

Integrating **local dynamics** and  
**pairwise coupling** from functional  
neuroimaging time series across  
**neuropsychiatric disorders**

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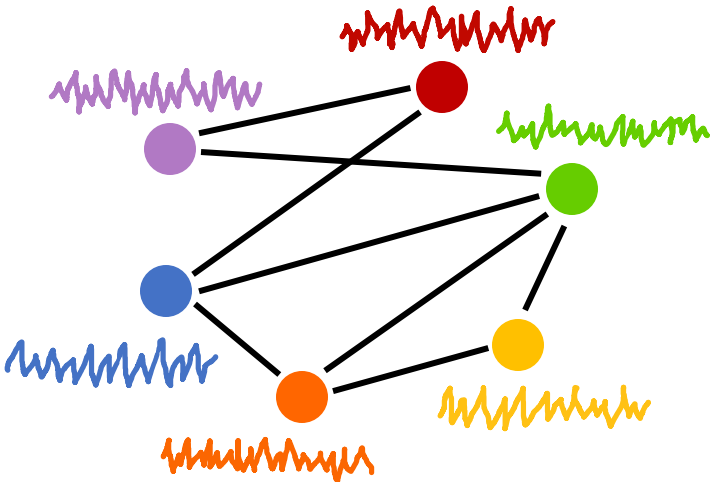


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# Complex system dynamics can be viewed as a multivariate time series

Example complex system

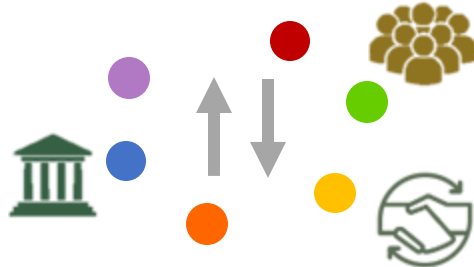


## Biology



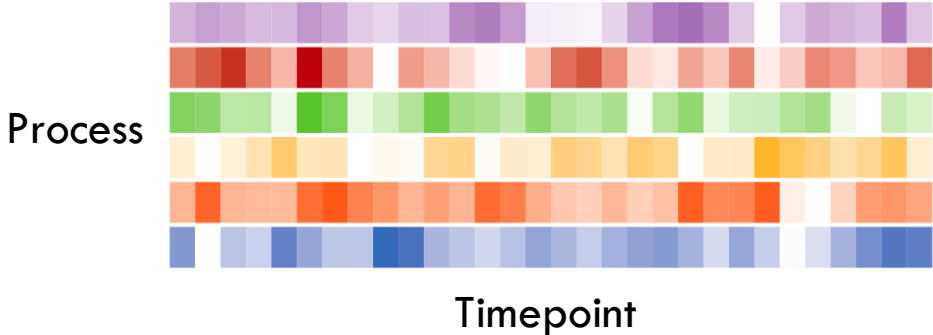
Brain function: perception, emotion, movement

## Economics



National economy: economic growth, recession

Multivariate time series (MTS) representation



## Physics



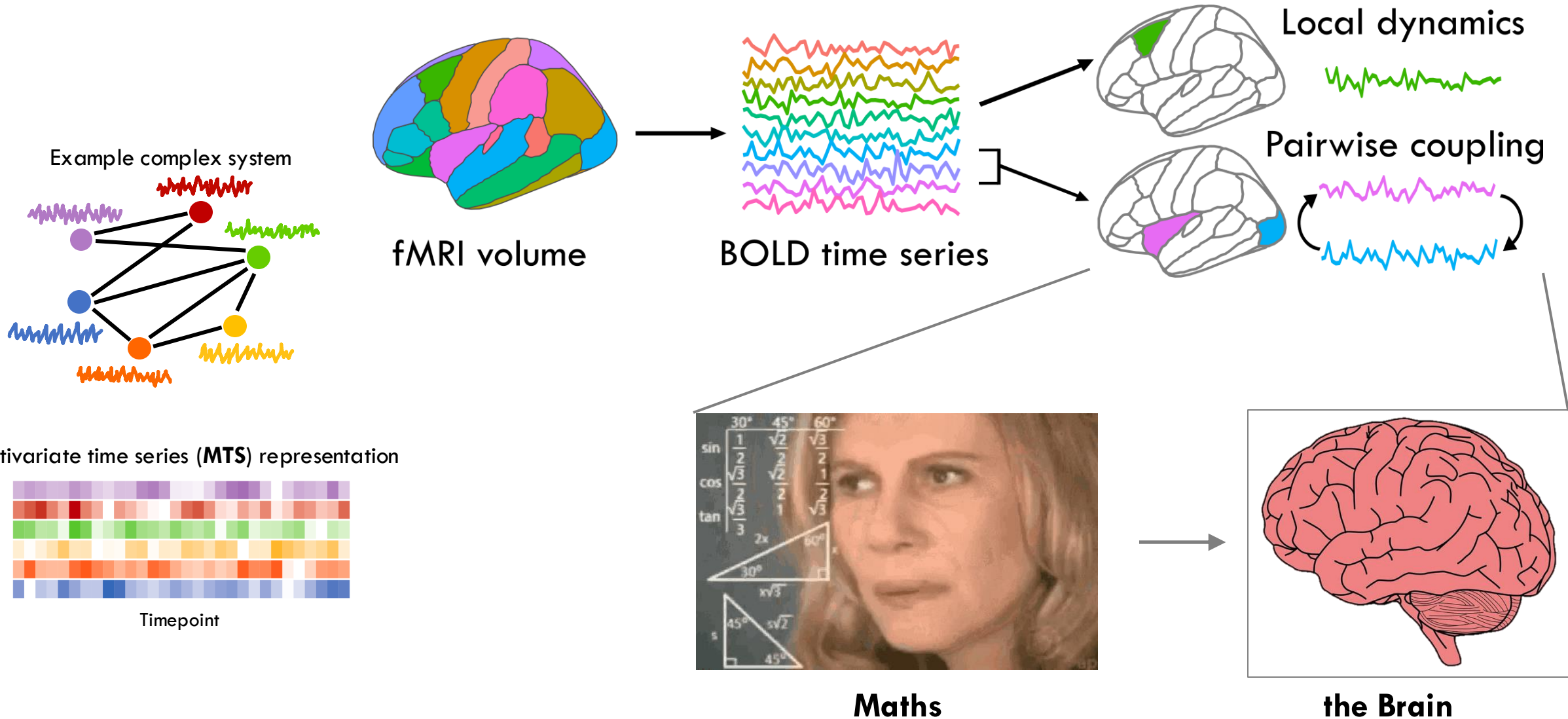
Fluid dynamics: vortices, turbulence

## Social networks

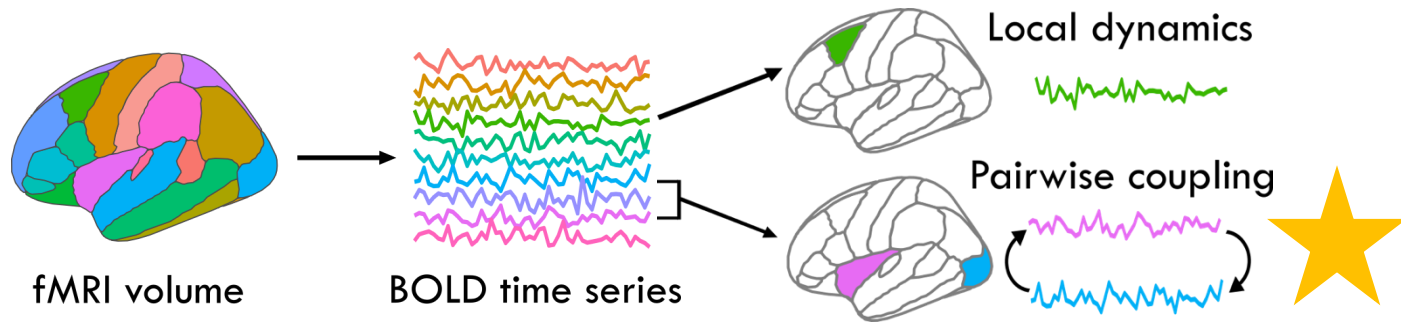


Facebook friends: community formation

# Representing the brain as a complex system

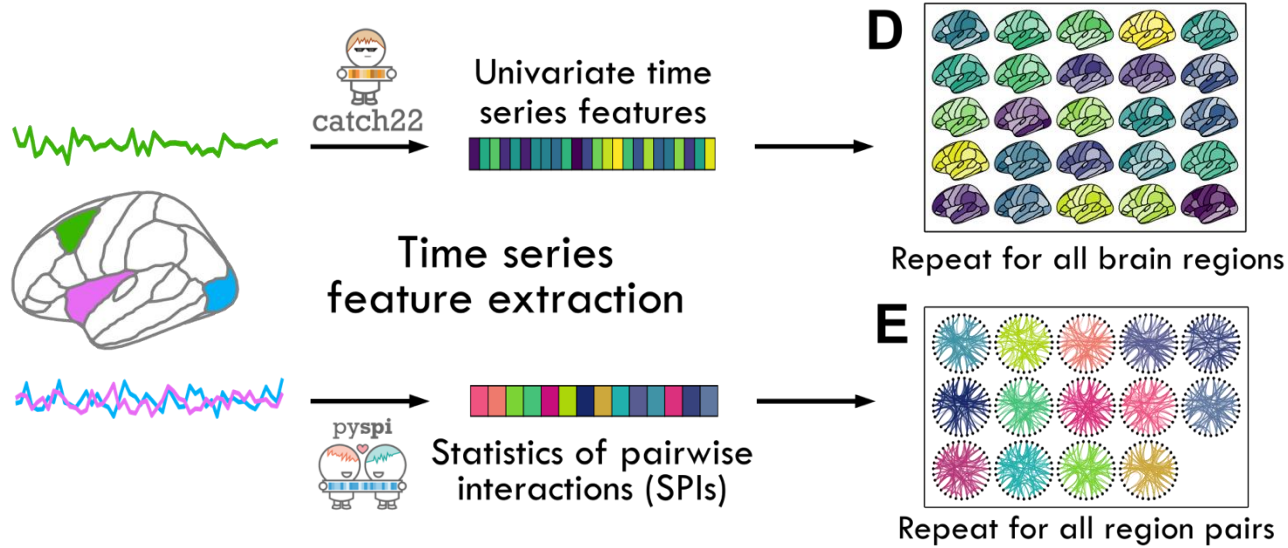


# Project aims: Systematically compare time series feature representations across four neuropsychiatric disorders



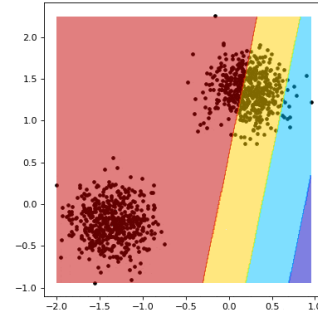
**Aim 1:** Compare representations of fMRI activity that include different statistics of local dynamics and pairwise coupling structures

- SCZ**  
N=48  
UCLA CNP
- BPD**  
N=49  
UCLA CNP
- ADHD**  
N=39  
UCLA CNP
- ASD**  
N=513  
ABIDE



**Aim 2:** Within each representation, compare the performance of multiple distinct time-series features that capture diverse properties of resting-state activity

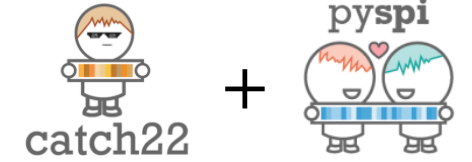
# Comparing case-control classification across fMRI representations



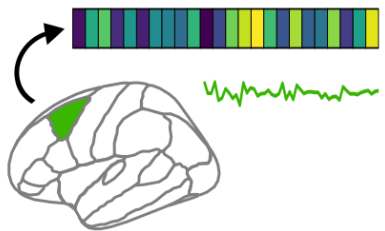
Linear support vector machine (SVM)

× 10-fold CV

× 10 repeats

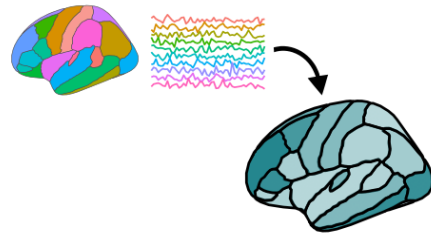


i. Local dynamics in an individual region



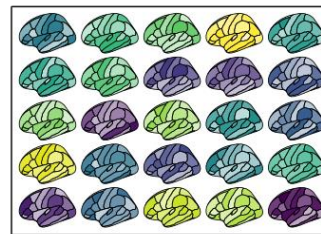
( $A_{\text{region}}$ )

ii. Whole-brain maps of an individual feature



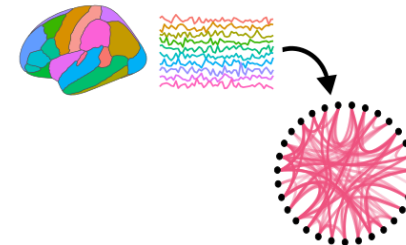
( $A_{\text{feature}}$ )

iii. Whole-brain maps of all features



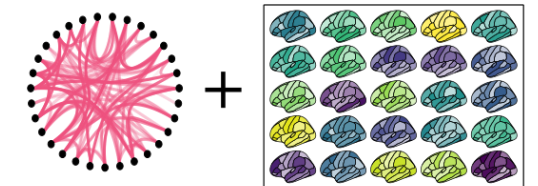
( $A_{\text{uni\_combo}}$ )

iv. FC across all region pairs with one SPI



( $A_{\text{FC}}$ )

v. FC across all region pairs by SPI plus all whole-brain maps of local dynamics

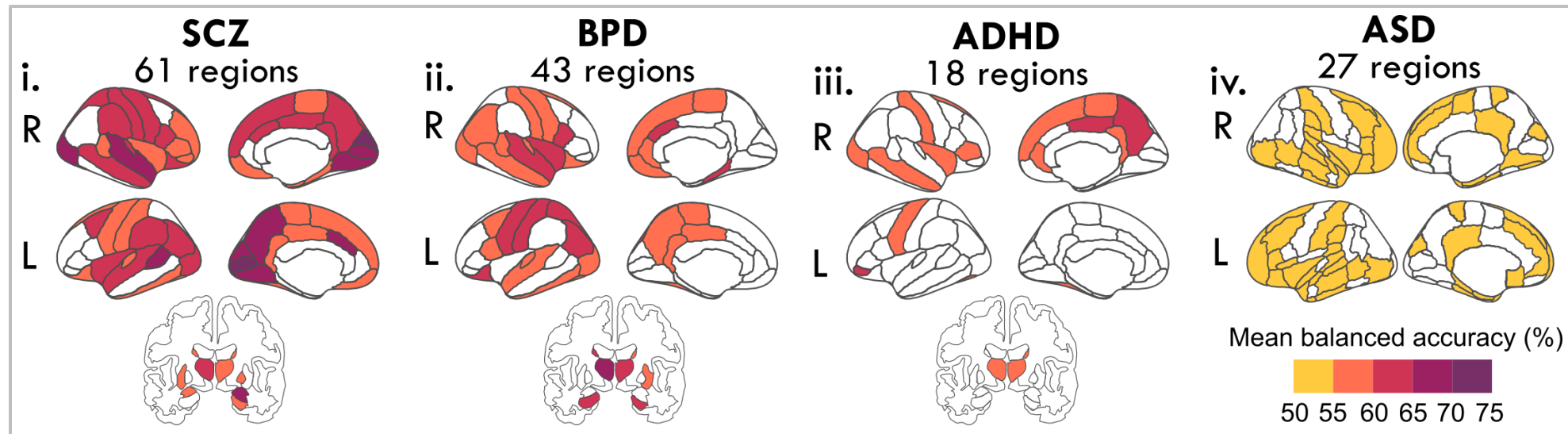
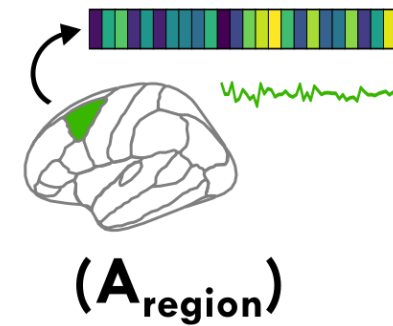


( $A_{\text{FC\_combo}}$ )

# Flash results for a flash talk

⚡ **Dynamical signatures of fMRI activity in individual brain regions can distinguish cases vs. controls with up to 72% accuracy**

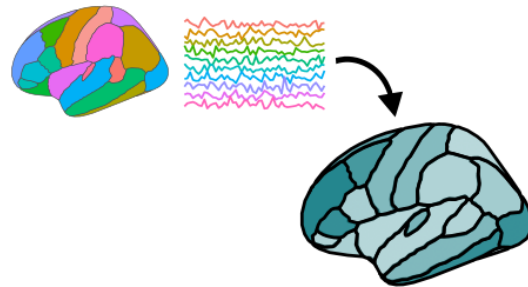
i. Local dynamics in an individual region



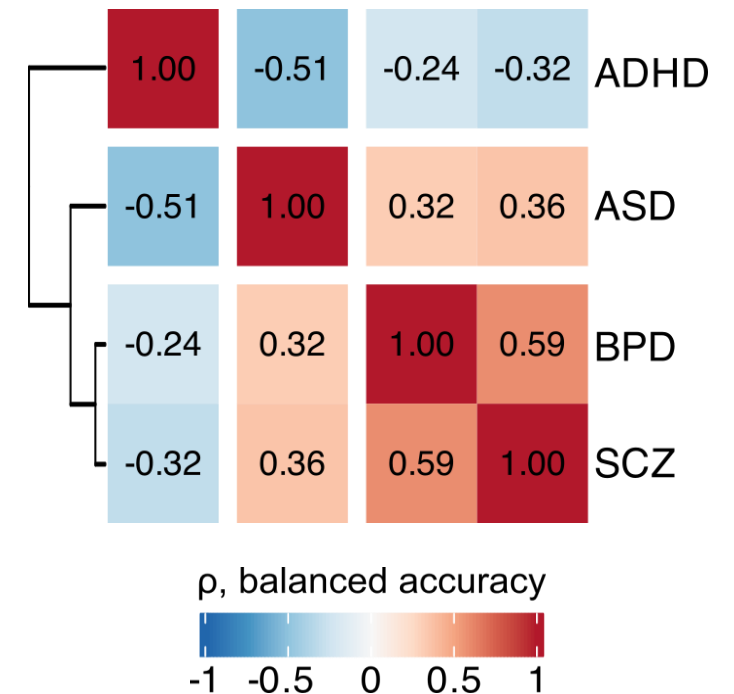
# Flash results for a flash talk

⚡ **SCZ and BPD** exhibit the most similar classification performance based on brain-wide maps of local dynamics, while **ADHD** is markedly different from the other three

ii. Whole-brain maps of an individual feature



( $A_{\text{feature}}$ )



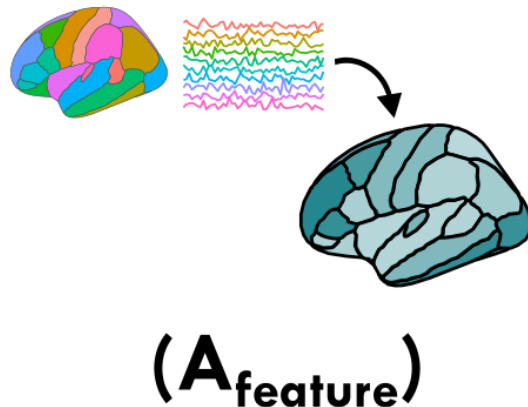
# Flash results for a flash talk

⚡ **fALFF** and **Pearson correlation coefficient** rank among the top-performing features → properties suited for **Gaussian, linear, stochastic** processes are well suited for resting-state fMRI

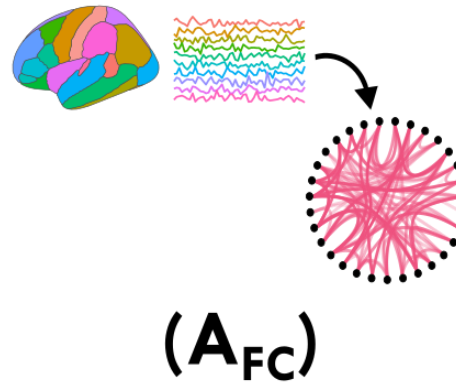
Balanced Accuracy (%)

	SCZ	BPD	ADHD	ASD
periodicity	62.6	61	58.3	52.6
SD	68.9	57.7		59.4
<b>fALFF</b>	63.6	62.9		53.7
embedding_dist	60.8	60.8		52.9
ACF_timescale	58.7	60.1		54.4
entropy_pairs	60.6	58.1		54.2
centroid_freq	61.2	57.1		53.9
low_freq_power	60.6	59.2		52
mean	64.7	60.9		
DFA	63.1			52.4

ii. Whole-brain maps of an individual feature



iv. FC across all region pairs with one SPI



Balanced Accuracy (%)

	SCZ	BPD	ADHD	ASD
<b>Pearson</b>	69.1	59.9		59.1
di_gaussian	62.4	60.9		56.4
DTW	64.5	57.7		55.4
coherence_magnitude	63.4			54
PSI_time_frequency		57		
power_envelope_corr	58.1			54.9
cointegration	55.4	59.4		53.4
phi_star		54.1	54	57.7
PSI_frequency		53.8		
transfer_entropy				52.5

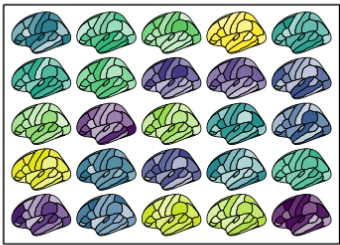
Bryant et al., manuscript in preparation



# Flash results for a flash talk

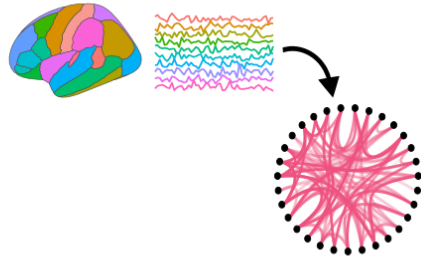
⚡ Most pairwise **functional connectivity** metrics are more informative with the inclusion of **brain-wide maps of local regional dynamics**

iii. Whole-brain maps of all features



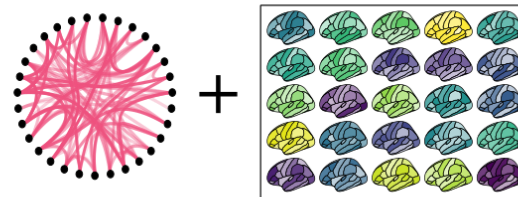
$(A_{uni\_combo})$

iv. FC across all region pairs with one SPI

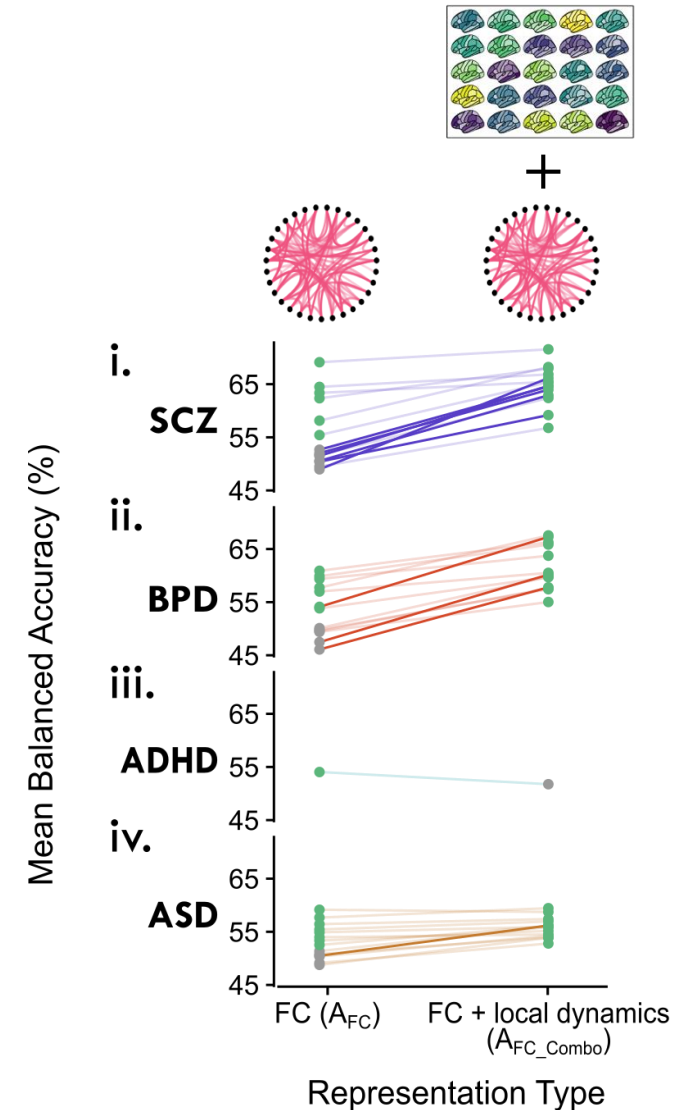


$(A_{FC})$

v. FC across all region pairs by SPI plus all whole-brain maps of local dynamics



$(A_{FC\_combo})$



Bryant et al., *manuscript in preparation*

# Thank you 😊



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