

EEG-based decoding of attended location: a comparison of convolutional neural networks, forward encoding models, and logistic regression

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Introduction

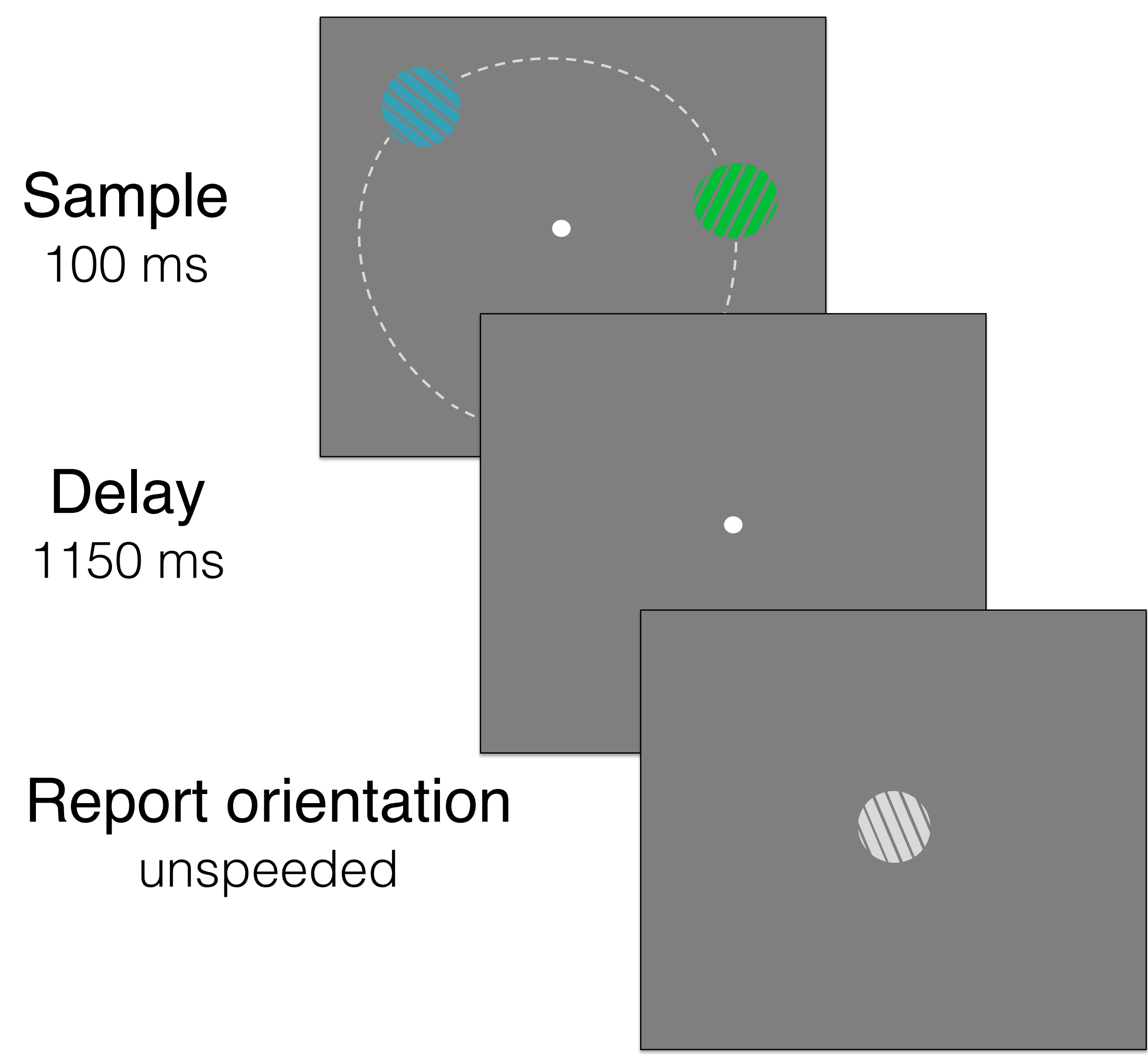
Covert spatial attention allows us to selectively process visual information

Spatial attention is decodable from EEG activity when averaged over trials

Compare decoding accuracy between various machine learning approaches on the single-trial level

Task & dataset

Participants cued to remember the orientation of either the blue or green shape



Data from Foster, Bsales, Jaffe, & Awh (2017)
Experiment 2b

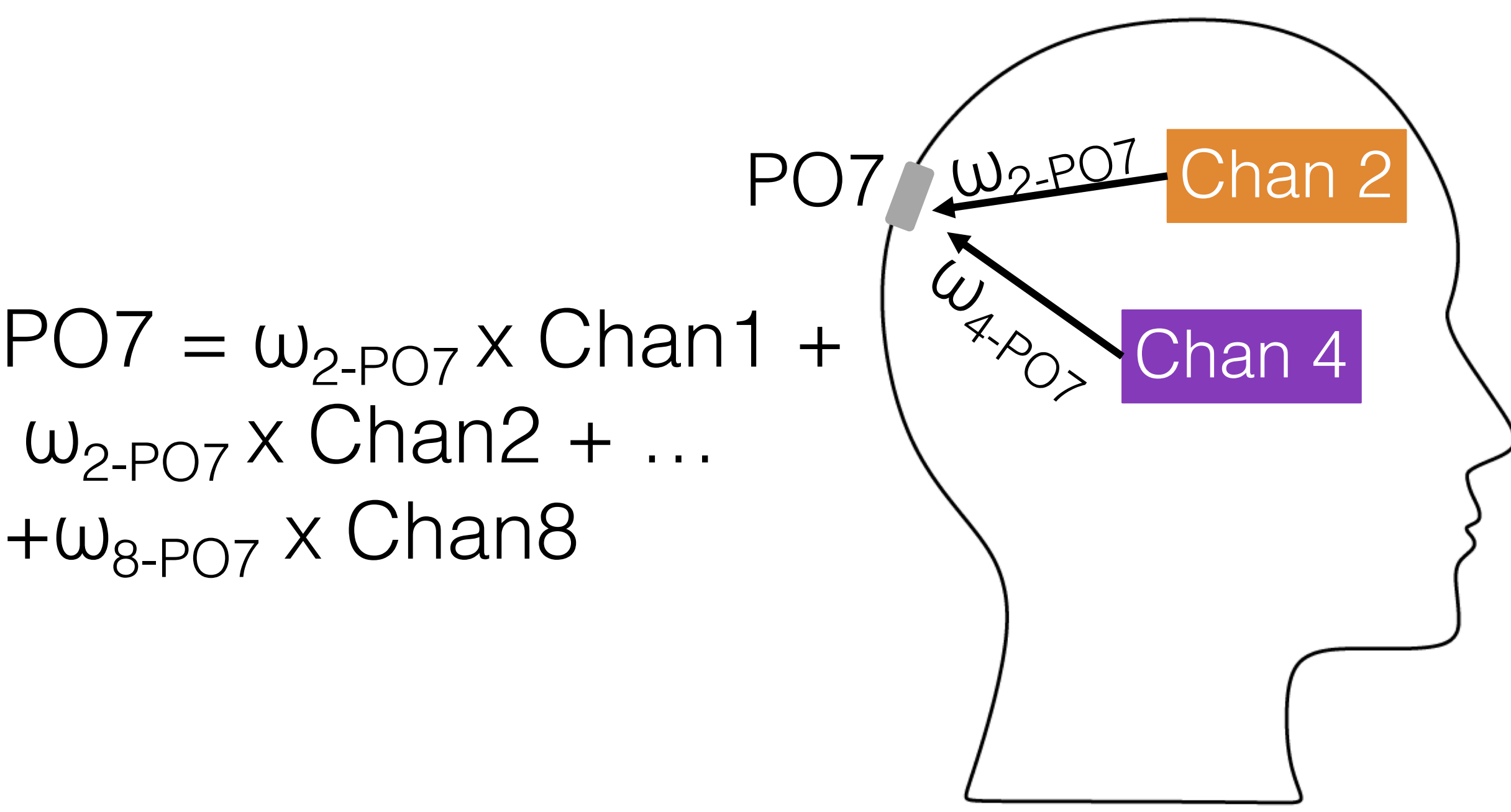
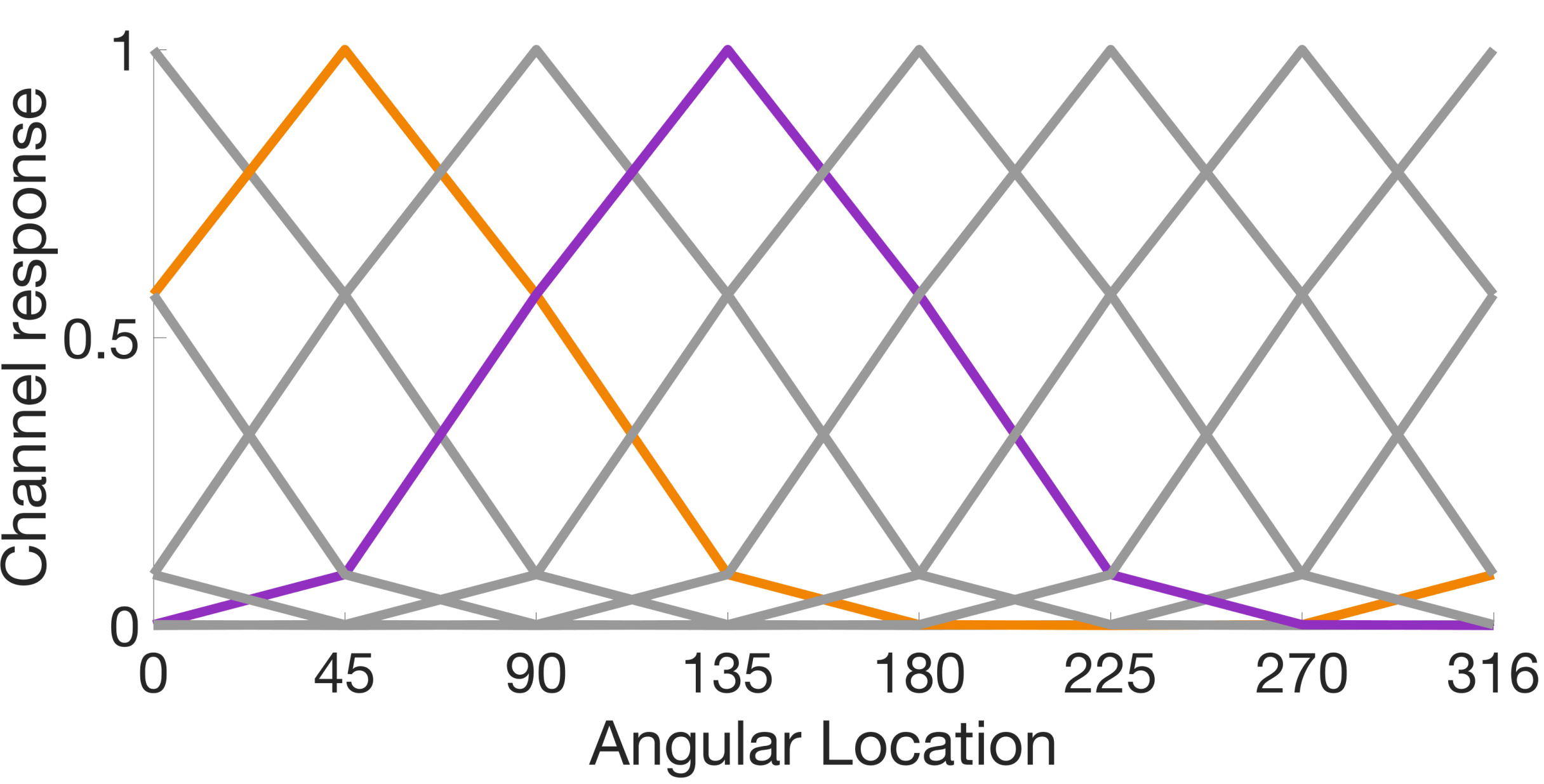
Forward encoding model

Brouwer & Heeger, 2009; Foster, et al, 2016

Alpha power at each electrode modeled as the weighted sum of 8 tuning channels, each tuned for a different angular location

Train:

Calculate the respective weights of each channel at each electrode to estimate channel outputs



Test:

Compare estimated channel outputs to known channel outputs for each location. Decoded location has highest correlation to estimated channel outputs

Logistic regression

Stratified k-fold

Convolutional neural networks

Schirrneister et al (2017)

Convolution (temporal) 25 linear units
Convolution (all electrodes) 25 exponential linear units

Deep Shallow

Max pooling
Stride 3x1

Max pooling
Stride 15x1

Convolution
50 exponential linear units

Linear classification
(Dense layer and softmax)
4 units

Max pooling
Stride 3x1

Convolution
100 Exponential linear units

Max pooling
Stride 3x1

Convolution
200 Exponential linear units

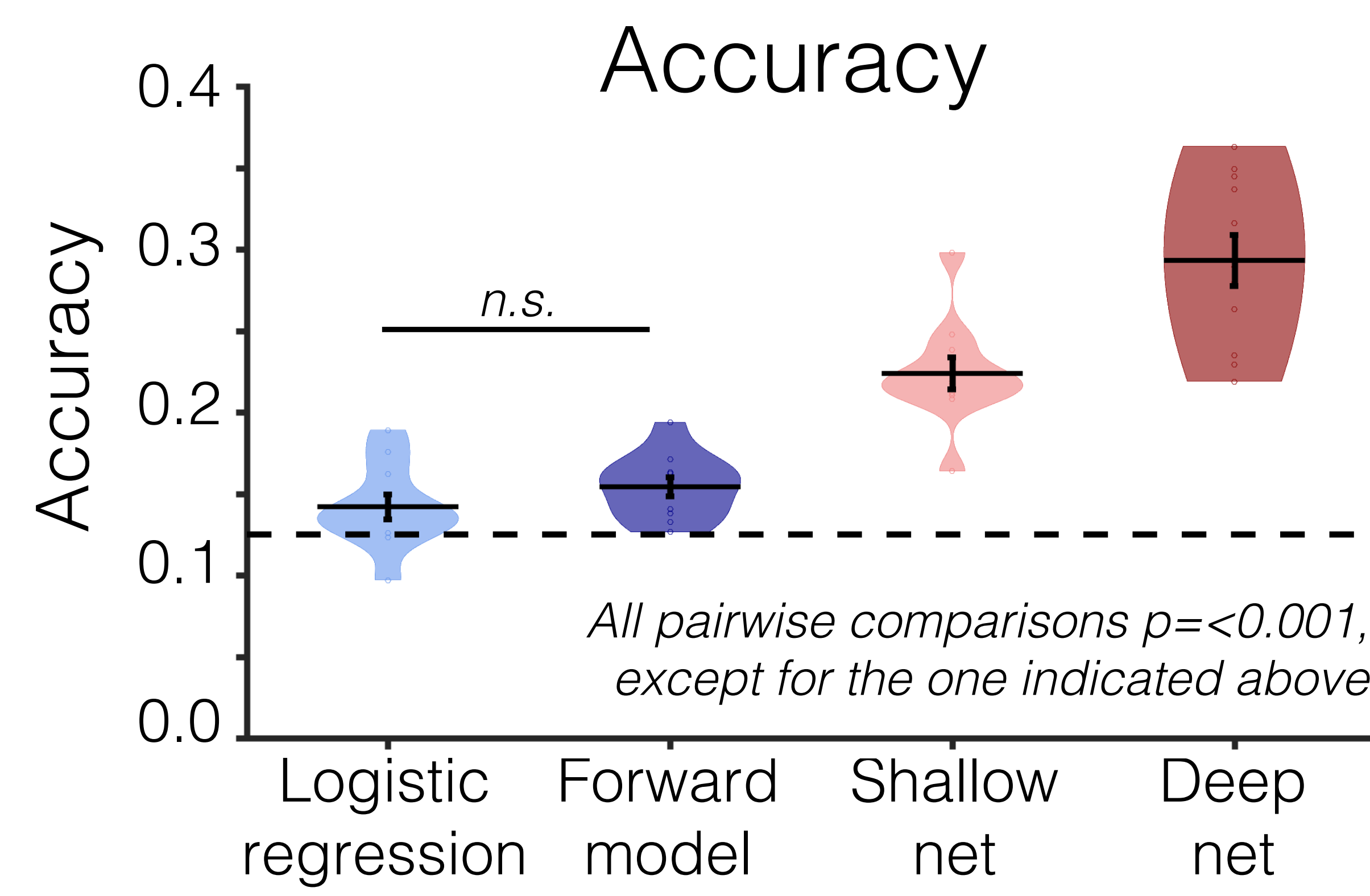
Max pooling
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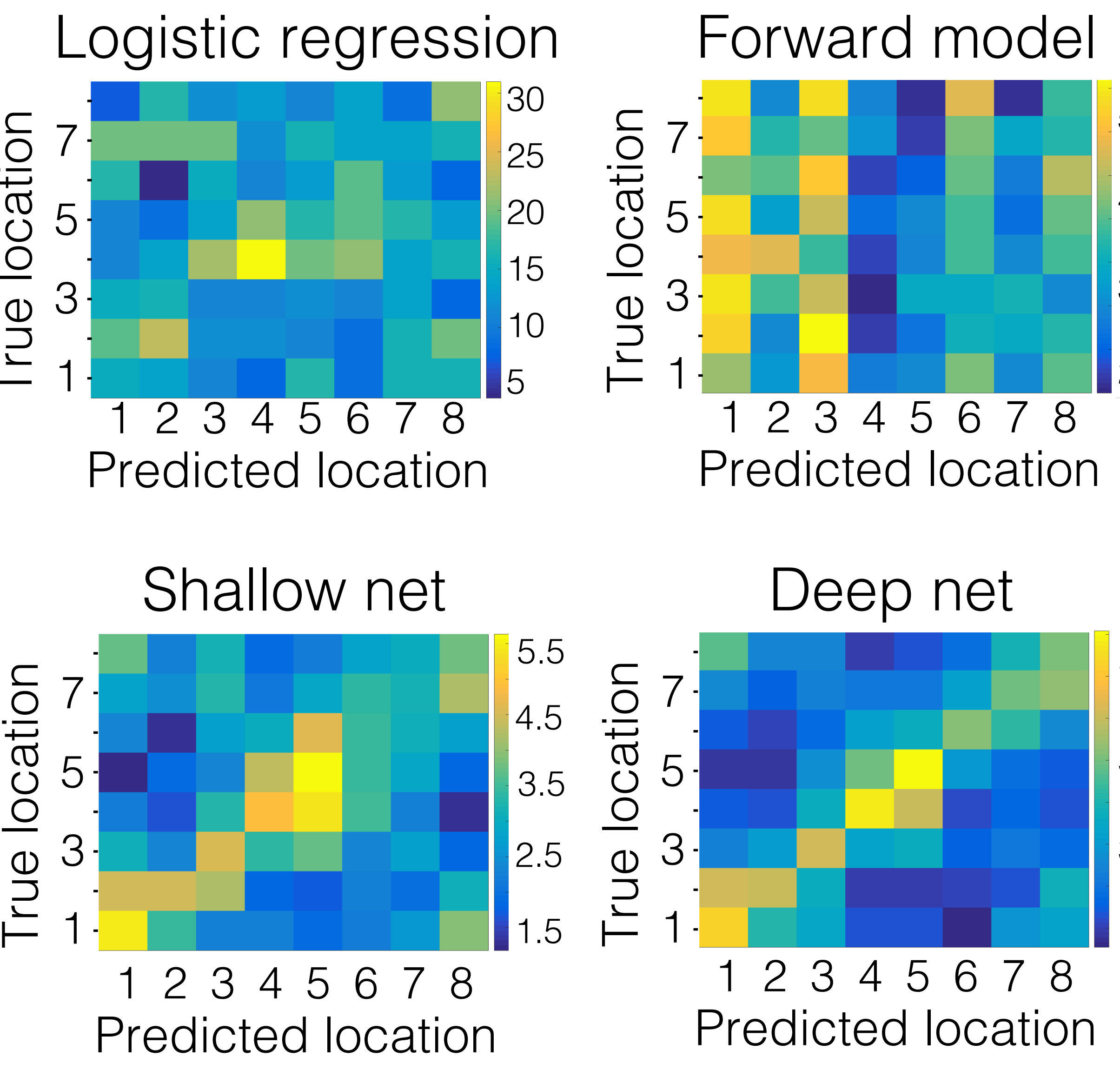
Additional details:

- Dropout
- Batch normalization
- Tied sample loss function
- Electrode-wise exponential moving standardization

Covert attention decoding



Confusion matrices



Conclusions

Neural networks are a powerful tool to decode covert spatial attention and can potentially be useful to track trial-by-trial fluctuations in working memory content