



兰州市第三人民医院  
THE THIRD PEOPLE'S HOSPITAL OF LANZHOU



西北师范大学  
NORTHWEST NORMAL UNIVERSITY



心理学院

# 人工智能与认知建模在精神分裂症 执行功能研究中的应用

报告人：张统一

[tyzhang9804@gmail.com](mailto:tyzhang9804@gmail.com)

西北师范大学心理学院 2024级心理学博士生

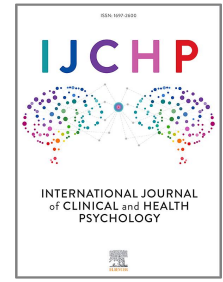
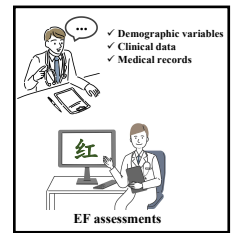
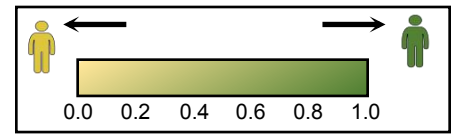
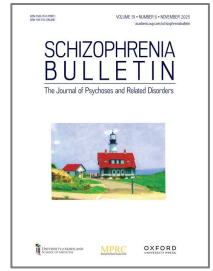
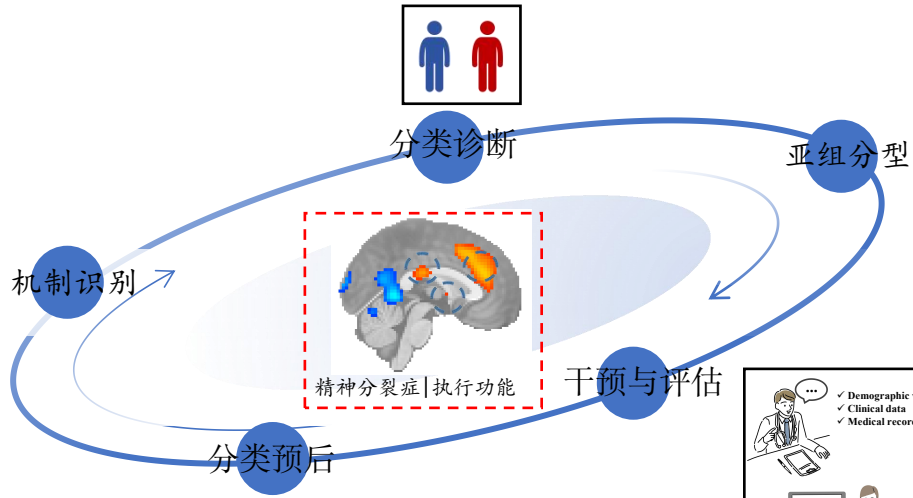
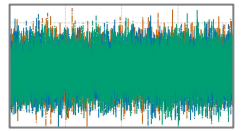
导师：赵鑫教授

兰州市第三人民医院 2025年12月05日



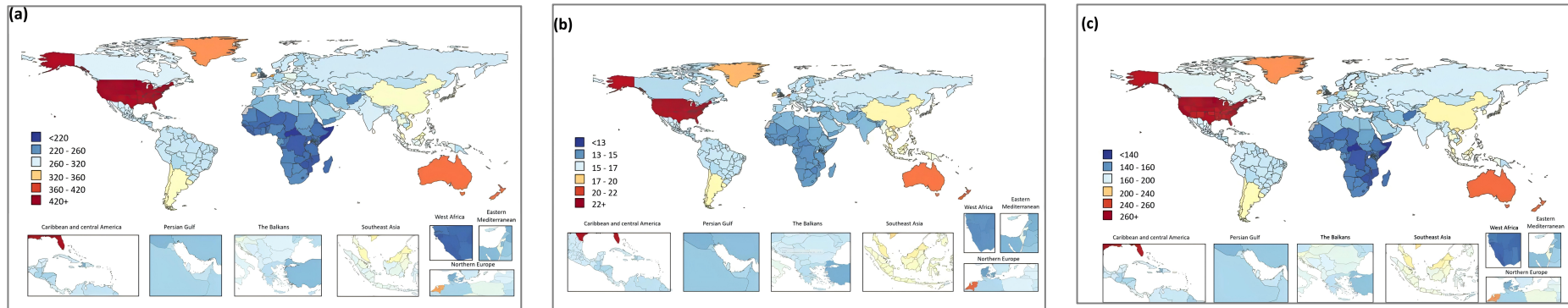
## 01 精神分裂症执行功能系列研究：与三院合作成果

## 02 课题组最新进展：大语言模型在心理健康中的应用








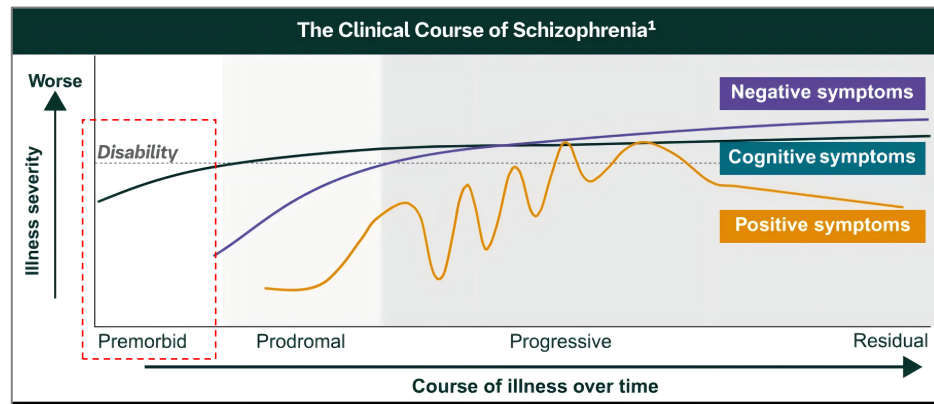
- 精神分裂症(Schizophrenia, SCZ)是一类病理机制复杂且高度异质性的慢性精神障碍
- 核心症状主要包括阳性症状、阴性症状以及认知损伤 (Owen et al., 2016, *The Lancet*)
- 以早发性、低恢复率、高复发性以及遗传倾向为特征 (Charlson et al., 2018, *Schizophrenia bulletin*)
- 患者通常面临高失业率和多种并发症
- 给患者个人和家庭带来沉重负担 → 对社会造成了极大的经济和社会压力



➤ 全球约**2400万**患者，患病率近**1%** (Marder & Cannon, 2019, *New England Journal of Medicine*)

➤ 我国患者人数达**680万** (Huang et al., 2019, *Lancet Psychiatry*)

Domains of Schizophrenia		
 <b>Positive symptoms<sup>1-4</sup></b> <b>PREVALENCE:</b> 100% of patients	 <b>Negative symptoms<sup>1,2,5,6</sup></b> <b>PREVALENCE:</b> over 60% of patients	 <b>Cognitive Symptoms<sup>1,5,7,8</sup></b> <b>PREVALENCE:</b> ~80% of patients
<b>Psychosis symptoms</b> <ul style="list-style-type: none"> <li>Delusions (unusual beliefs not based on reality)</li> <li>Hallucinations</li> </ul>	<b>Experiential symptoms</b> <ul style="list-style-type: none"> <li>Anhedonia (lack of pleasure)</li> <li>Avolition (loss of motivation)</li> <li>Asociality (social withdrawal)</li> </ul>	<b>Deficits across cognitive domains</b> <ul style="list-style-type: none"> <li>Attention and concentration</li> <li>Emotion processing</li> <li>Learning and memory</li> <li>Reasoning and problem solving</li> <li>Speed of processing (ability to process and respond to visual and verbal information)</li> <li>Theory of mind (ability to understand other's mental states)</li> <li>Social functioning</li> <li>Verbal fluency</li> </ul>
<b>Movement disorders</b> <ul style="list-style-type: none"> <li>Inability to move normally, with agitated body movements</li> <li>Psychomotor immobility</li> </ul>	<b>Expression symptoms</b> <ul style="list-style-type: none"> <li>Alogia (decreased content or amount of speech)</li> <li>Flat affect (reduced facial and vocal expression)</li> </ul>	
<b>Thought disorders</b> <ul style="list-style-type: none"> <li>Disorganized speech</li> </ul>		
Multiple FDA-approved pharmacological treatment options are available for positive symptoms <sup>9</sup>	There are no FDA-approved treatments indicated for patients with cognitive or negative symptoms <sup>1,10</sup> 抗精神药物的治疗效果较差	



核心症状主要包括**阳性症状**、**阴性症状**以及**认知损伤** (Owen et al., 2016, *The Lancet*)

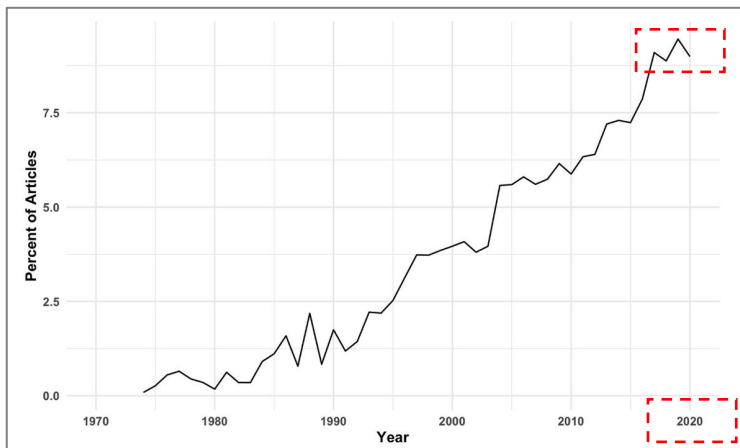


图1 精神分裂症认知障碍研究文献增长趋势

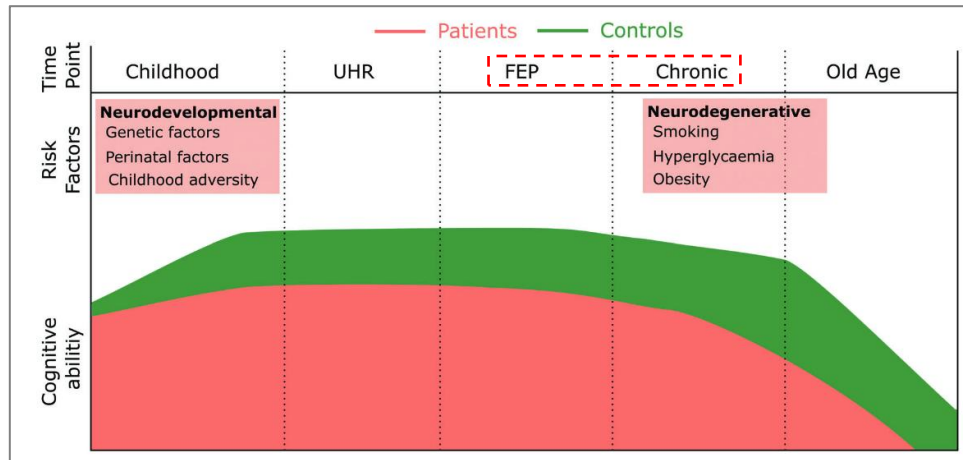


图2 精神分裂症认知障碍随年龄的变化趋势



**执行功能（Executive Functions, EFs）**作为认知核心，与精神分裂症的核心病理过程关联最为紧密，被广泛视为解码精神分裂症病理机制的关键途径（Barch & Ceaser, 2012, *Trends Cogn. Sci.*; Barch & Sheffield, 2014, *World Psychiatry*; Eisenberg & Berman, 2010, *Neuropsychopharmacol.*; Kerns et al., 2008, *Biol. Psychiatry*）。

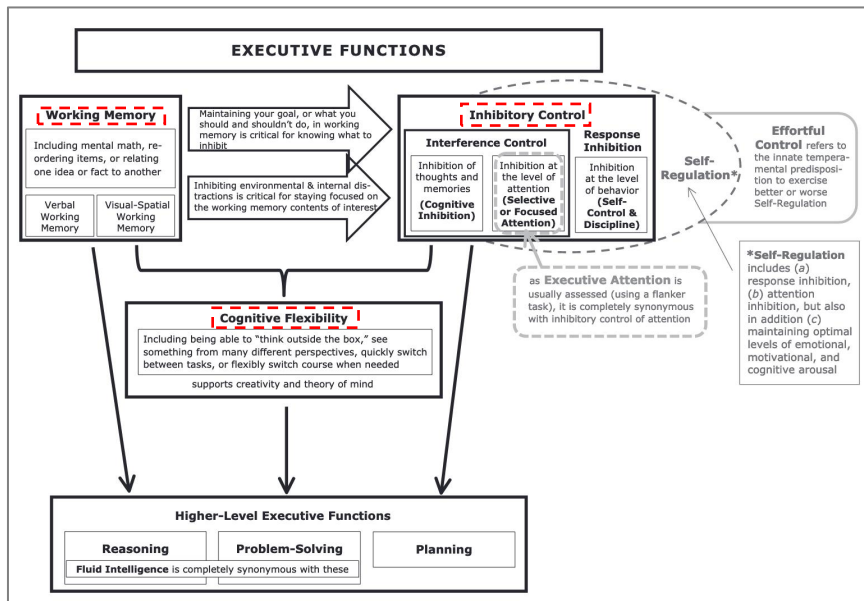


图1 执行功能的理论模型

(Diamond, 2013, *Annual Review of Psychology*)

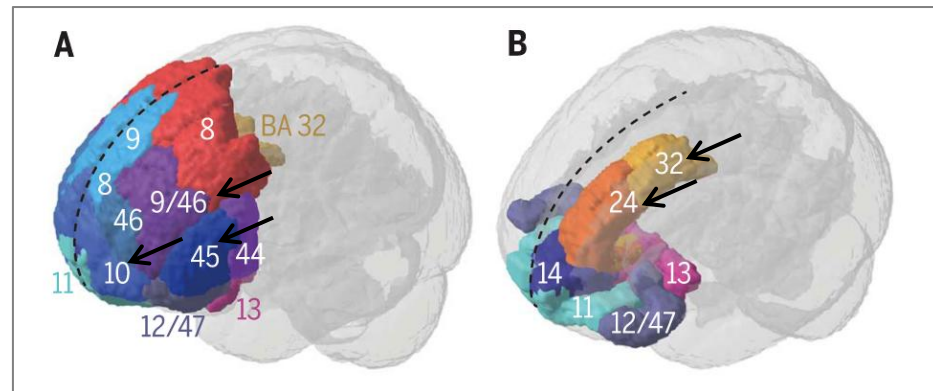
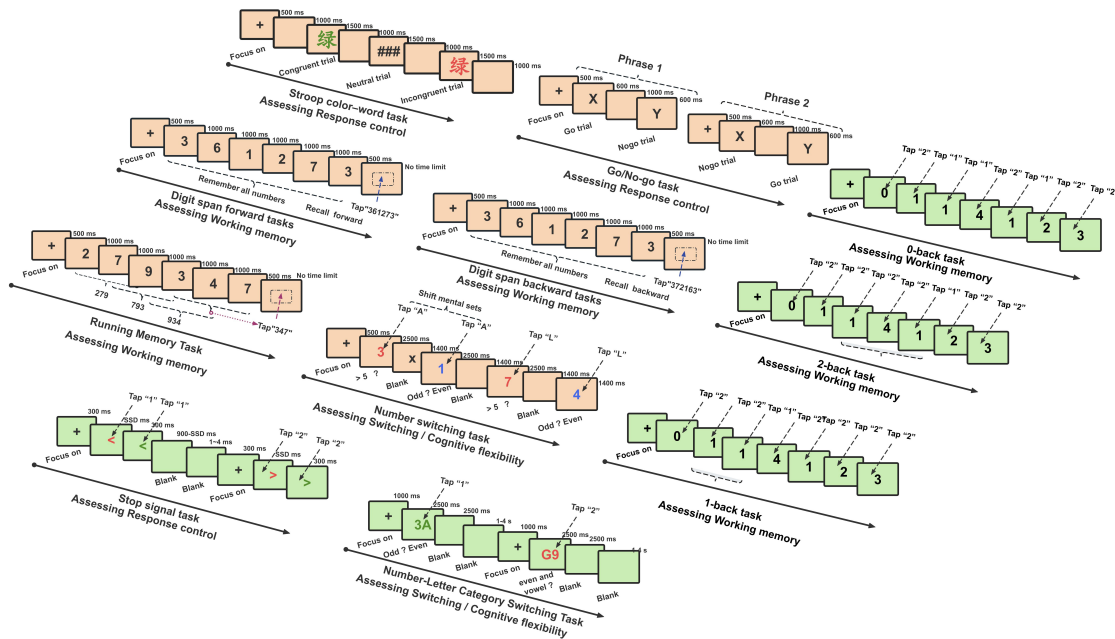


图2 执行功能的生物学基础

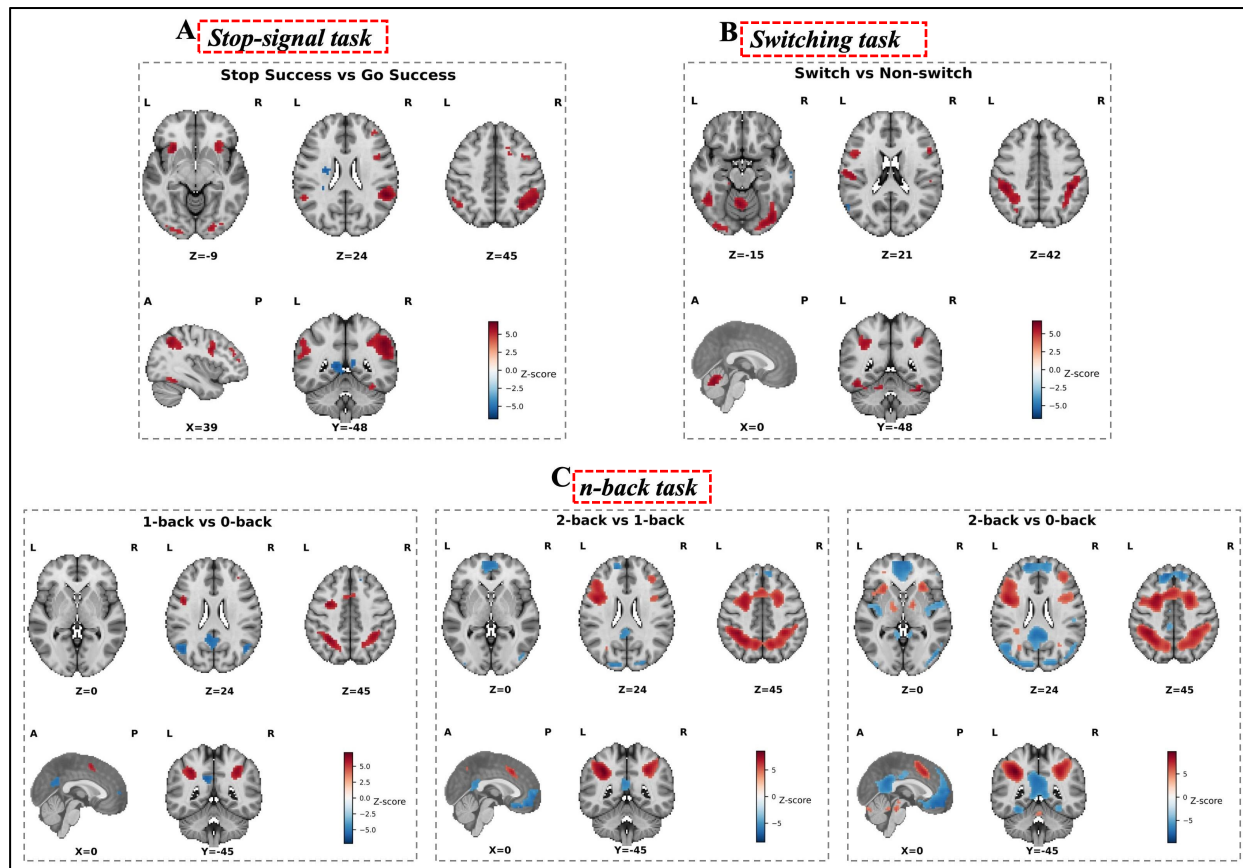
(Carlén, 2017, *Science*)

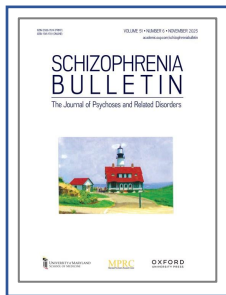
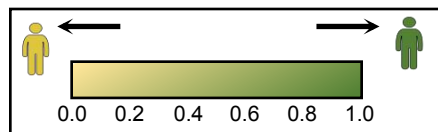
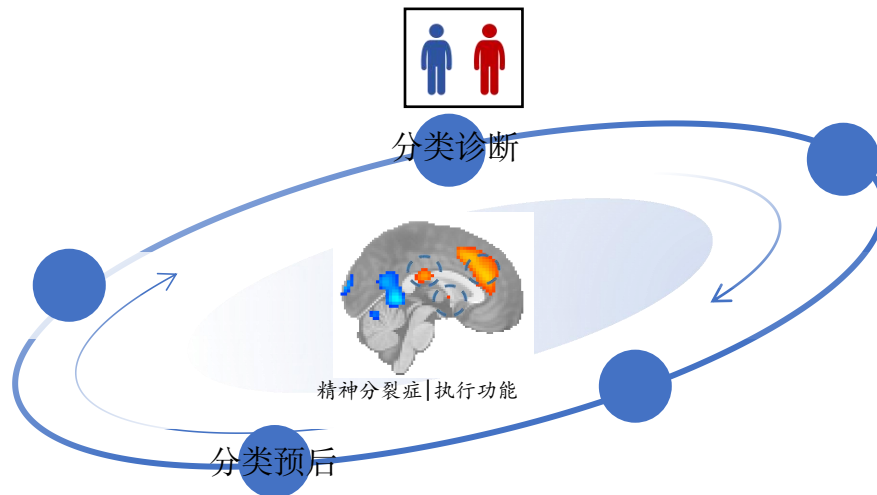


## 执行功能的行为测量与评估

(Zhao et al., 2018, *Developmental Science*)

# 不同执行功能子成分的脑区激活模式





# 第一项研究：精神分裂症的分类诊断与预后预测

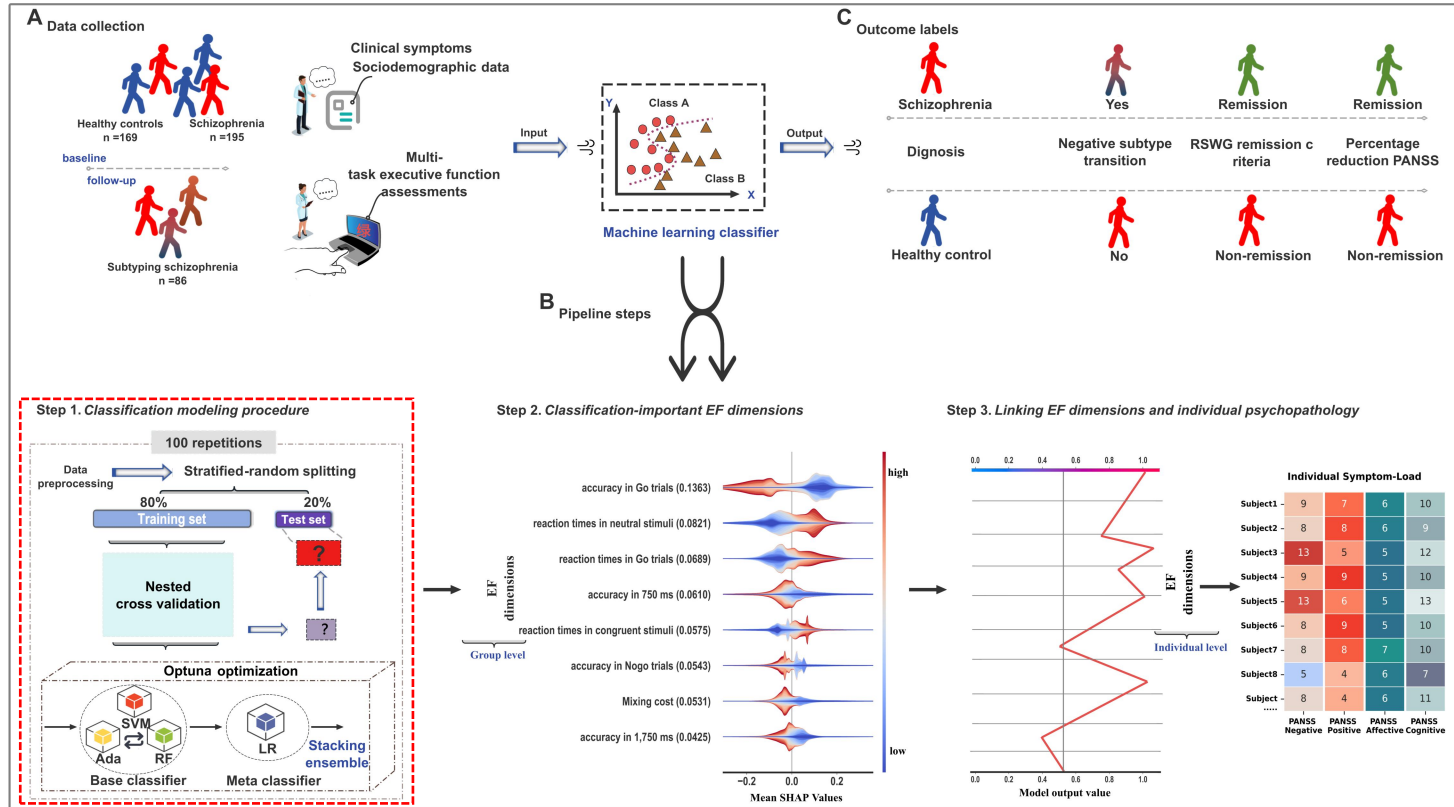
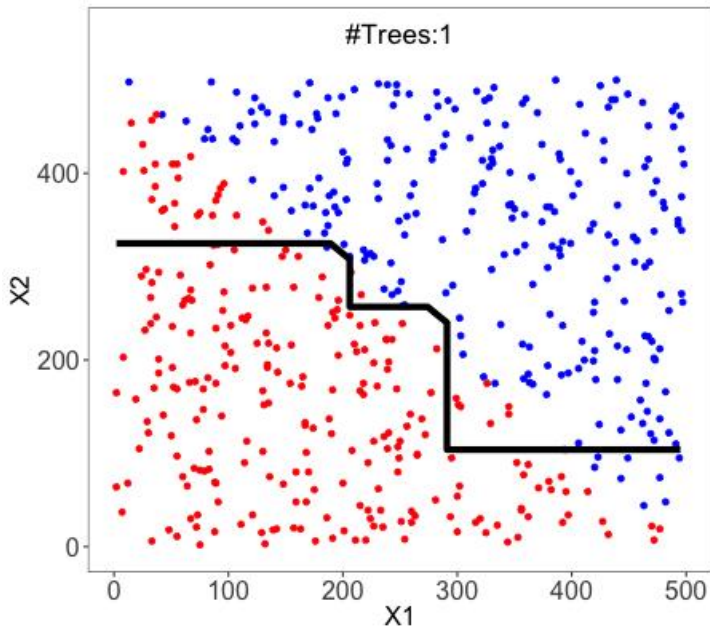
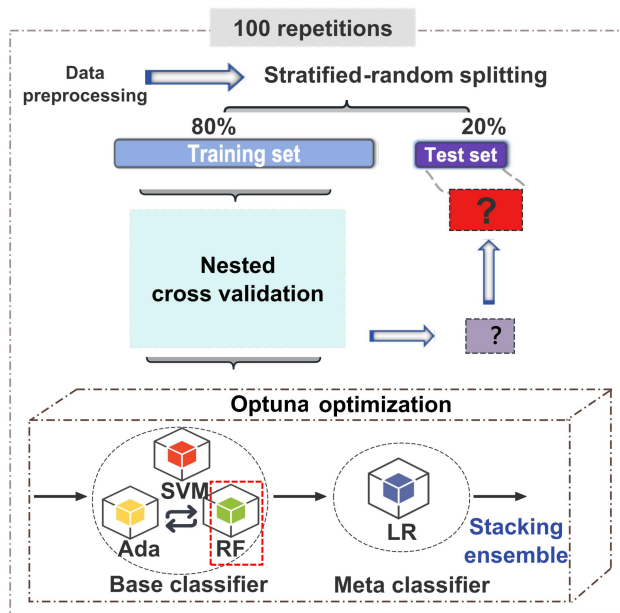


图1 研究设计与分析流程图

## Step 1. Classification modeling procedure



机器学习分类流程（以随机森林算法为例）

# 第一项研究：精神分裂症的分类诊断与预后预测

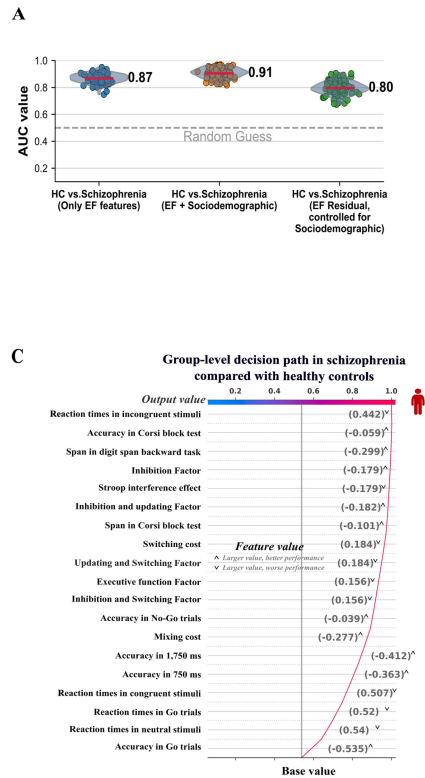


图2 诊断分类性能与特征重要性

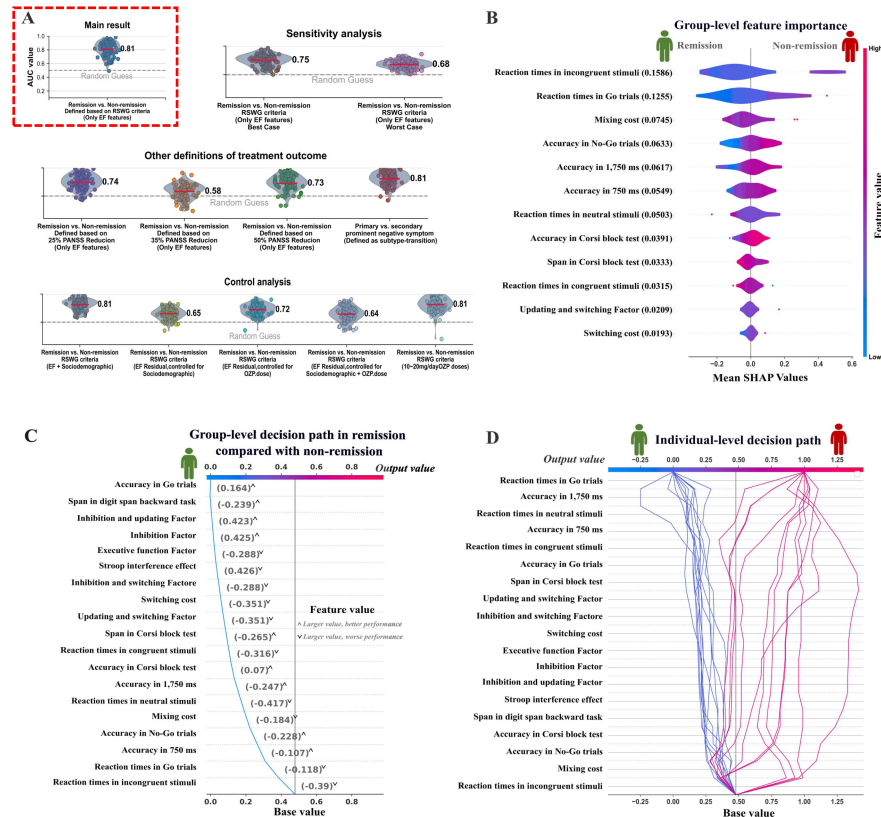
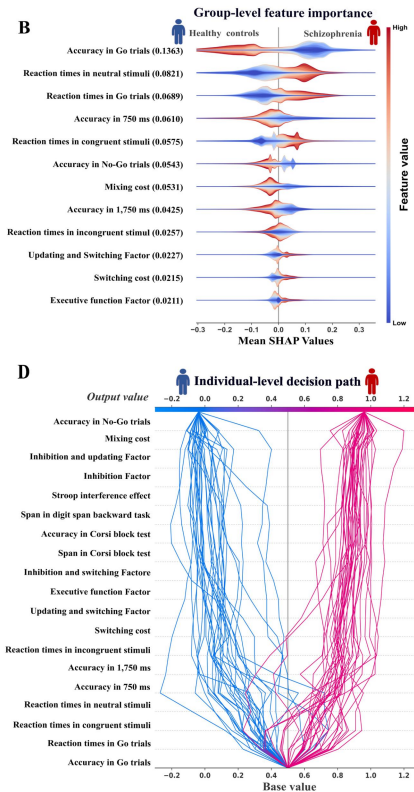
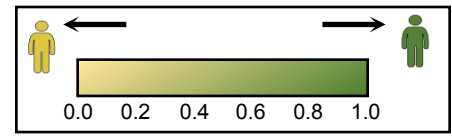
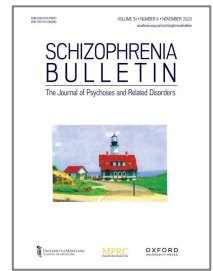
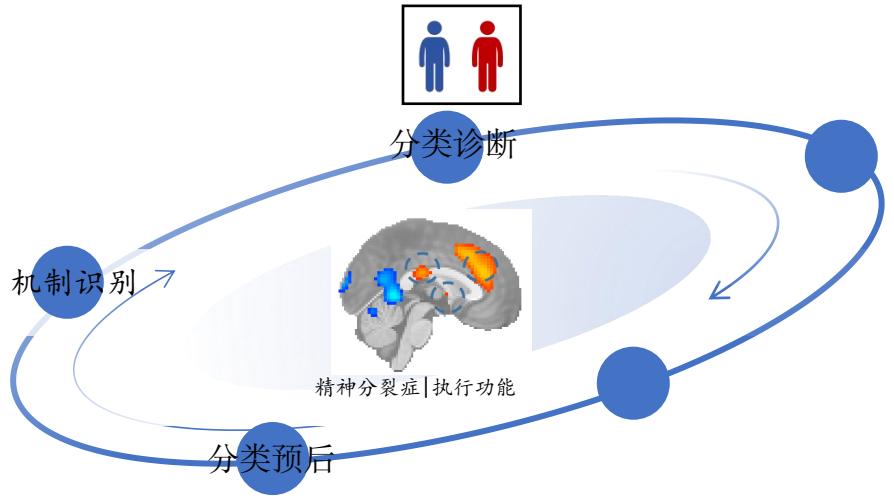
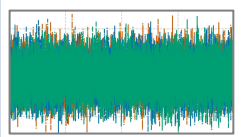
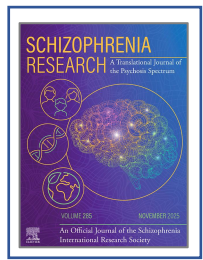


图3 预后预测性能与特征重要性



# 第二项研究：计算机制识别

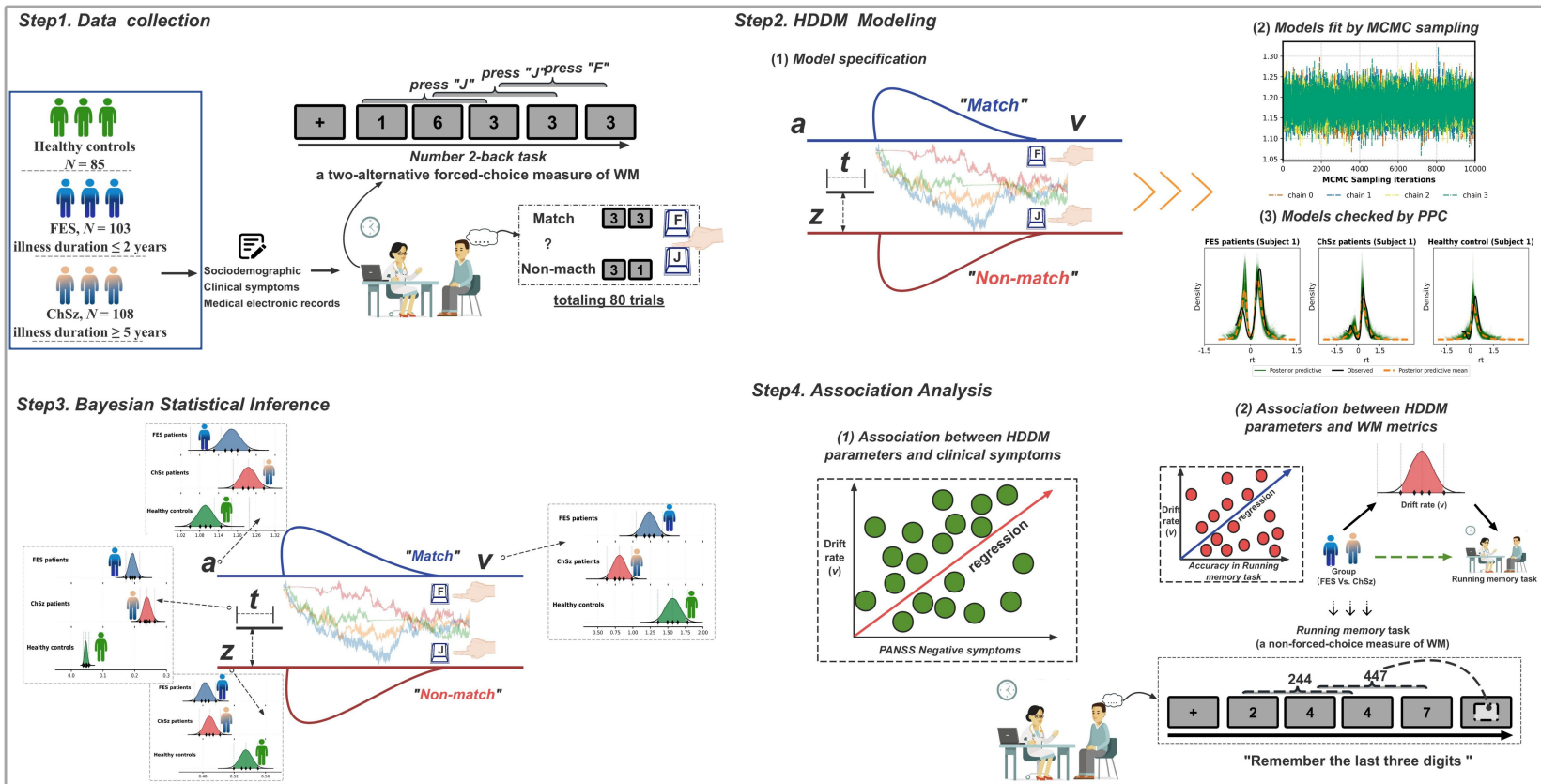
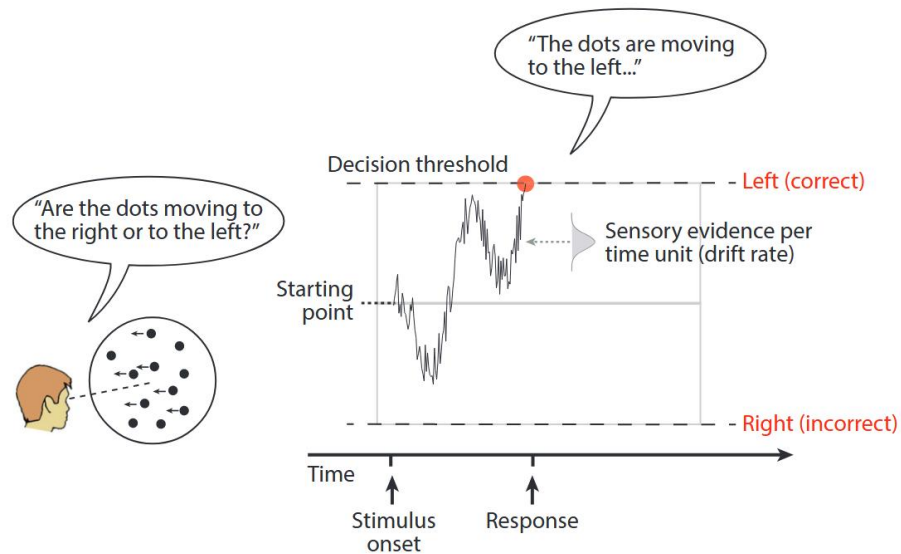
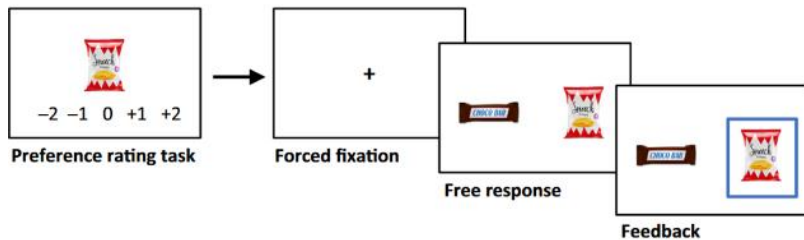
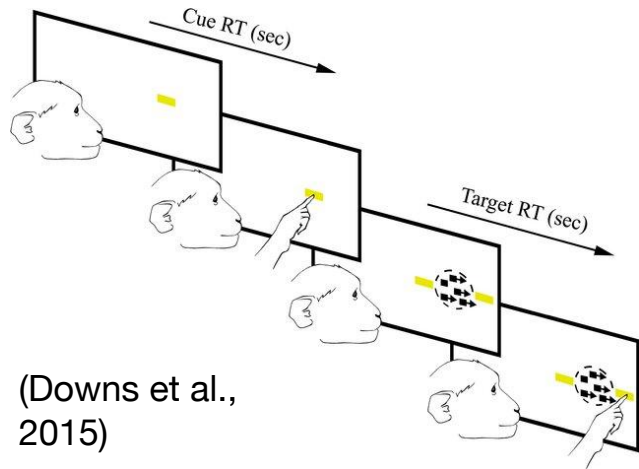
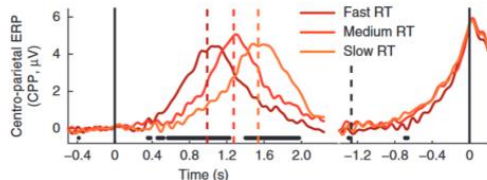
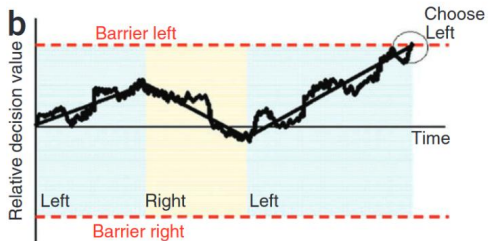
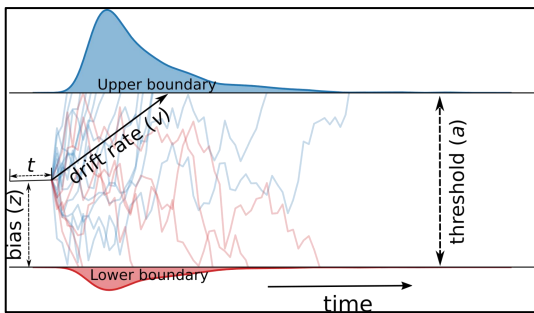
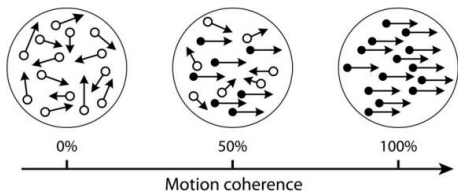


图1 研究设计与分析流程图





中央顶叶正波 (centro-parietal positivity, CPP) (O'Connell et al., 2012)



why  
(phenomenon or problem)

Computational Level



what  
(mechanism or rules)

Algorithmic Level

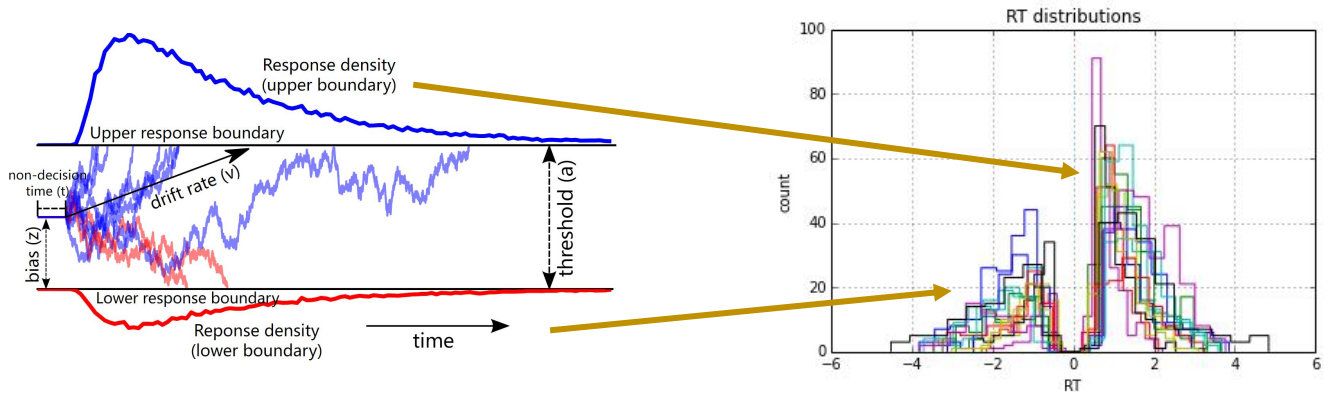


how  
(hardware)

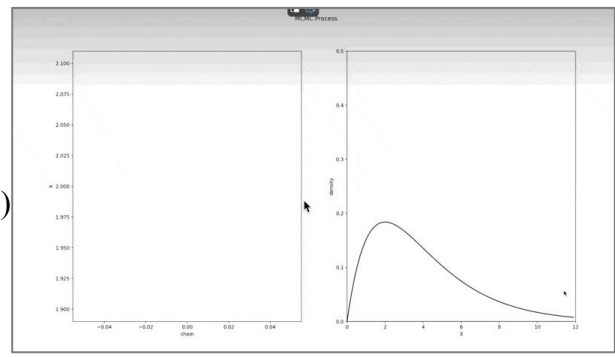
Implementation Level

prediction  
 explanation

Parameters	
$v$	
$a$	
$\tau$	
$z$	



马尔科夫链蒙特卡洛  
 (Markov Chain Monte Carlo, MCMC)  
 采样过程



## 第二项研究：计算机制识别

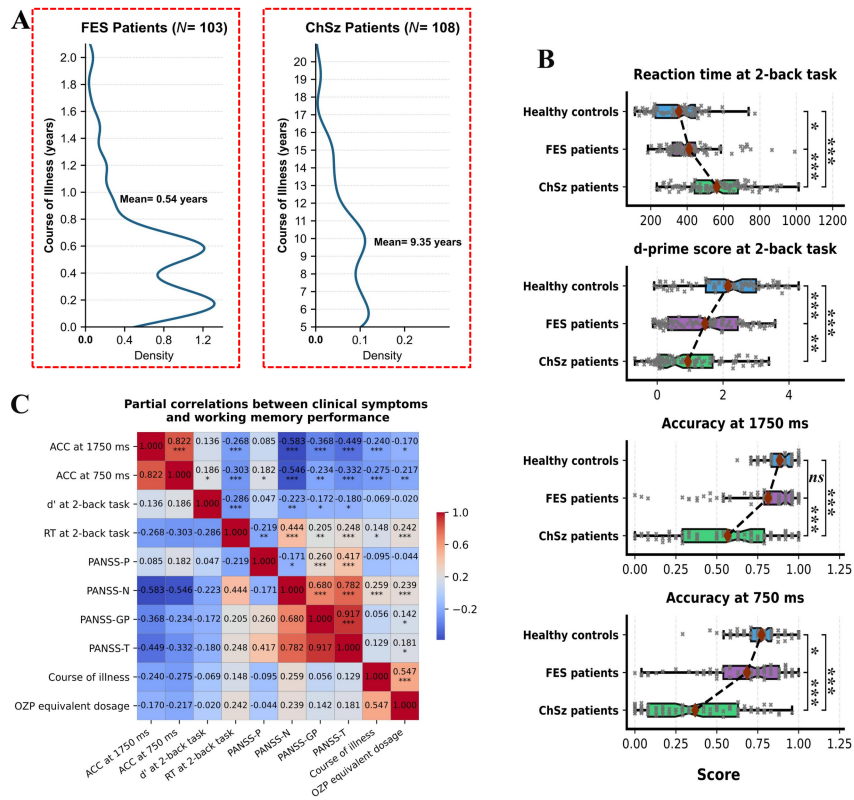


图2 单变量行为测量结果

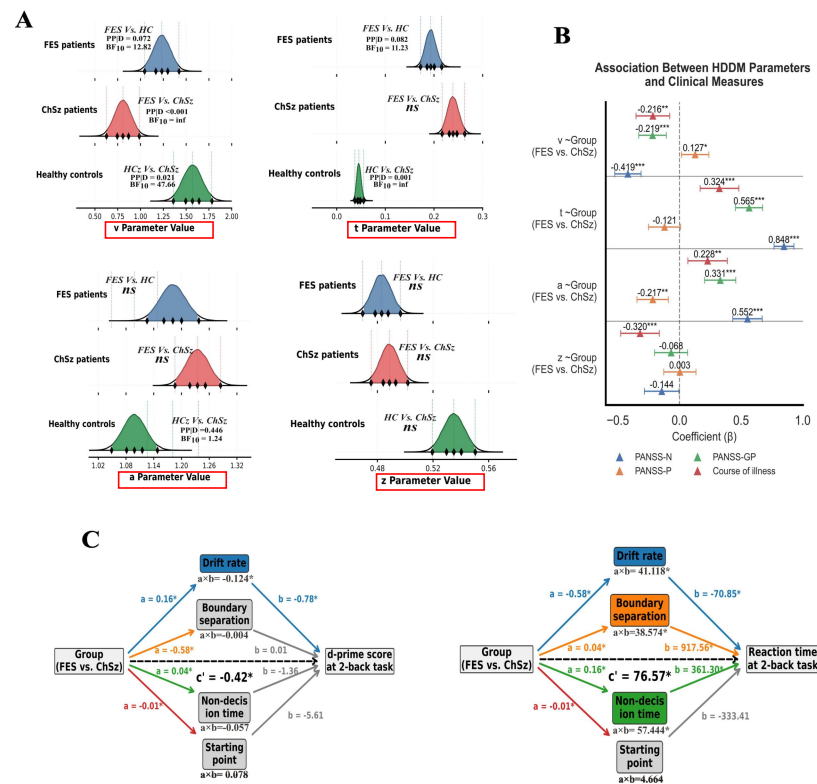
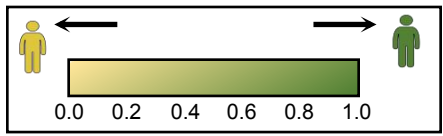
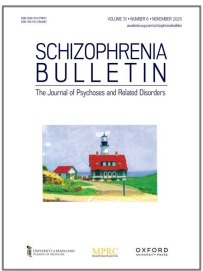
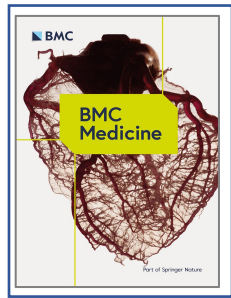
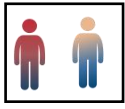
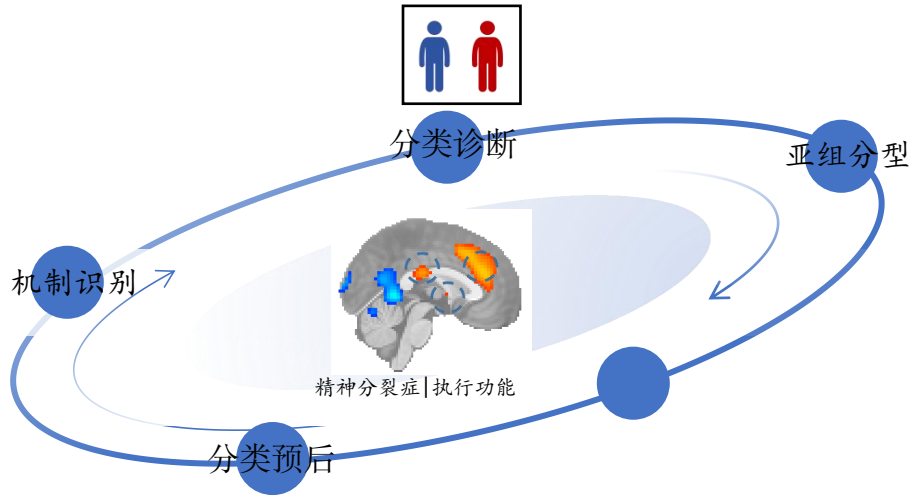
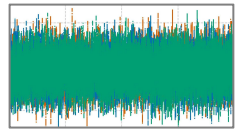
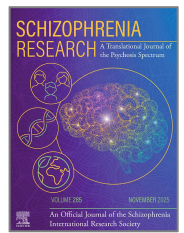
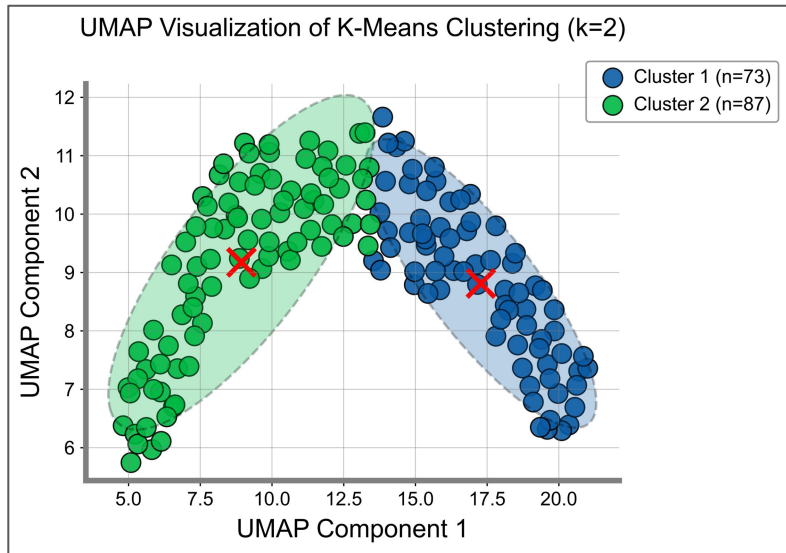
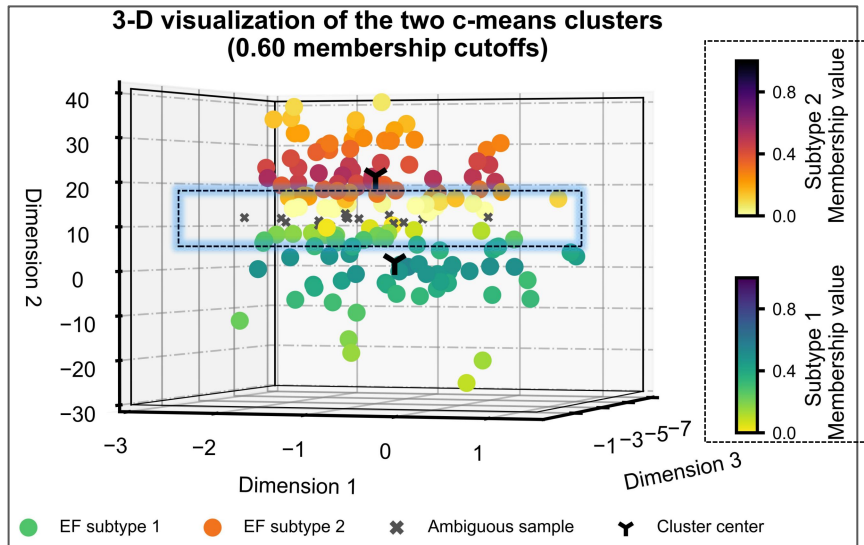


图3 HDDM模型结果与中介效应分析





传统聚类算法



模糊聚类算法

### 第三项研究：亚组分型

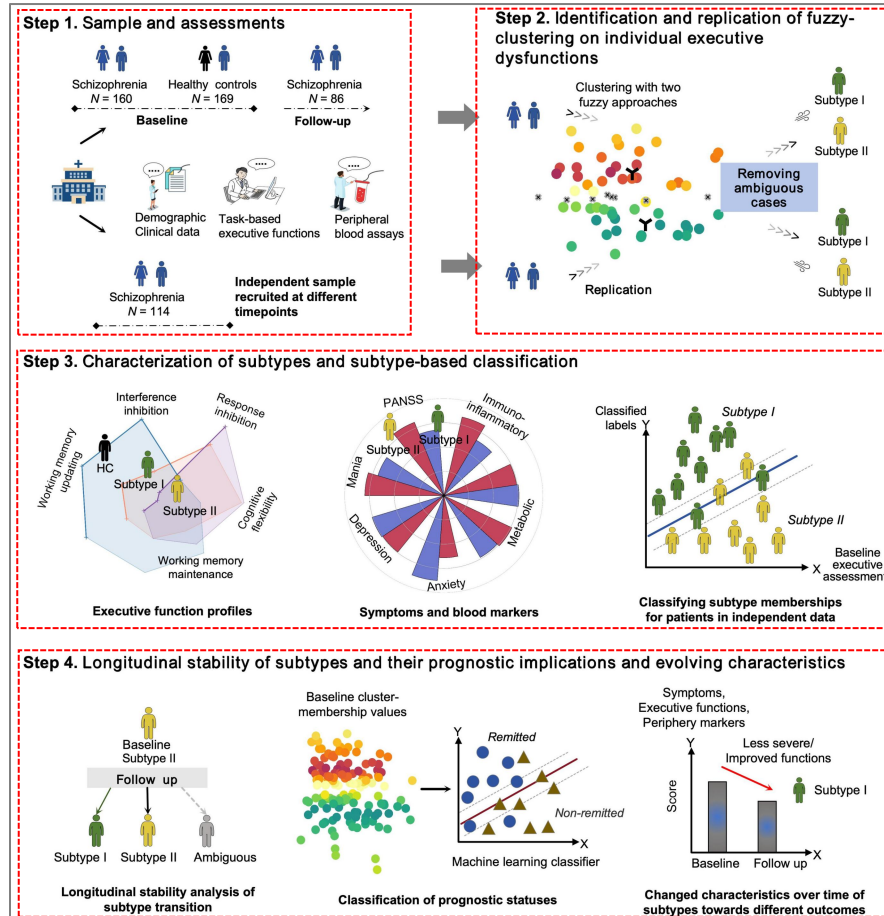
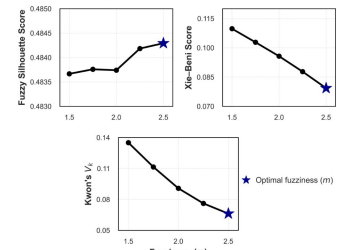


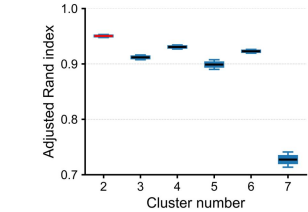
图1 研究设计与分析流程图

# 第三项研究：亚组分型

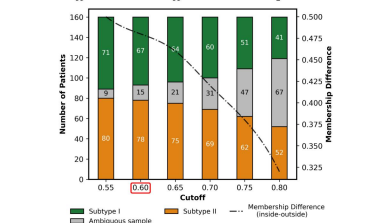
**A** Clustering metrics for  $K=2$  cluster solutions



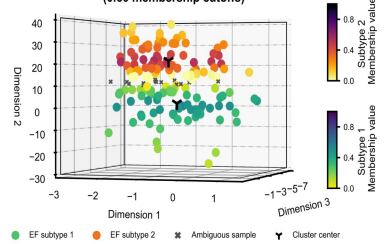
Subsampling stability of clustering solutions



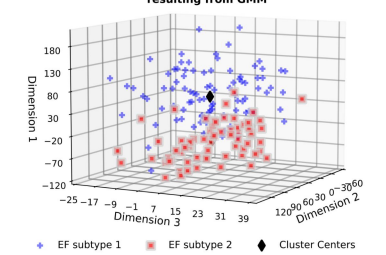
**D** Number of patients per subtype and inside-outside membership difference under different membership thresholds



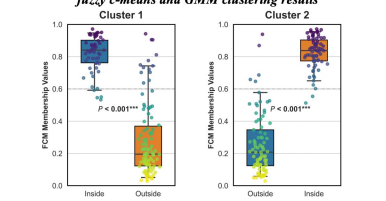
**B** 3-D visualization of the two c-means clusters (0.60 membership cutoffs)



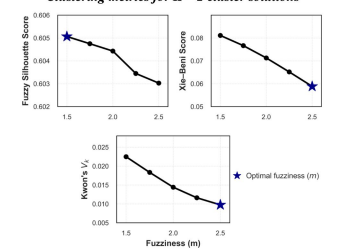
**C** 3-D visualization of the two clusters resulting from GMM



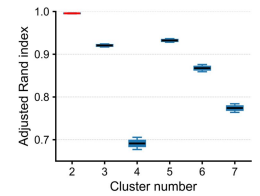
**E** Patients inside and outside the intersection of the fuzzy c-means and GMM clustering results



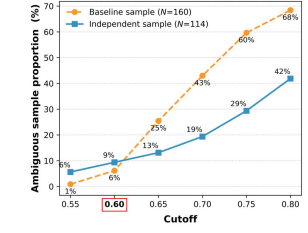
**A** Clustering metrics for  $K=2$  cluster solutions



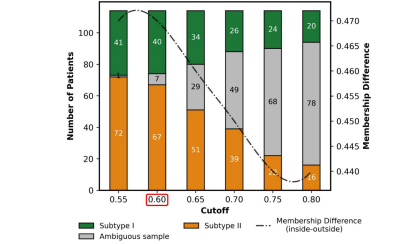
Subsampling stability of clustering solutions



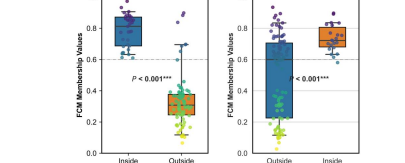
**C** The proportion of ambiguous samples in the total sample at two time points



**B** Number of patients per subtype and inside-outside membership difference under different membership thresholds



Patients inside and outside the intersection of the fuzzy c-means and GMM clustering results



**D** Subtype-based classification (tested on an independent sample of patients)

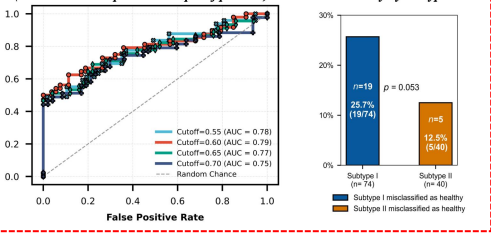


图2 基线数据聚类结果

图3 一年后重复聚类验证结果

### 第三项研究：亚组分型

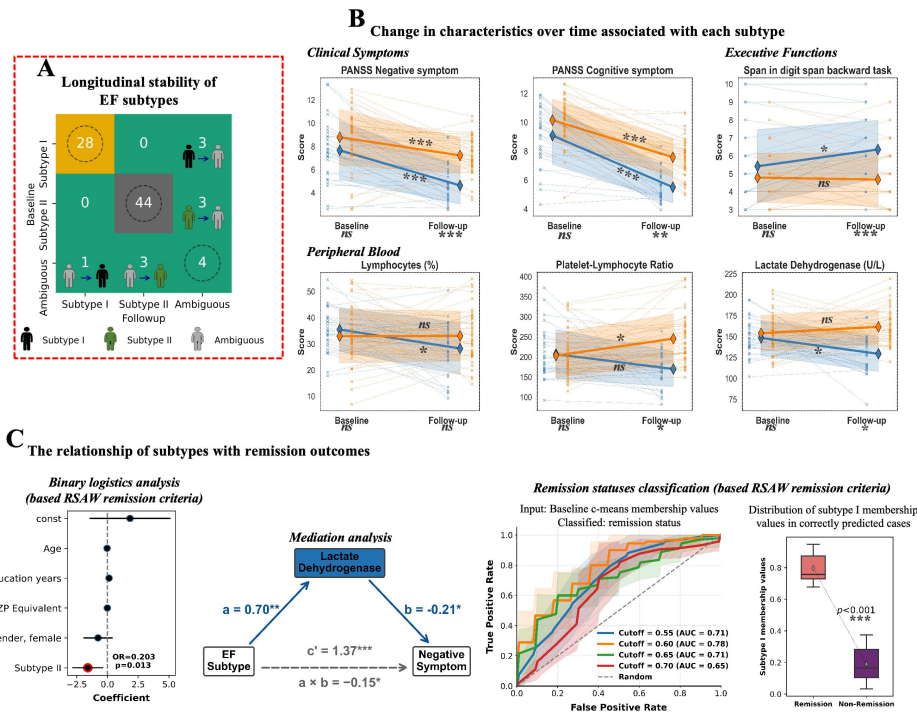
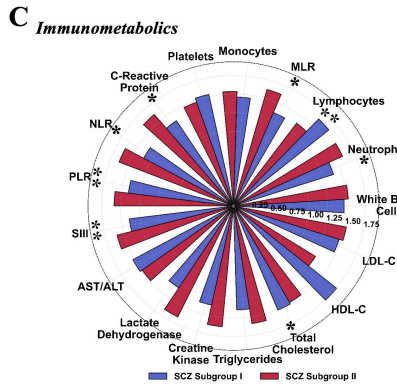
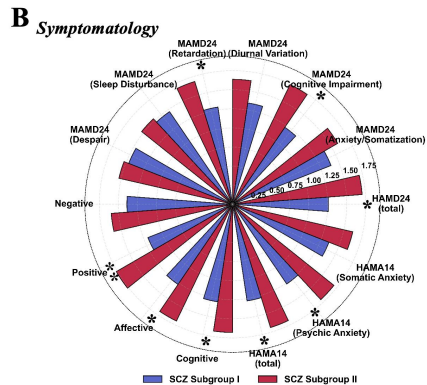
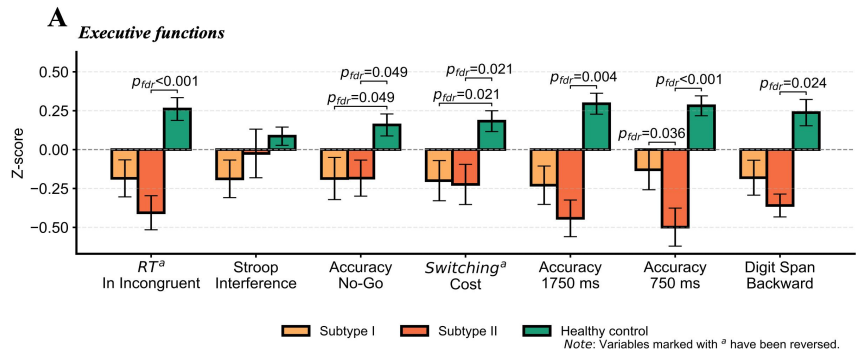


图4 亚组间执行功能、临床症状及外周血液指标差异

图5 亚组分类的稳定性与预后预测价值

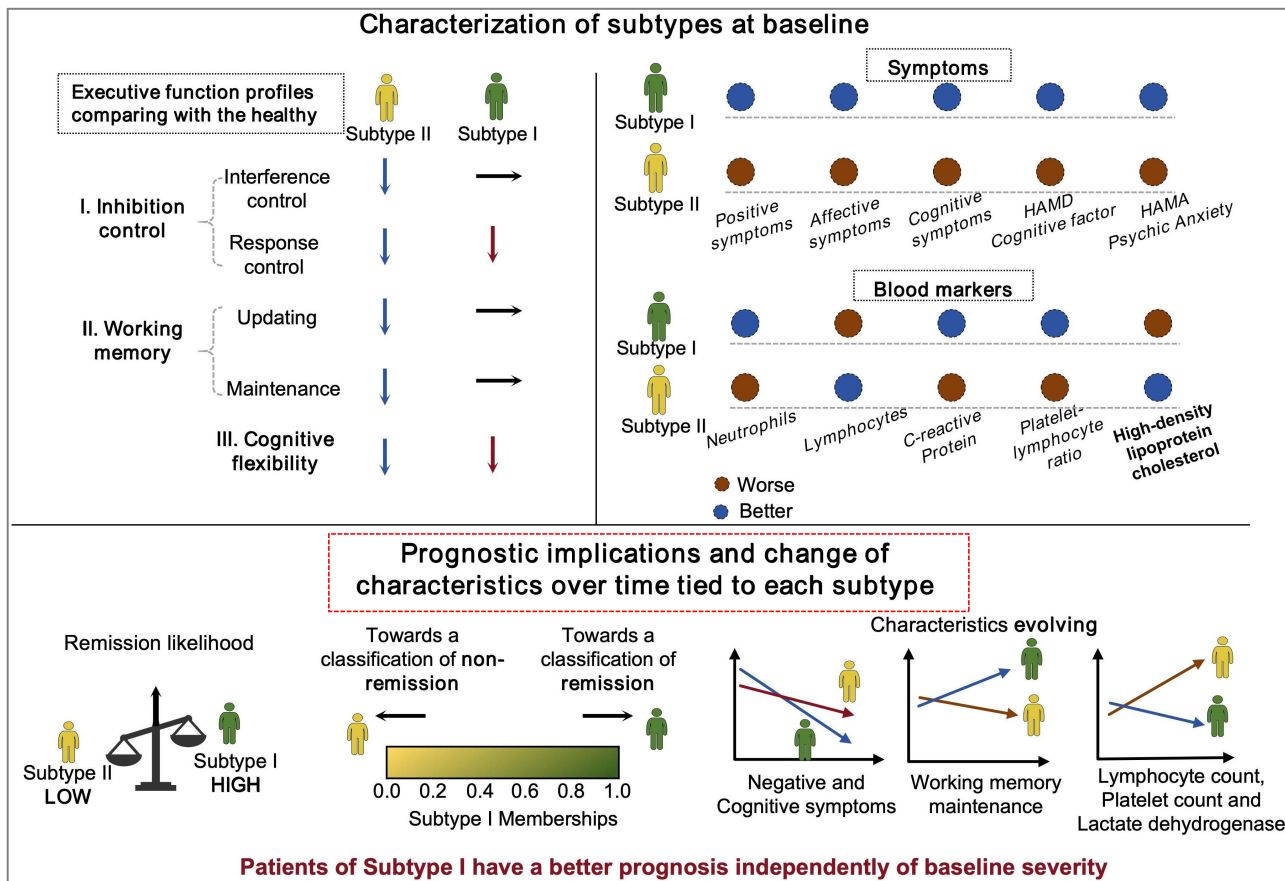
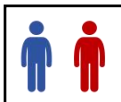
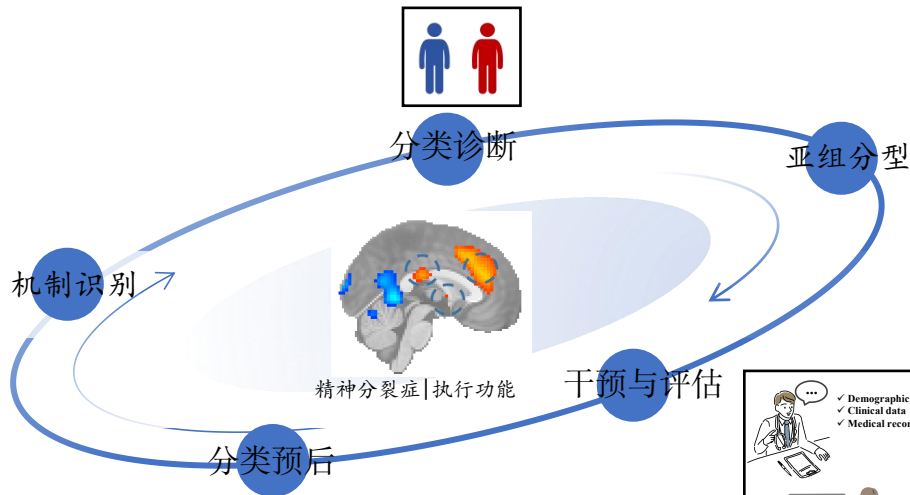
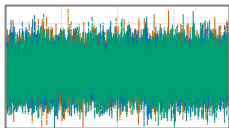
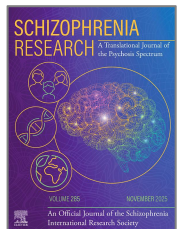
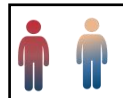


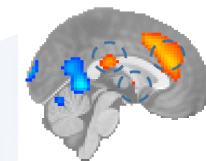
图6 主要研究发现汇总



分类诊断



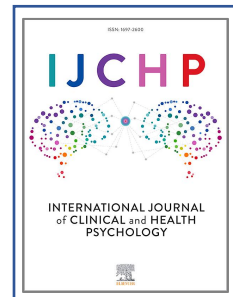
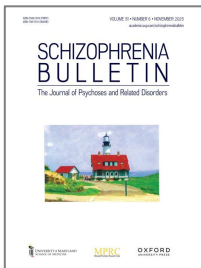
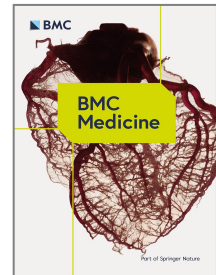
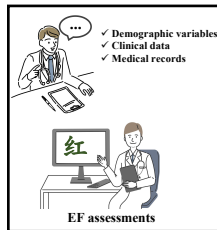
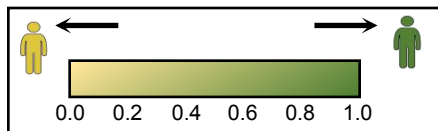
亚组分型



精神分裂症 | 执行功能

干预与评估

分类预后





- 执行功能缺陷严重影响精神分裂症患者日常功能，现有**药物疗效有限**
- 传统评估采用**二元分类**（有效/无效），忽视认知改善的**连续性**
- **基于机器学习**将执行功能变化概念化为从精神病性向神经典型的连续谱转变

# 第四项研究：干预与评估

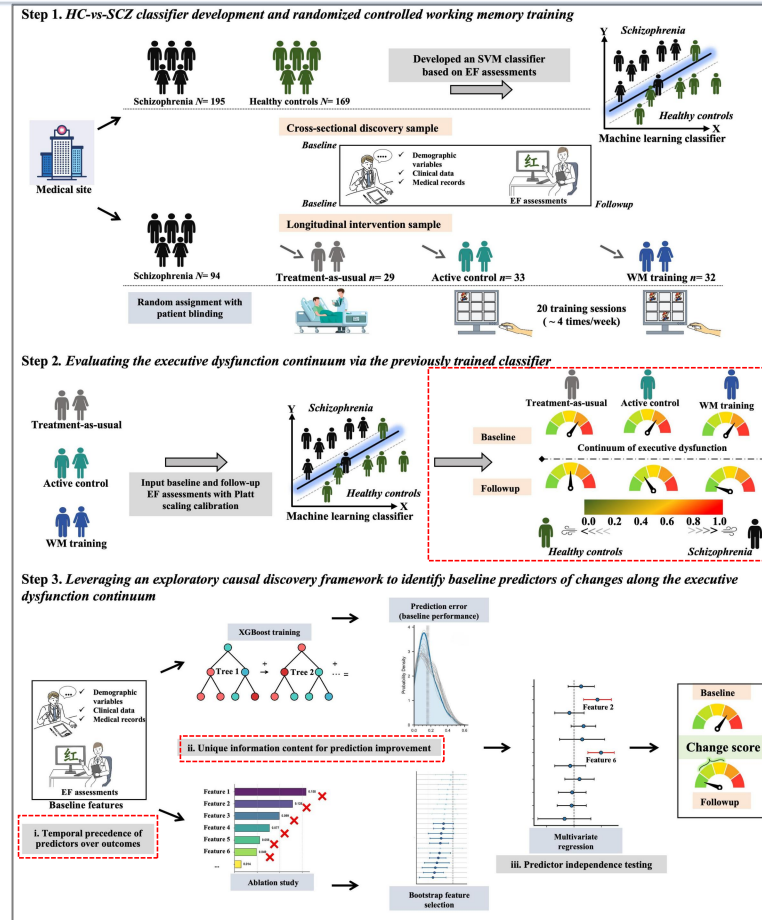


图1 研究设计与分析流程图

## Step 1. Classification modeling procedure

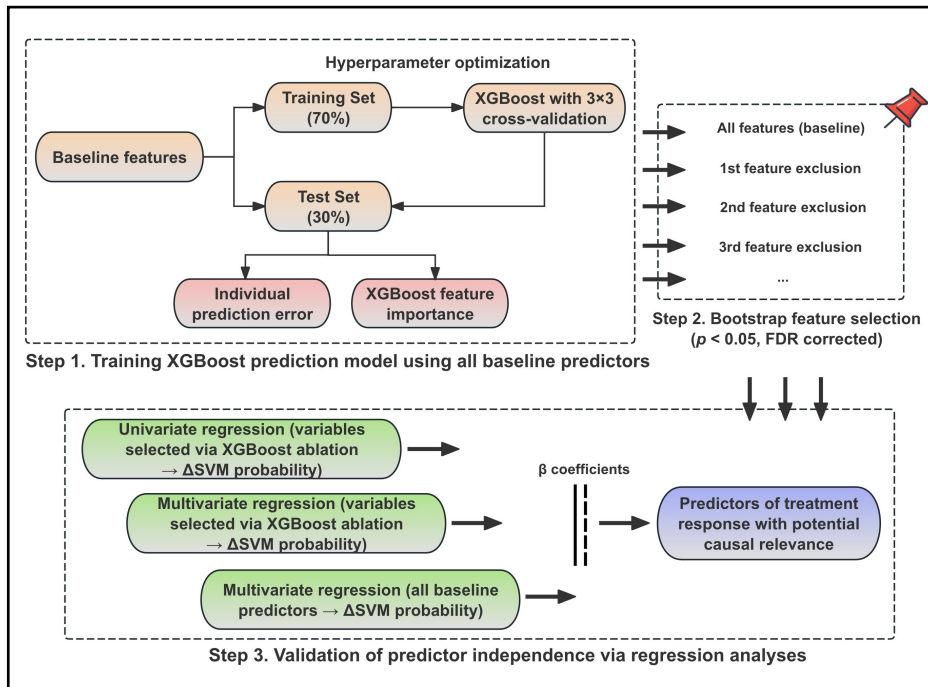
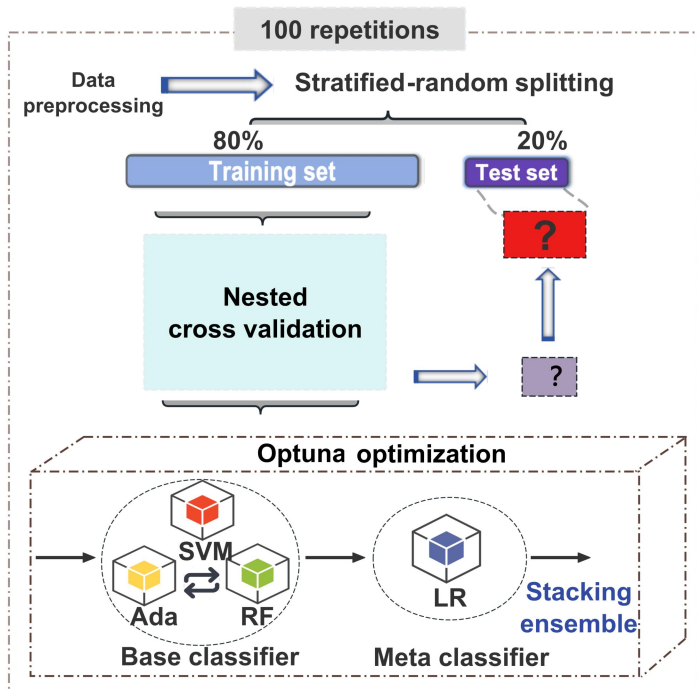


图2 探索性因果推断机器学习分析流程

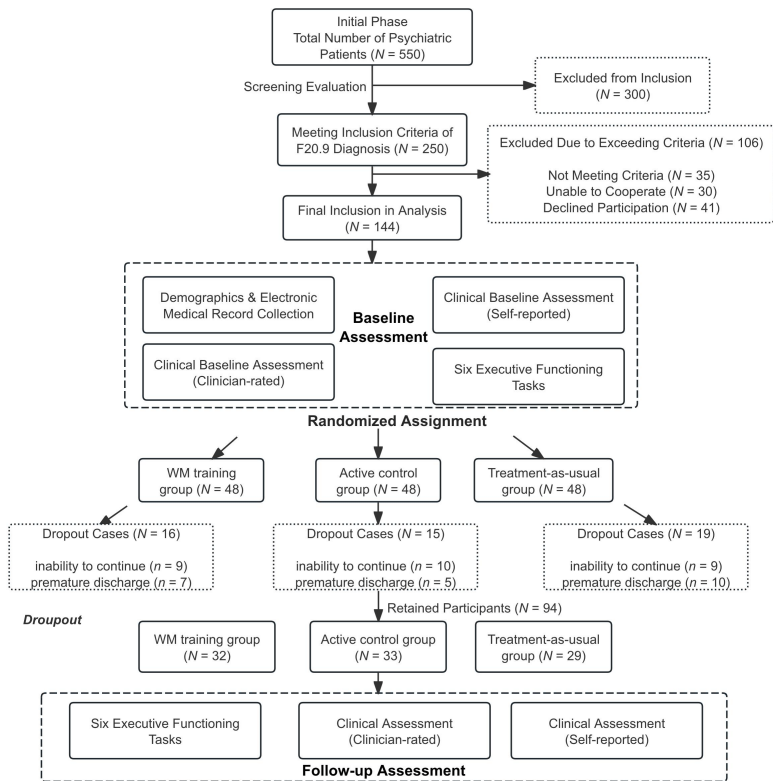


图2 被试招募流程

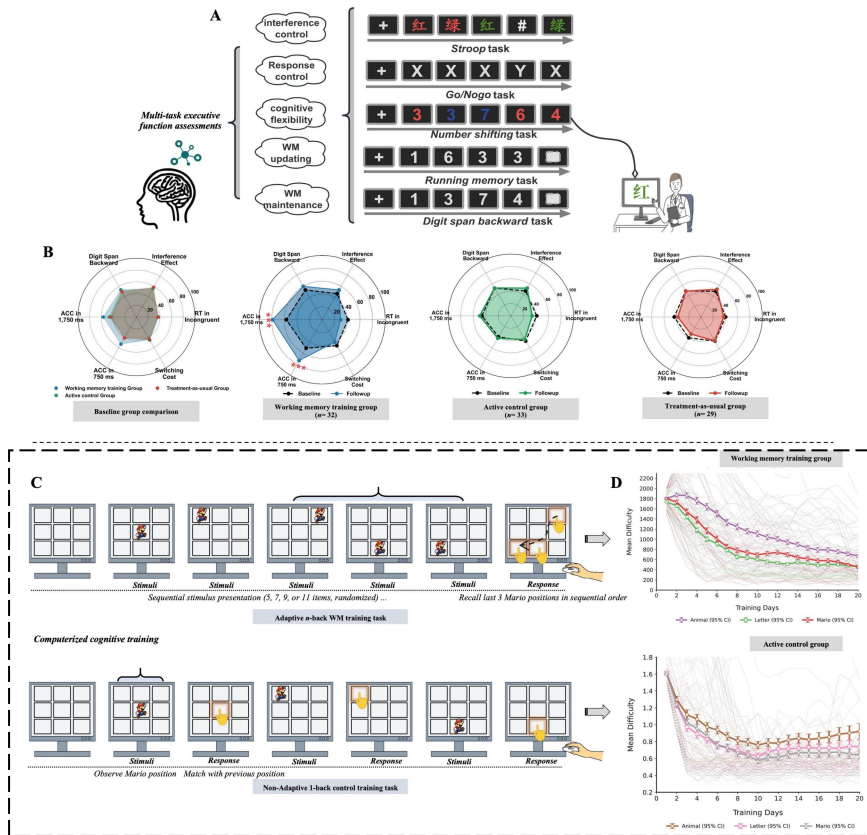


图3 执行功能评估结果与训练效果

# 第四项研究：干预与评估

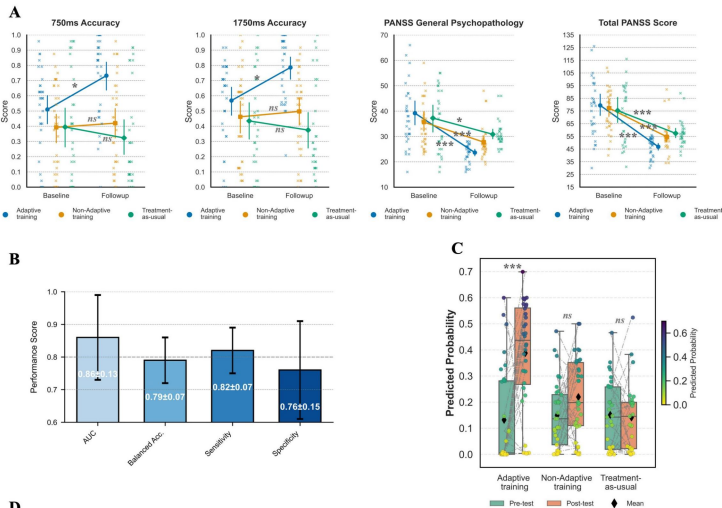


图5 机器学习分类器性能及概率转变分析

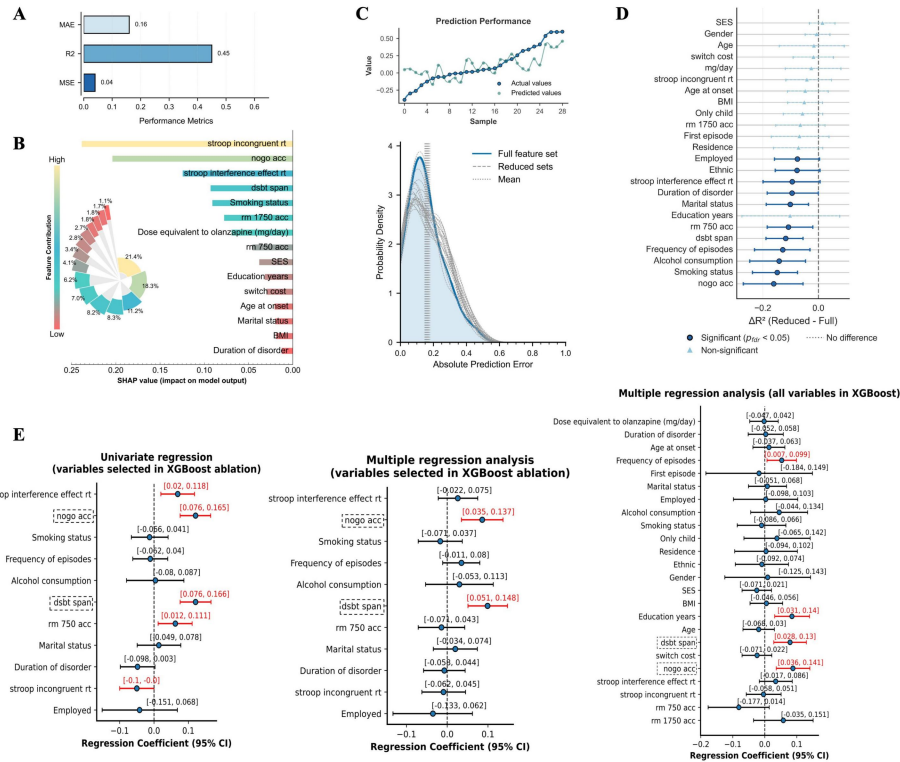
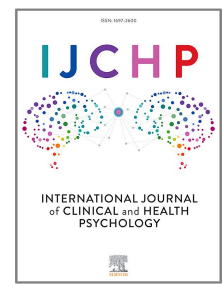
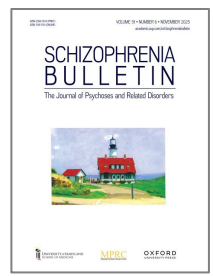
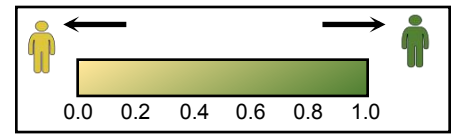
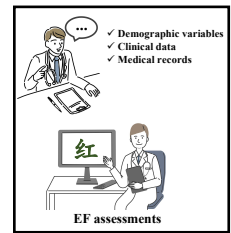
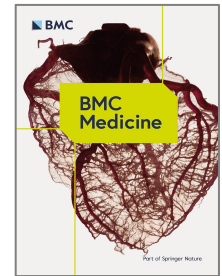
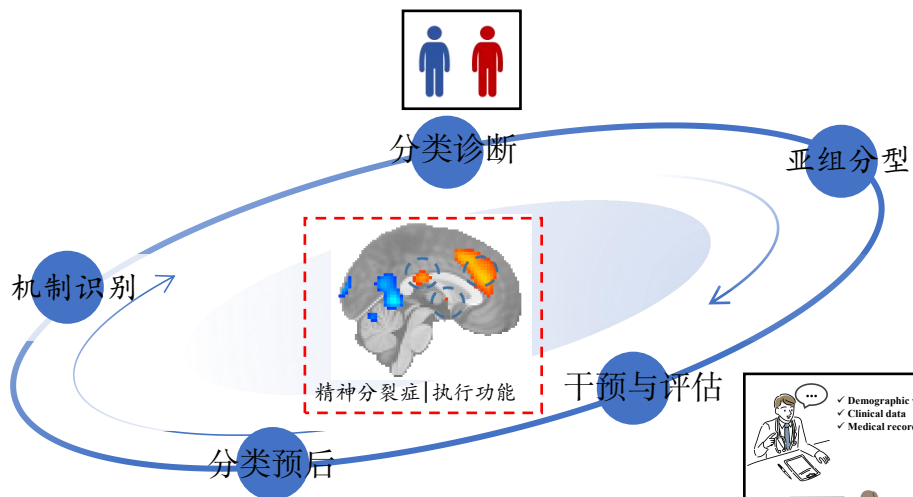
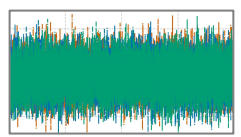
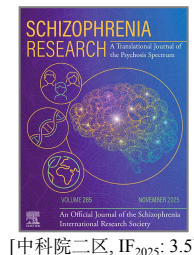


图6 基线预测因子识别与重要性分析





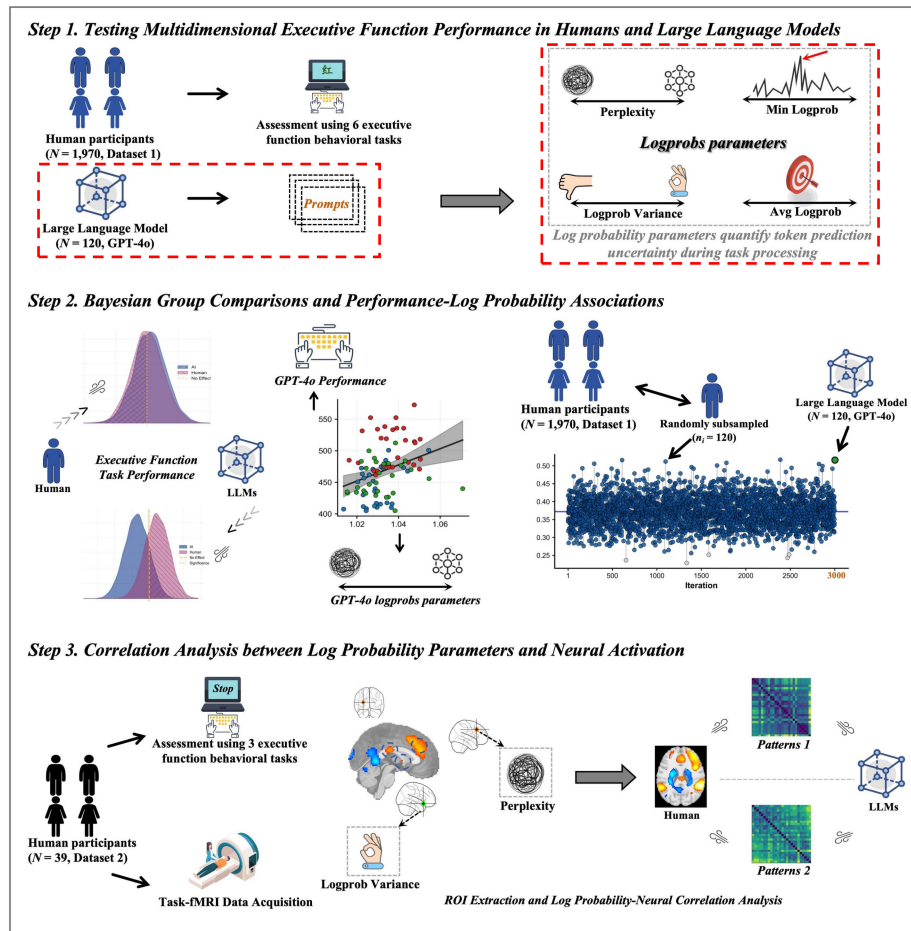
## 01 精神分裂症执行功能系列研究：与三院合作成果

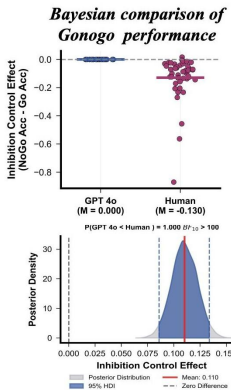
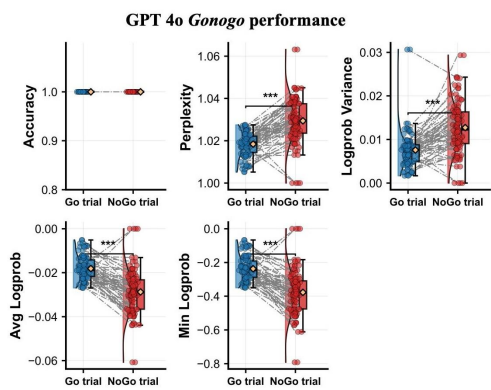
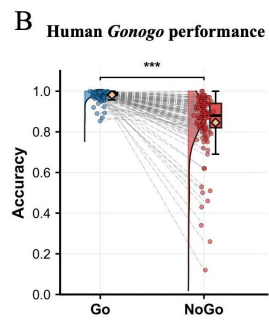
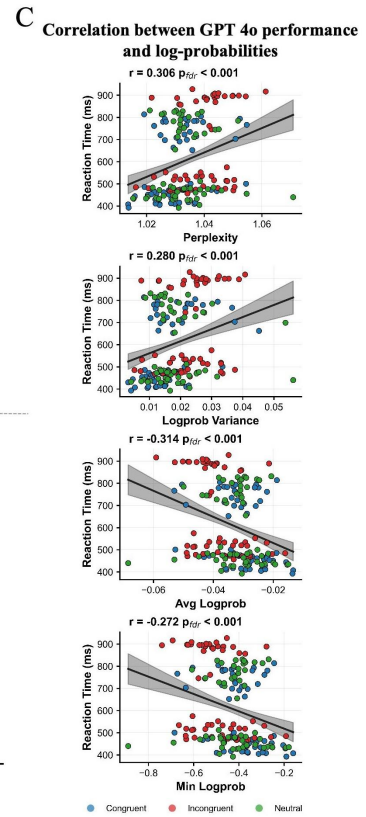
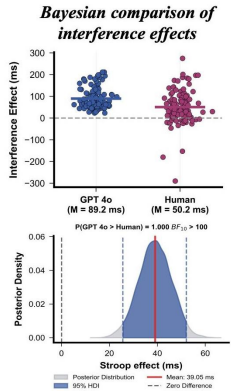
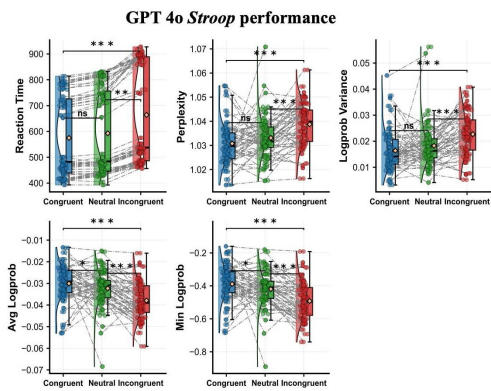
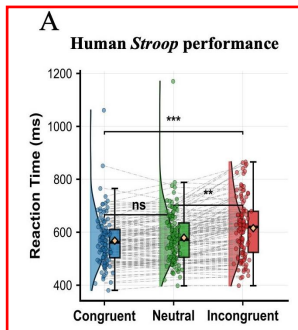
## 02 课题组最新进展：大语言模型在心理健康中的应用



## 课题组最新研究进展及临床应用：大语言模型与心理健康

图1 研究设计与分析流程图

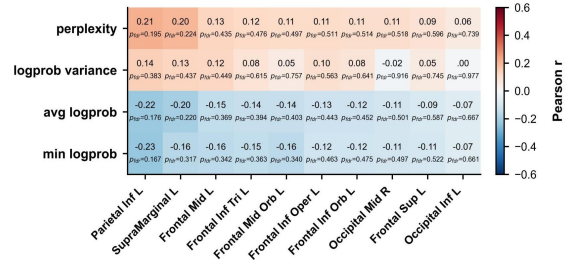
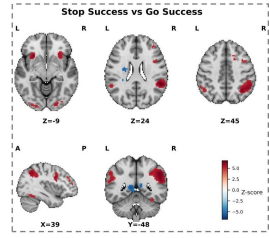




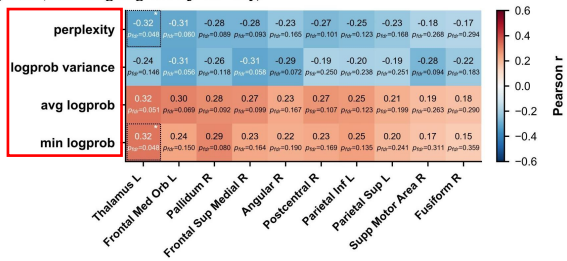
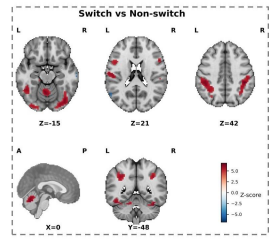
AI 能否模拟人类的抑制控制功能?

AI 完成执行功能任务时的内部参数与人脑神经机制存在关联吗？

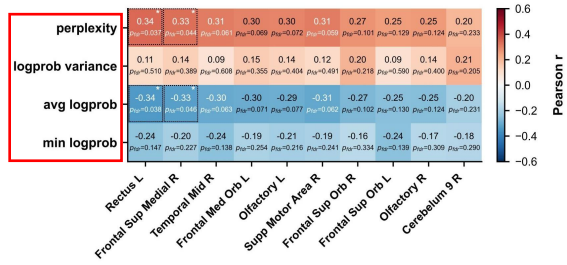
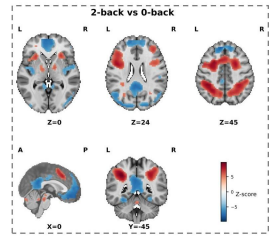
## A Stop-signal task (assessing inhibitory control)



## B Switching task (assessing cognitive flexibility)



## C n-back task (assessing working memory)





AI 在一定条件下能模拟健康人类的执行功能。

AI 能否模拟不同精神障碍患者的执行功能缺陷？




nature

Explore content ▾ About the journal ▾ Publish with us ▾

[nature](#) > [articles](#) > article

Article | [Open access](#) | Published: 09 April 2025

## Towards conversational diagnostic artificial intelligence

[Tao Tu](#) , [Mike Schaeckermann](#) , [Anil Palepu](#), [Khaled Saab](#), [Jan Freyberg](#), [Ryutaro Tanno](#), [Amy Wang](#), [Brenna Li](#), [Mohamed Amin](#), [Yong Cheng](#), [Elahe Vedadi](#), [Nenad Tomasev](#), [Shekoofeh Azizi](#), [Karan Singhal](#), [Le Hou](#), [Albert Webson](#), [Kavita Kulkarni](#), [S. Sara Mahdavi](#), [Christopher Semturs](#), [Juraj Gottweis](#), [Joelle Barral](#), [Katherine Chou](#), [Greg S. Corrado](#), [Yossi Matias](#), ... [Vivek Natarajan](#)  [+ Show authors](#)

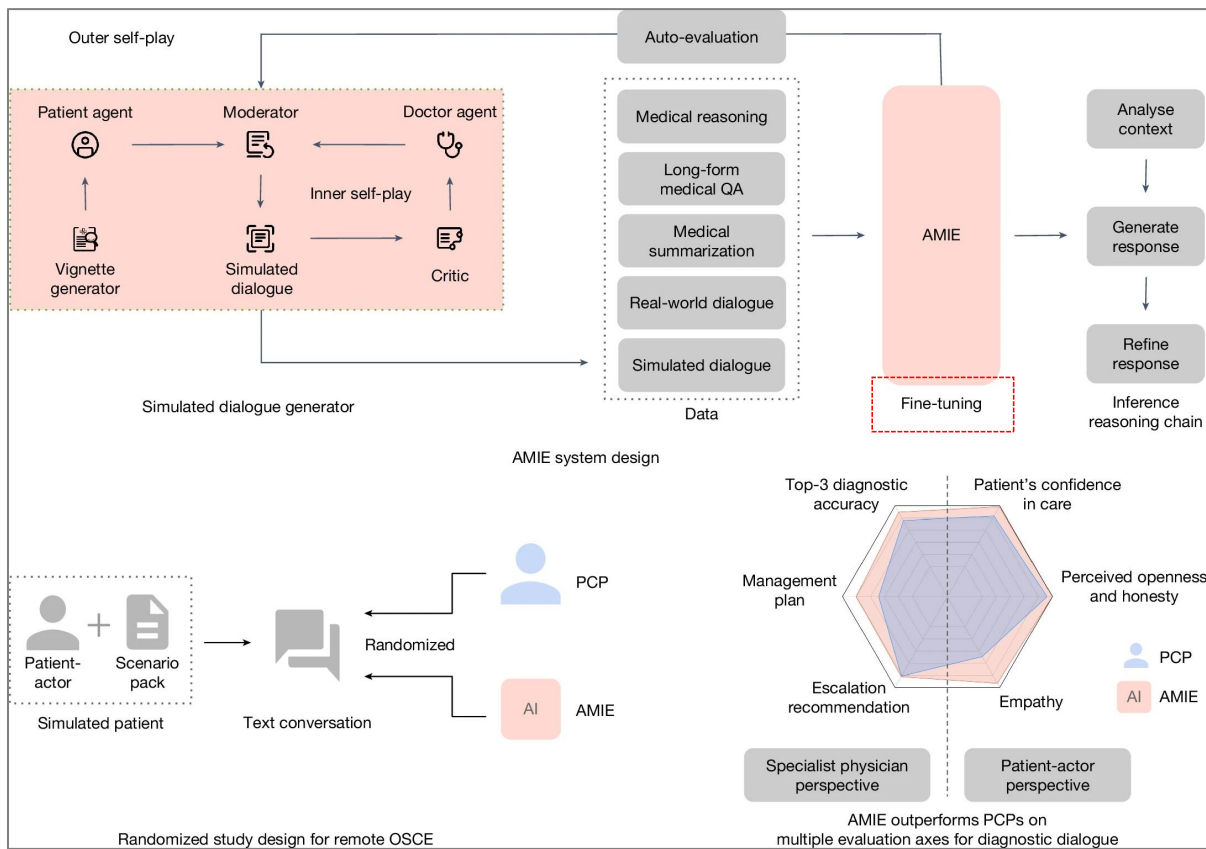
[Nature](#) **642**, 442–450 (2025) | [Cite this article](#)

**121k** Accesses | **102** Citations | **371** Altmetric | [Metrics](#)

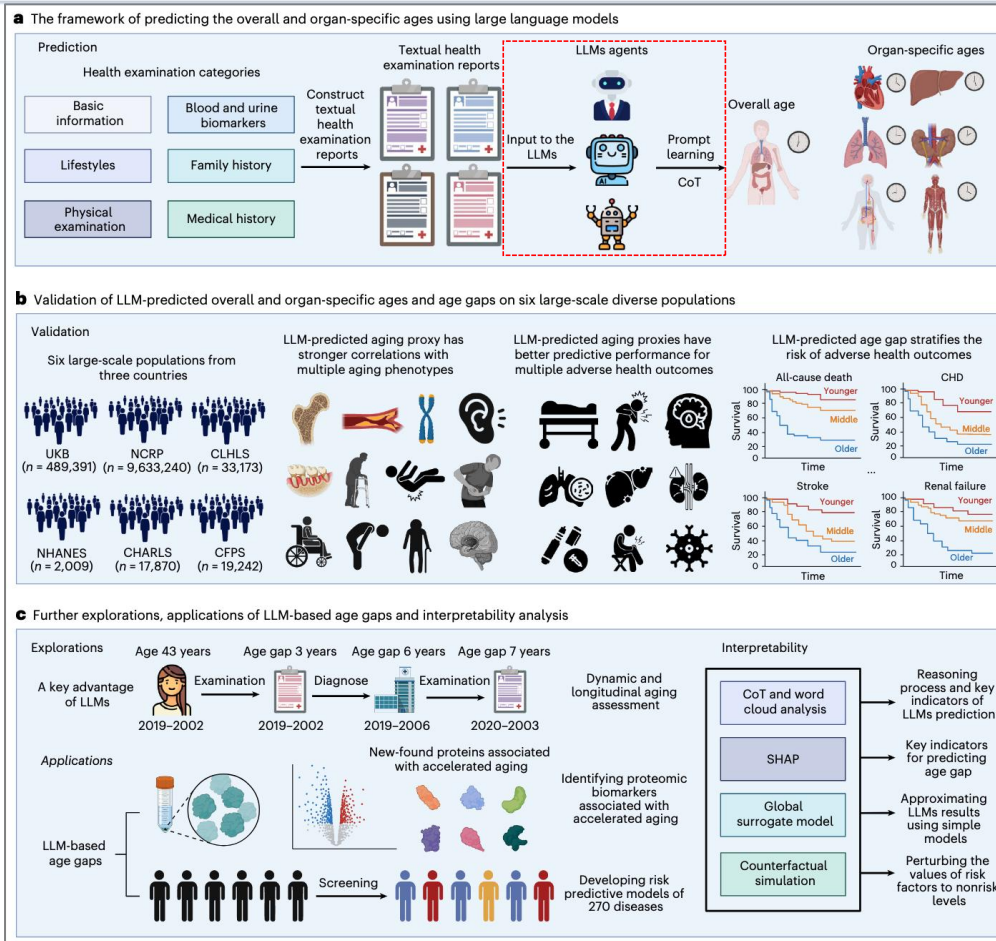
(Tu et al., 2025, *Nature*)

- ◆ 医患对话是医学的核心，熟练的病史采集能实现有效诊断、管理和建立信任。
- ◆ 对话式诊断AI系统有望提升医疗可及性和质量。

## 对话式诊断AI系统： 训练框架、推理策略与评估结果



## 基于大语言模型的衰老评估框架





## 01 精神分裂症执行功能系列研究：与三院合作成果

## 02 课题组最新进展：大语言模型在心理健康中的应用



西北师范大学  
NORTHWEST NORMAL UNIVERSITY



心理学院

# 人工智能与认知建模在精神分裂症执行功能研究中的应用



兰州市第三人民医院  
THE THIRD PEOPLE'S HOSPITAL OF LANZHOU



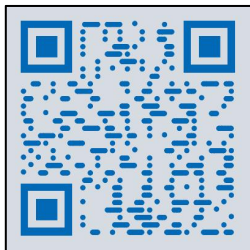
西北师范大学  
NORTHWEST NORMAL UNIVERSITY



心理学院



# 恳请各位专家批评指正！



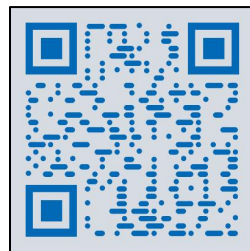
下载本次汇报 PDF 文件

报告人：张统一

[tyzhang9804@gmail.com](mailto:tyzhang9804@gmail.com)

西北师范大学心理学院 2024级心理学博士生

导师：赵鑫教授



下载本次汇报 PDF 文件

兰州市第三人民医院 2025年12月05日