Neural decoding from stereotactic EEG: accounting for electrode variability across subjects

38th Conference on Neural Information Processing Systems (NeurIPS 2024)

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1. University of Pennsylvania, 2. Stanford University, 3. Archimedes, Athena RC

Background

How do thoughts translate into actions?

Thoughts **Actions**

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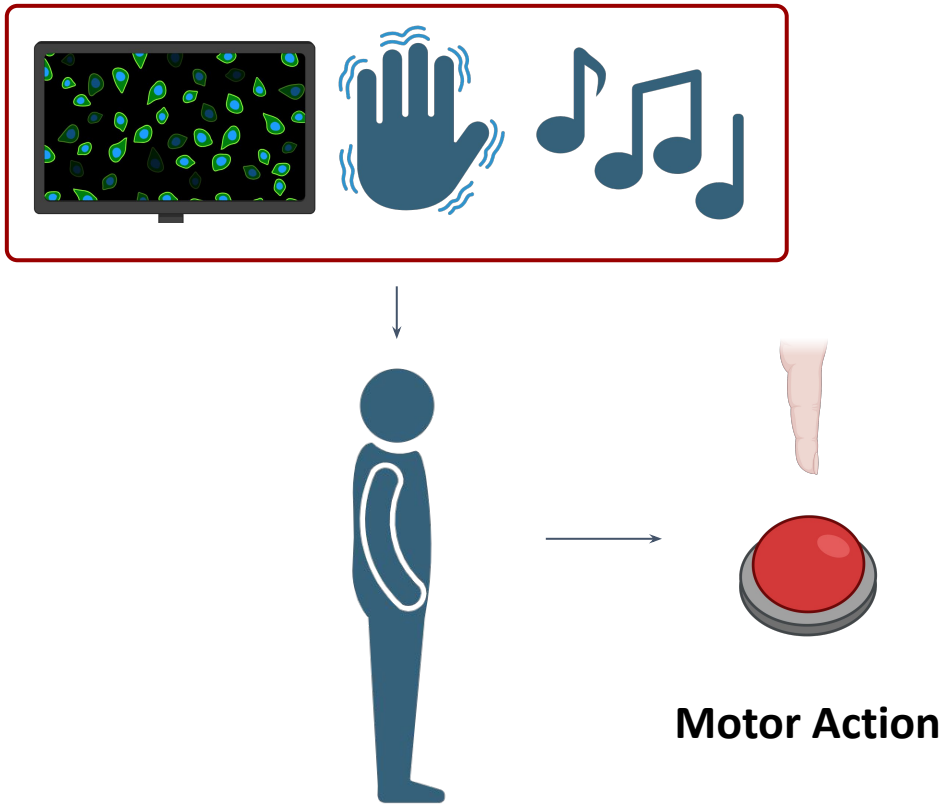
Thoughts **Actions**

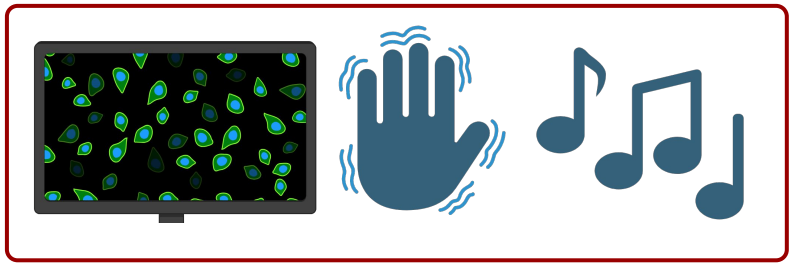
Behavioral Experiment

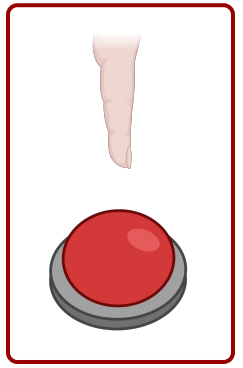


Motor Action

Background

Behavioral Experiment

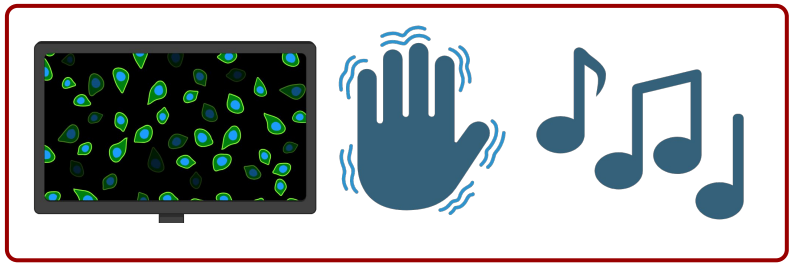




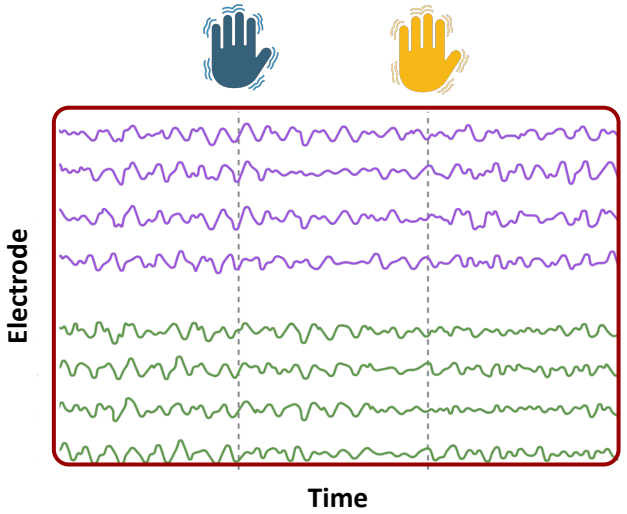
Motor Action (y)

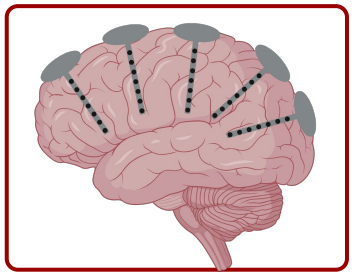
Background

Behavioral Experiment

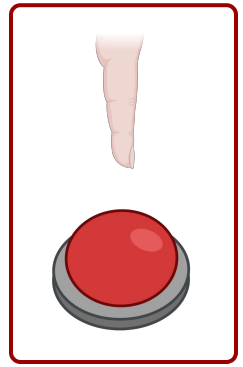


Neural Activity (x)





f(x) = y



Motor Action (y)

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Challenges to building neural decoders based on sEEG.

Small Cohort Size

Only few behavioral trials per subject

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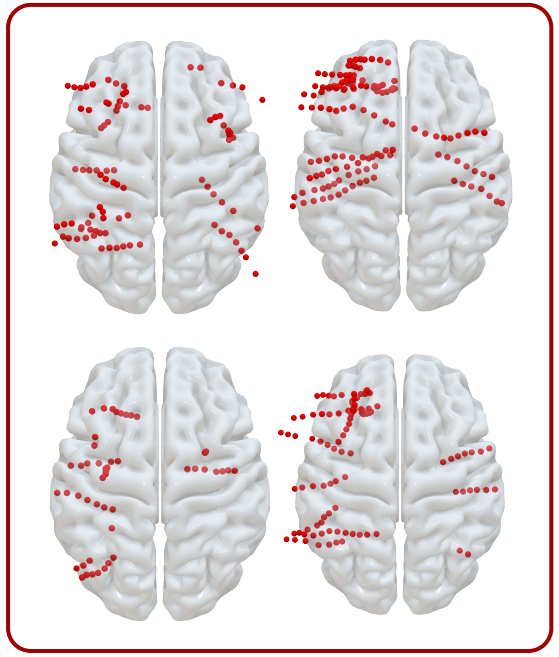
Highly variable electrode number/placement across subjects



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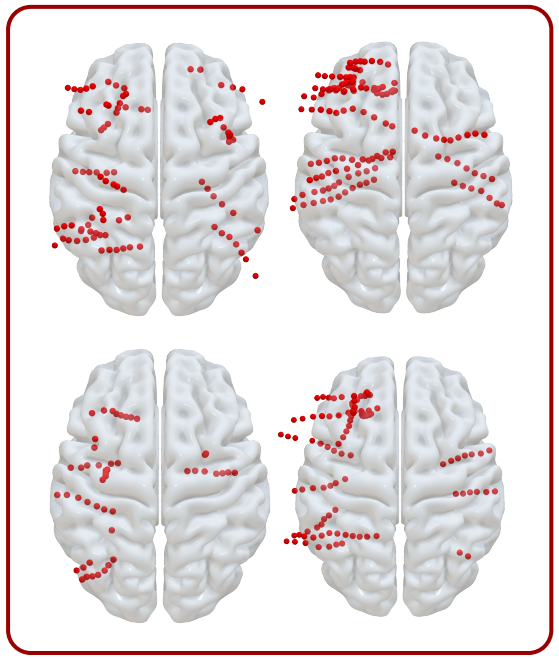
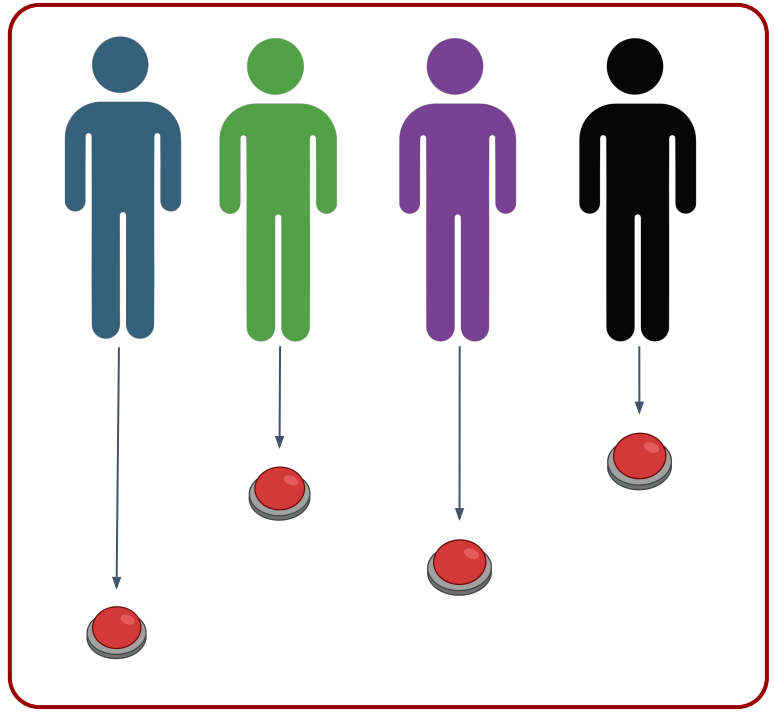


Baseline behavior highly variable across subjects



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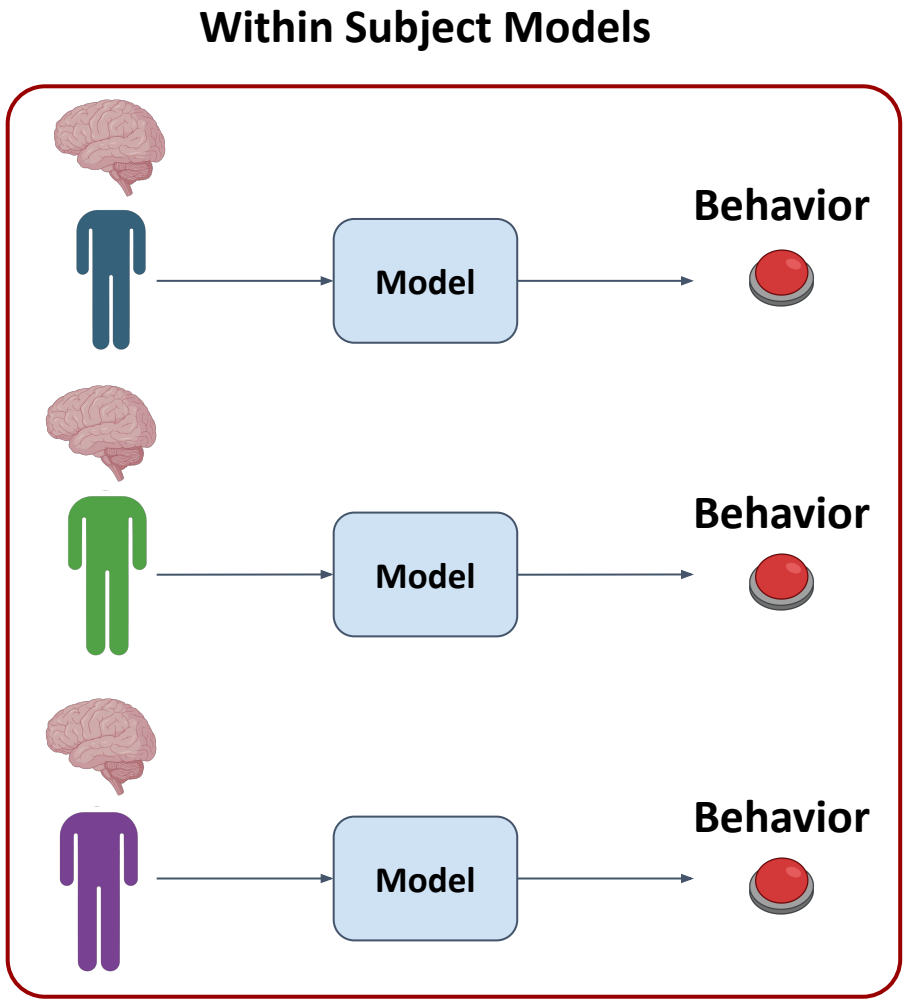
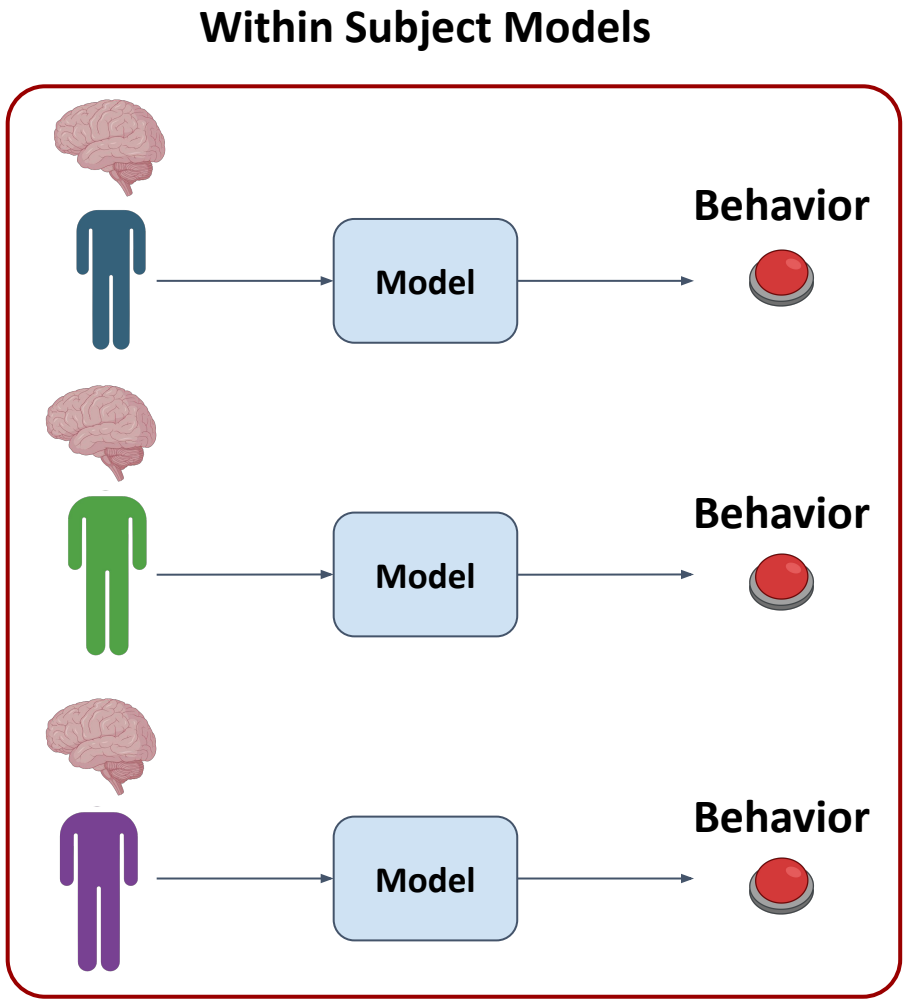
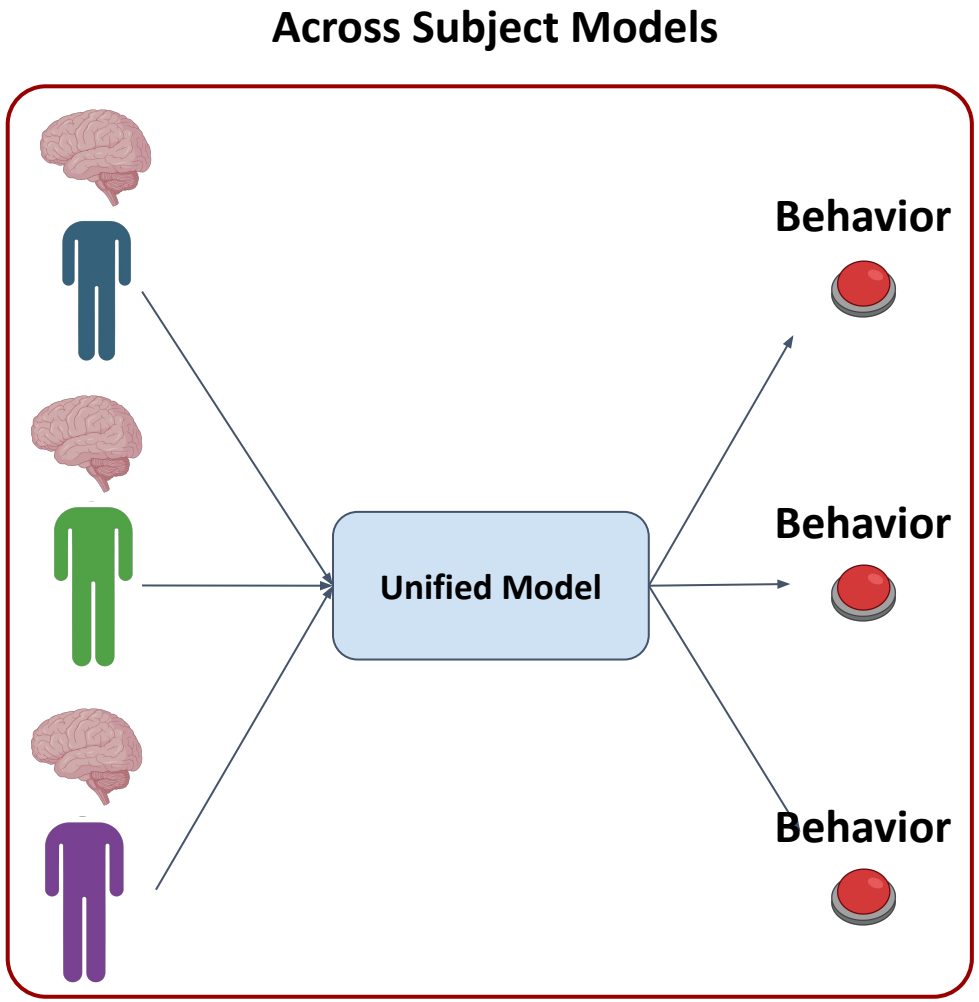

Within Subject Models
Behavior
Model
Behavior
Model
Behavior
Model

Background





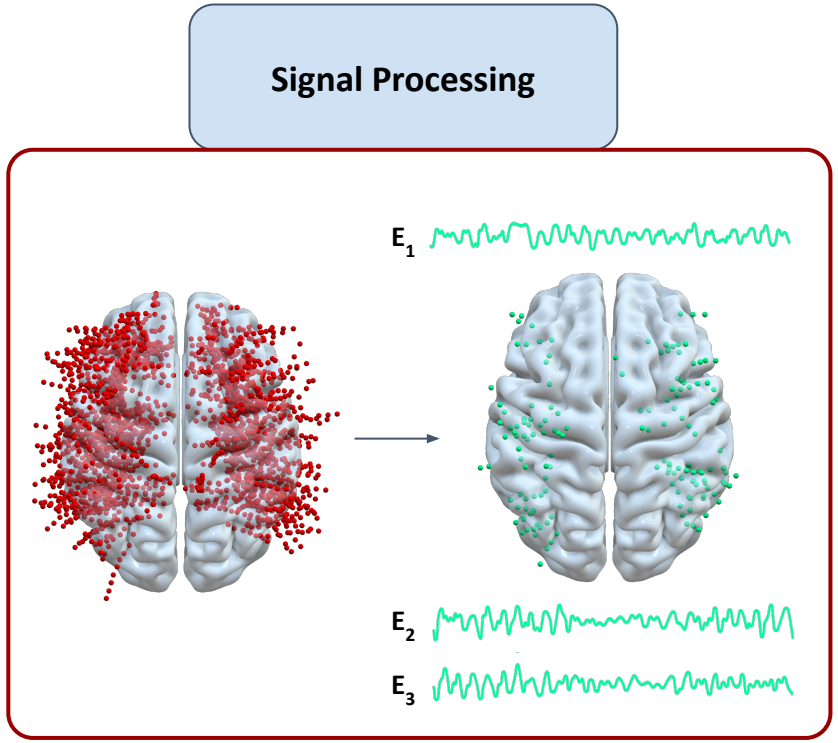
Question: Can we build unified models to decode behavior across subjects using sEEG?

Framework: Seegnificant

I. Signal processing for electrode selection

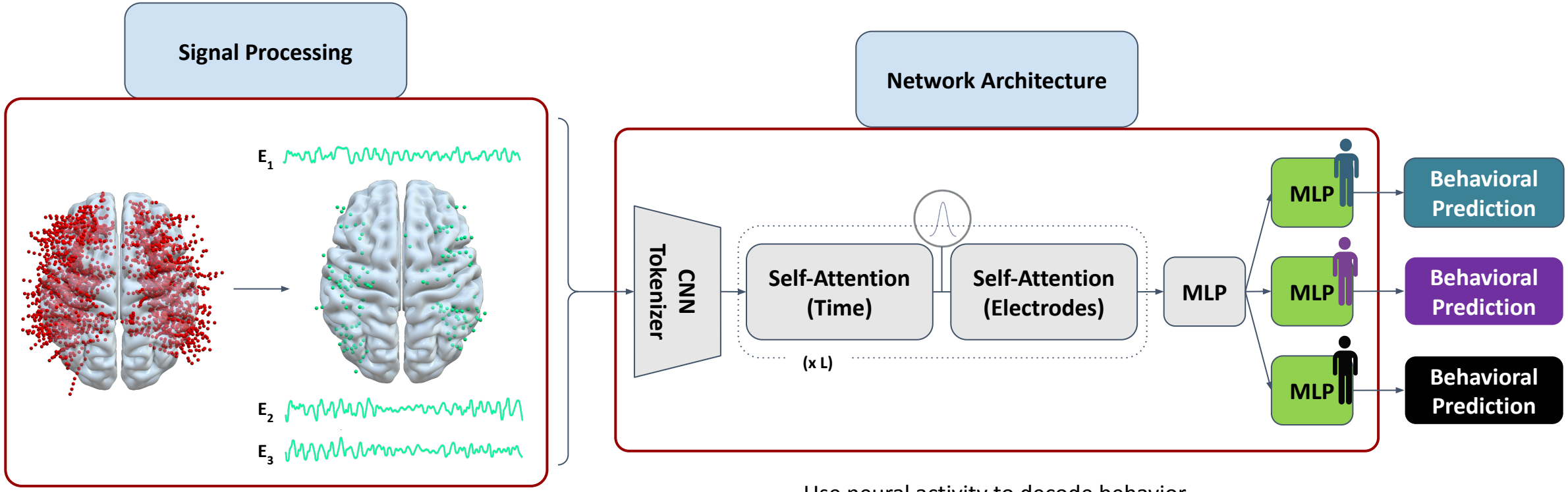
II. Build ANN to decode behavior from neural activity of selected electrodes

Framework: Seegnificant



Identify behaviorally relevant electrodes based on high-γ band activity.

Framework: Seegnificant



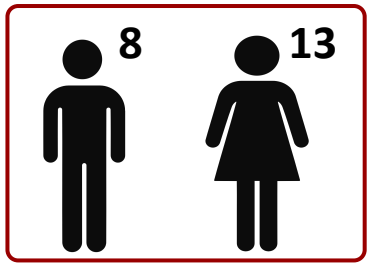
Identify behaviorally relevant electrodes based on high-γ band activity.

Use neural activity to decode behavior.

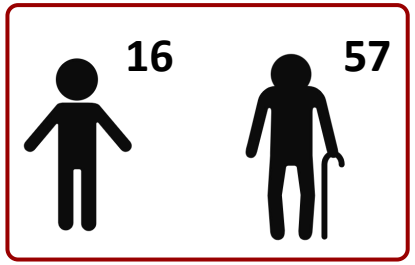
Dataset

Study Participants

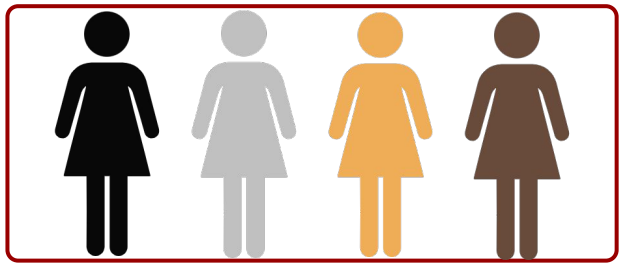
Sex



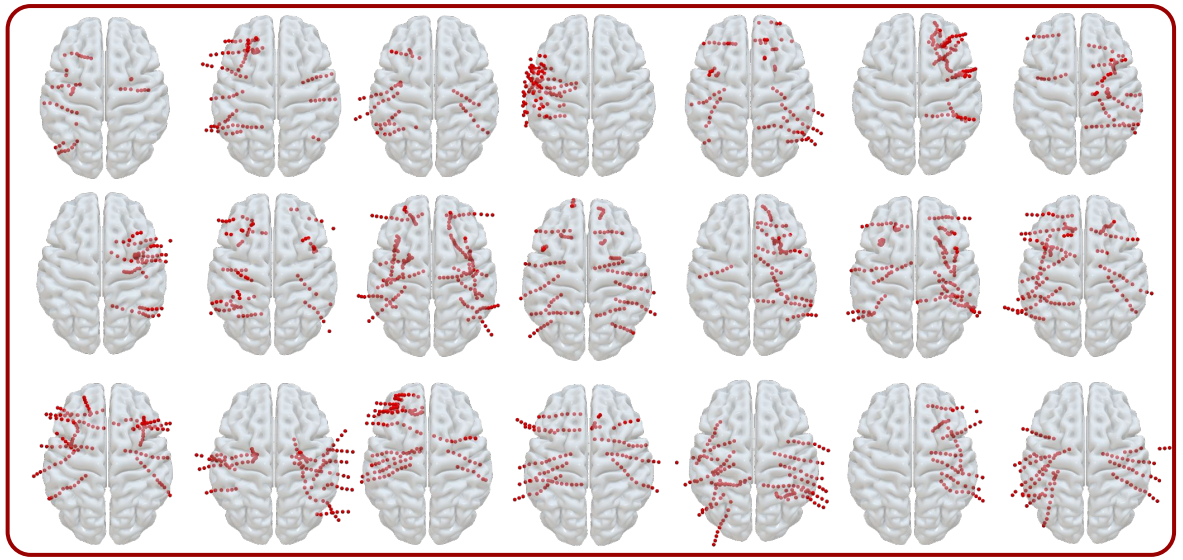
Age



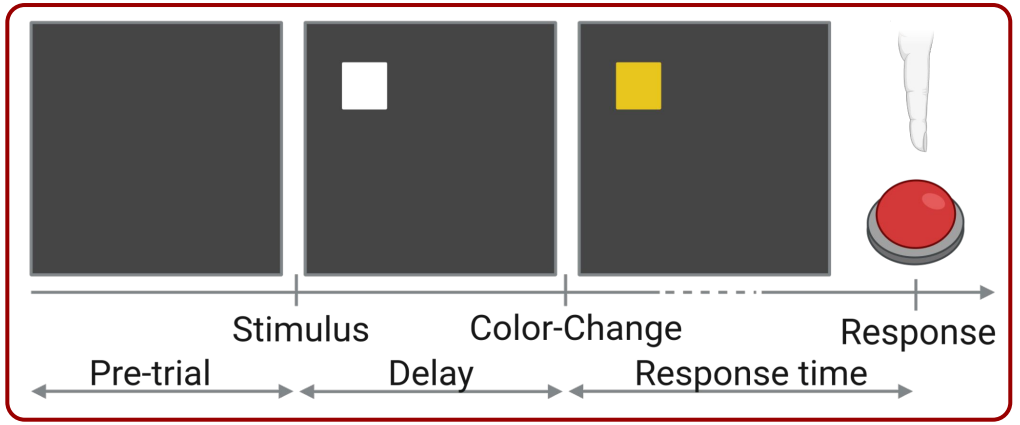
Ethnicity



Neural recordings: sEEG



Behavioral task

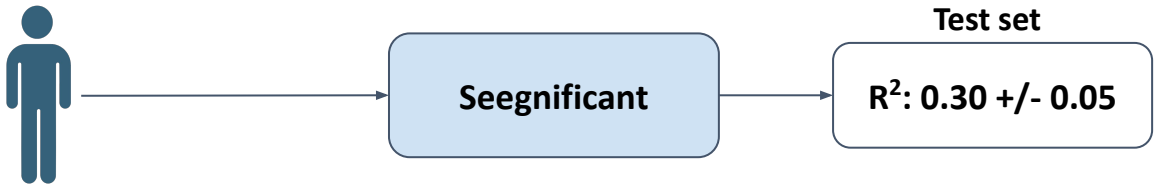


Goal: decoding the trial-wise response time of subject using their sEEG.

Results: Single-subject vs multi-subject models

$$R^2 = 1 - \frac{\sum (y_i - \hat{y}_i)^2}{\sum (y_i - \bar{y}_i)^2}$$

Single-subject models (SS)



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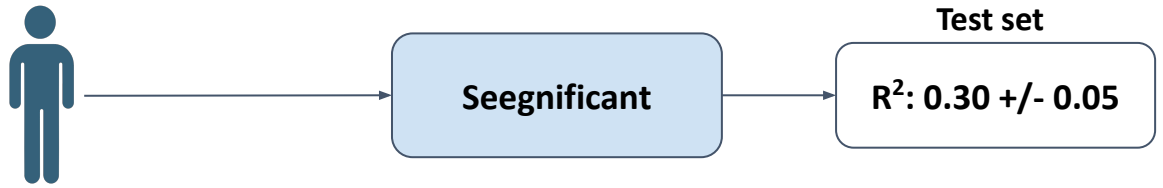
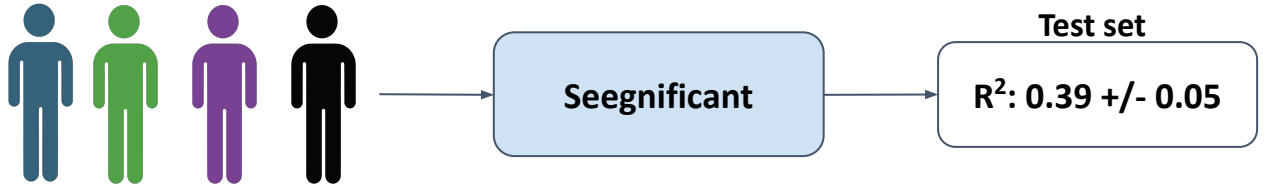
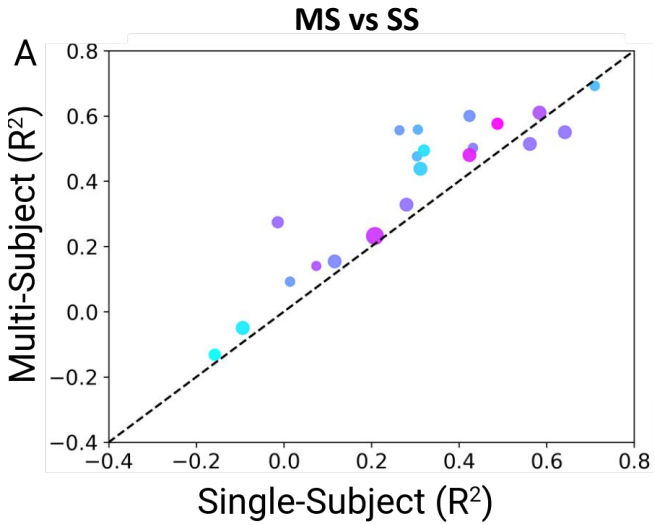


Multi-subject models (MS)





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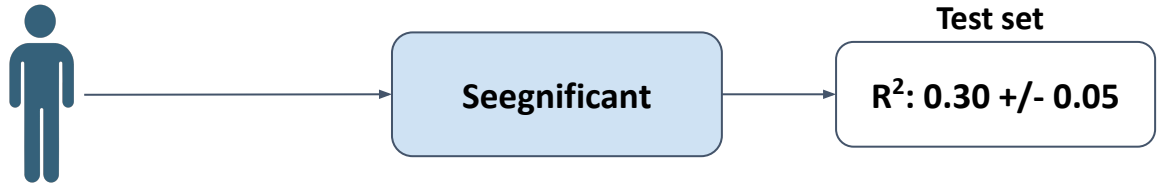

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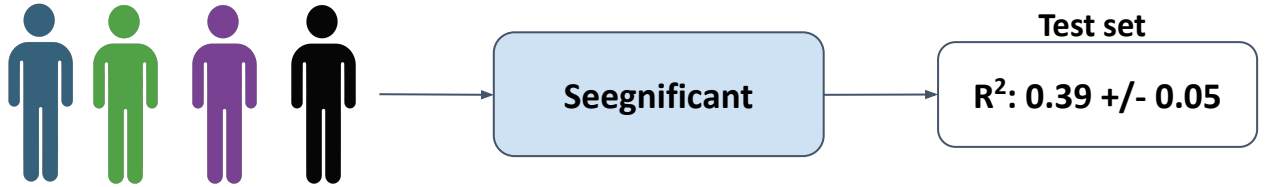
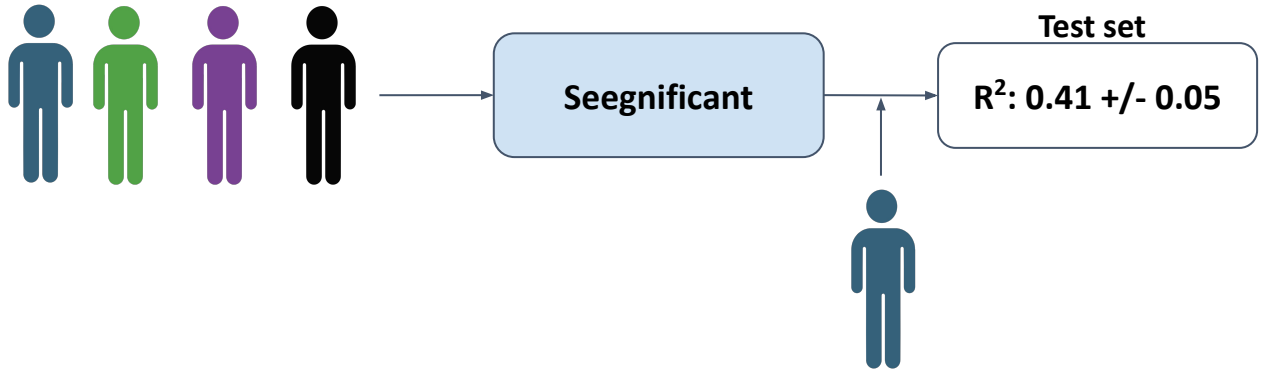
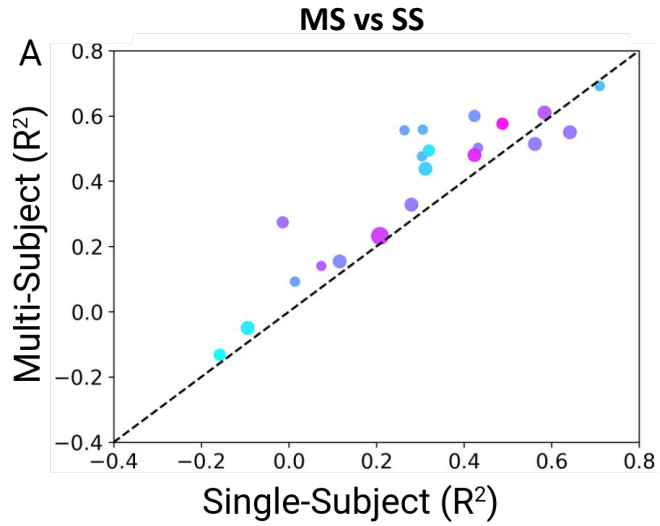
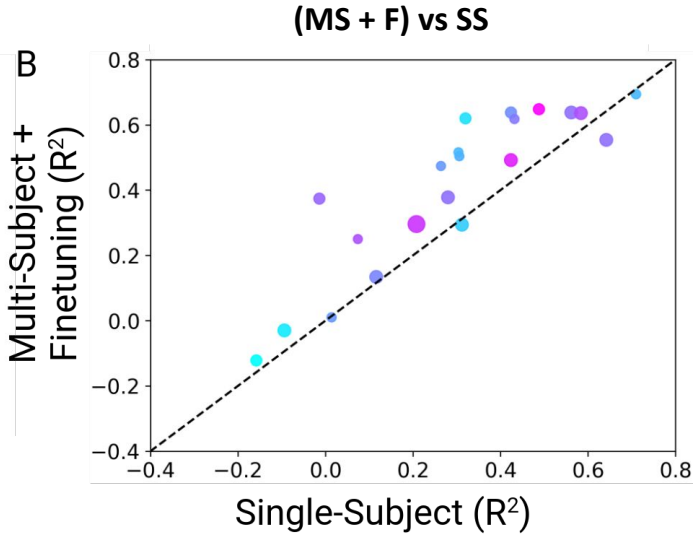


Multi-subject models + finetuning to single subjects (MS + F)

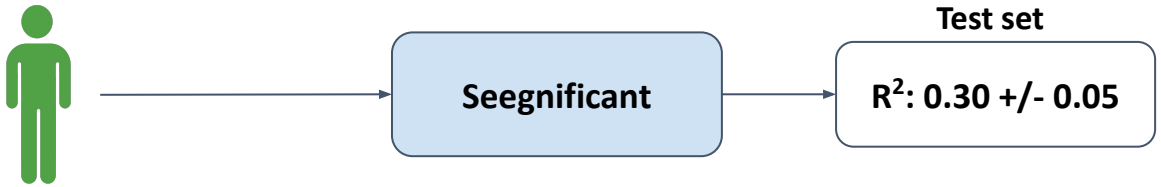






Results: Transferring pretrained multi-subject model to left-out subjects

Single-subject models (SS)



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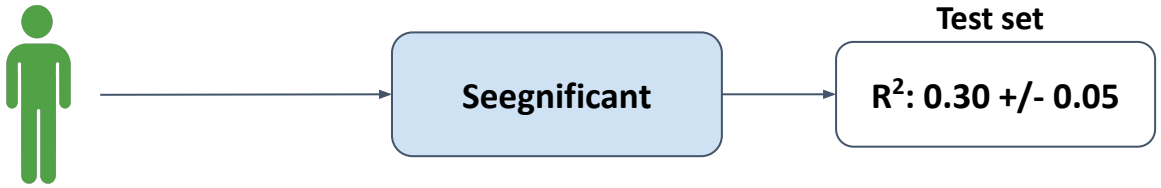
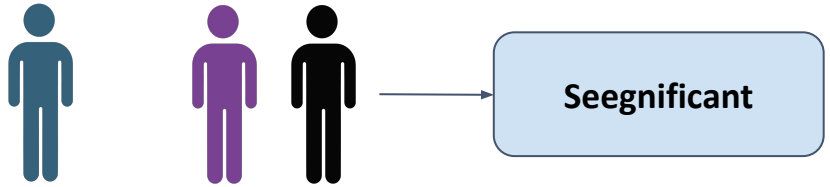


Multi-subject models with all subjects but one (MS)



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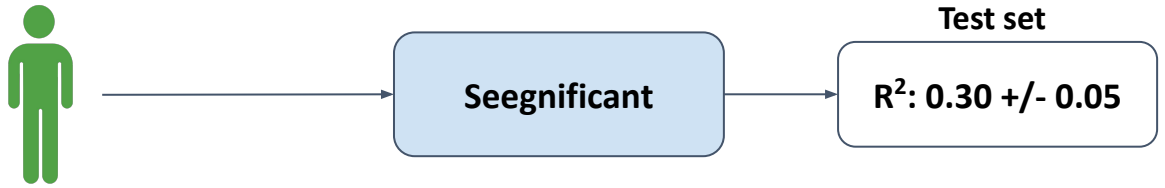
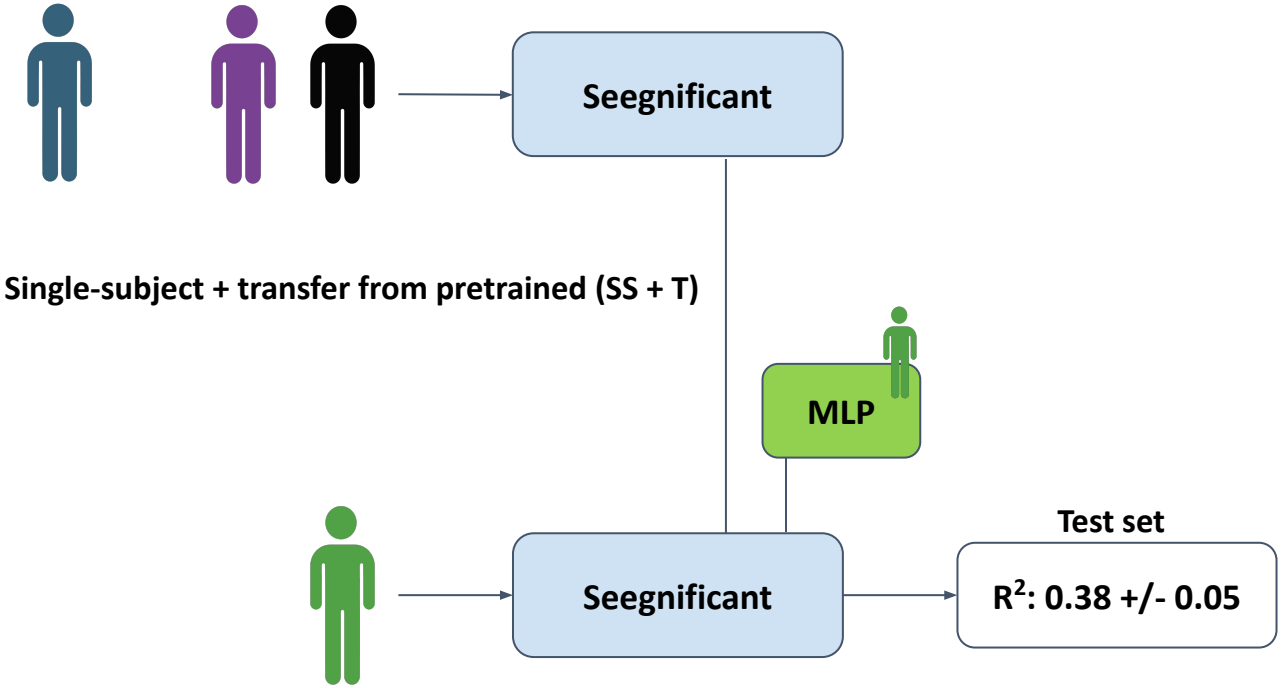
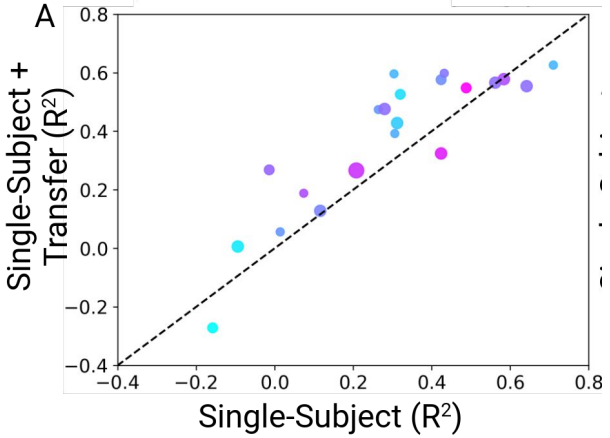


Multi-subject models with all subjects but one (MS)

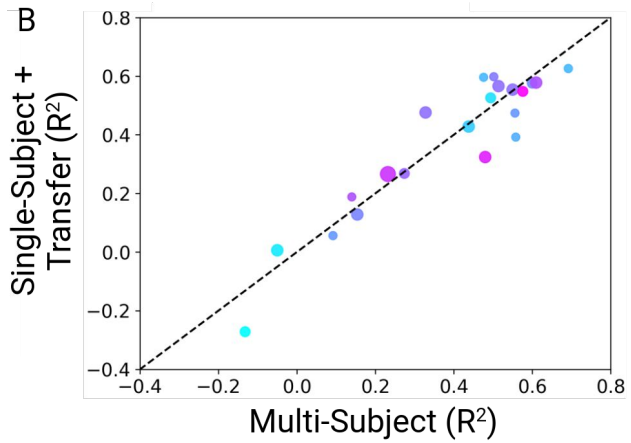
Single-subject + transfer from pretrained (SS + T)



(SS + T) vs SS

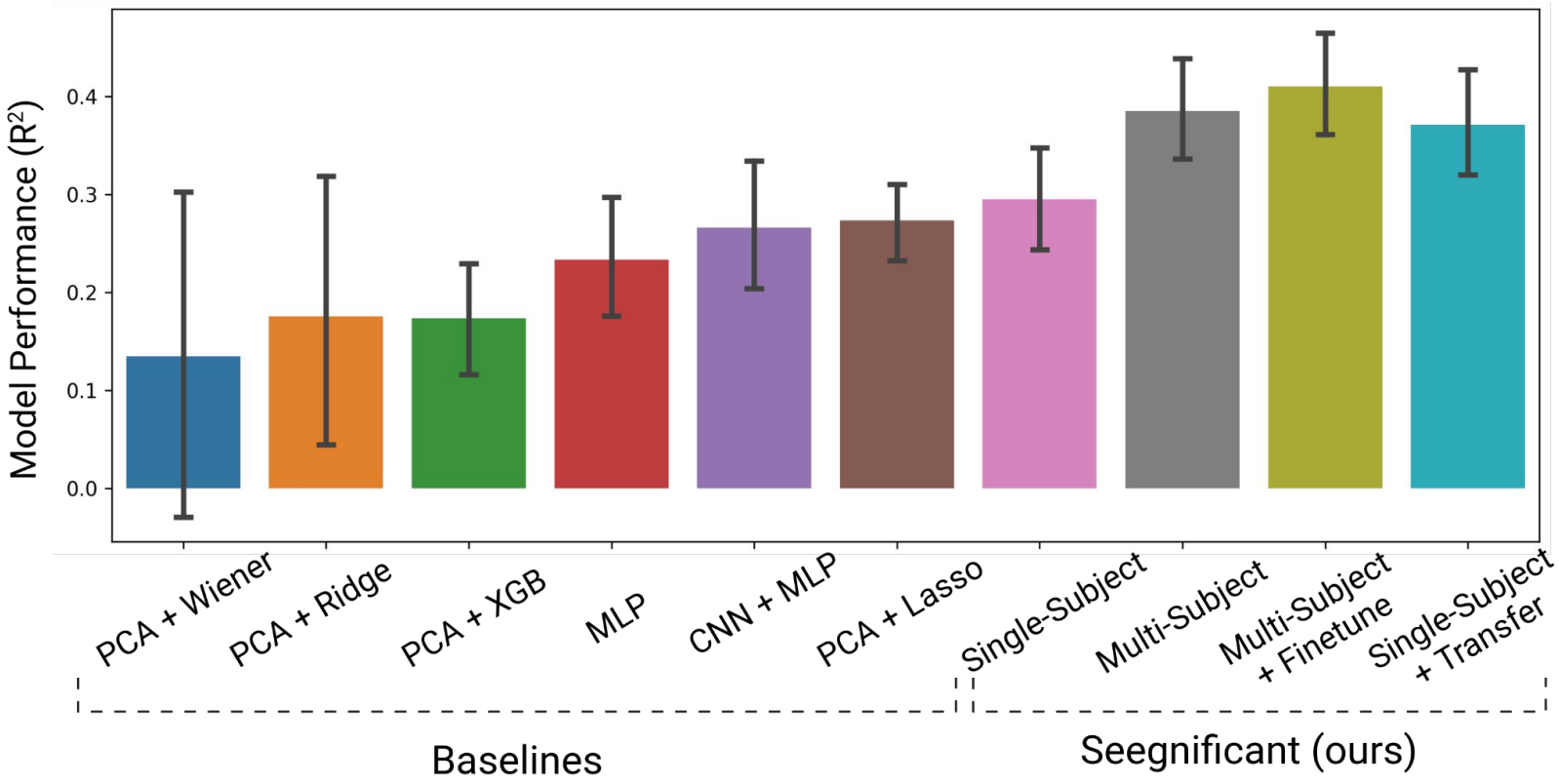


(SS + T) vs MS



Results: Baseline comparisons

Baseline Models	Seegnificant (Single-Subject)	Seegnificant (Multi-Subject)	Seegnificant (Multi-Subject + Finetune)	Seegnificant (Single-Subject + Transfer)
$R^2 \leq 0.27$ +/- 0.05	R^2: 0.30 +/- 0.05	R^2: 0.39 +/- 0.05	R^2: 0.41 +/- 0.05	R^2: 0.38 +/- 0.05



Summary

- We introduce Seegnificant: a training framework and architecture that can be used to decode behavior across subjects using sEEG data.
- Using Seegnificant, we show:
  - Training unified, multi-subject models for neural decoding based on sEEG is possible.
  - Training models on multiple subjects improves decoding performance compared to training on single subjects.
  - Multi-subject models can be efficiently transferred to new subjects.

Our paper and code is available at

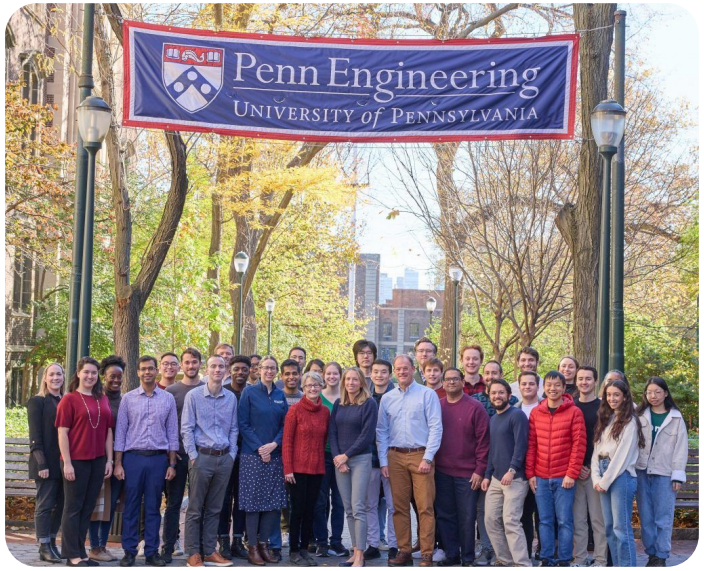
gmentz.github.io/seegnificant

Acknowledgements

Vitale Lab

Team Seegnificant

CNT Center Neuroengineering Therapeutics



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