B[FM]^2: Brain Foundation Model via Flow Matching with SplitUNet

Jaedong Hwang

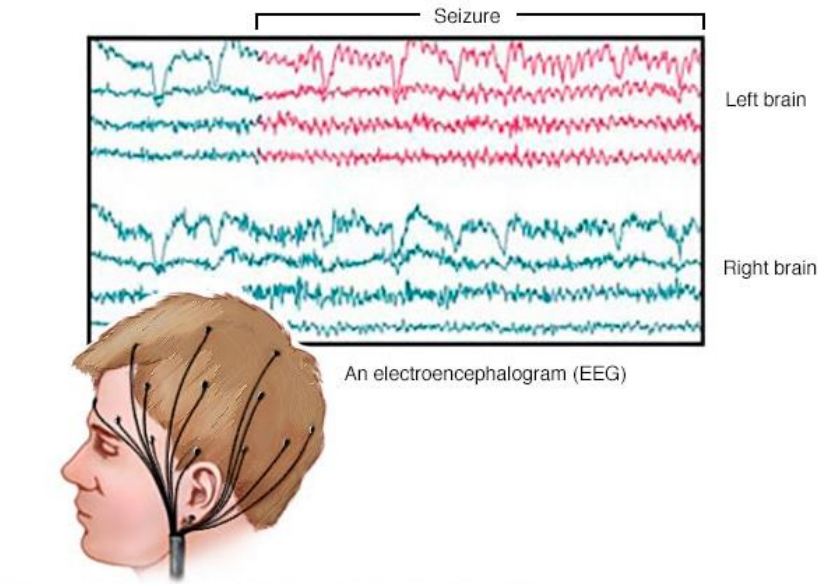
Massachusetts Institute of Technology

NeurIPS 2026

project page

EEG (Electroencephalography)

- Inexpensive and easily collectable
- High temporal resolution
- Publicly available
  - 25,545 Participants 450 Public Datasets in OpenNeuro
- Helps diagnose various diseases:
  - Brain tumors.
  - Brain damage from a head injury.
  - Brain disease that can have a variety of causes, known as encephalopathy.
  - Inflammation of the brain, such as herpes encephalitis.
  - Stroke.
  - Sleep conditions.



An electroencephalogram (EEG)

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https://www.mayoclinic.org/tests-procedures/eeg/about/pac-20393875

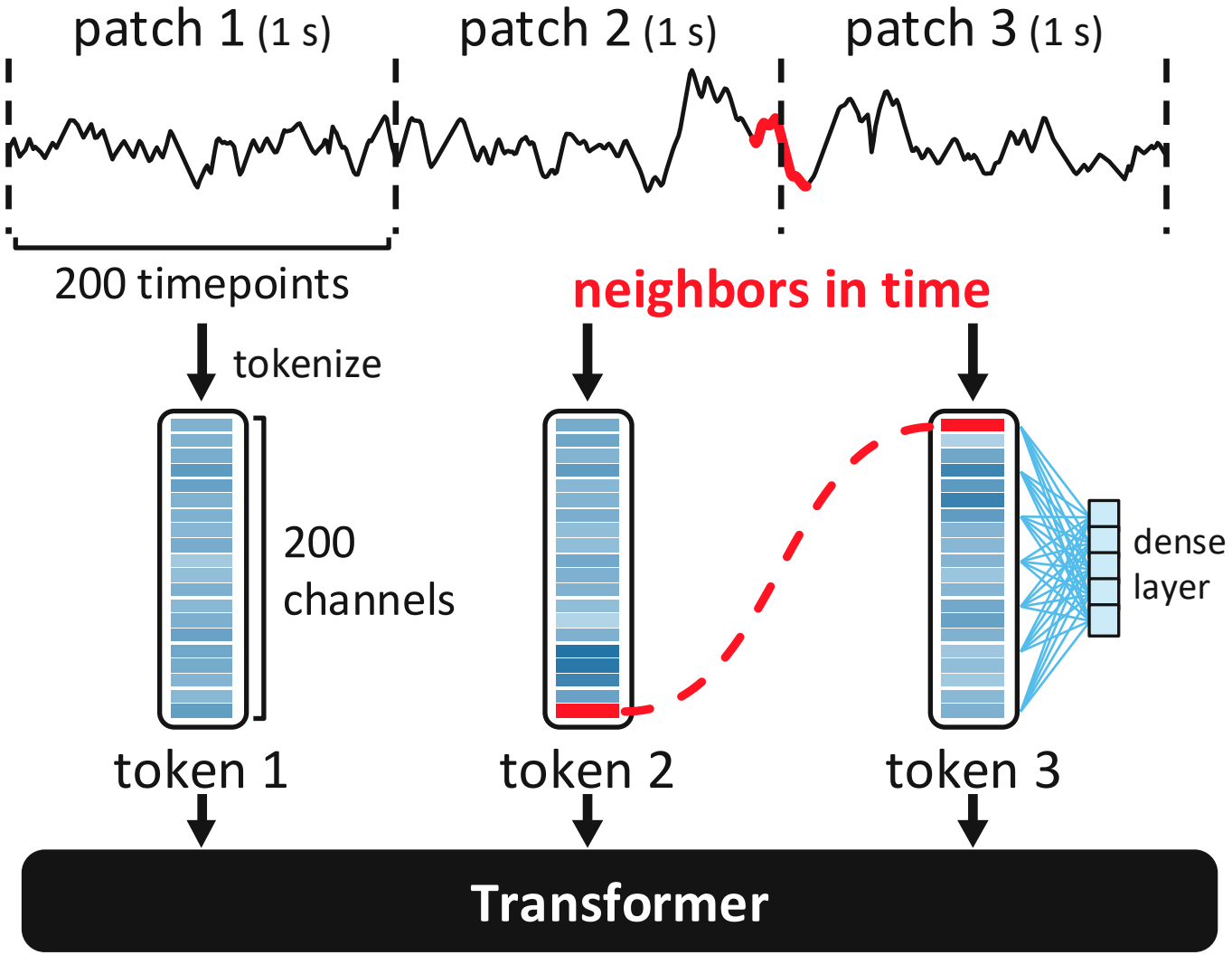
Brain Foundation Models are mainly developed using EEG

- Goals: Learn universal representation in pretraining to apply for the downstream tasks.



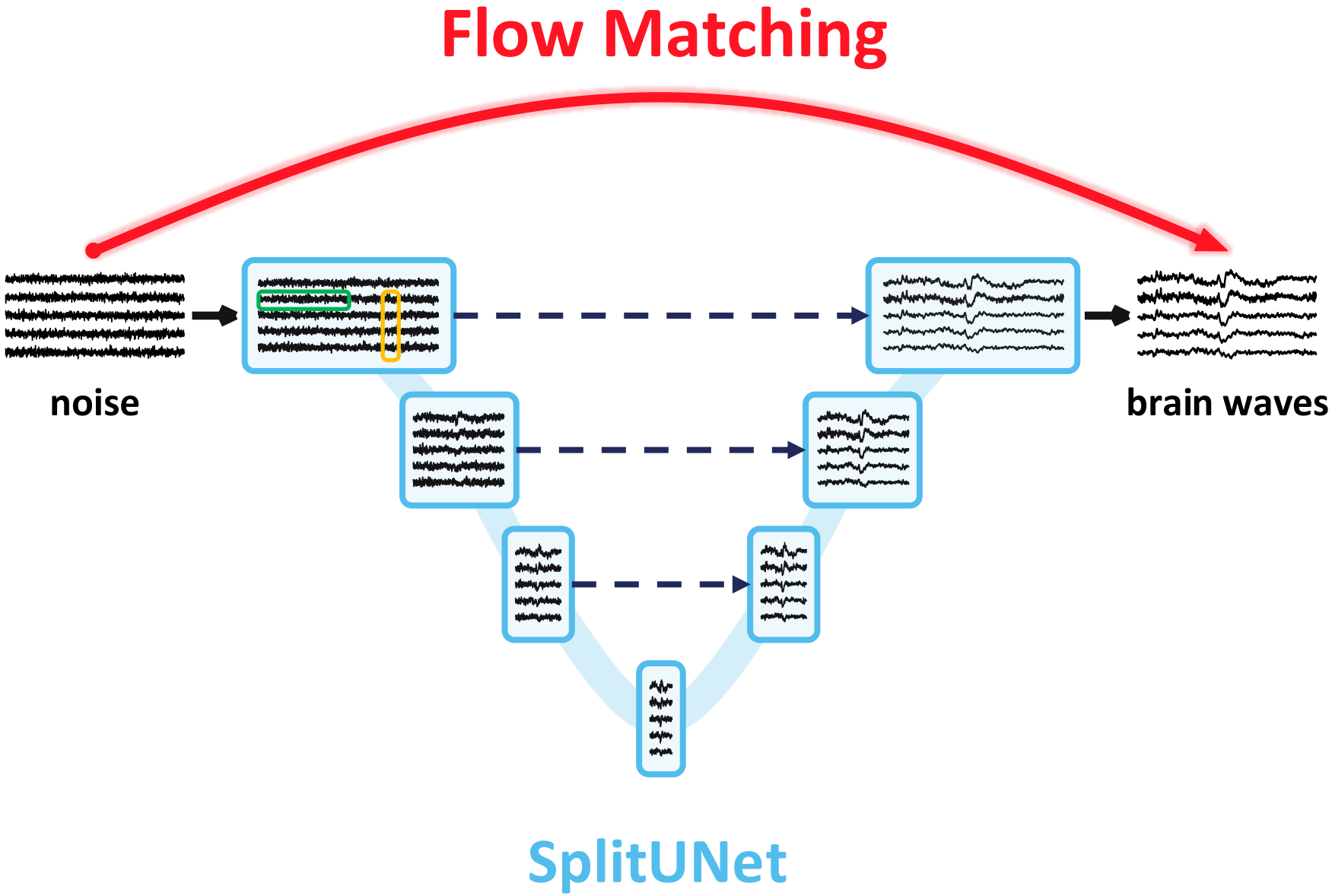
Zhou, Xinliang, et al. "Brain foundation models: A survey on advancements in neural signal processing and brain discovery." IEEE Signal Processing Magazine 42.5 (2025): 22-35.

Most Brain Foundation Models are based on Transformers



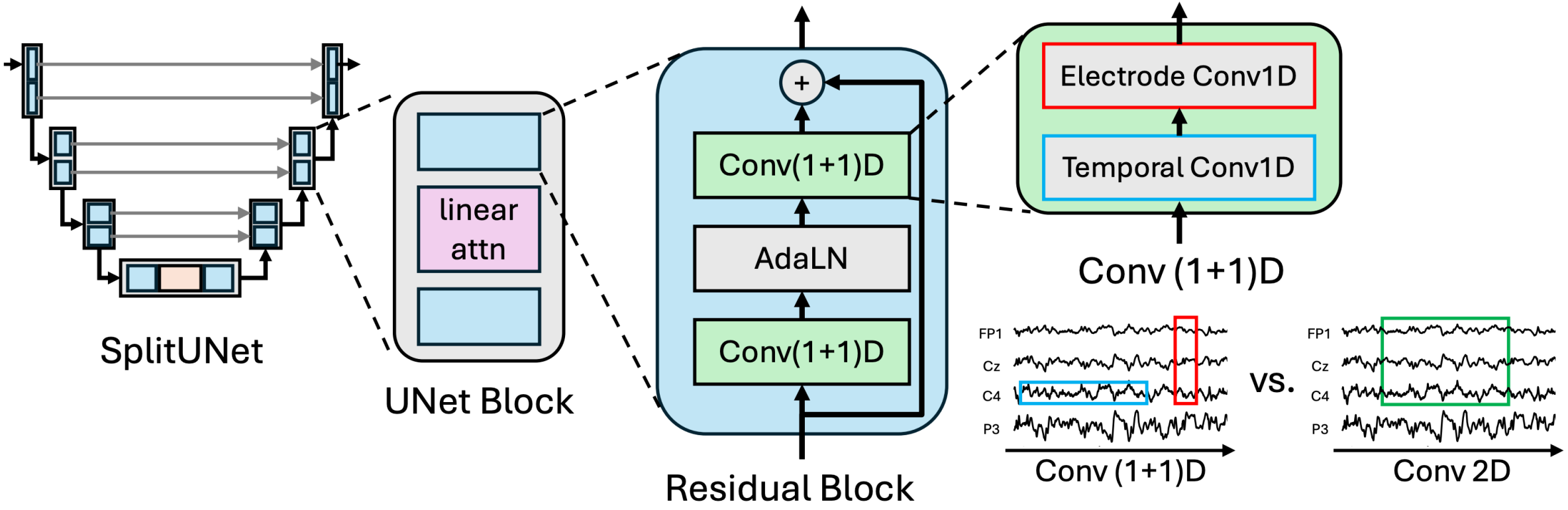
Tokenization Breaks Temporal Continuity of EEG signals!

B[FM]^2: Brain Foundation Model via Flow Matching



SplitUNet: Decomposing Electrode and Time axis

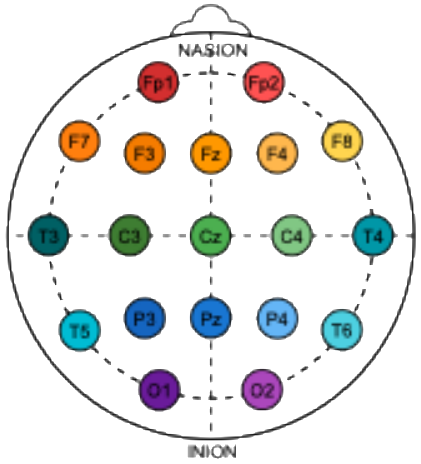
- Decompose 2D (Electrode × Time) convolution into two 1D convolutions.
- Downsample only the temporal dimension.



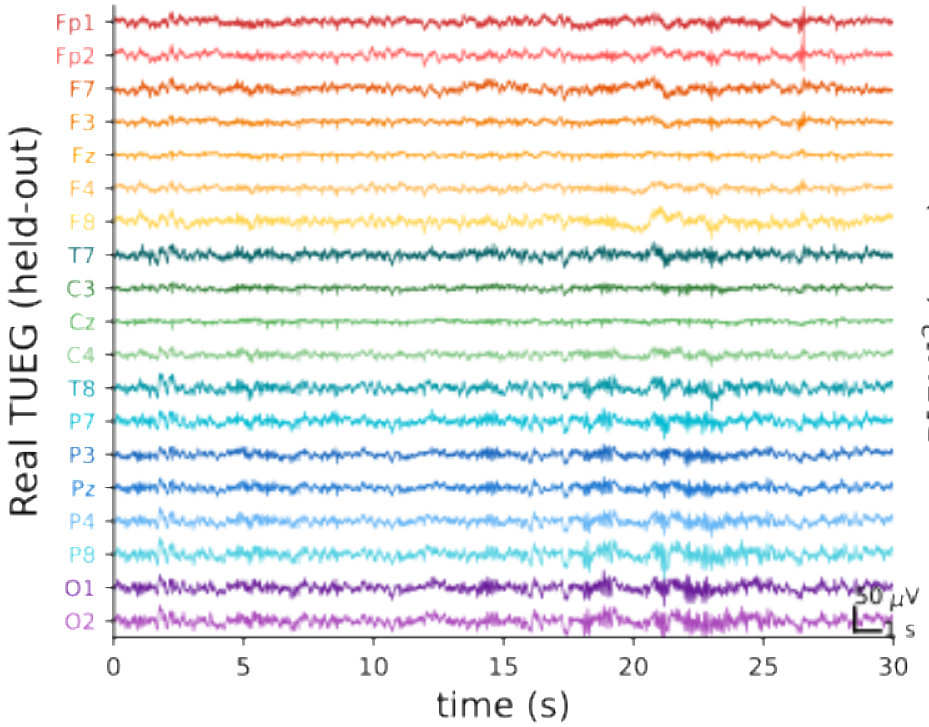
Hwang, Jaedong, et al. "B[FM]²: Brain Foundation Model via Flow Matching with SplitUNet." arXiv preprint arXiv:2606.20812 (2026).

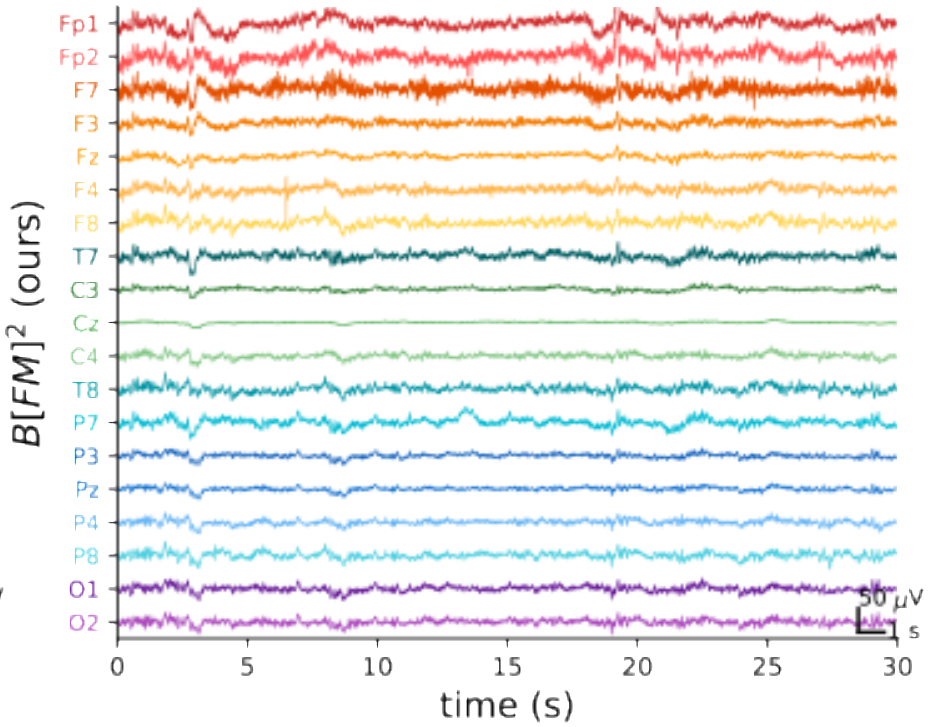
Real vs. Generated

- 10-20 monopolar coordinate

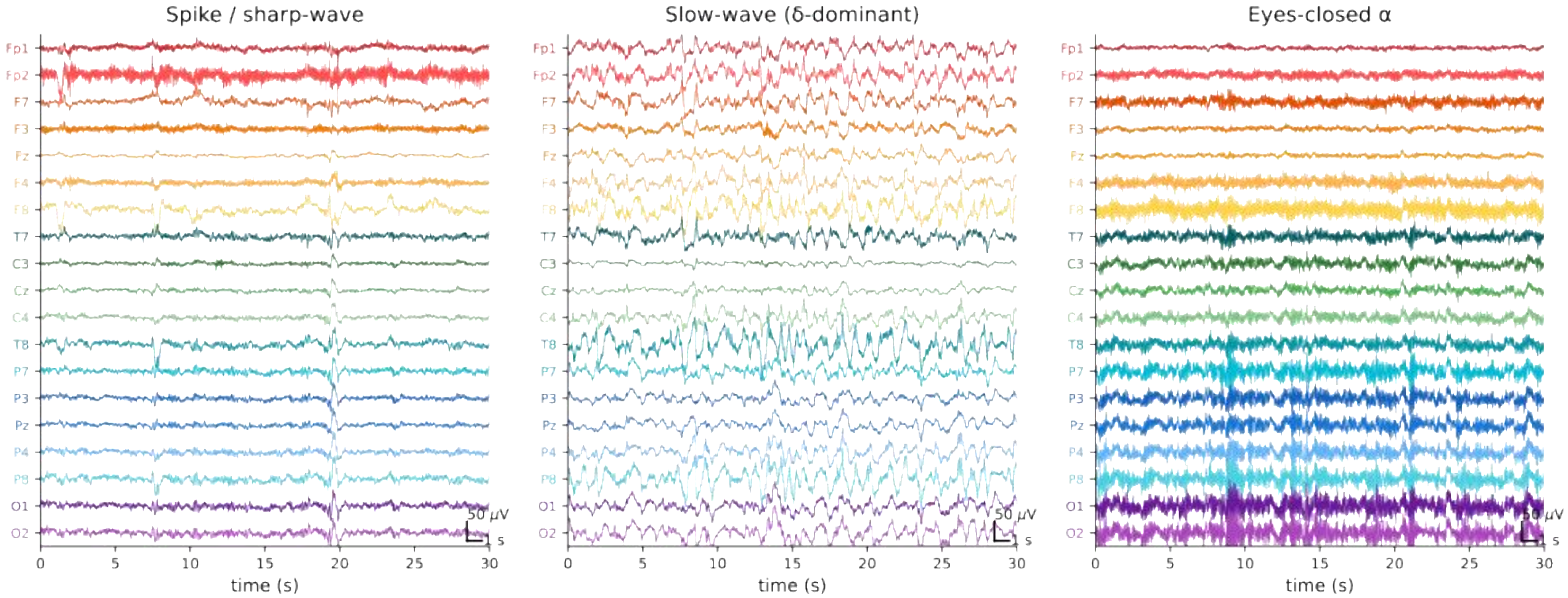


10-20 System



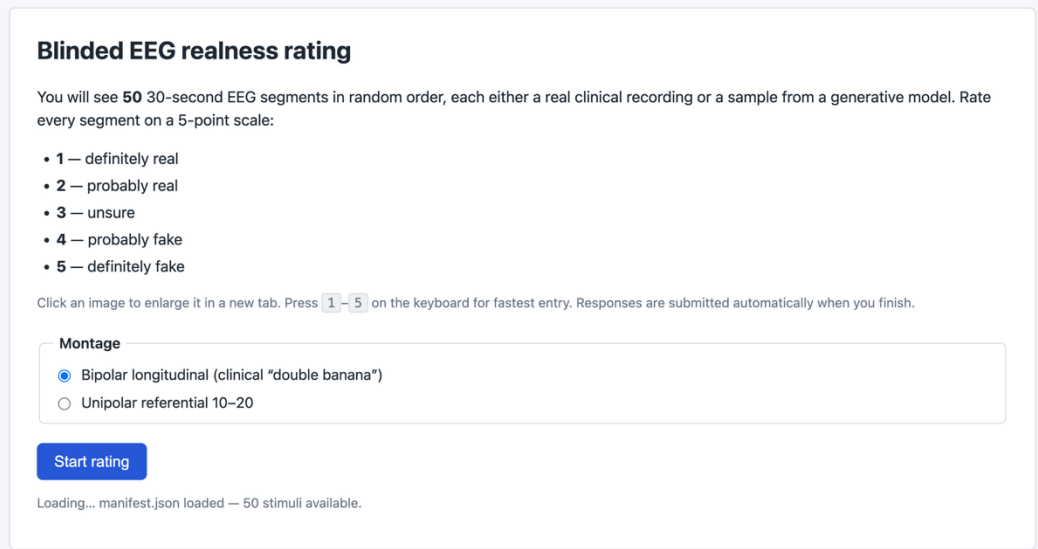


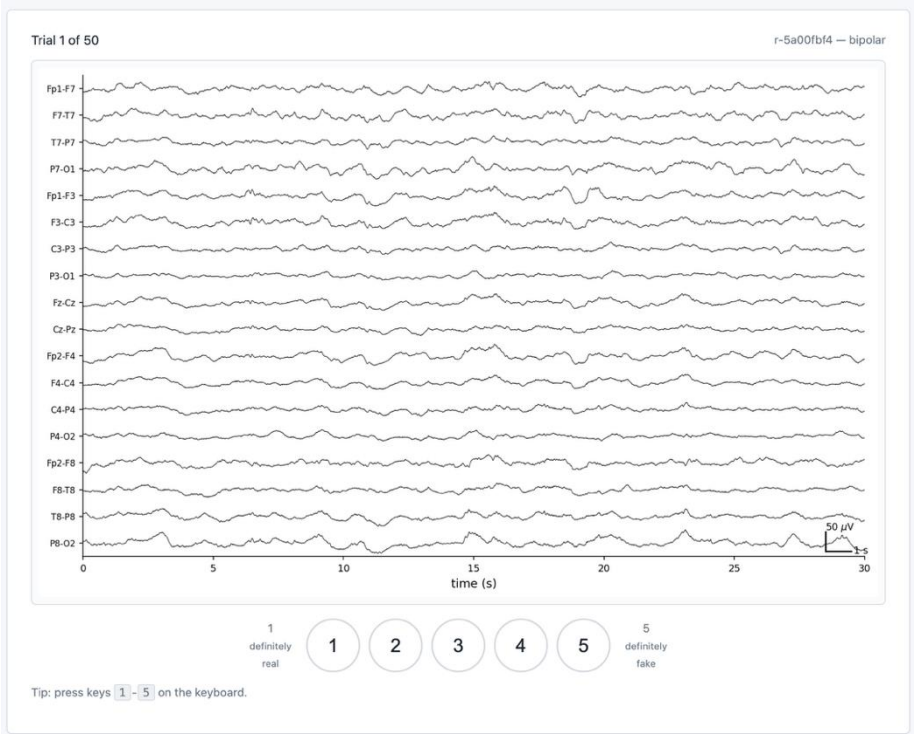
B[FM]^2 generates physiologically diverse EEG patterns



Human evaluation with 2 Neurologists

- Bipolar representation (double banana)
- Evaluate fakeness 1-5 for 50 samples.

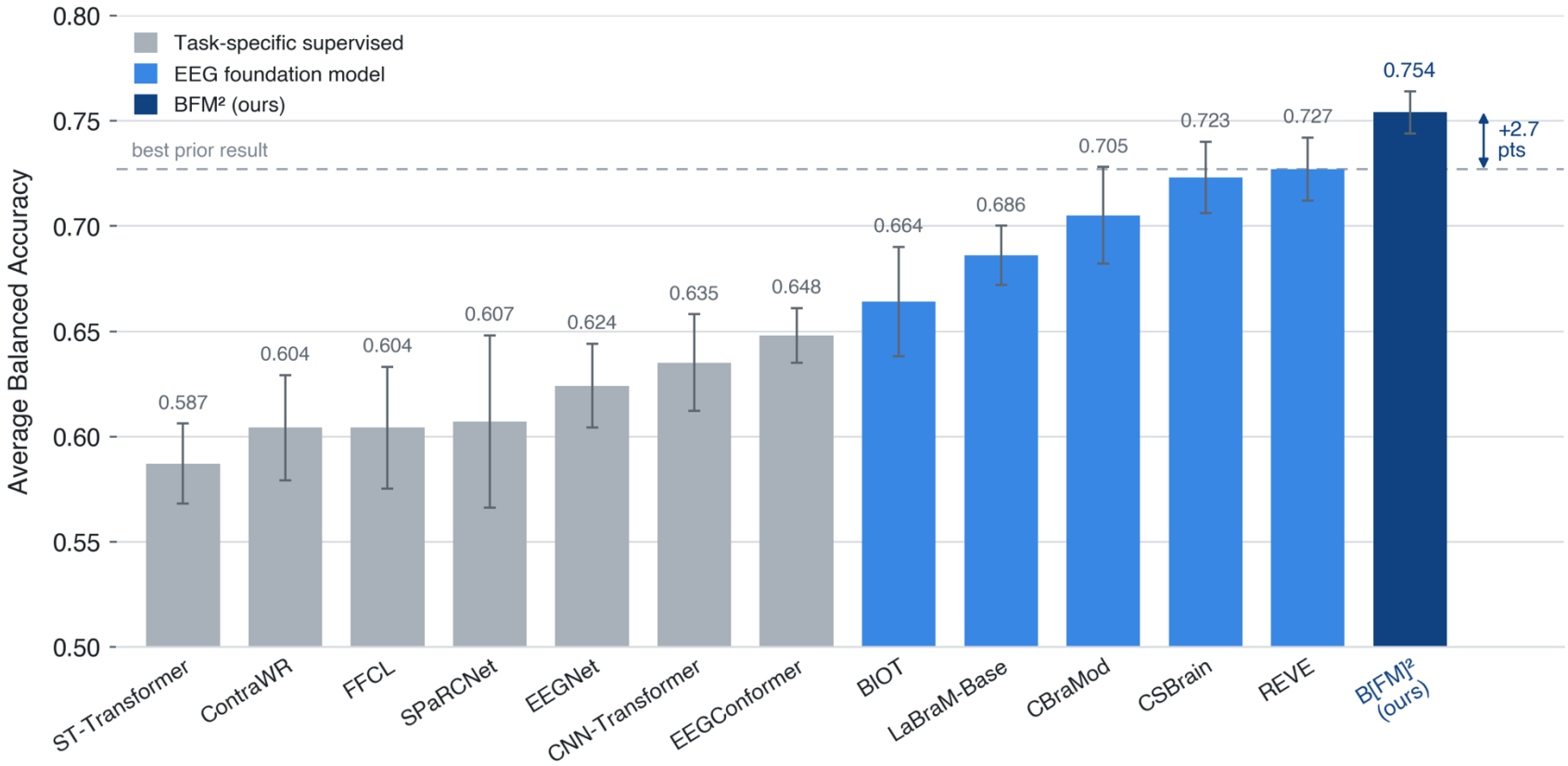




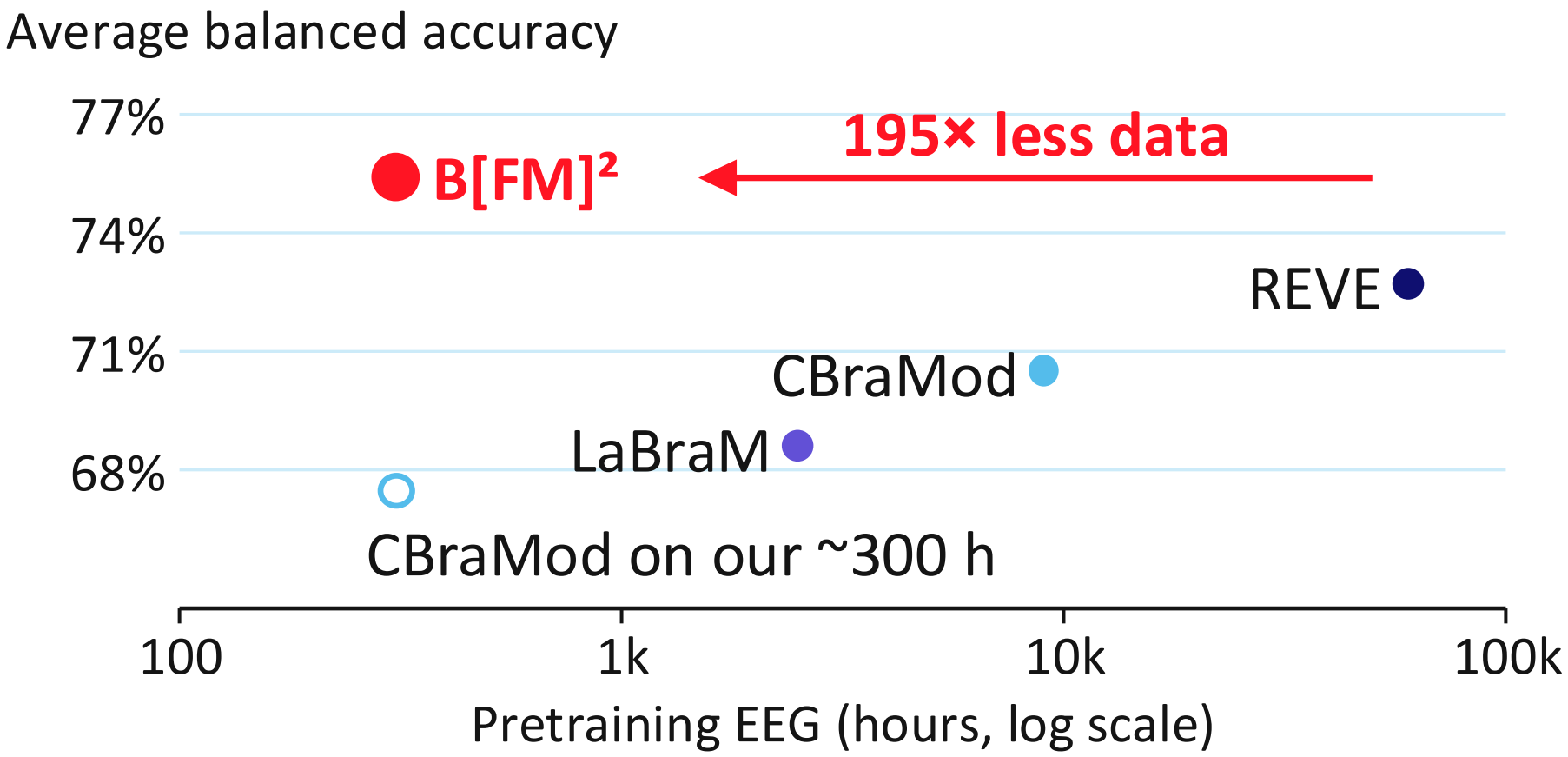
Reader	Mean realness (↓ for real, ↑ for fake)		Mann-Whitney U		Agreement	
	Real Data	B[FM]^2	U	p	ρ	Cohen's κ
R1	2.96 ± 1.02	2.60 ± 1.04	251.5	0.204	0.052	-0.096
R2	3.08 ± 1.12	2.32 ± 0.80	188.5	0.011		
Pooled	3.02 ± 1.06	2.46 ± 0.93	876.0	0.007	-	-

B[FM]^2 outperforms in various downstream tasks

Task	Dataset
Mental Disorder	Mumtaz
Mental Stress	MAT
Seizure Detection	Siena
Sleep staging	ISRUC
	HMC
Event Type	TUEV
Abnormal Detection	TUAB
Emotion Recognition	SEED-V
Motor Imagery	BCIC-IV-2a

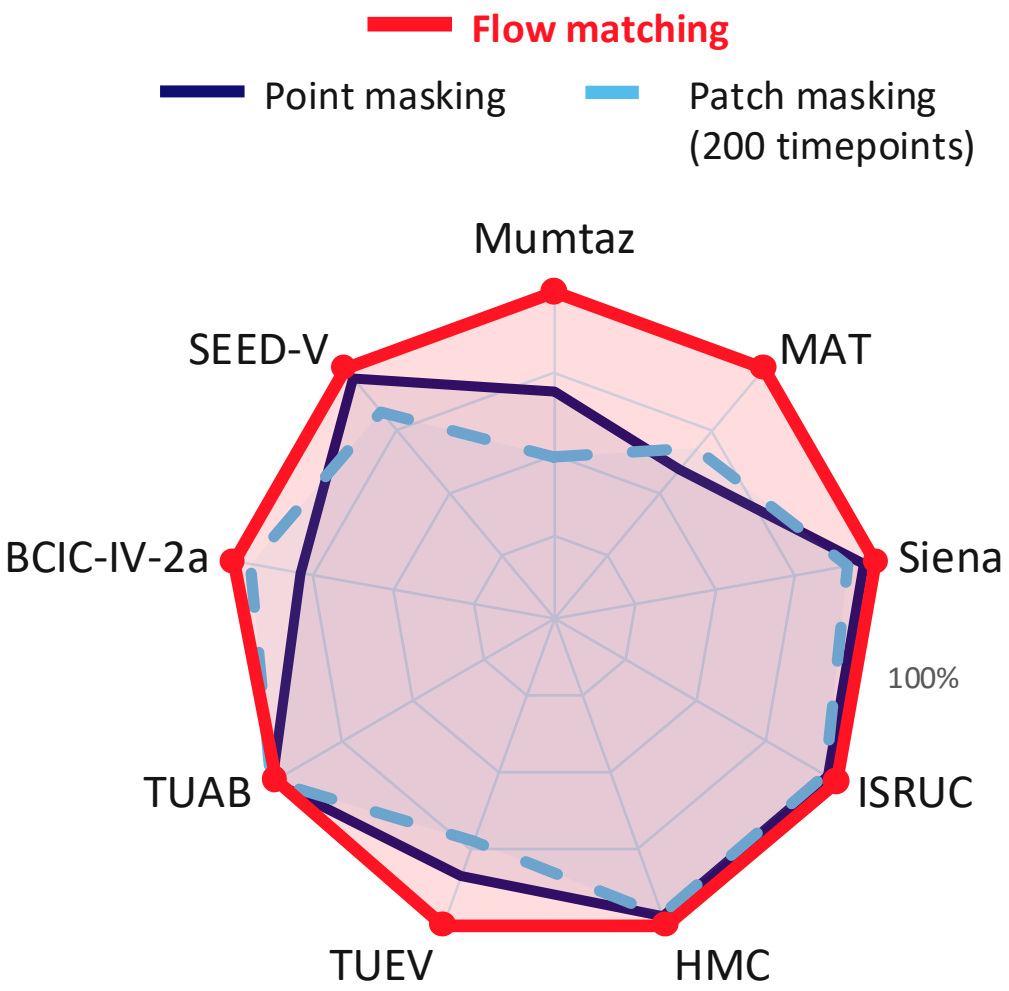


B[FM]² requires much less pretraining data

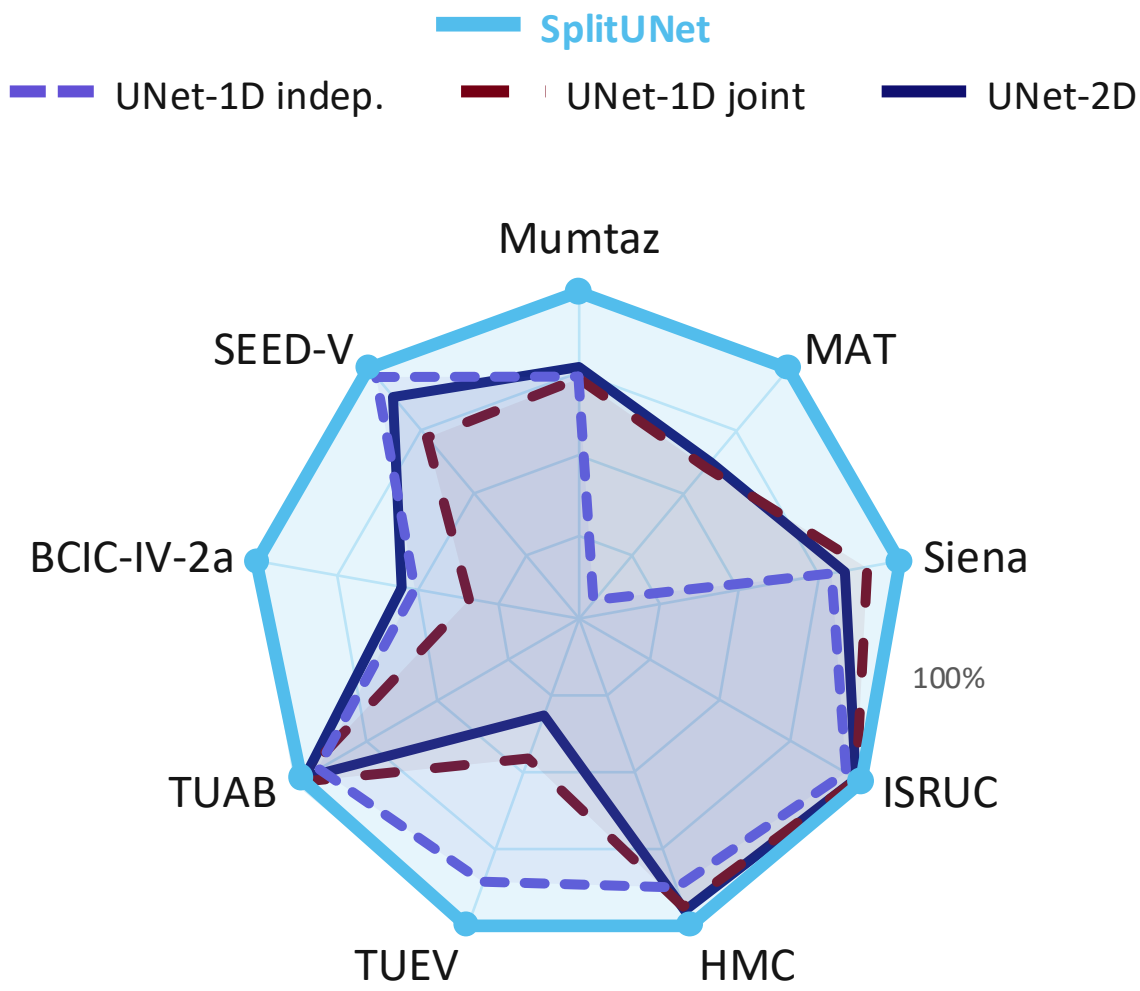


What are the factors that lead to performance improvement?

Objective (SplitUNet fixed)



Backbone (flow matching fixed)



Conclusion

- **Flow matching** pretrains on raw EEG, with no patches or masking.
- **SplitUNet** separates time and electrode convolutions.
- **State of the art** performance with much fewer pretraining data.
- **Generated EEG** that neurologists could not reliably tell from real EEG.

Thank you!



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project page

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