# A recurrent neural network for visual object recognition:
An interactive account for rapid superordinate categorization & the basic-level advantage

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Background

Empirical findings: people can categorize objects at the superordinate level by 120ms post visual stimuli onset [1], which has been taken as an evidence for a feed-forward view of visual recognition [2].

We assess whether an interactive recurrent neural network model can explain ultra-rapid superordinate classification in behavior, EEG, and ECoG, while also explaining the basic-level categorization advantage.
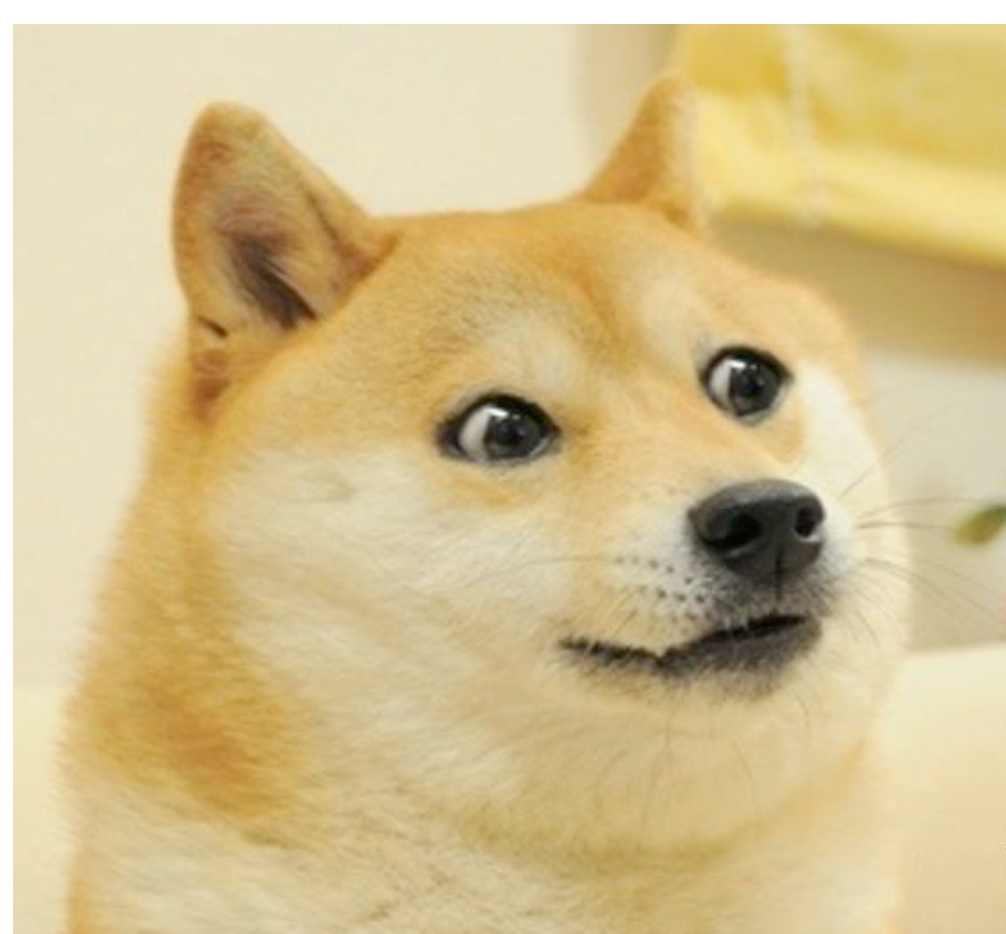

Terminology:

- Superordinate: "Animal"
- Basic: "Dog"
- Subordinate: "Shiba Inu"
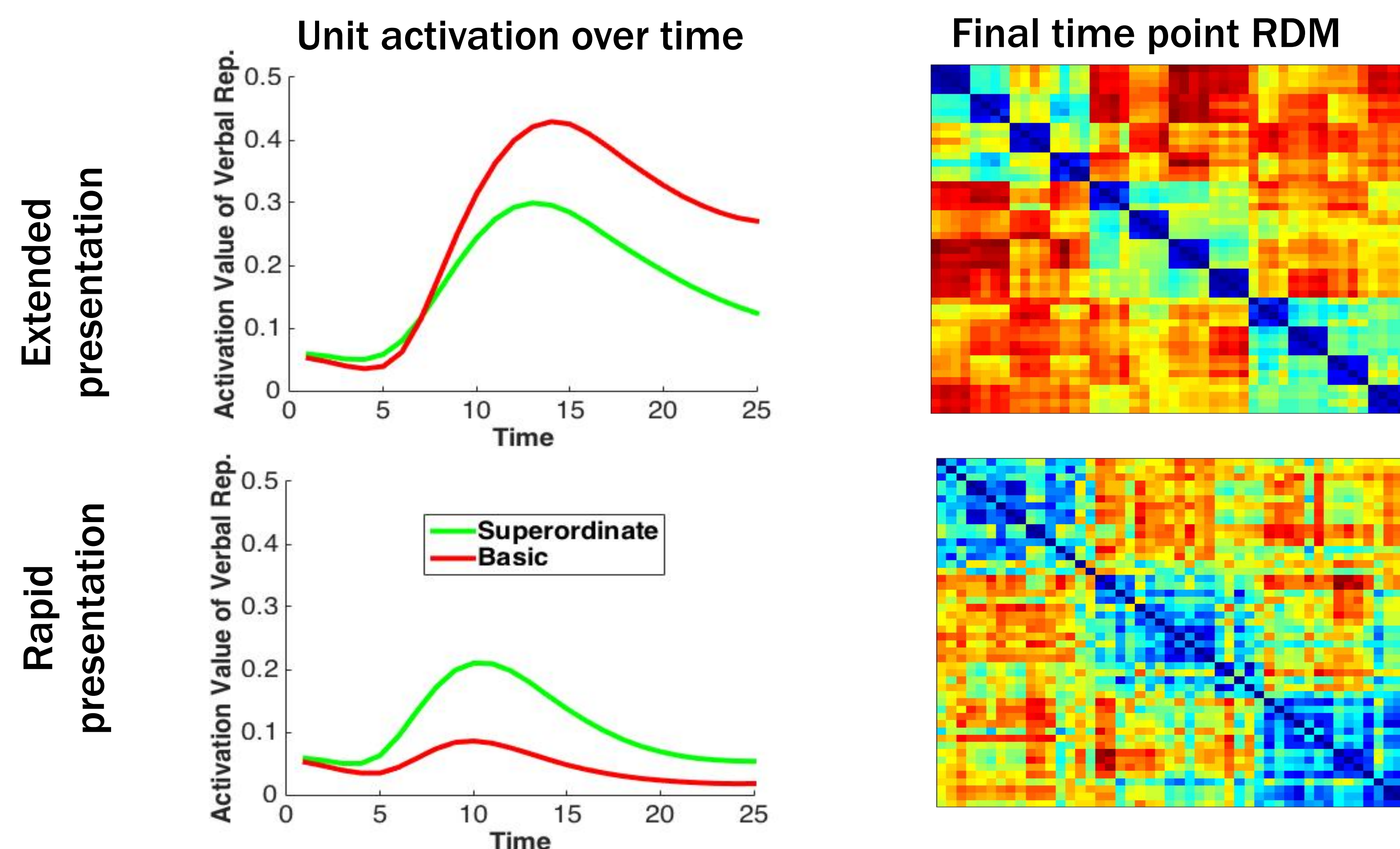
The PDP Modeling Framework

Information processing occurs through propagation of activations among neuron-like processing units.

Similar concepts are represented by similar distributed patterns of activation over units [3], which is illustrated by the temporal MDS plot below.

Details: We used a recurrent neural network model to simulate temporal dynamics in a visual recognition task. The semantic layer learns cross-modality representations from the environment. Superordinate and basic-level structure is captured by the similarity structure of individual patterns. The model is trained to produce basic-level names more often than superordinate names.
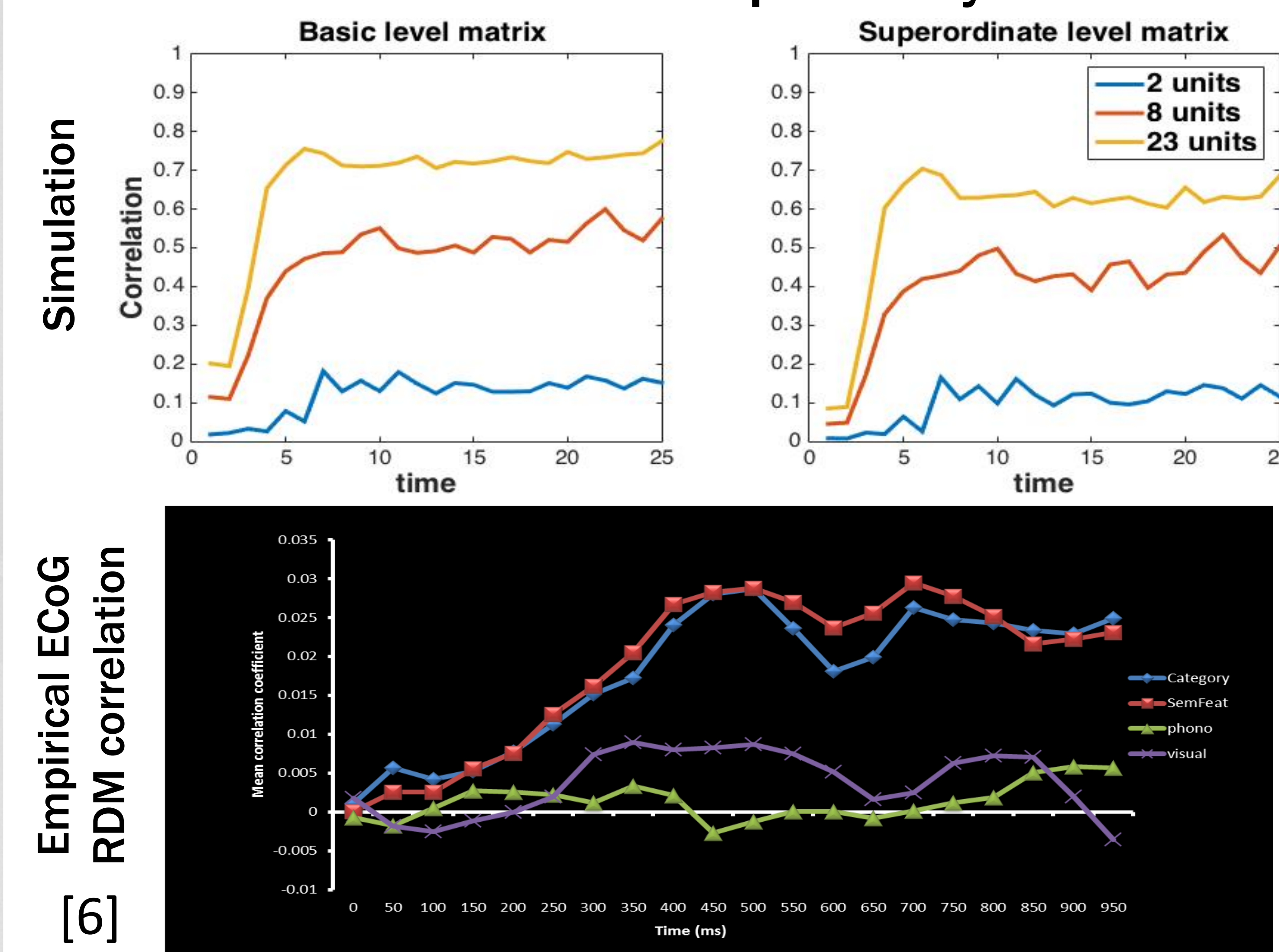
Model architecture

CMDS over time

Different colors correspond to different sup. classes.
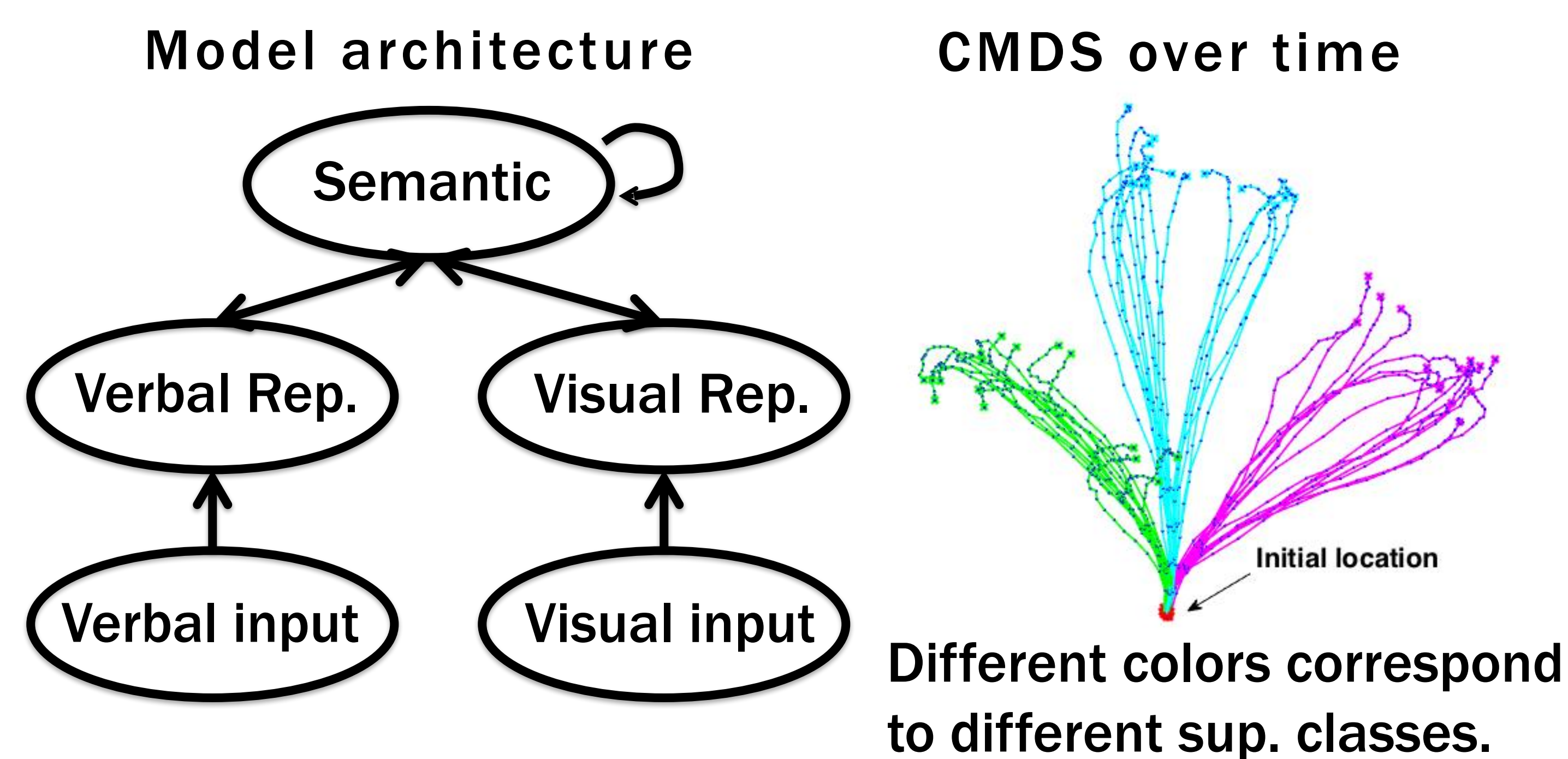
Simulate behavioral results for visual recognition
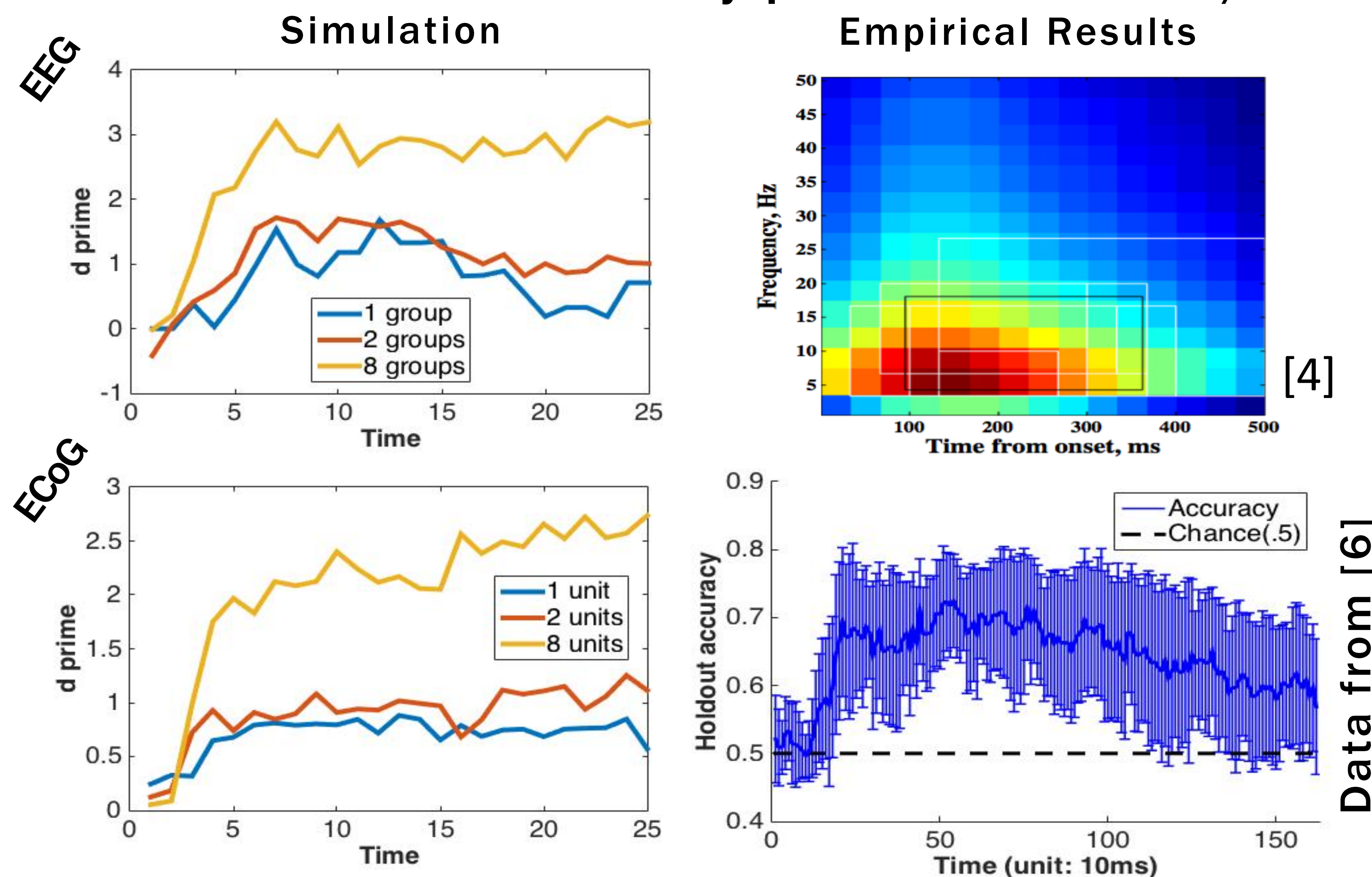
Unit activation over time

Final time point RDM

The model shows both a basic level advantage with slow presentation and ultra-rapid categorization pattern with brief presentation.

Simulate MVPA accuracy pattern from EEG/ECoG

Simulation

Empirical Results

[4]

Data from [6]

- When signal is spatially smoothed (EEG) decoding peaks and drops
- When signal is sparsely sampled (ECoG) it can be decoded throughout

Simulate RDM temporal dynamics

[6]

Correlation of model RDMs [5] with idealized superordinate and basic-level RDMs is equivalent and stable over time[6].

Summary

Our recurrent neural network is consistent with:
i) Behavioral results:
 - Basic level advantage in untimed setting
 - Superordinate but not basic ultra-rapid classification
ii) Neuroimaging results
 - Decoding over narrow window with EEG
 - Decoding over broad window with ECoG
 - RDM temporal correlation over broad window

Conclusion: The neural-cognitive mechanisms underlying ultra-rapid & unconstrained visual object recognition can be interactive.

References

[1] Wu, C.-T., et al. (2015). *Journal of Cognitive Neuroscience*, 27(1), 141–149.
[2] Serre, T., Oliva, A., & Poggio, T. (2007). *PNAS*, 104(15), 6424–6429.
[3] Rogers, T. T., & Patterson, K. (2007). *J Exp Psychol Gen*, 136(3), 451–469.
[4] Murphy, B., et al. (2011). *Brain and Language*, 117(1), 12–22.
[5] Kriegeskorte, N. (2008). *Frontiers in Systems Neuroscience*. 2, 4.
[6] Chen, Y., et al. (2016). Cortex, 79, 1–13.

Simulation source code:
https://github.com/QihongL/categorization_PDP

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