Learning Structure from the Ground-Up—Hierarchical Representation Learning by Chunking

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Accouple of “DF”s and “JK”s?

What did you expect me to say about these sequences?

D F J K J K J K D F D F J K D F

Chunking is a ubiquitous learning phenomenon

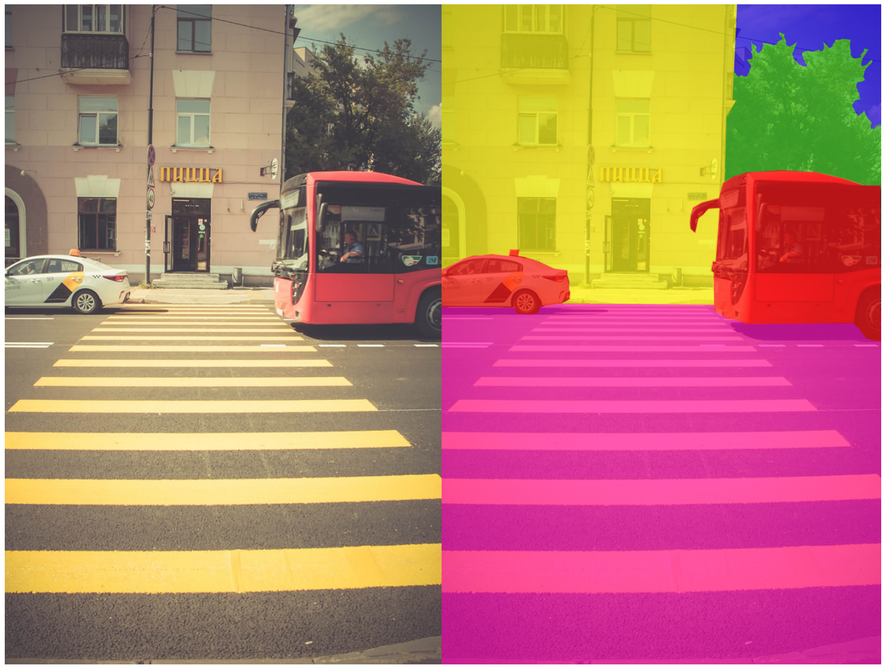
Language

... As you might know ...

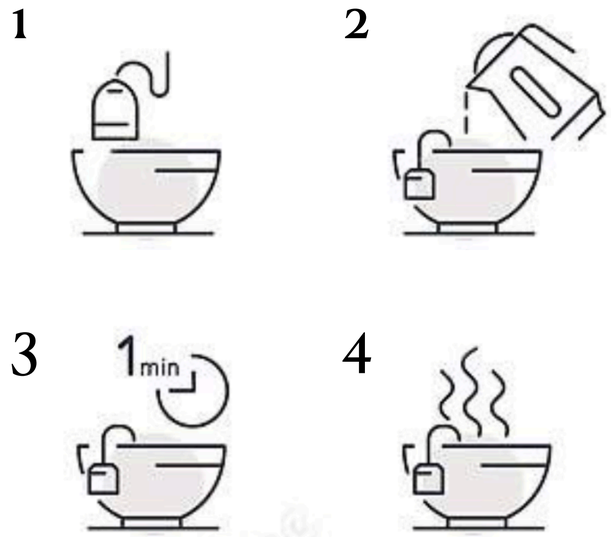
... the thing is ...

It is a bit like ...

Vision

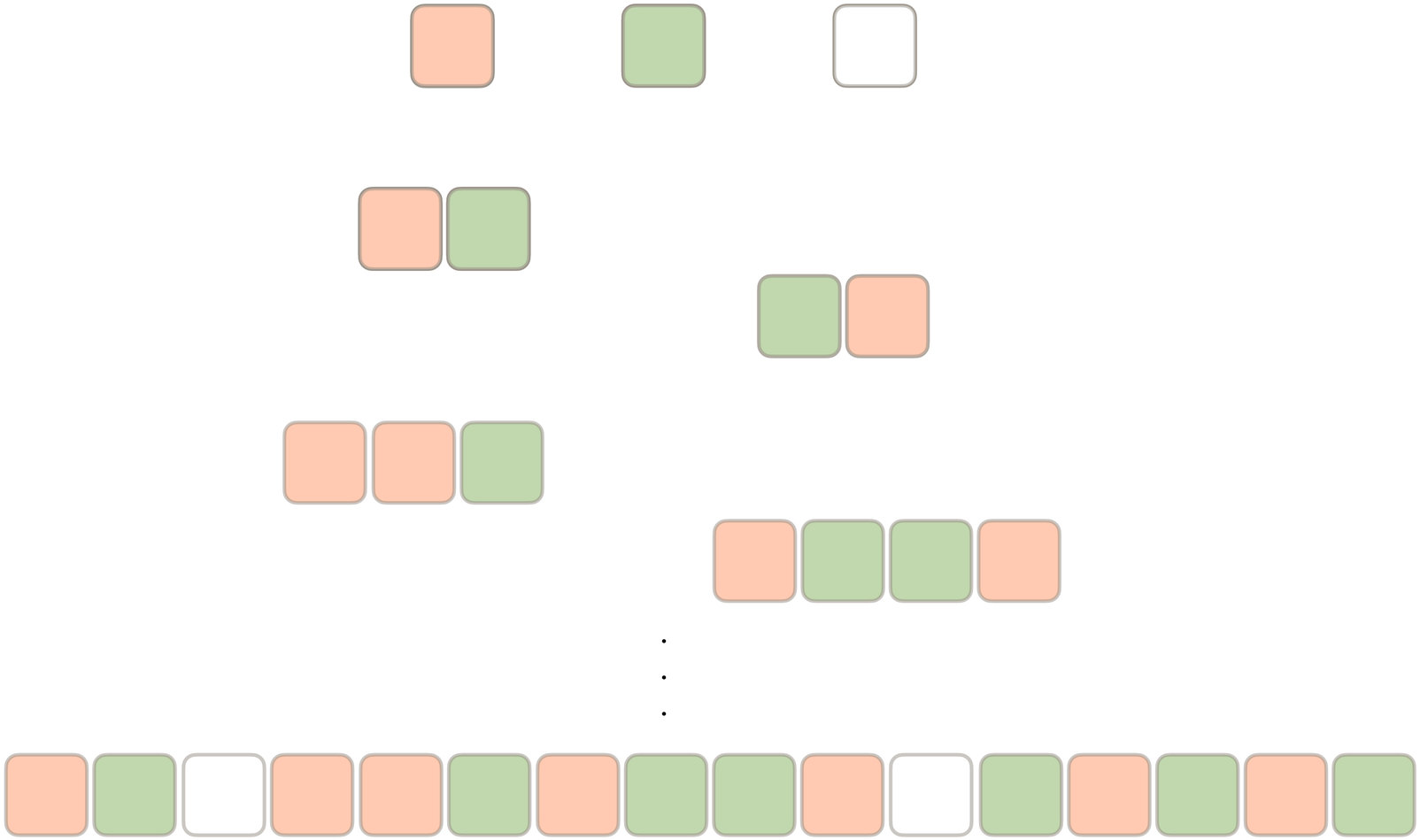


Action



Chunking facilitates memory compression (Gobet et al., 2001; Miller, 1956), compositional generalization (Schulz et al., 2017), predictive processing (Koch & Hoffmann, 2000; Müssgens & Ullén, 2015), and communication (Schulz et al., 2020)

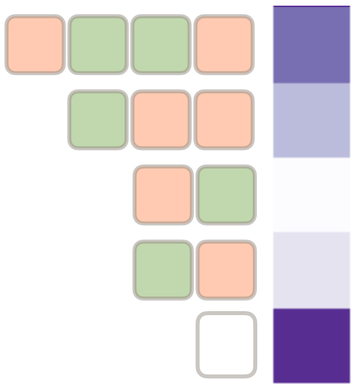
What if perceptual sequences come from a hierarchical structure?

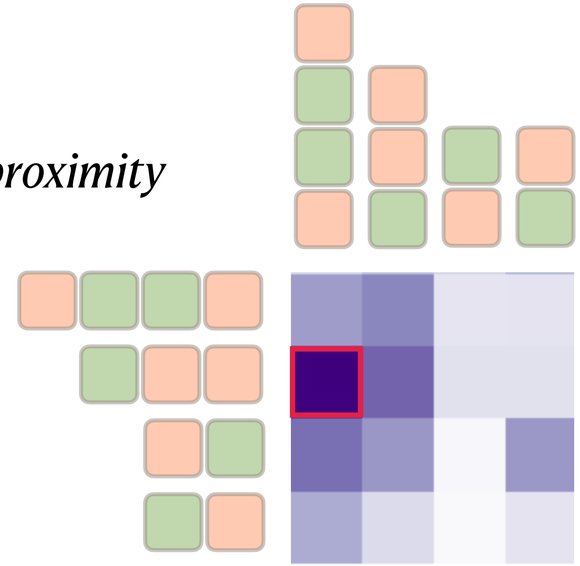


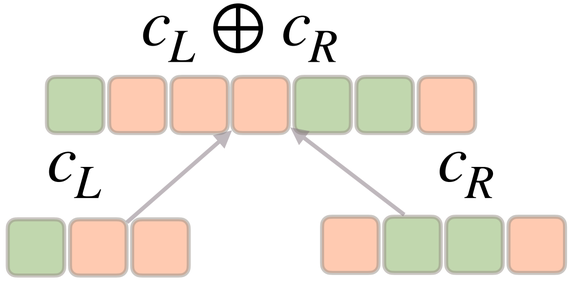
The Hierarchical Chunking Model (HCM)

Sequence:

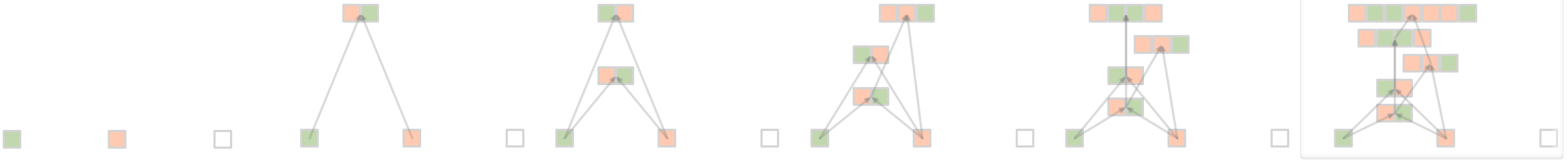
Inspiration: the Gestalt
principle of *grouping by proximity*





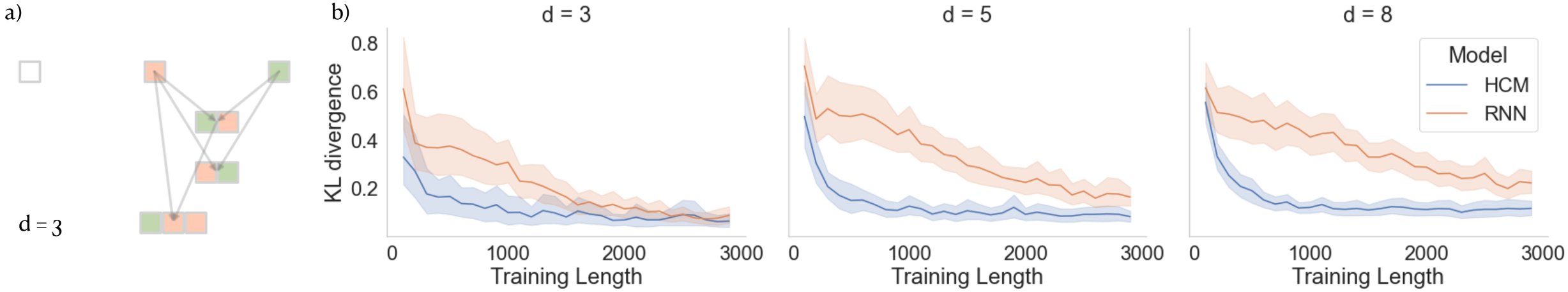


Final Chunk Hierarchy



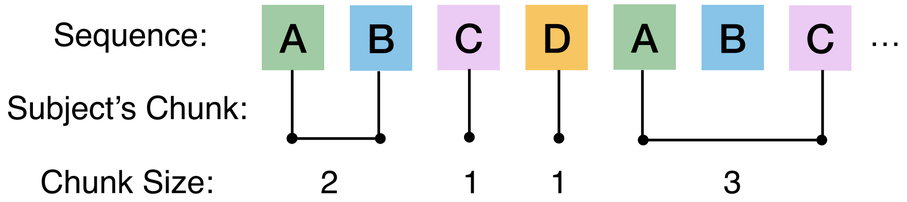
t = 10 t = 20 t = 60 t = 100 t = 150 t = 200

Comparative Advantage to RNN when the sequence contains underlying hierarchy

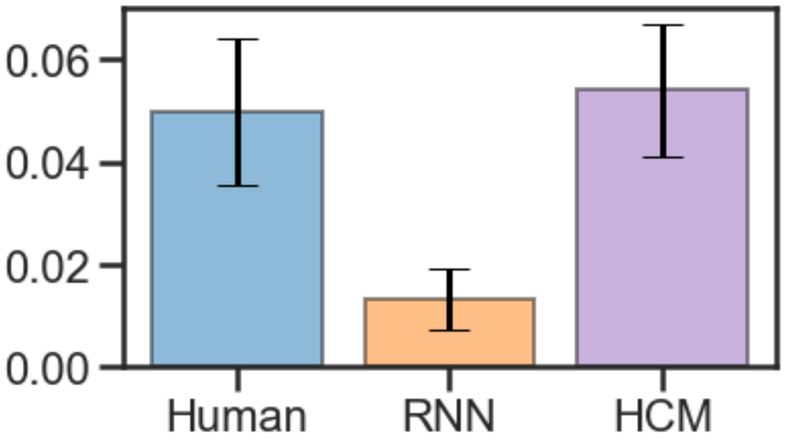


HCM resembles more to human chunk learning

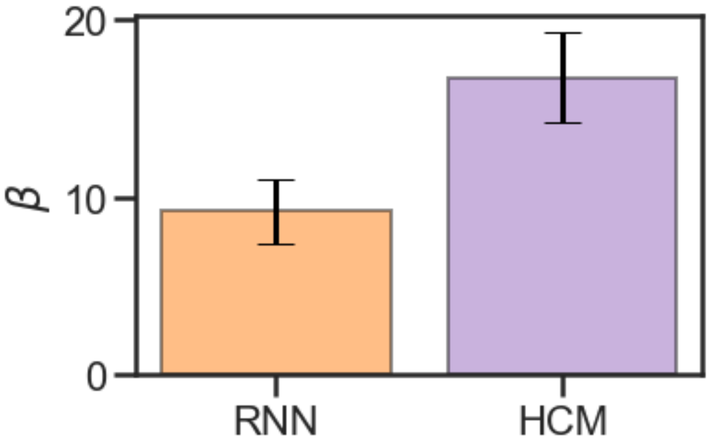
Sequence Learning Experiment



Chunk Increase Rate

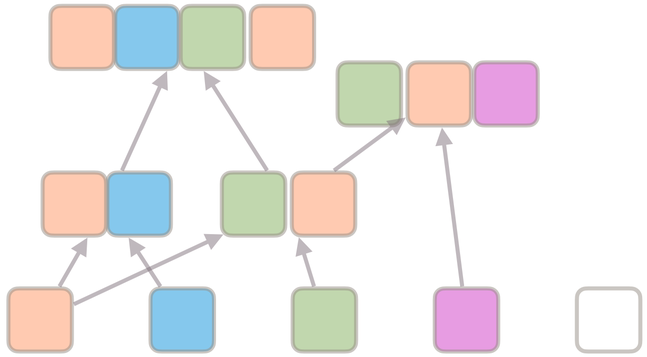


Standardized Regression Coefficient

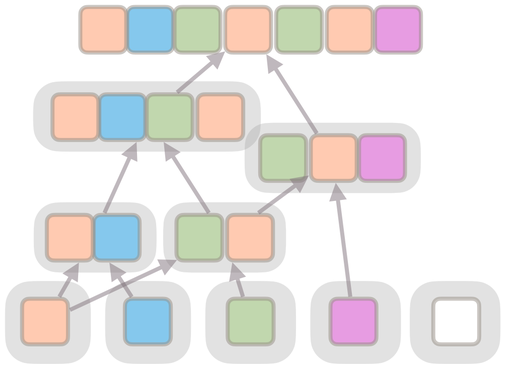


HCM permits transfer between environments

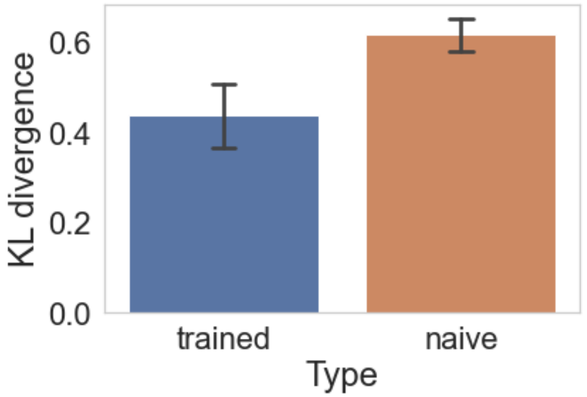
Learned Representation



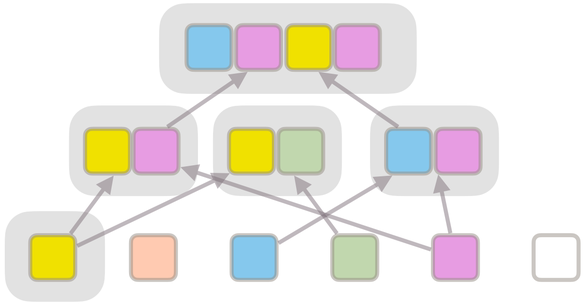
Facilitative Environment



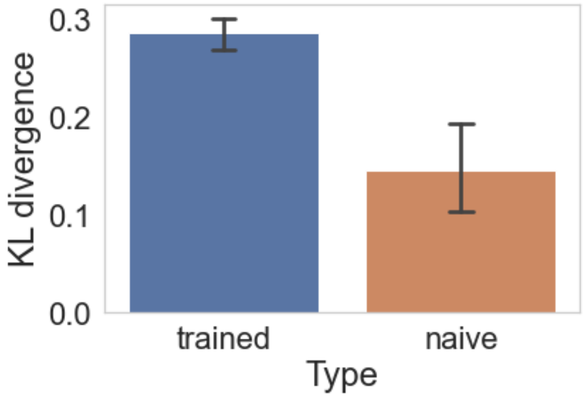
Facilitation



Interfering Environment

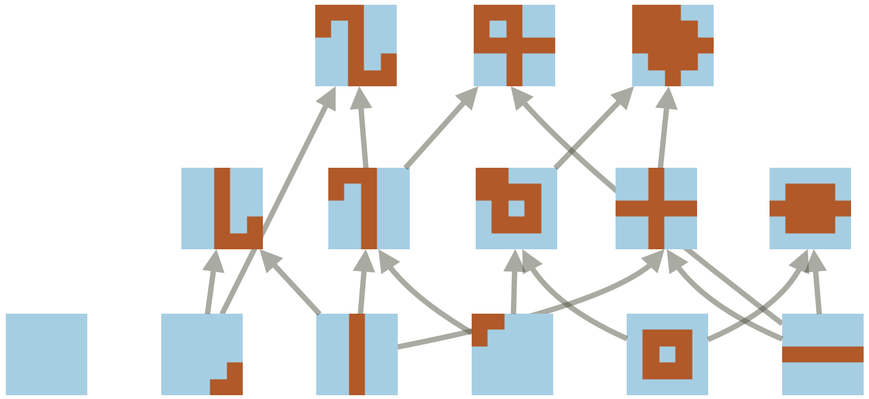


Interference



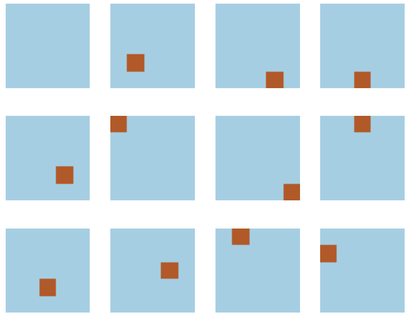
Generalizing Chunk Learning Principles to Visual-Temporal Domain

Visual Hierarchical Model

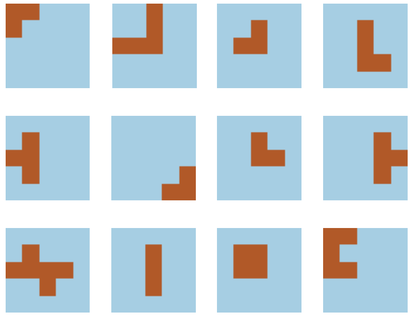


HCM Learns Compositional Structure in the Visual Domain

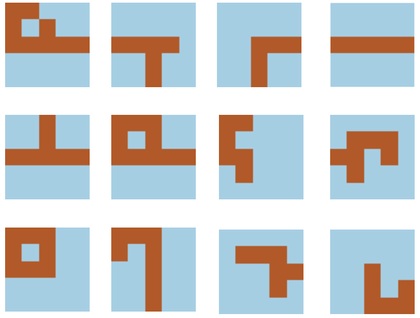
Simple



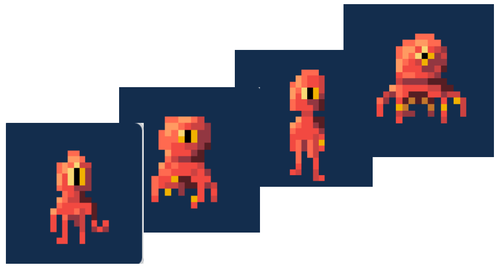
Intermediate

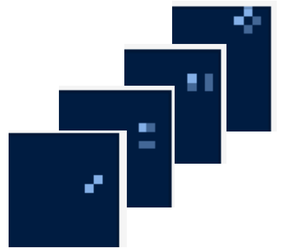


Complex



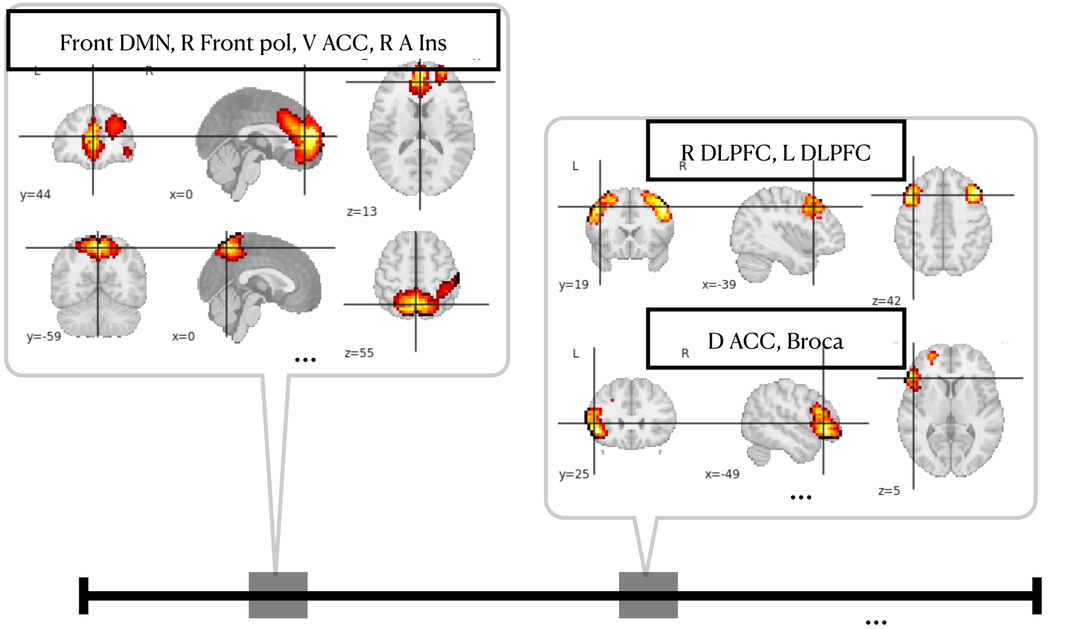
HCM Learns Part-whole Structure that Resembles Object Entities



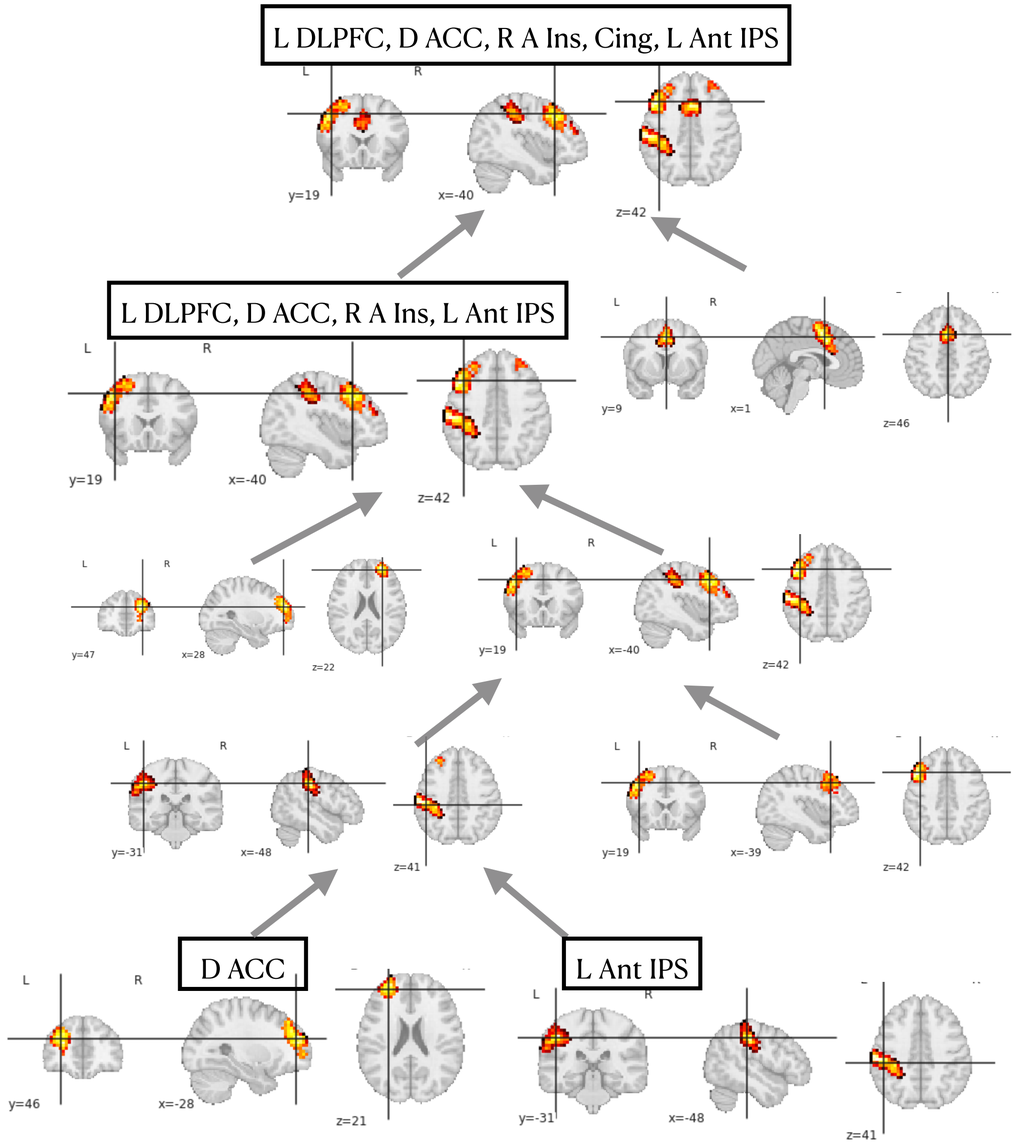


Learning Hierarchies of Brain Activation from Resting-state fMRI data

Discovering patterns of functional activity
HCM's Chunks can be Matched with Stimulus Onsets



Learning Hierarchical Activation Patterns



Acknowledgement

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