Cognitive architectures and predictive models

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Marr's three levels

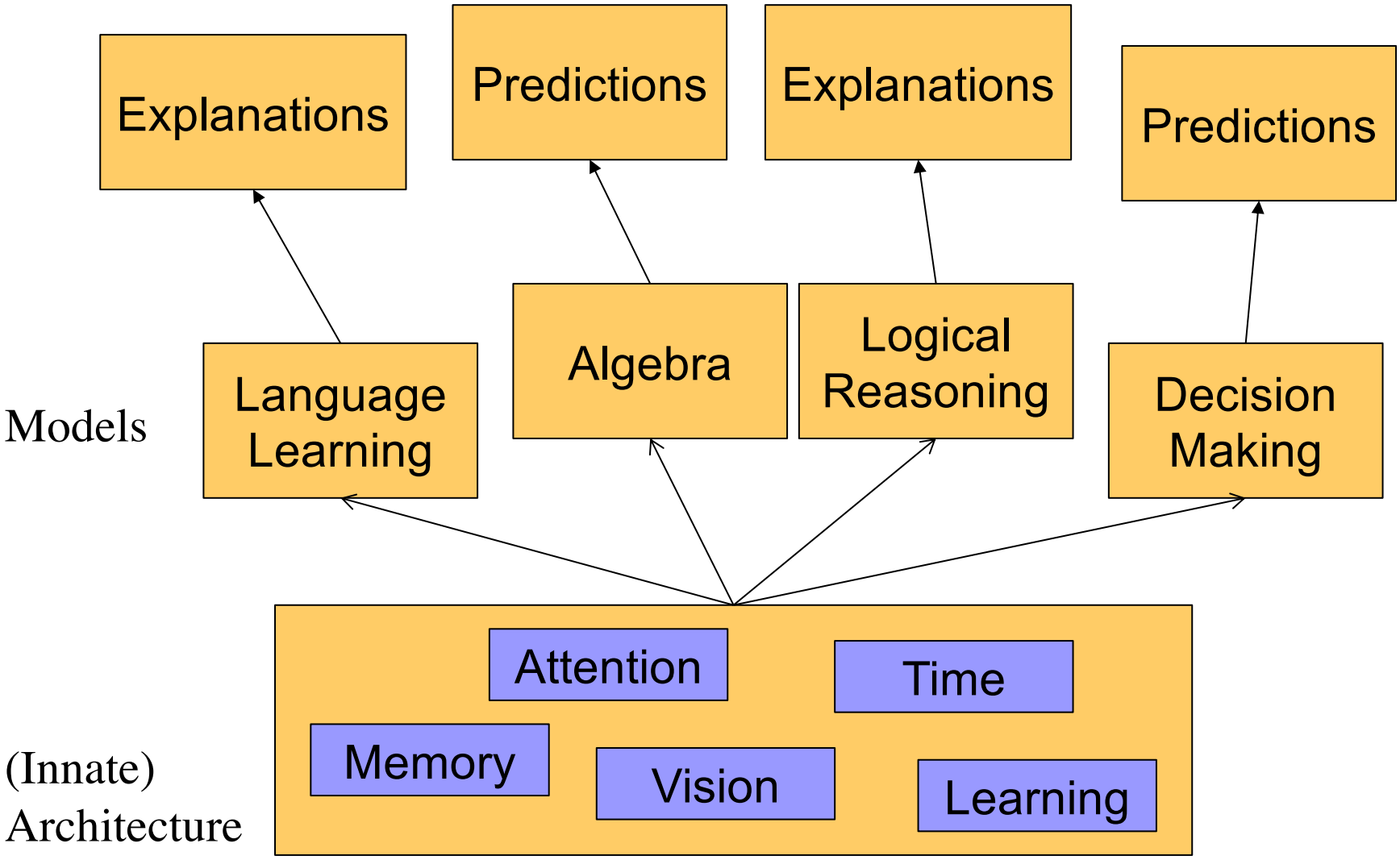
Levels of description

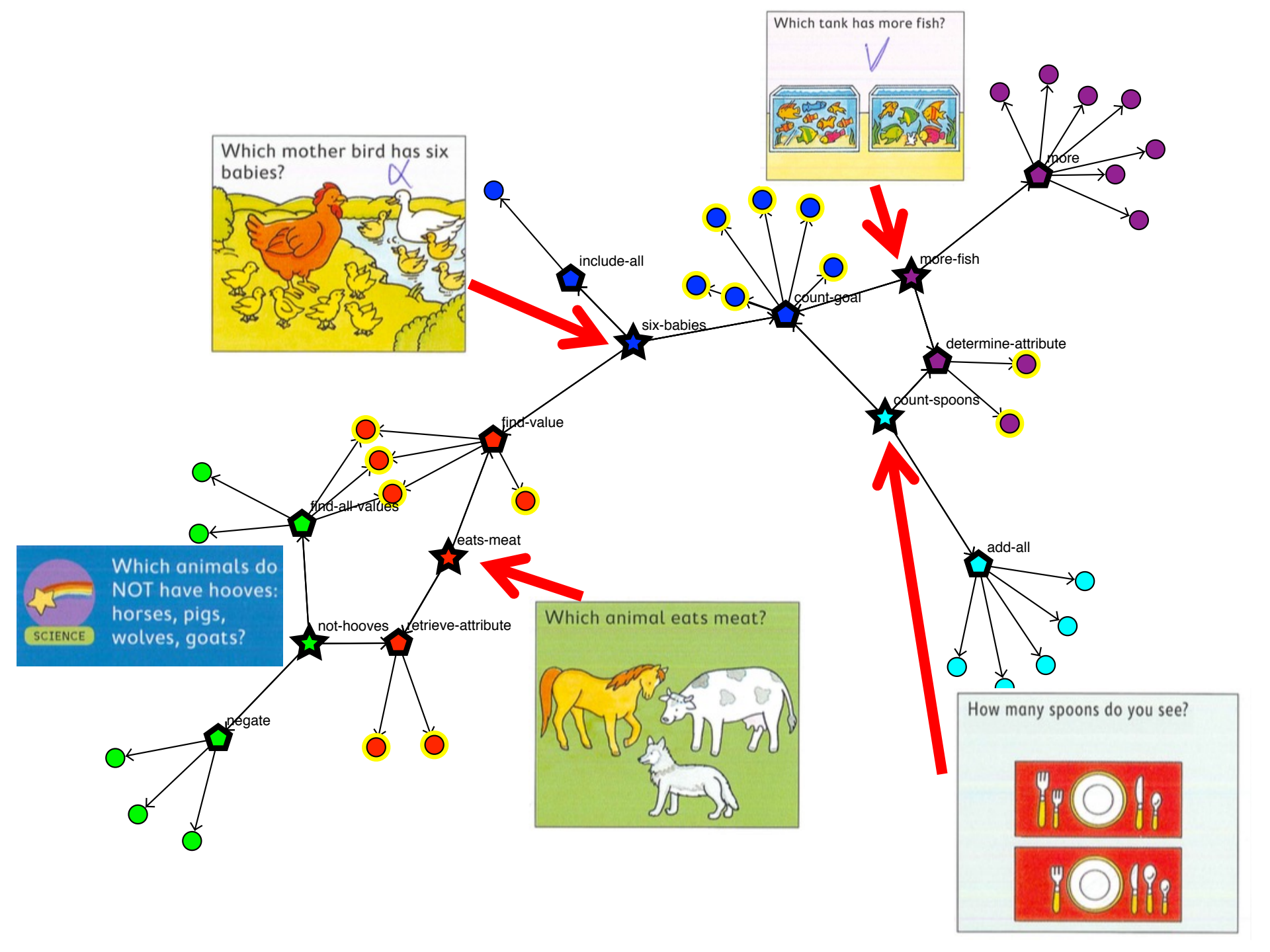
Computational	Flight
Algorithmic	Flapping
Implementational	Feather

https://www.kfki.hu/~tbalazs/cogtom/web/rellax/cogtom.html

Allen Newell, John Anderson: Cognitive architectures

- Innate set of domain-independent mechanisms to explain all of cognition
- Combined into a implementation platform that can be used to build models of particular phenomena
- Models produce predictions


Explanations
Predictions
Explanations
Predictions
Models
Language Learning
Algebra
Logical Reasoning
Decision Making
(Innate) Architecture
Attention
Time
Memory
Vision
Learning


Which tank has more fish?
Which mother bird has six babies?
more
include-all
more-fish
count-goal
six-babies
determine-attribute
count-spoons
find-value
find-all-values
eats-meat
add-all
SCIENCE
Which animals do NOT have hooves: horses, pigs, wolves, goats?
not-hooves
retrieve-attribute
negate
Which animal eats meat?
How many spoons do you see?

Example: Working Memory

Miller (1956):

Limits of working memory:

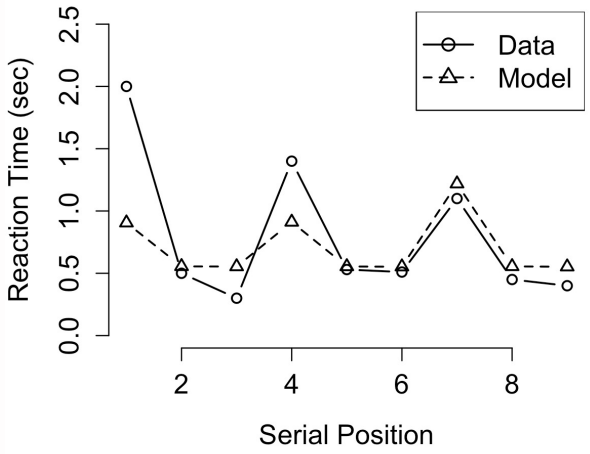
7 ± 2 items

Example: Working Memory

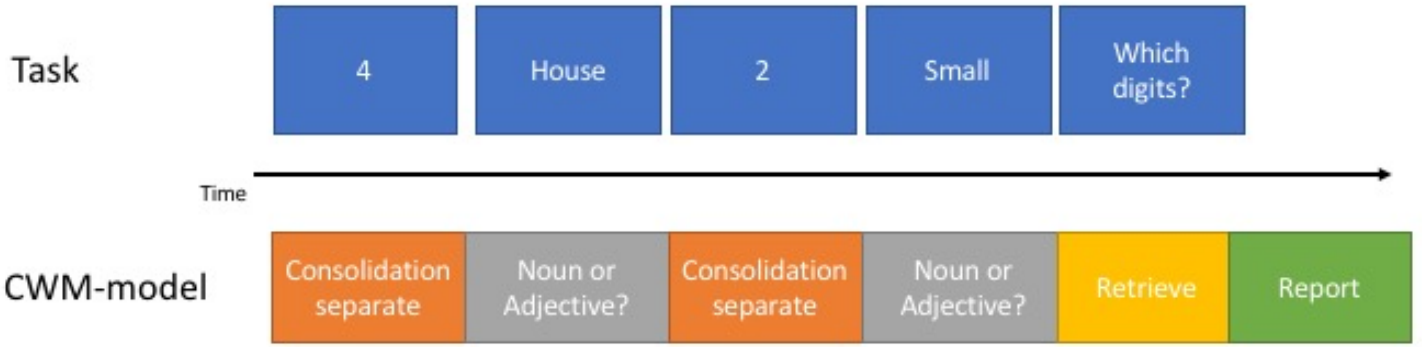
- How to chunk information in memory? Together or separate?
- Phone numbers: 050 363 6435
  - Three chunks
- Complex working memory tasks:
  - All separate chunks

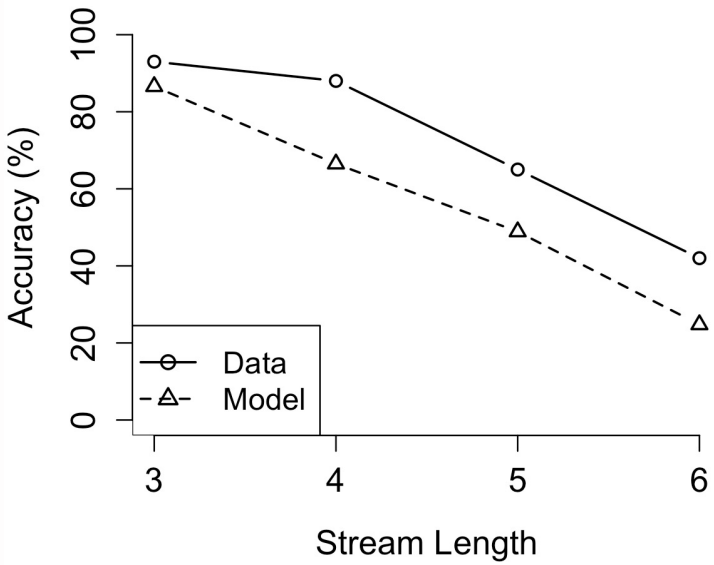
Hoekstra, Martens & Taatgen (2020). A Skill-based Approach to Modeling the Attentional Blink. *Topics in Cognitive Science, 12*(3), 1030-1045.

Simple WM task



Complex WM task



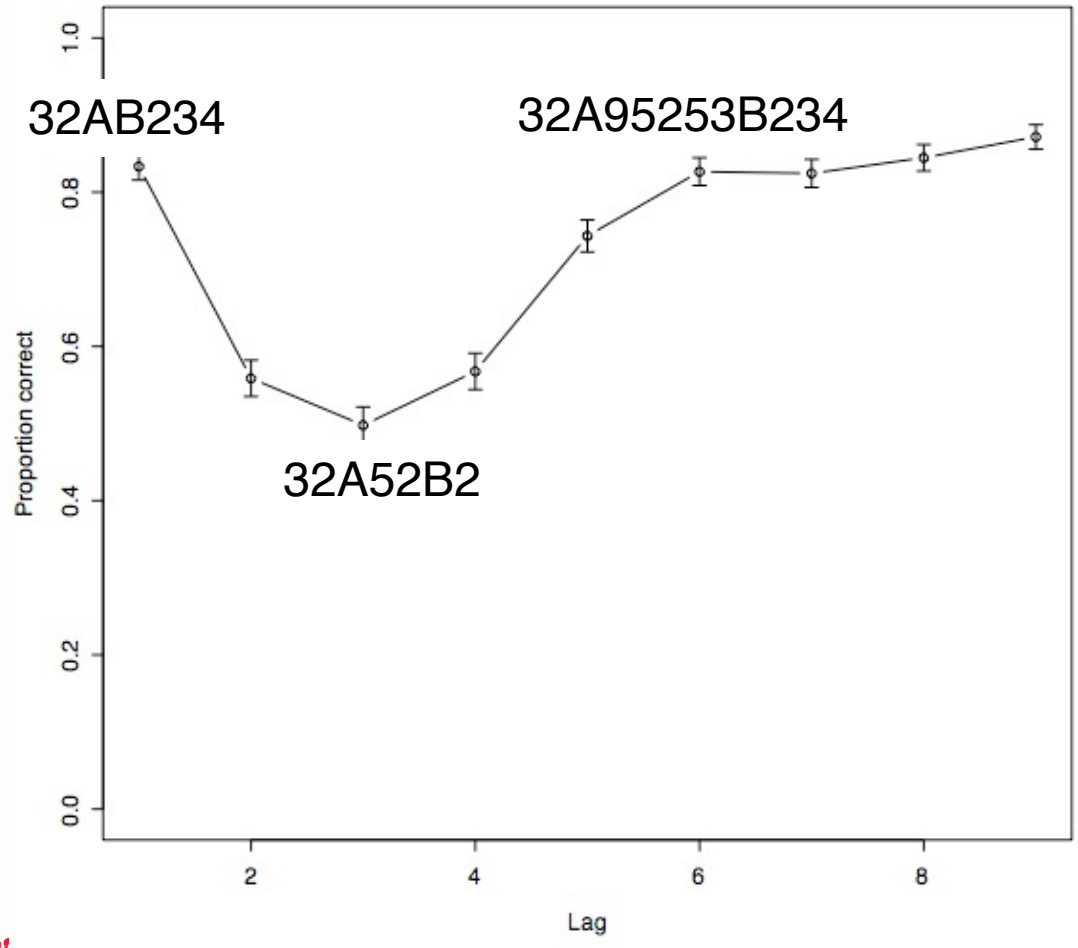


Combine skills for a new task

- Corné also modeled a visual search task, using skills to identify a target, and move attention
- Using the skills from these tasks, he created a new model *just by combining existing skills*

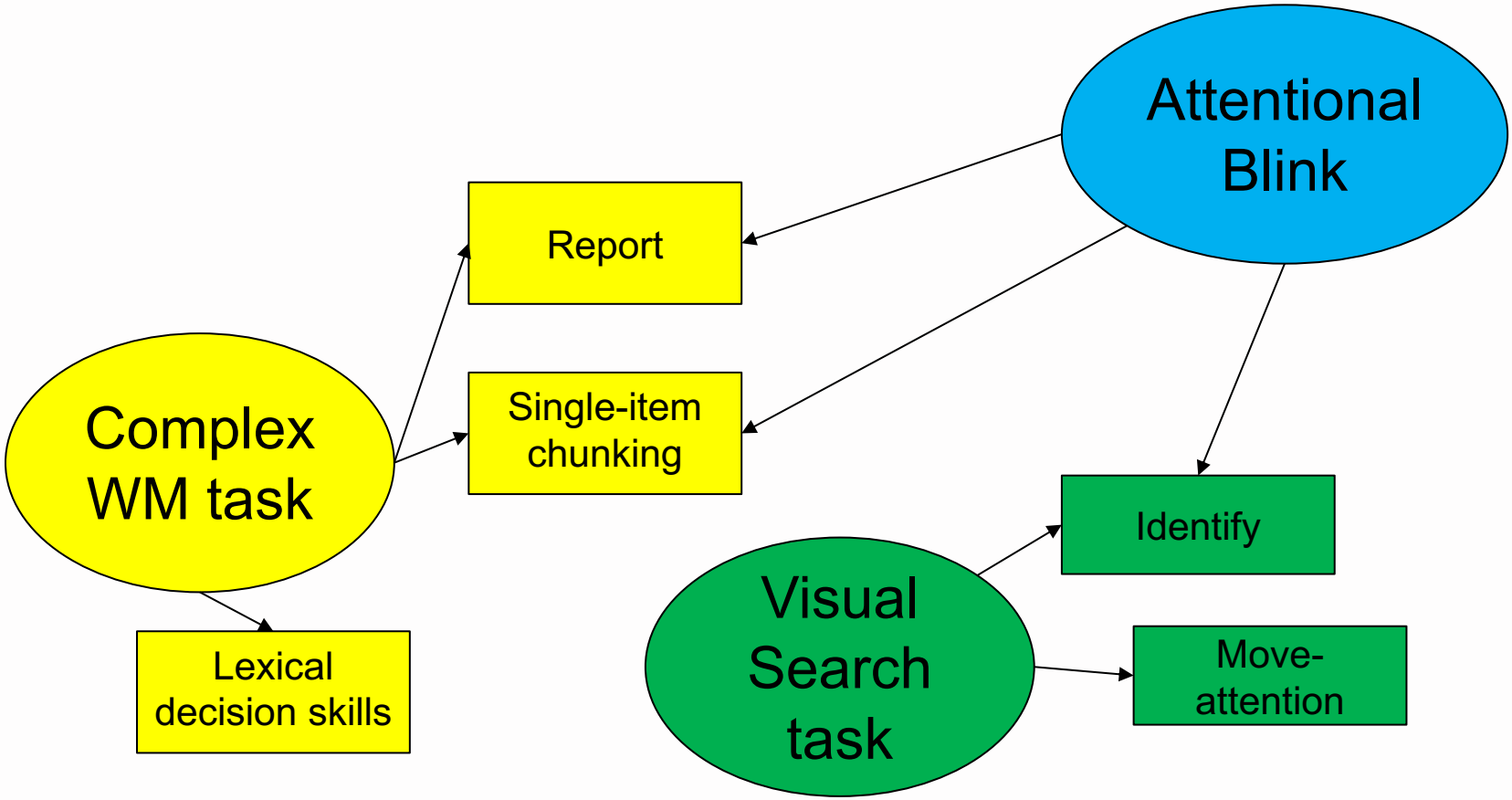
Attentional Blink

Typical accuracy for second target

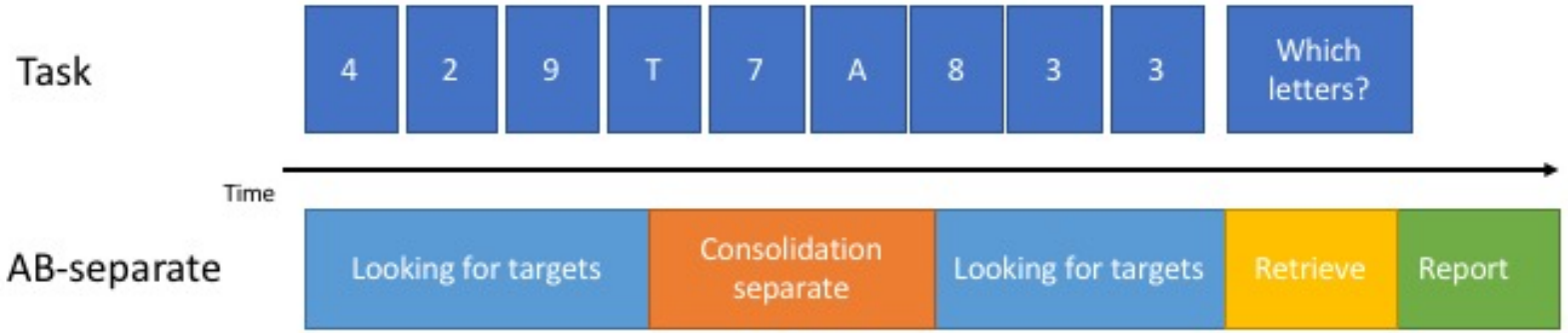


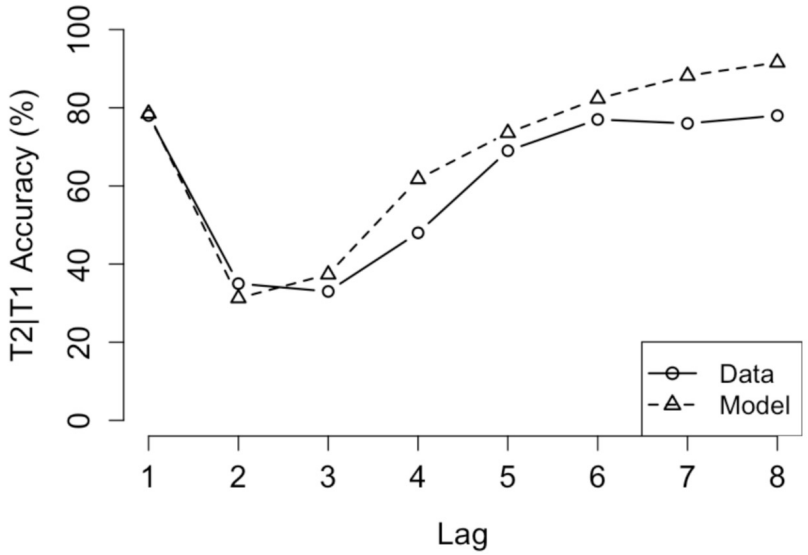
Lag (x-axis) = distance (in time) between first and second target

Use skills from other tasks to explain performance on new task

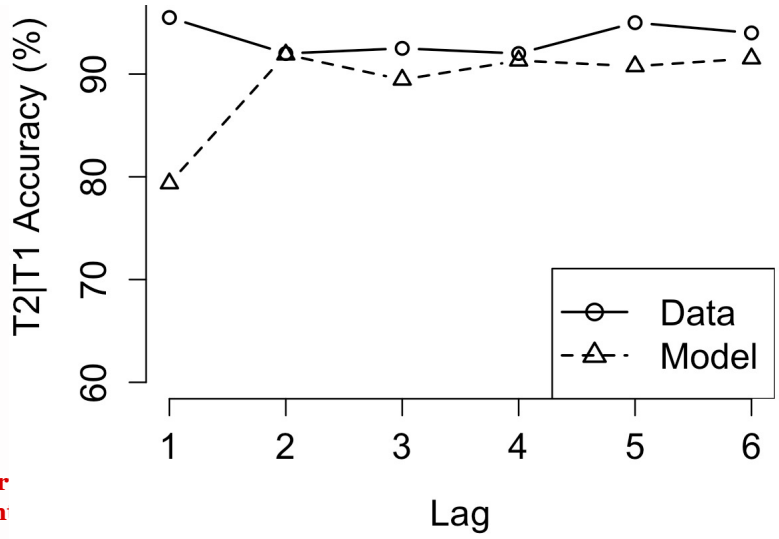


Model results

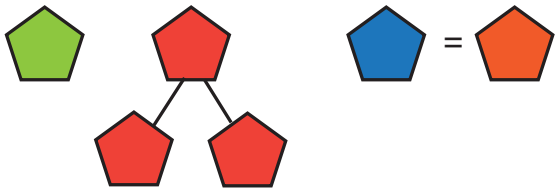




But with the chunked WM skill



Higher-level representations
(language)

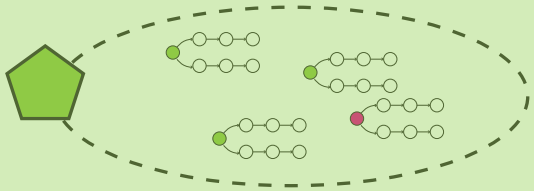


Tasks
Combinations of goals (parallel, sequential or hierarchical)

Reasoning, Instance-based learning

Composition

Corné Hoekstra:
Attentional Blink is due to poor choice of skills



Skills
Sequences of operators wi
binding, processed serially

Reinforcement Learning

Reuse of Operators

Operators
Sequences of primitive operations, processed in parallel

Compilation

Overlap in

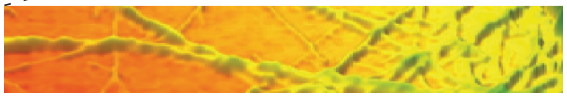
Mark Ji:
Infant learning of simple grammatical patterns

Primitive operations
Comparing and projecting
between workspace locatio

Associative Learning

Myself:
Implementation of PRIMs in Nengo

Clusters of neurons (Neng
Representation: activation p



Neuromorphic architecture (Learning Materials)