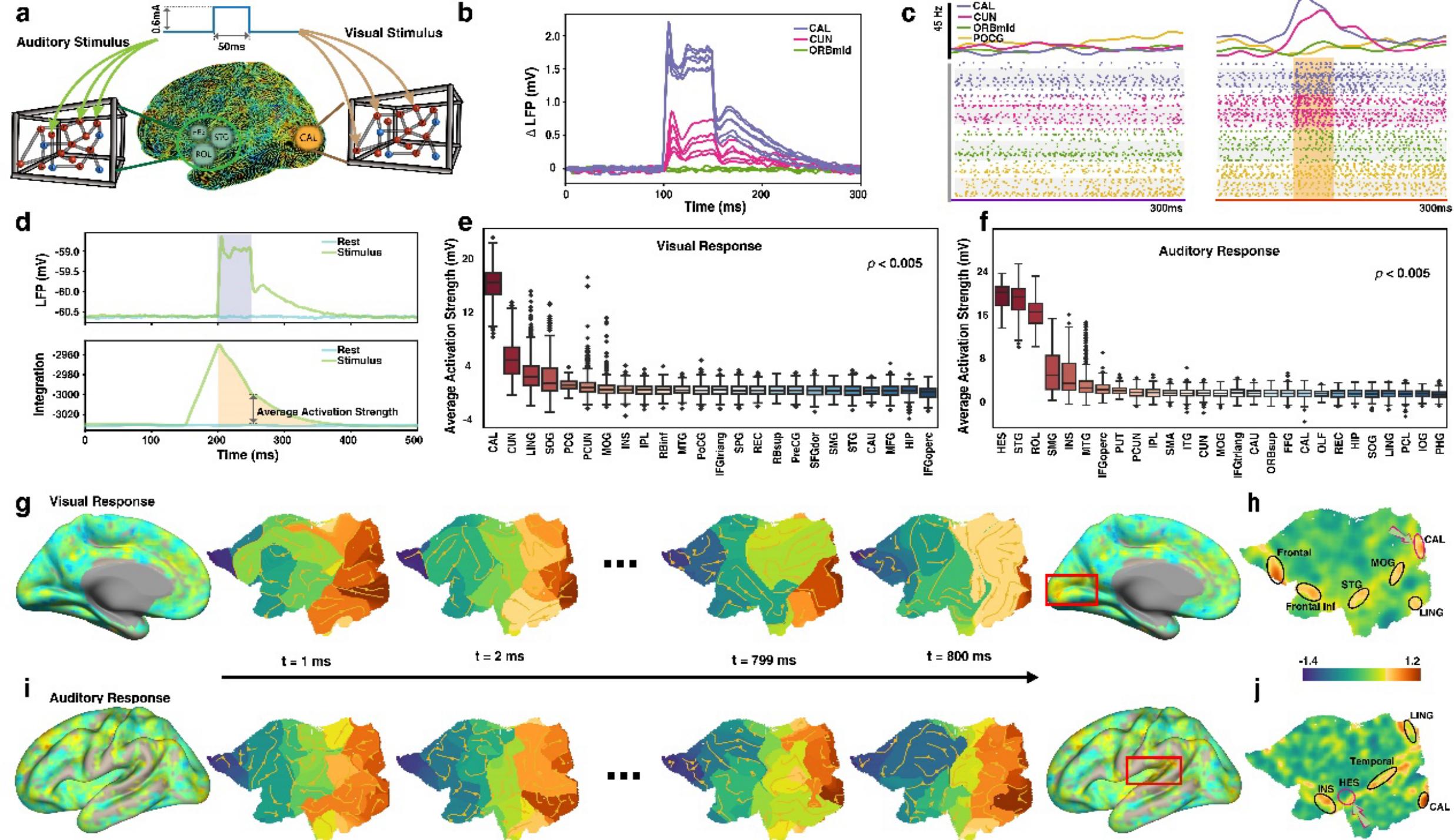


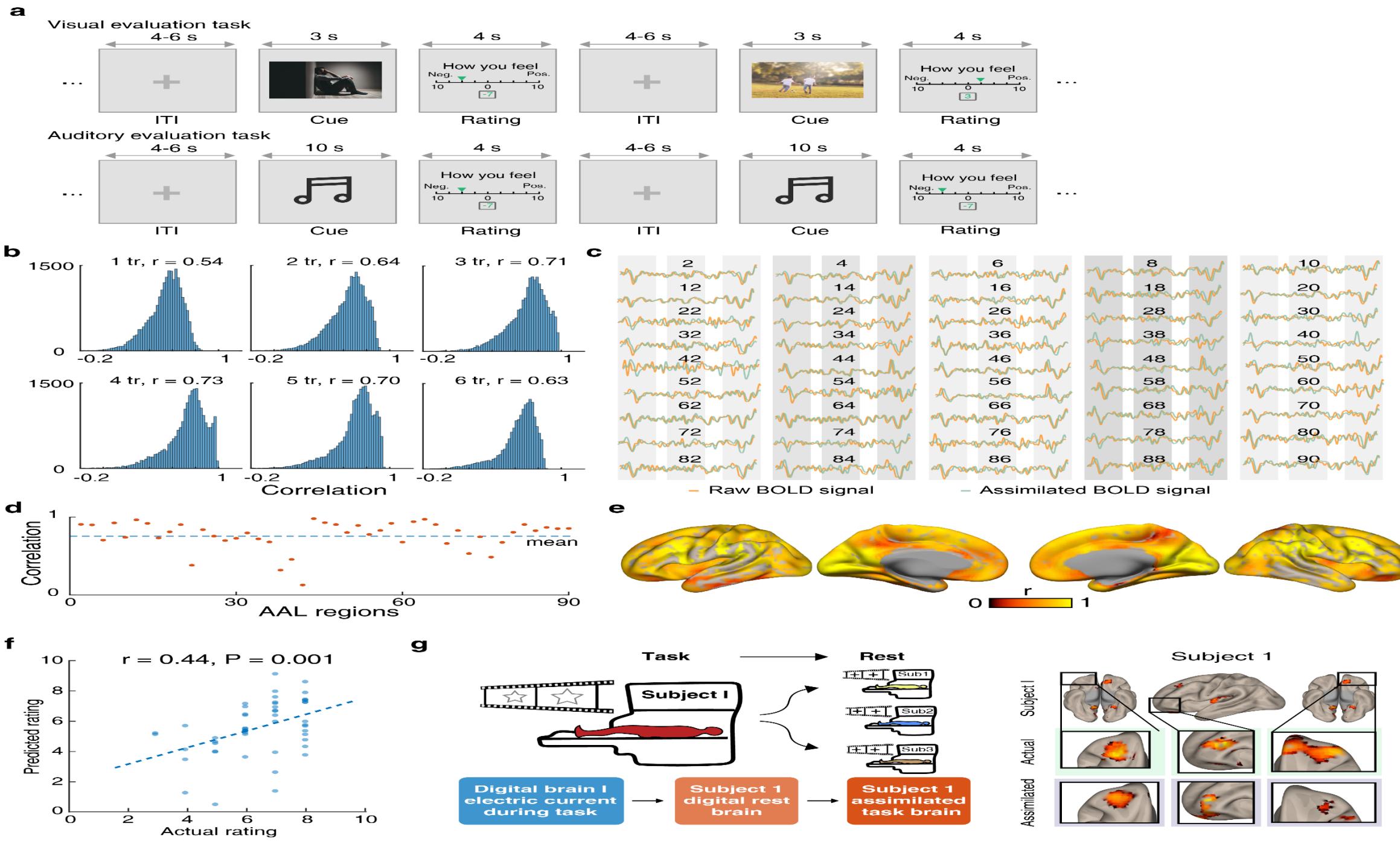


Front



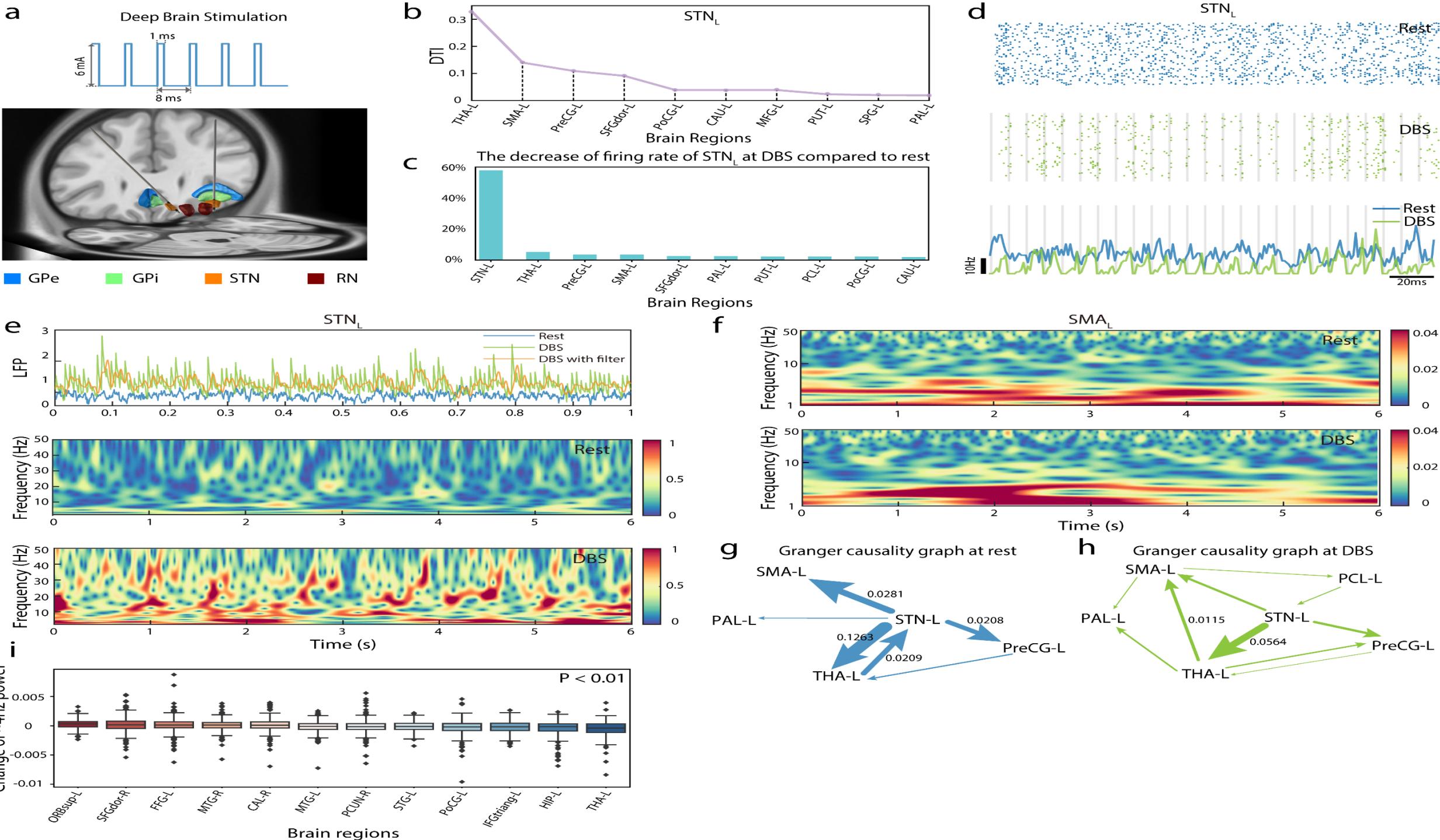
Back



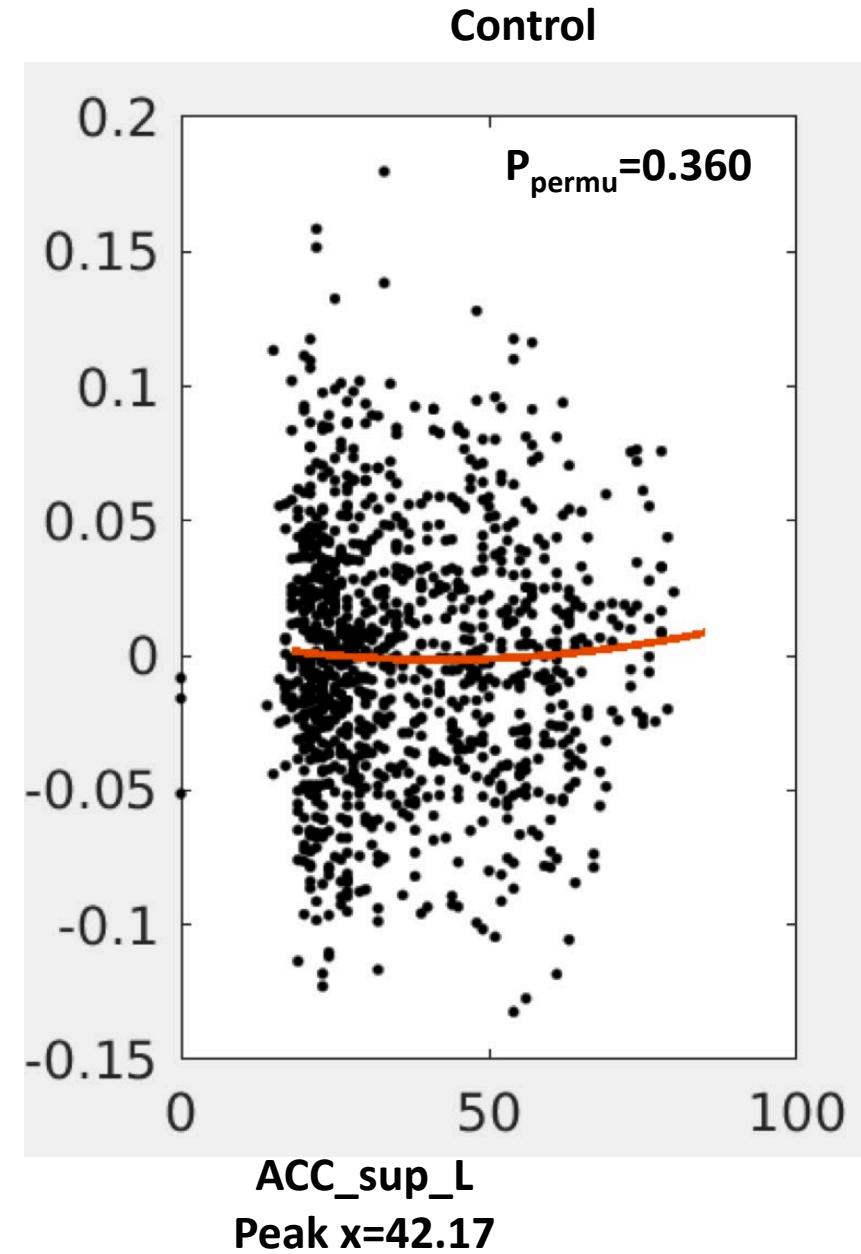
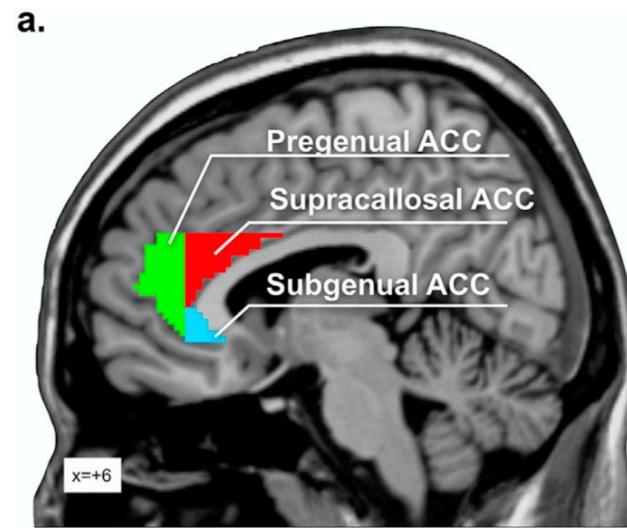
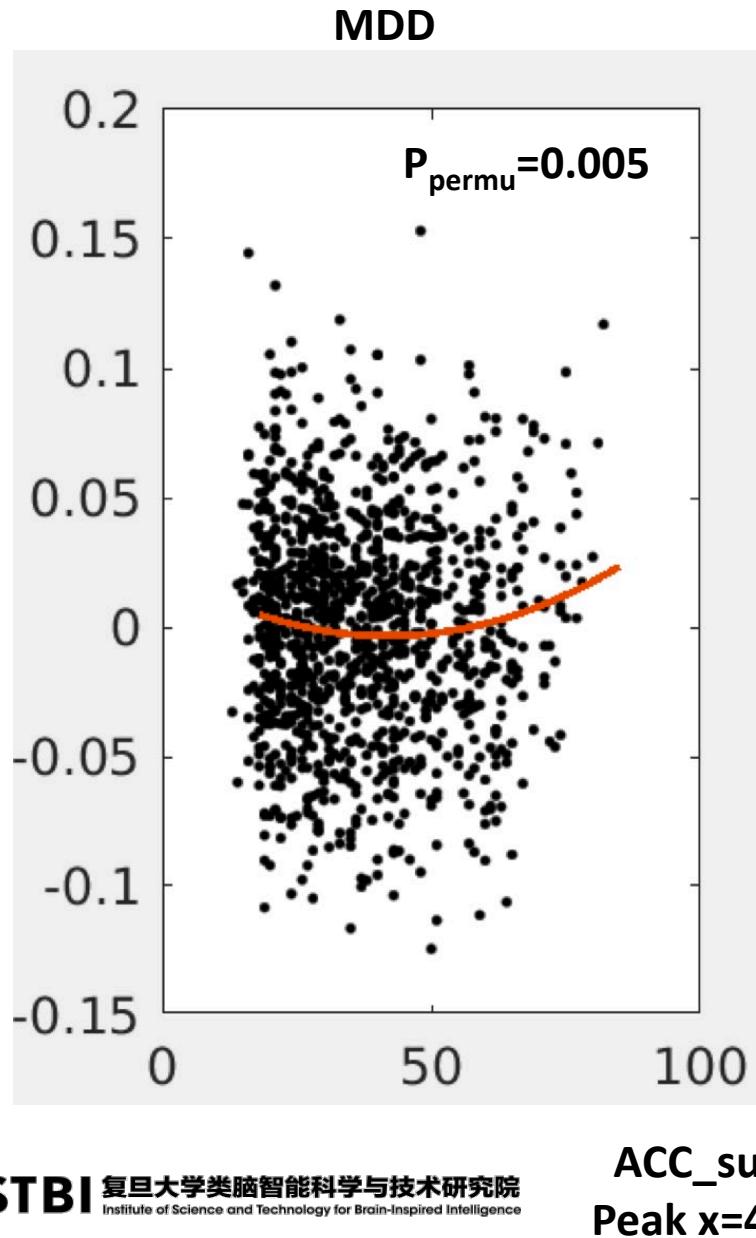


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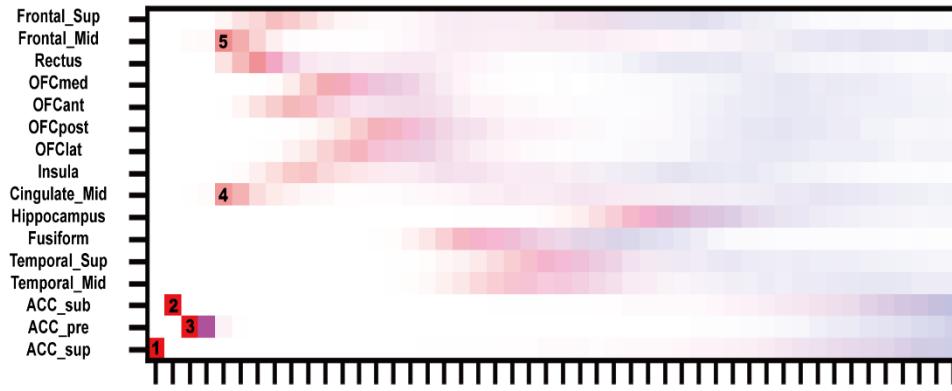


Depression: ACC-based midlife crisis

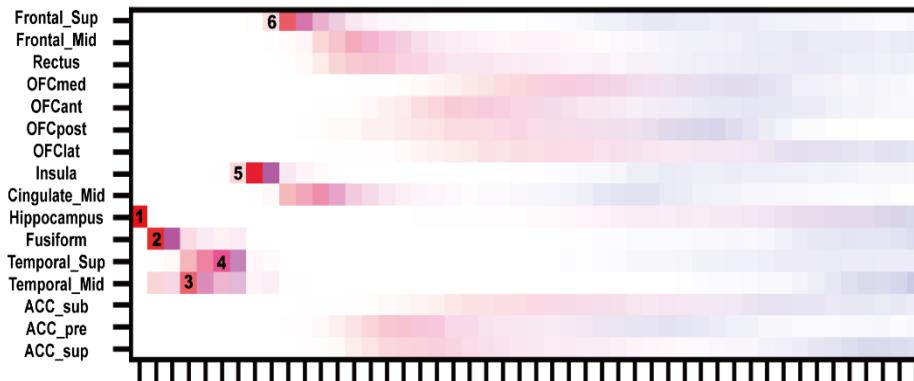


Depression: Two neuroanatomical subtypes

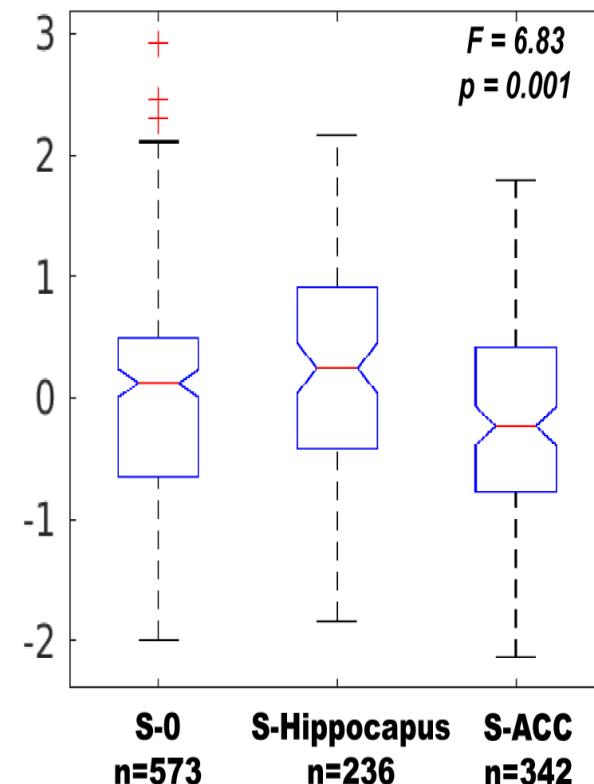
Subtype 1 ($f=0.53$, $n=610$)



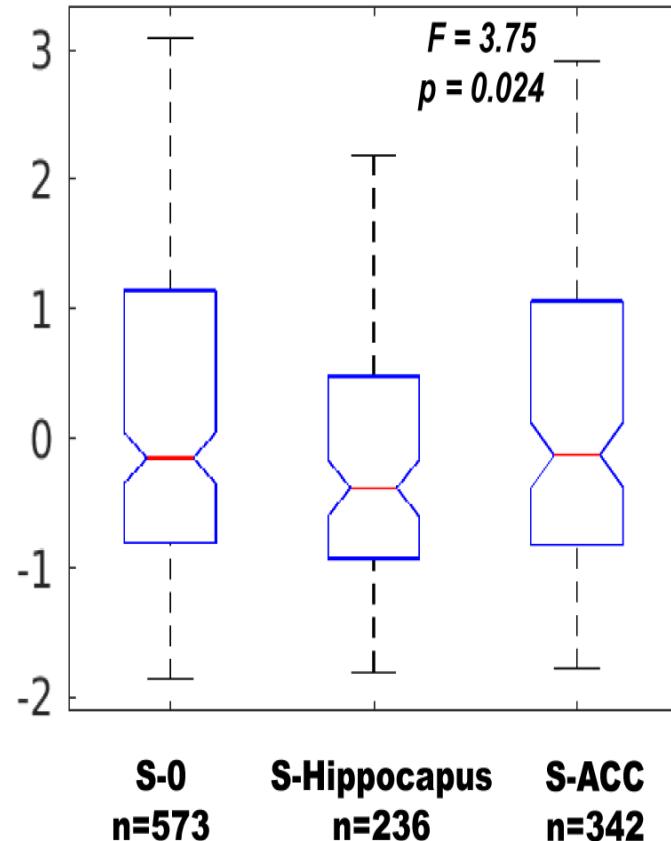
Subtype 2 ($f=0.47$, $n=541$)



HAMD17-Somatic anxiety
Gastrointestinal, indigestion, cardiovascular, palpitations,
headaches, respiratory, genitourinary, etc.

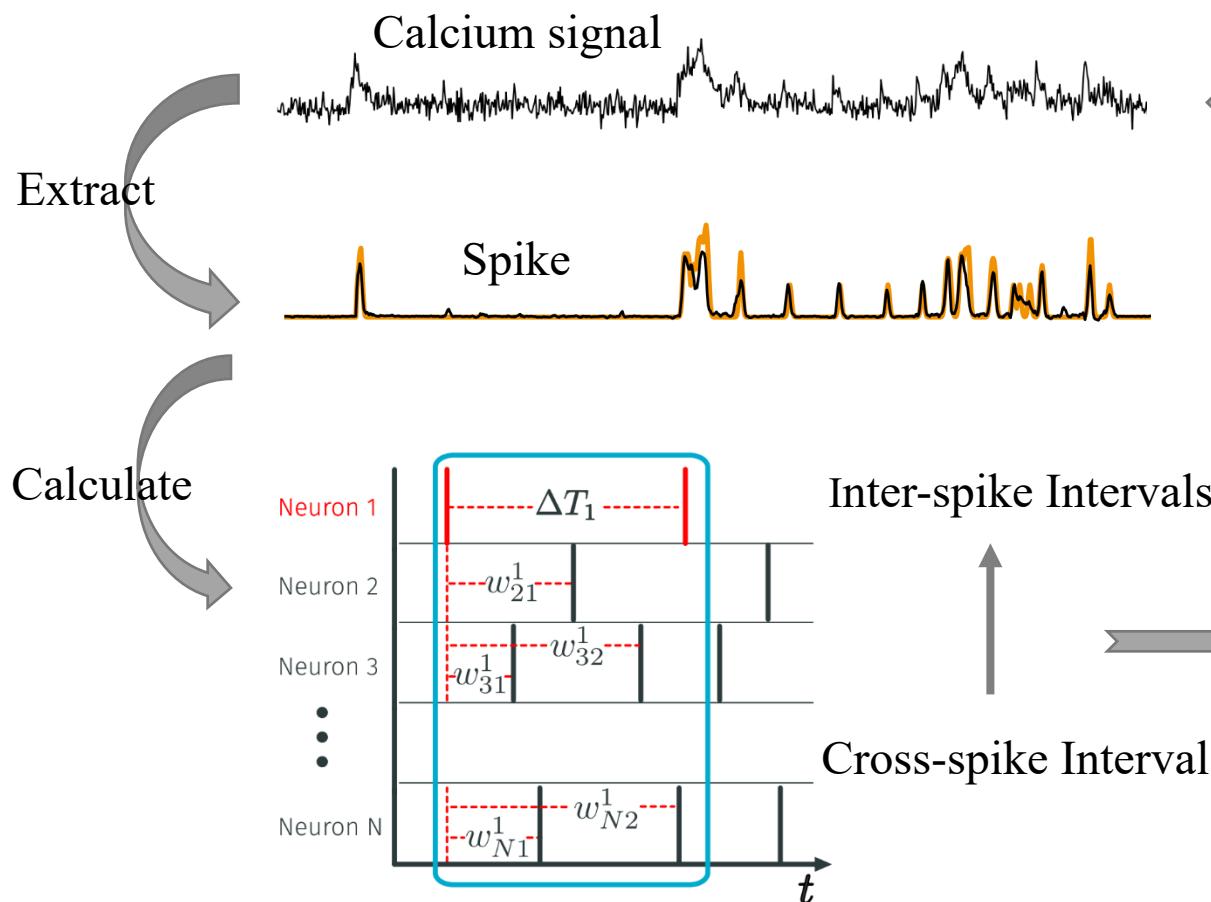


HAMD17 - Suicide



Zebra Fish (Dr Du JL, 100,000 neurons)

Flow Chart

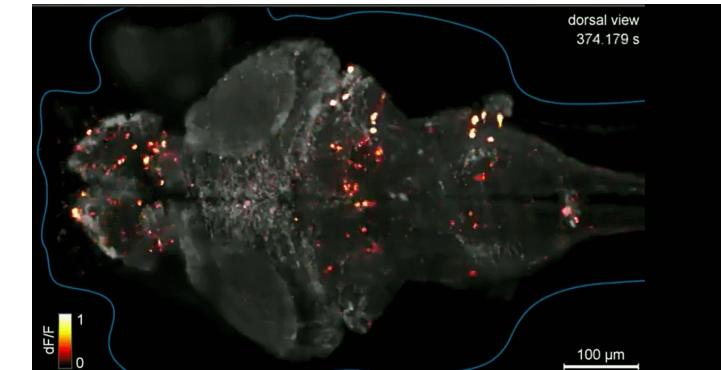


Collect

Infer

Inter-spike Intervals

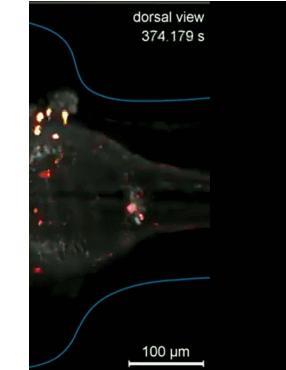
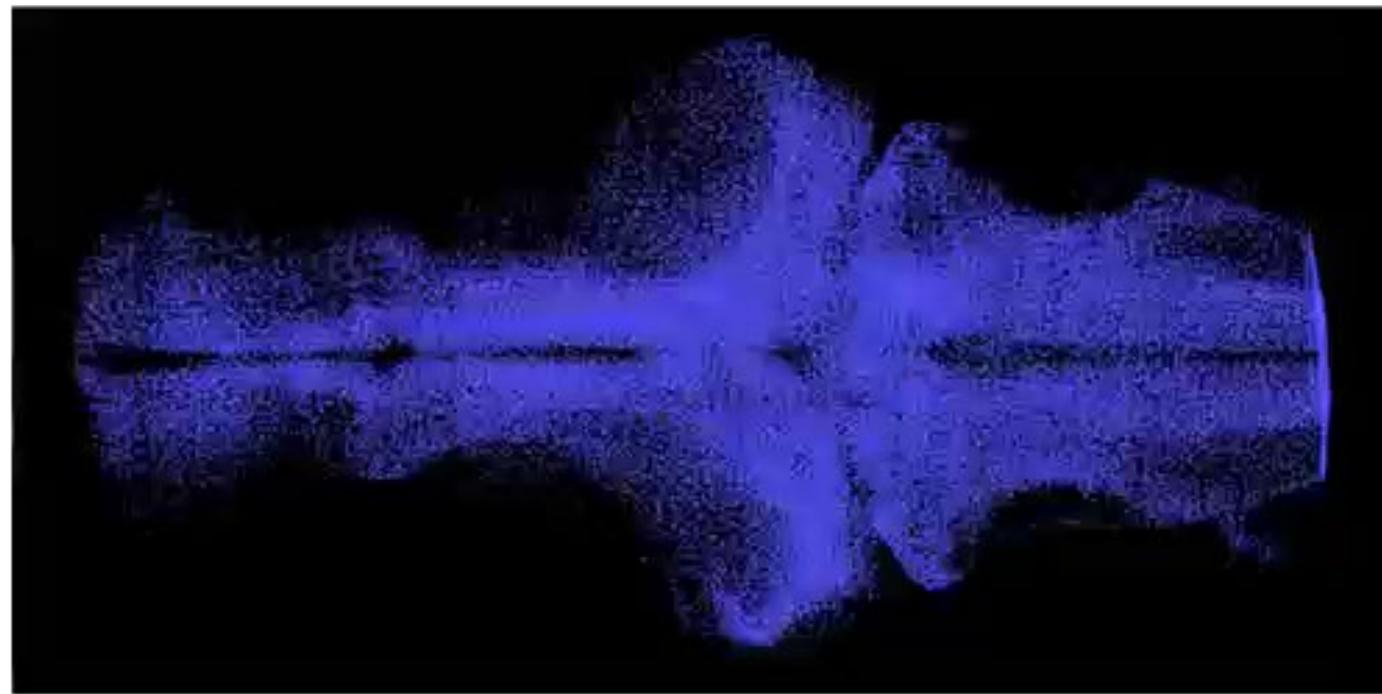
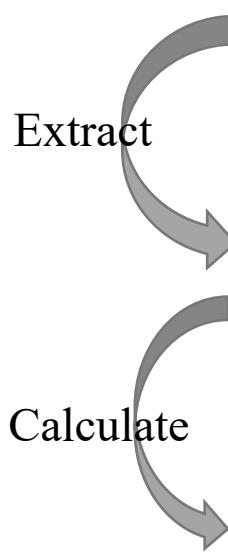
Cross-spike Intervals



Dynamical
Projection

Zebra Fish (Dr Du JL, 100,000 neurons)

Flow Chart



Dynamical
Projection



Hybrid
OA

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BJPsych

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