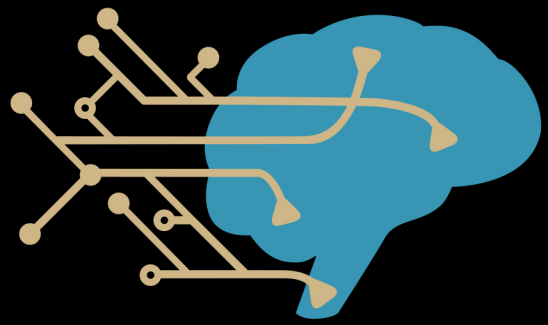

CENTER *for*
NEUROTECHNOLOGY

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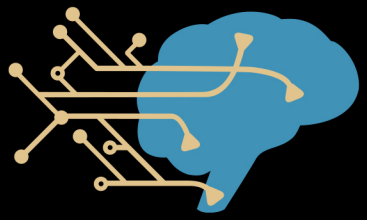

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AUGUST 27, 2020

Transferring generalized neural decoders across participants and recording modalities

Zoe Steine-Hanson
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Computer Science
and Engineering
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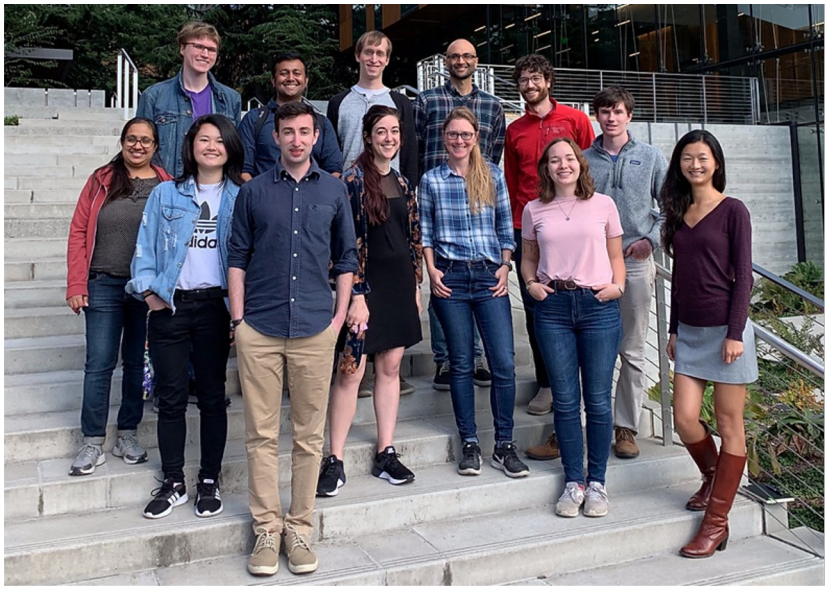
Brunton Lab



GRIDlab

Harborview staff

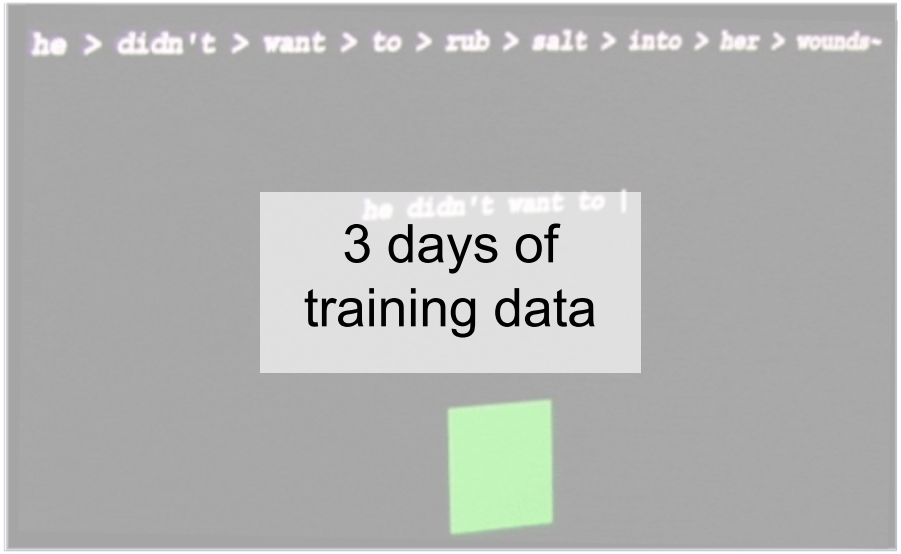
DARPA

NSF

Alfred P. Sloan FOUNDATION

Washington Research FOUNDATION

Hochberg et al. 2012



Willett et al. 2020

Problem

Neural training data is limited and obtaining it can be time-consuming

Solution

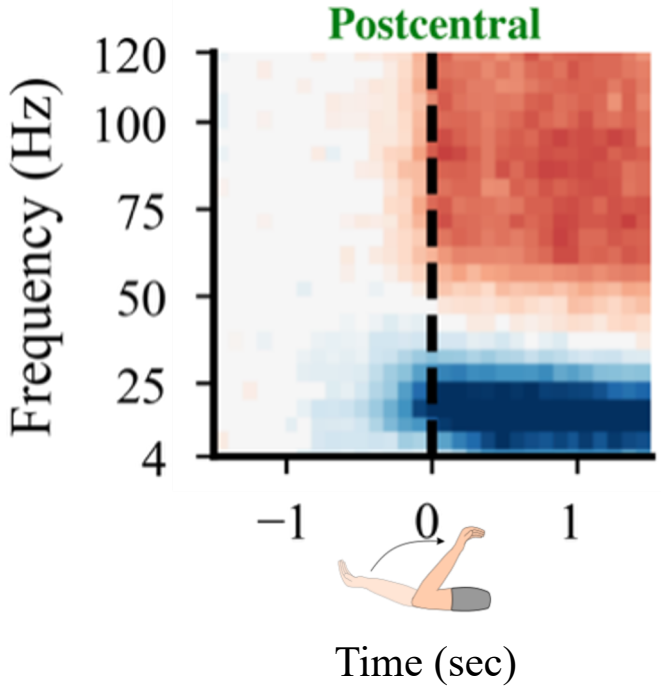
Train a decoder on data pooled across many participants, then fine-tune

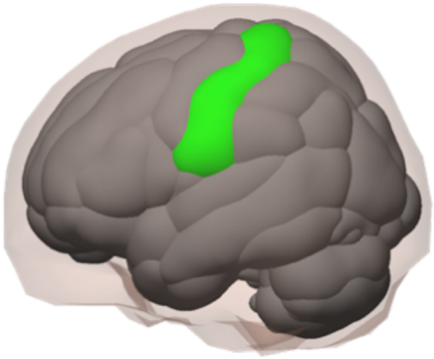
Requires generalized decoders

Decoders robust to cross-participant differences

So what differs from one person to the next?

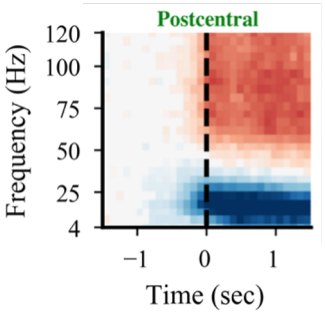
1. Specific frequency bands

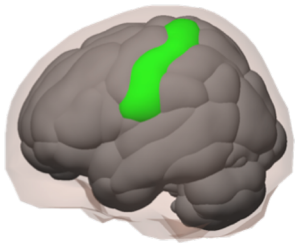


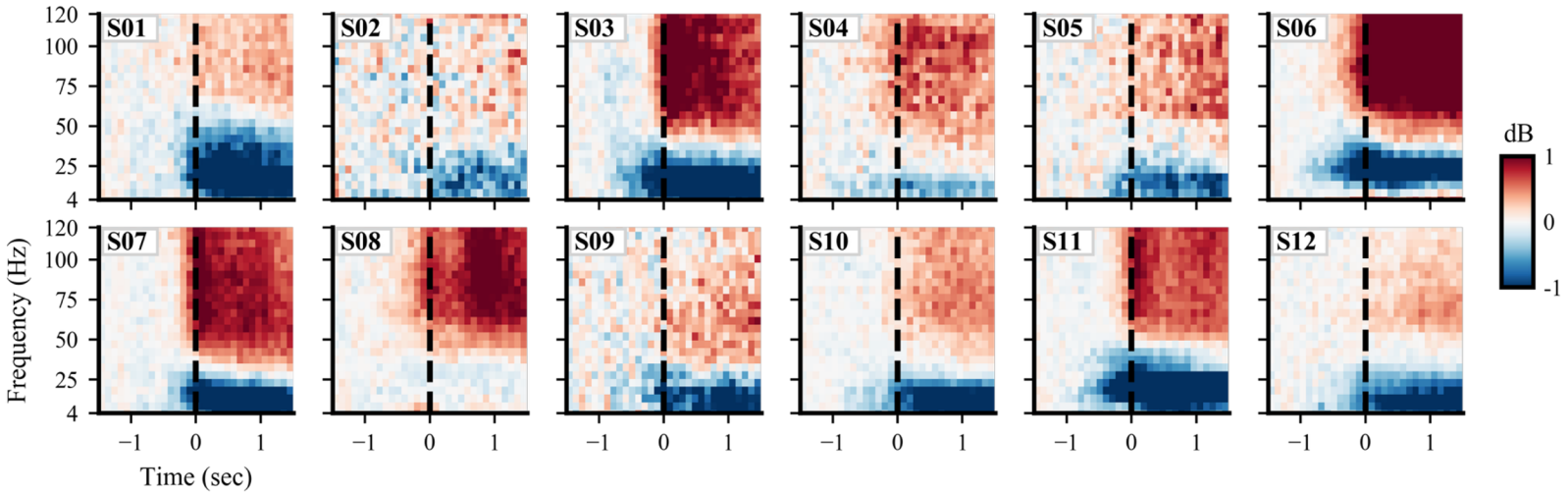


So what differs from one person to the next?

1. Specific frequency bands



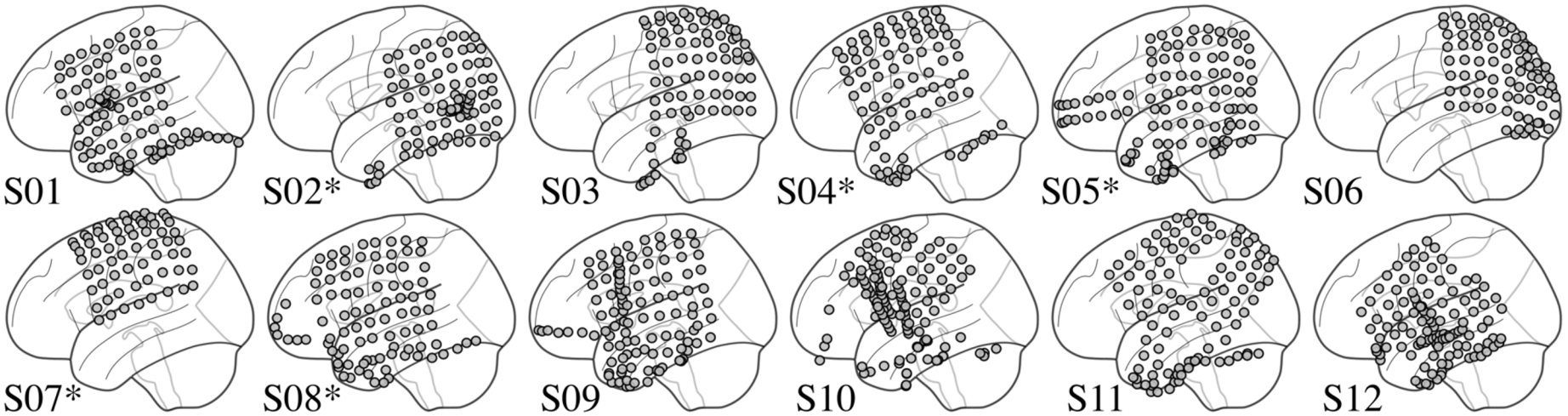


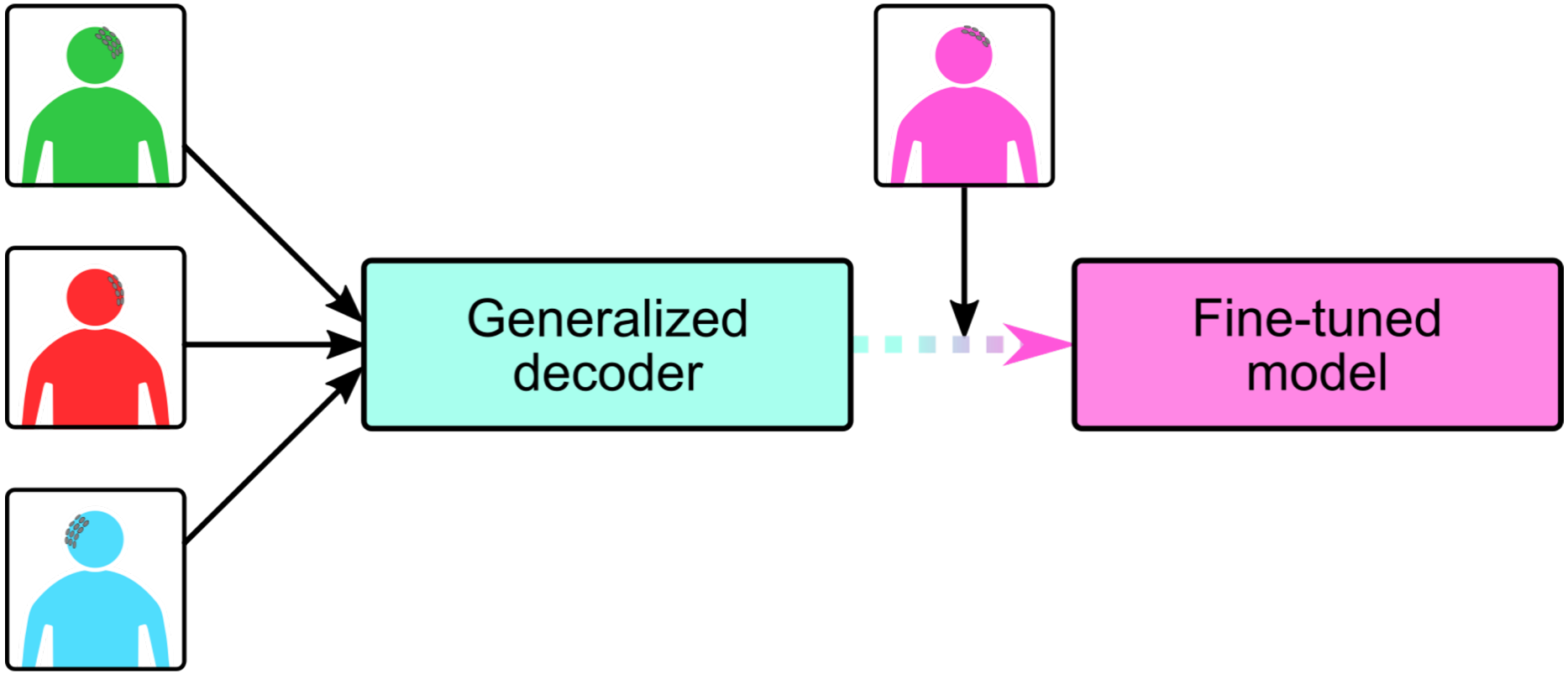


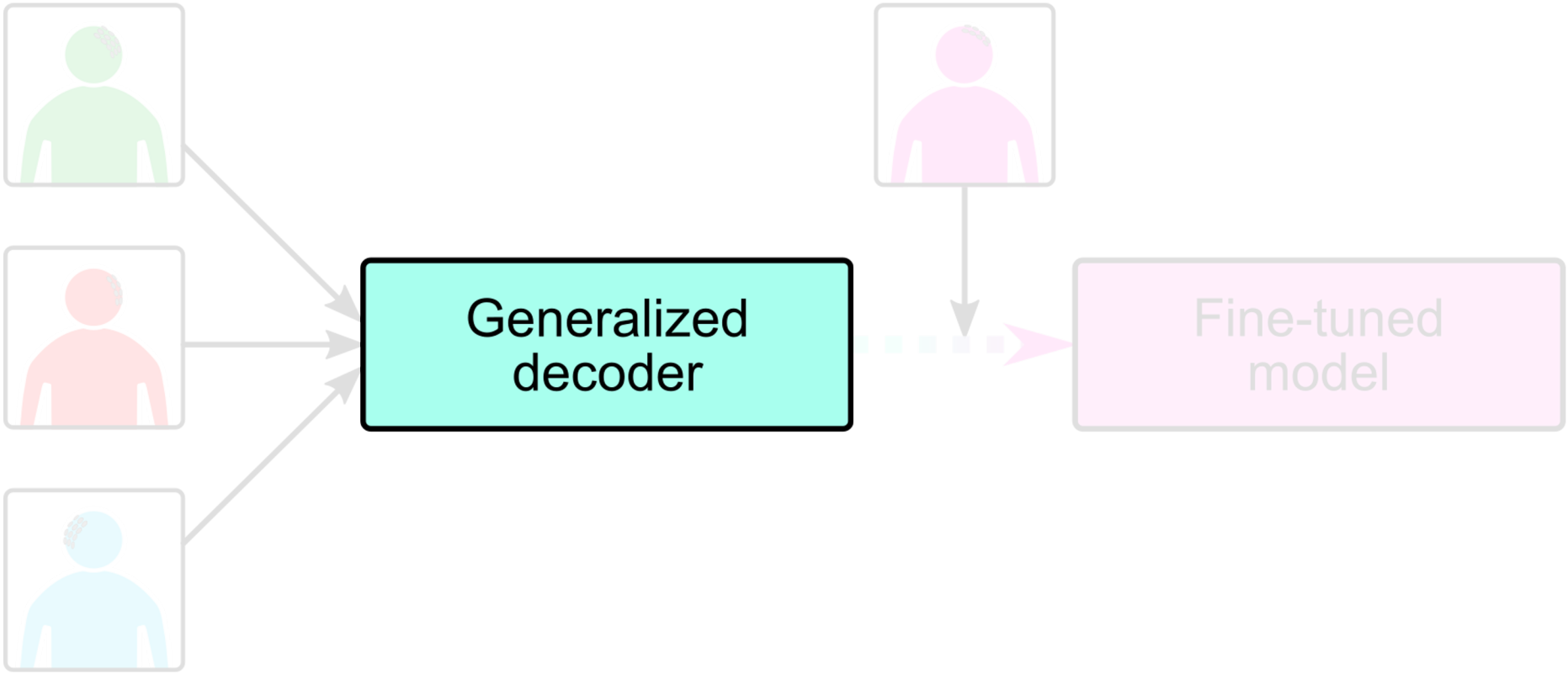
So what differs from one person to the next?

1. Specific frequency bands
2. Electrode placement

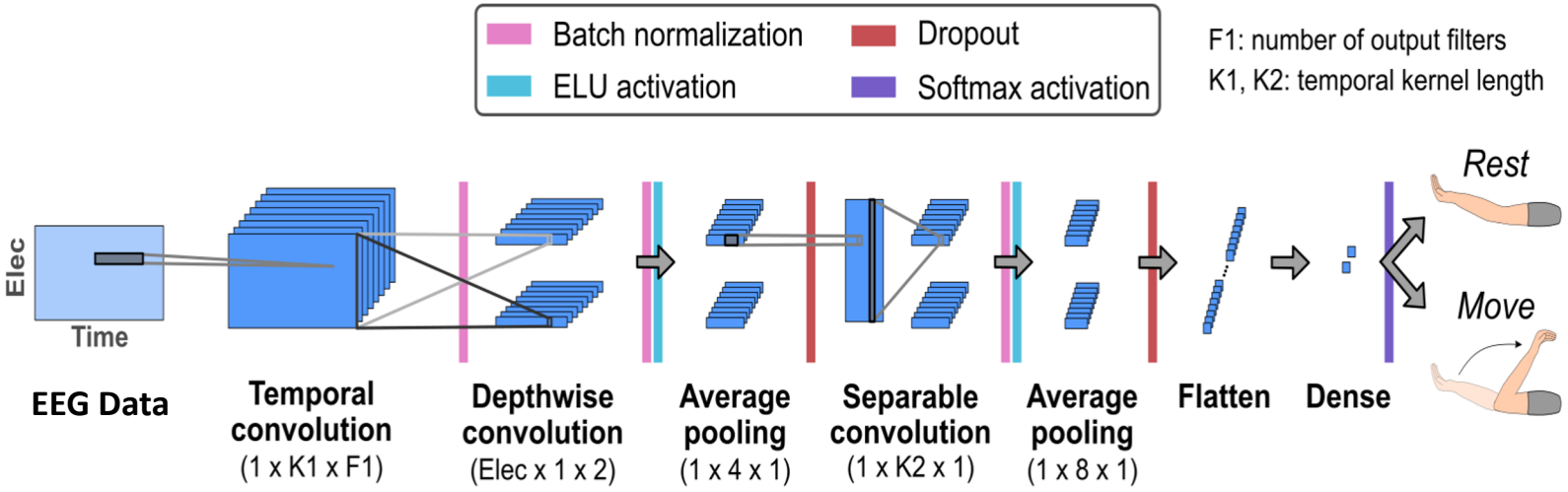
ECoG




Generalized
decoder
Fine-tuned
model


Generalized decoder
Fine-tuned model

Previous research – CNNs for decoding



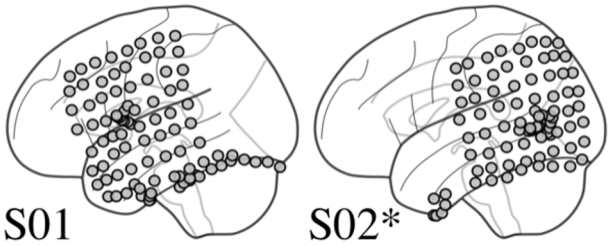
Model from Lawhern et al. *JNE* 2018

EEGNet

2 problems to solve

1. **Find data-driven frequency bands**

2. **Handle inconsistent electrode placements**

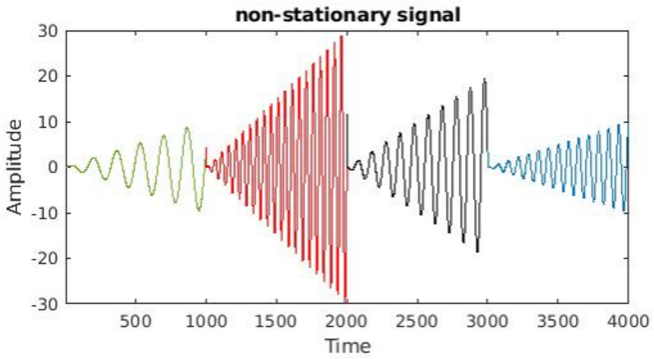


2 problems to solve

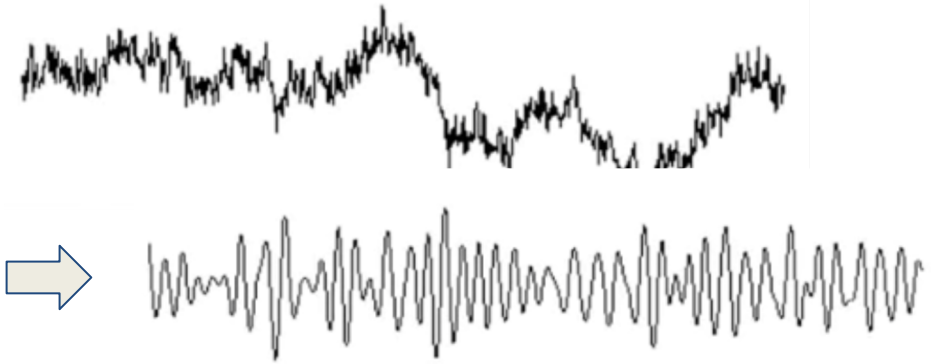
1 **Find data-driven frequency bands**

2 Handle inconsistent electrode placements

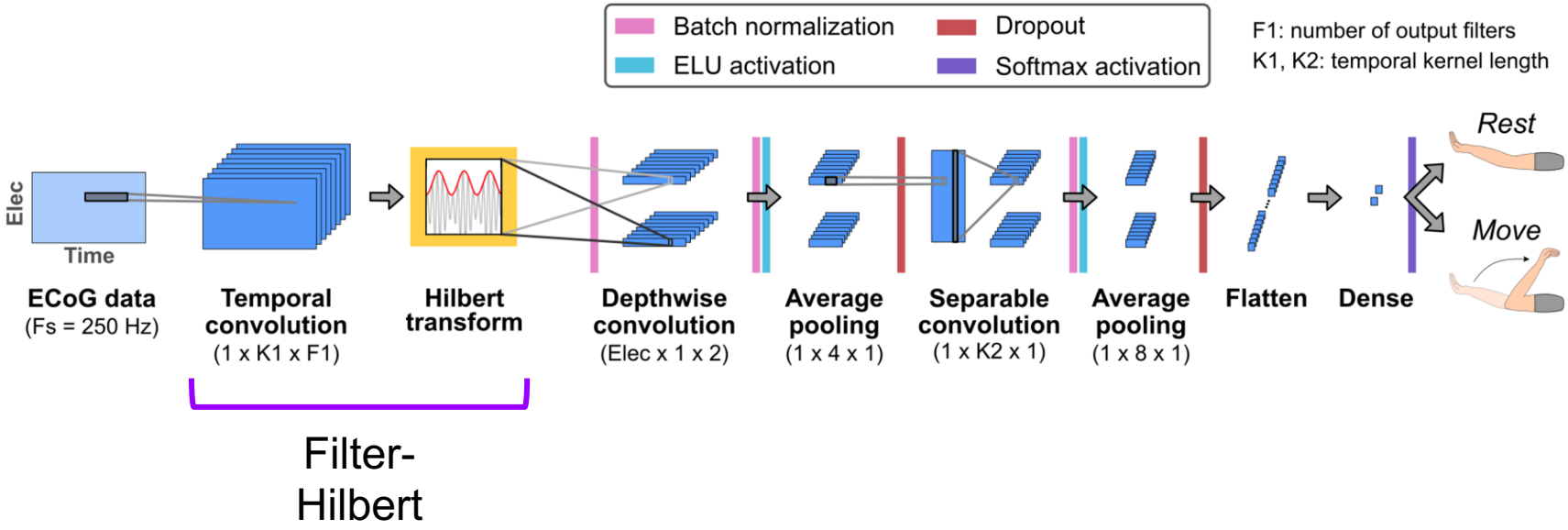
Time domain - Hilbert Transform



- Hilbert transform is not easily interpreted for broadband signals
- So, need to **bandpass filter the data** first (Filter-Hilbert method)



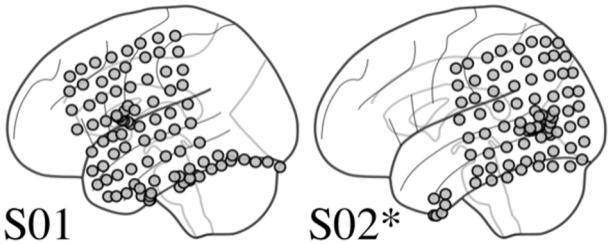
Add Hilbert transform layer to EEGNet



2 problems to solve

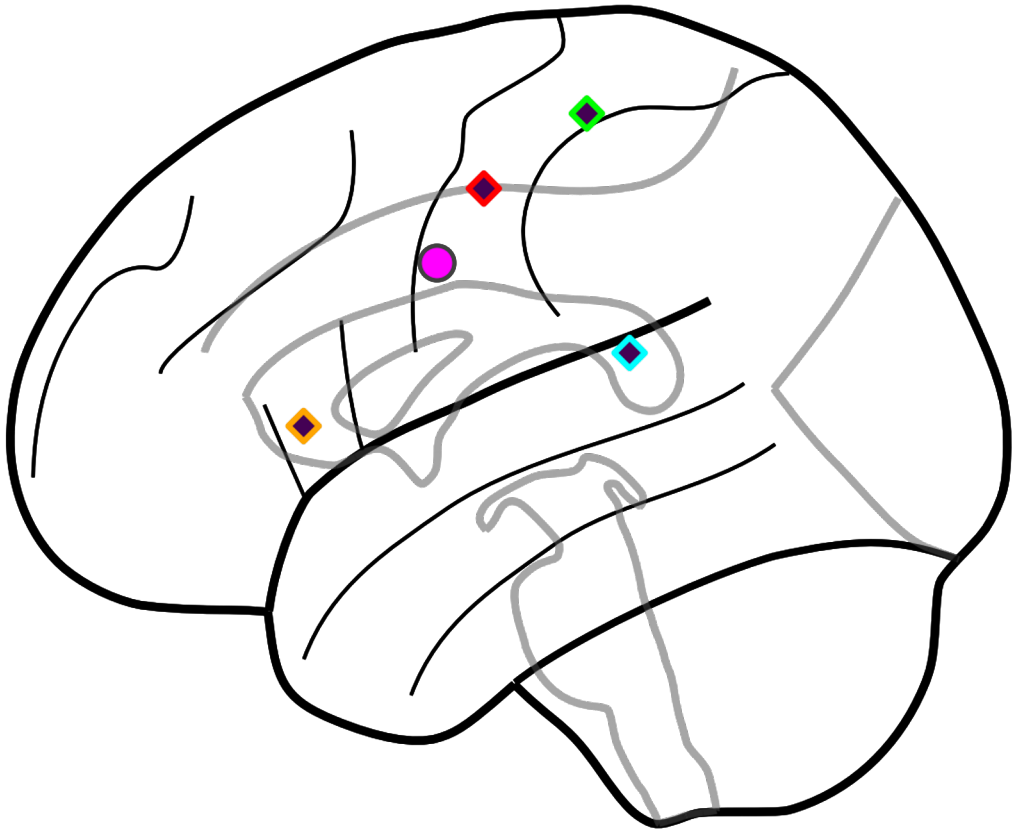
1 Find data-driven frequency bands ✓

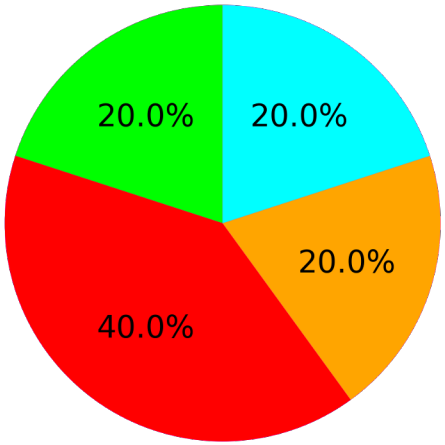
2 **Handle inconsistent electrode placements**



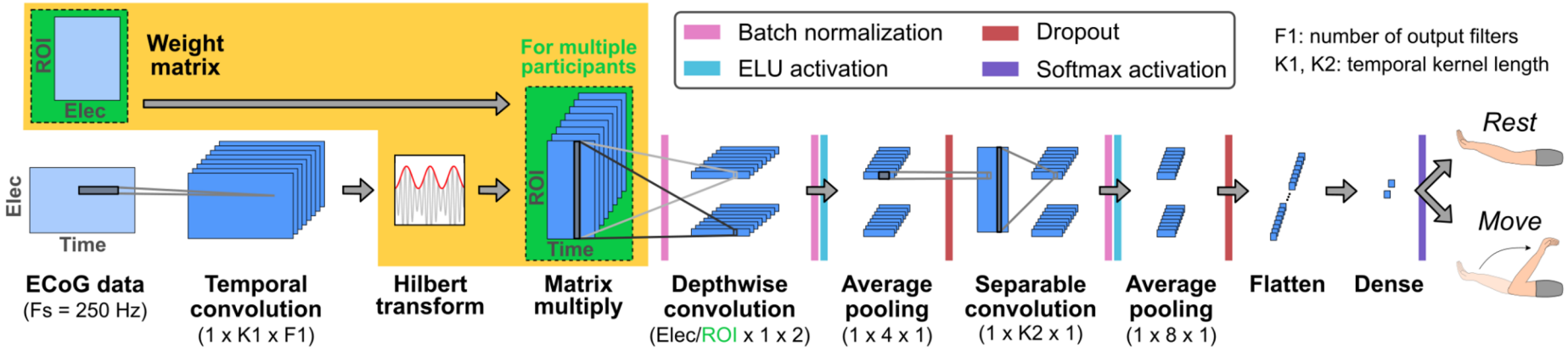
Project data onto common brain regions

Radial basis function interpolation



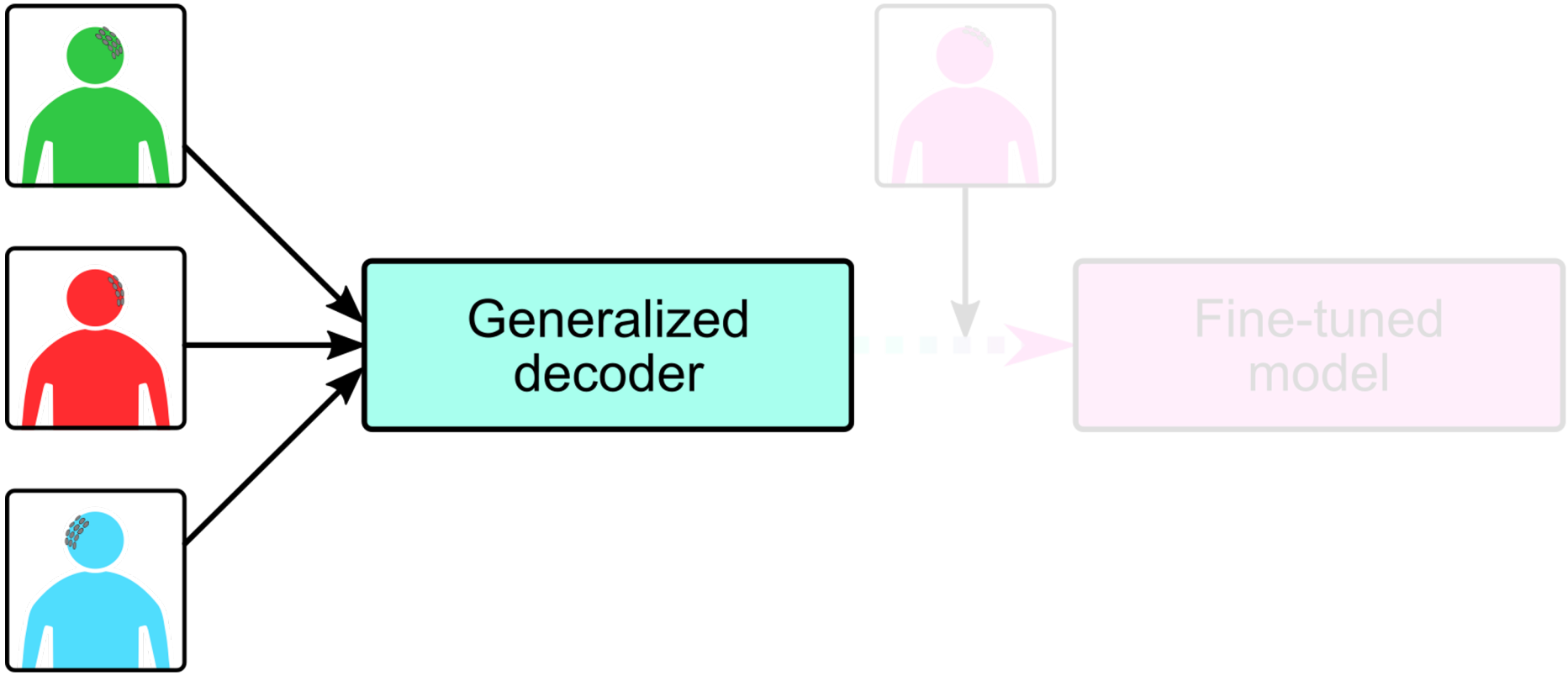


Final model - HTNet



1 Find data-driven frequency bands

2 Handle inconsistent electrode placement


Generalized decoder
Fine-tuned model

Testing HTNet on real data

ECoG:

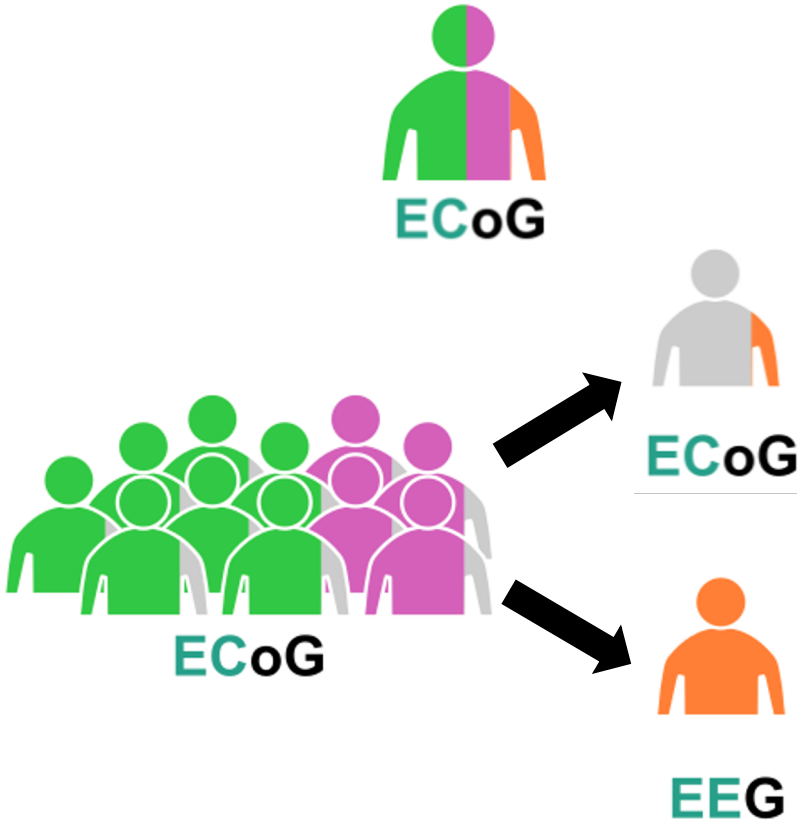
- **12 participants**
- **Naturalistic arm movements v. rest**
- **302–1894 events each**

EEG:

- **15 participants**
- **Cued elbow flexion v. rest**
- **120 events each**

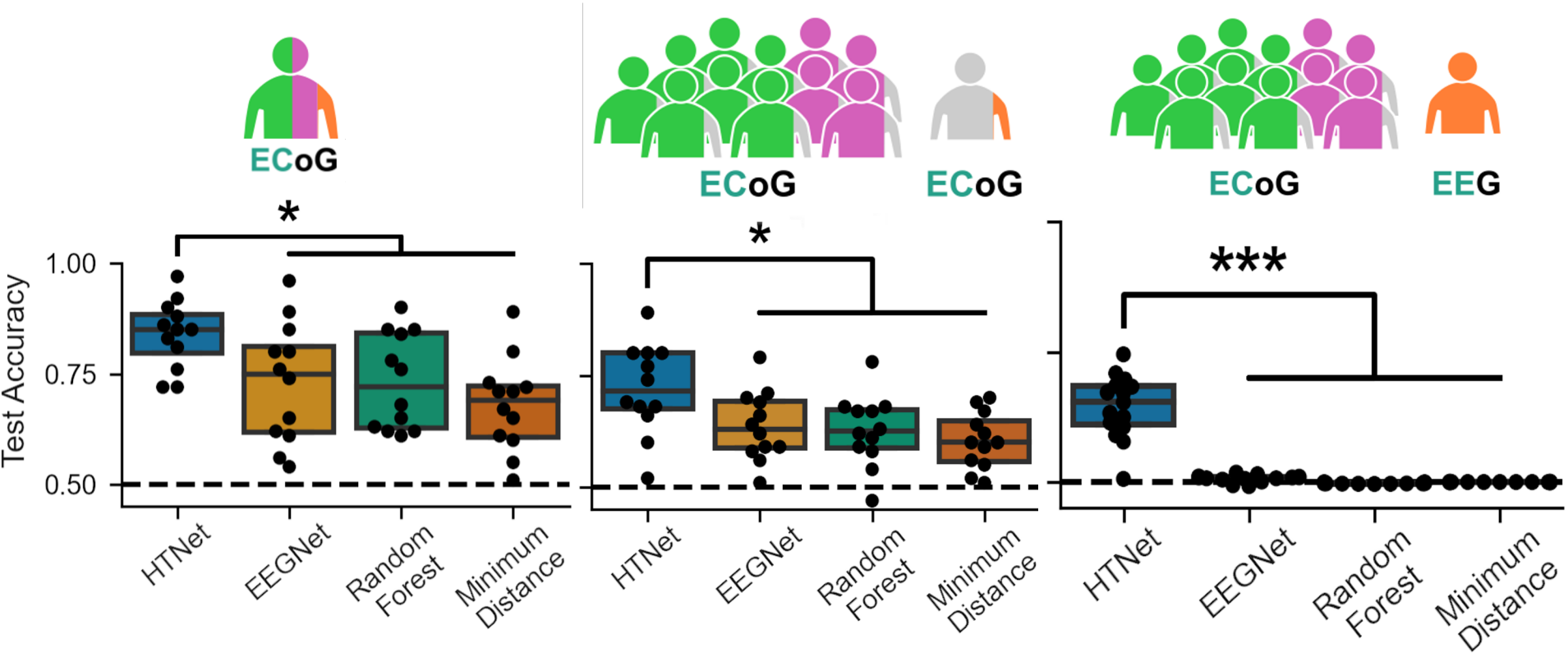
Experimental design

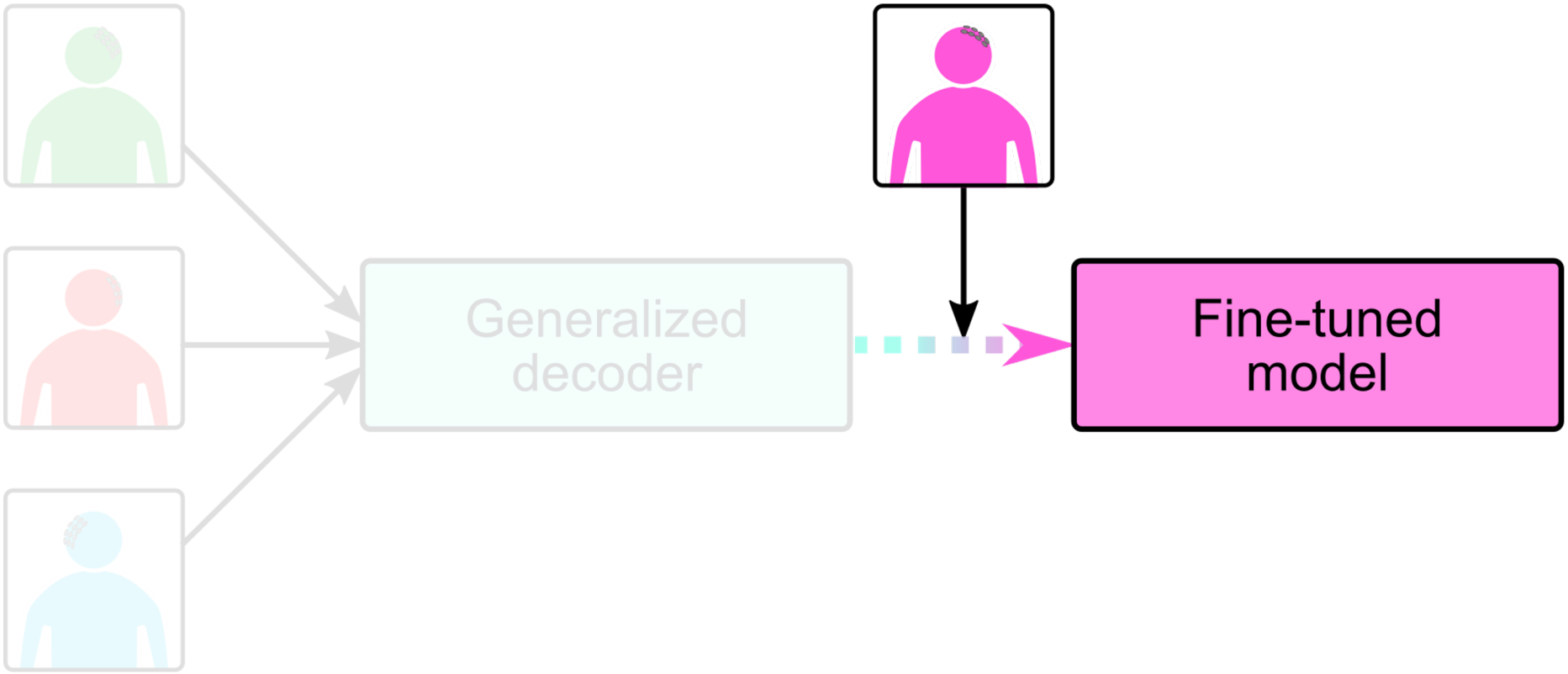
Train set
Validation set
Test set



1. Tailored decoder
2. Generalized decoder, same modality
3. Generalized decoder, unseen modality

HTNet best across all experiments




Generalized decoder
Fine-tuned model

Fine-tuning experimental design

Pretrain
(ECoG)

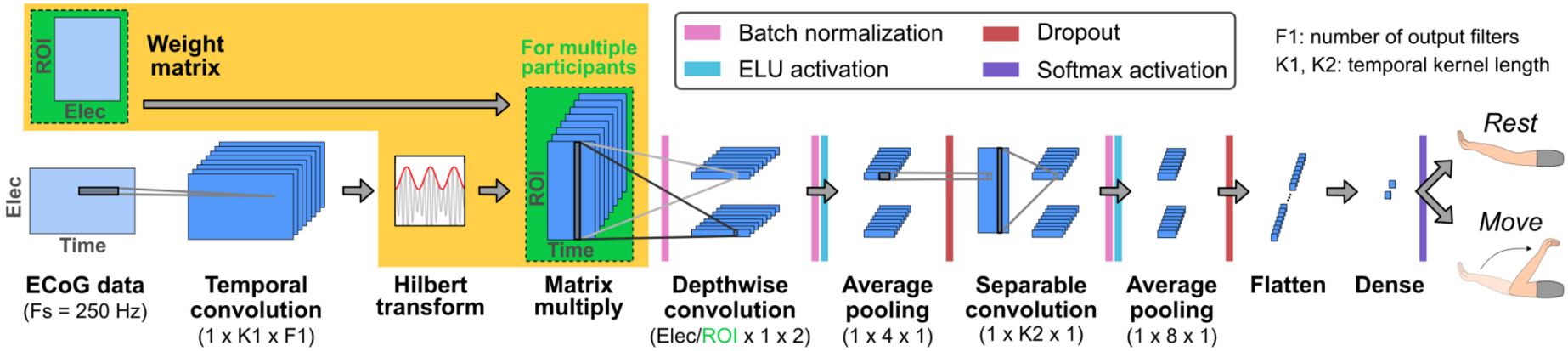
Fine-tune
(ECoG)

1. Same modality

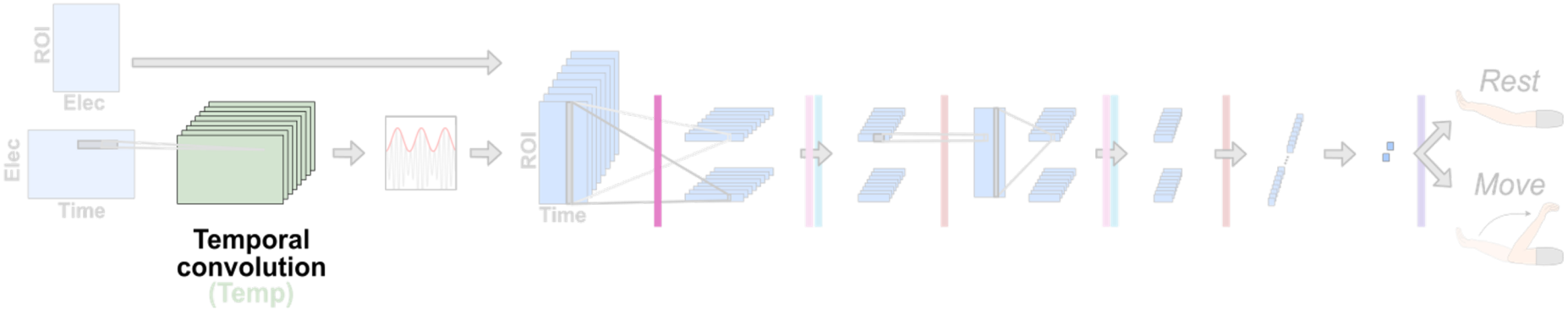
Fine-tune
(EEG)

2. Unseen modality

Fine-tuning HTNet convolutions

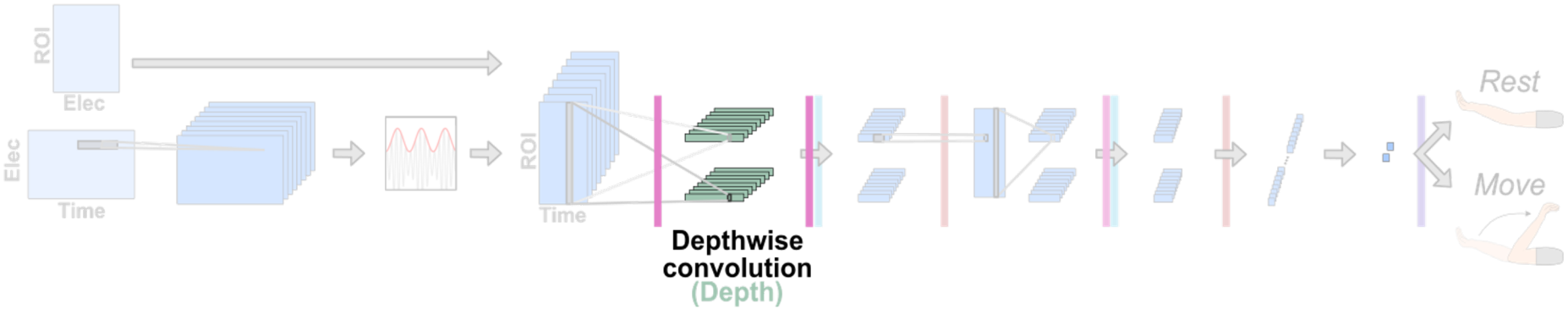


Fine-tuning HTNet convolutions



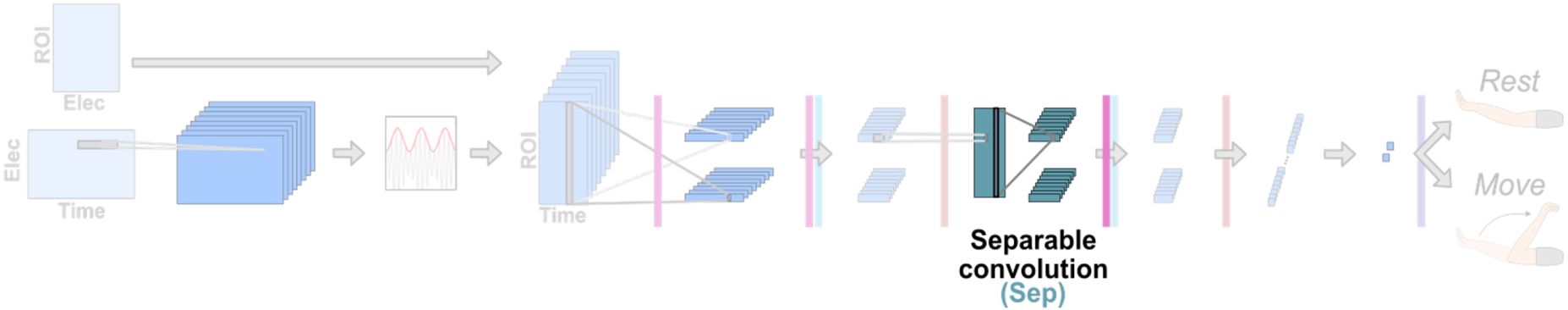
Parameters: 532

Fine-tuning HTNet convolutions



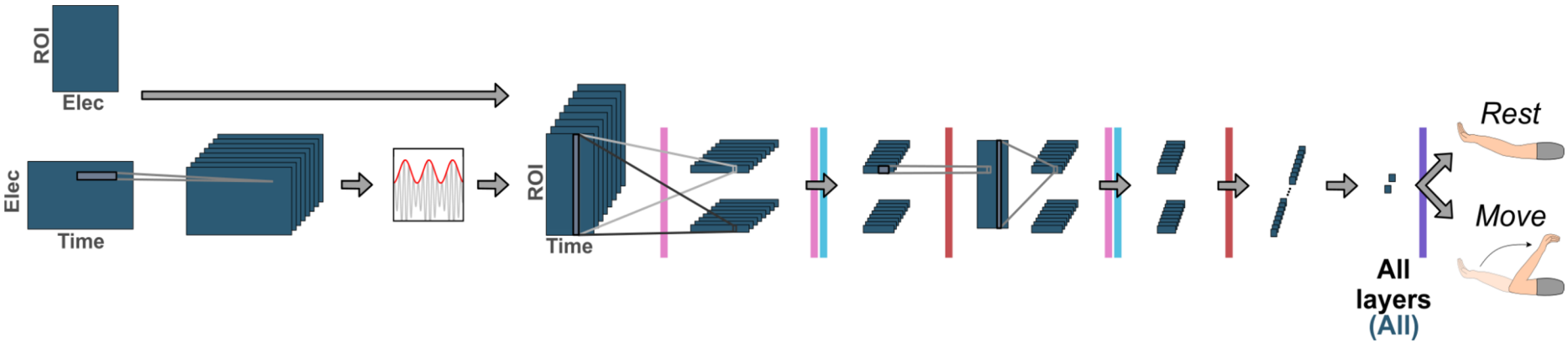
Parameters: 5700

Fine-tuning HTNet convolutions



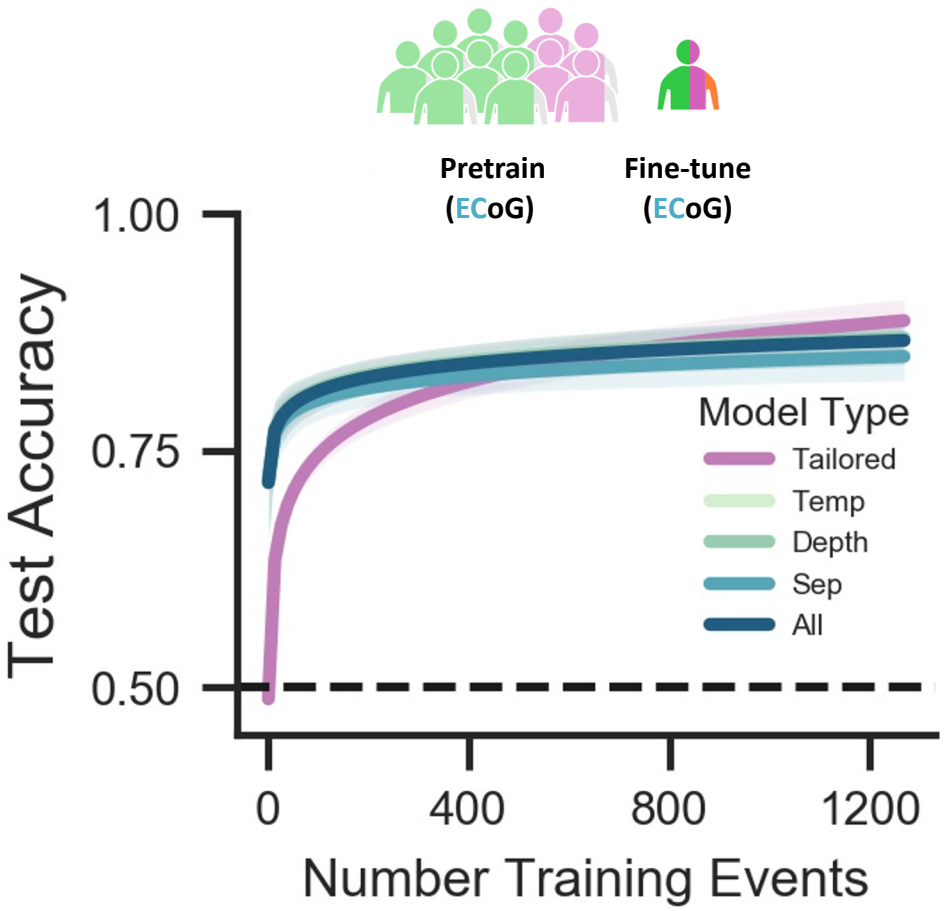
Parameters: 4940

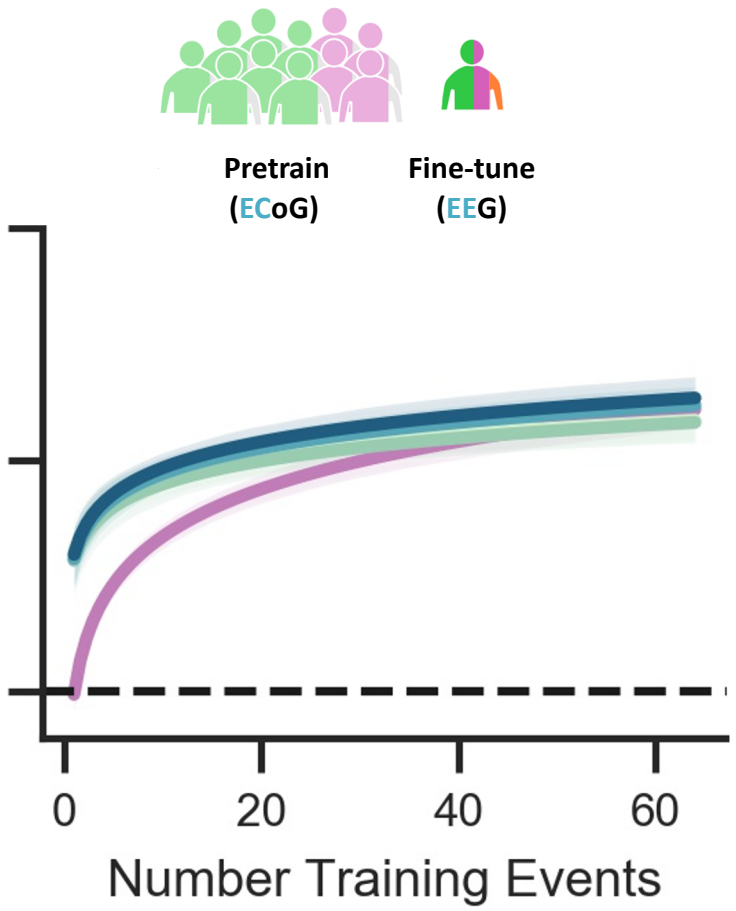
Fine-tuning HTNet convolutions

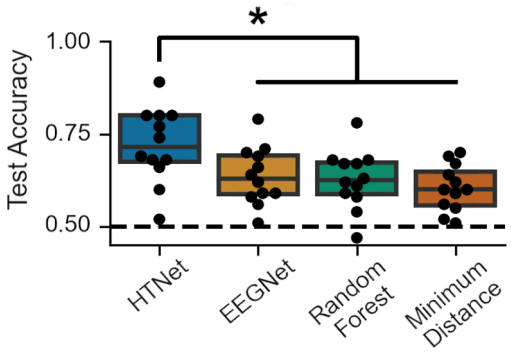


Parameters: 12238

Fine-Tuning Does Better Than Tailored With Little Data







Generalized decoder

Fine-tuned model