Evolving Cognitive Models of Verbal Learning

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Genetically Evolving Models in Science

- **GEMS Project:** https://gems-science.netlify.app/

CPNSS@ 

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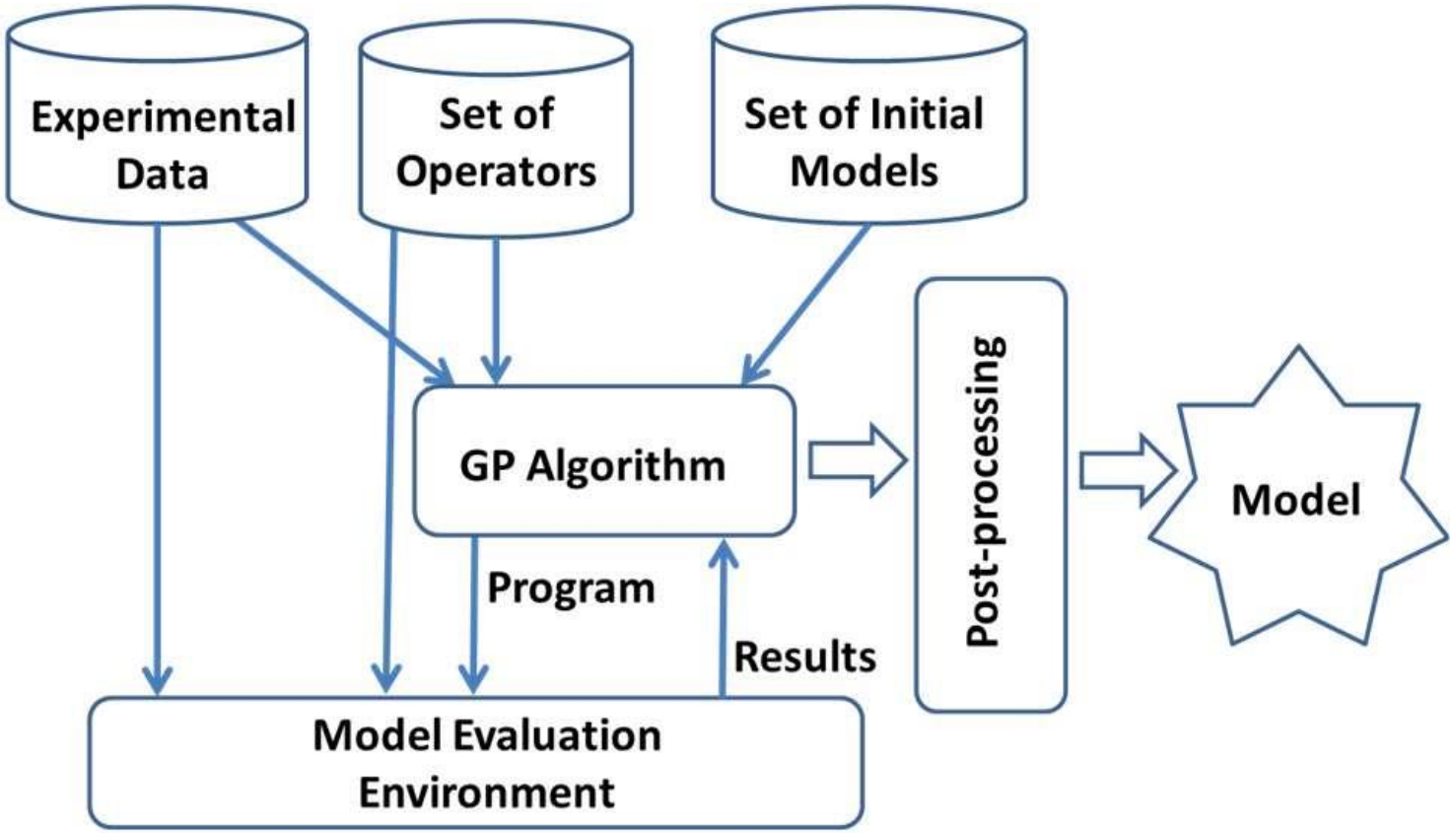
Plan

- GEMS
- GEMS Architecture
- CHREST
- Verbal learning
- GEMS interfacing with CHREST
- Experiment 1: Constant Learning Time
- Experiment 2: Intralist Similarity

Genetically Evolving Models of Science (GEMS)

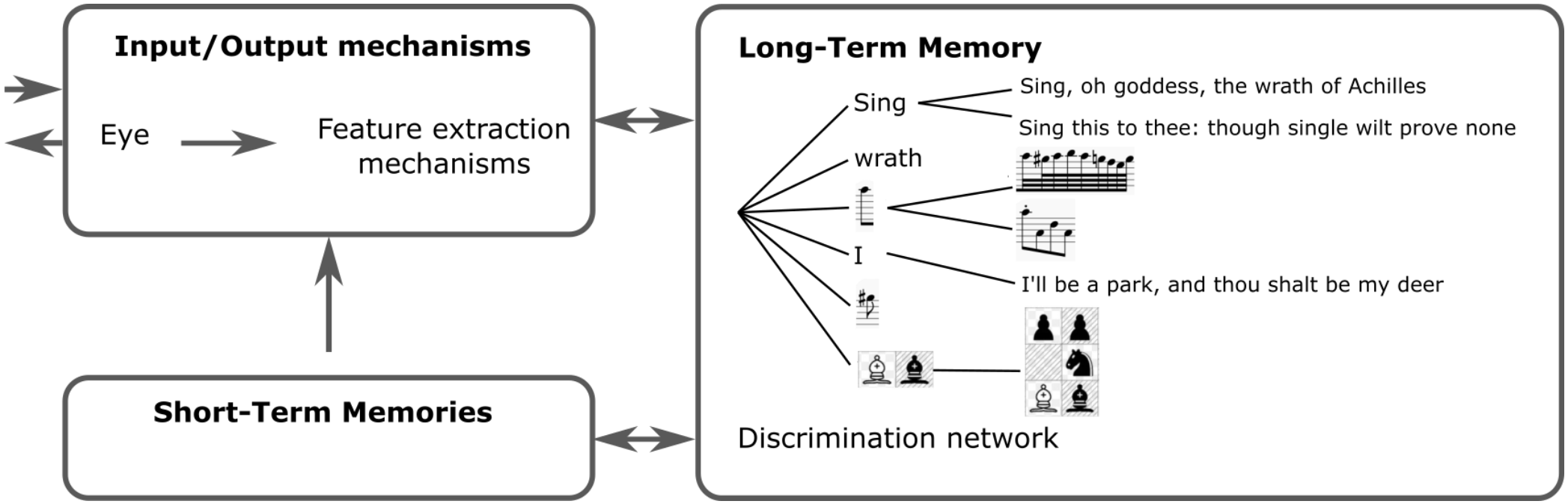


CHREST and Verbal Learning

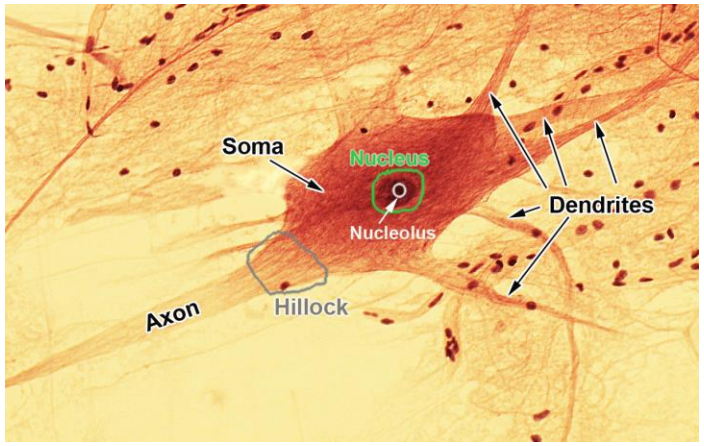
Outline:

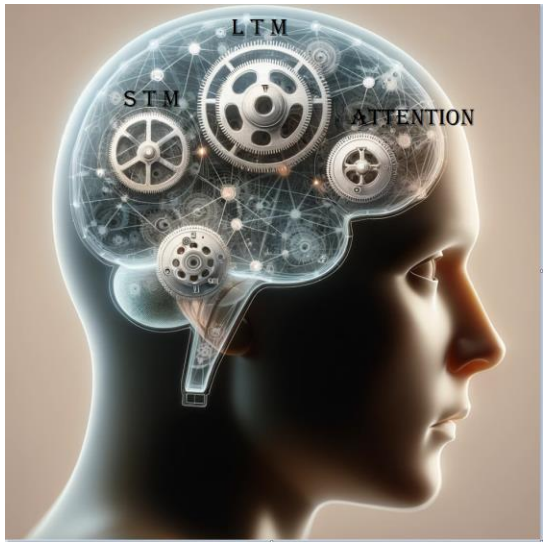
- What is CHREST
- Why should we care
- How it works
- Verbal learning simulation

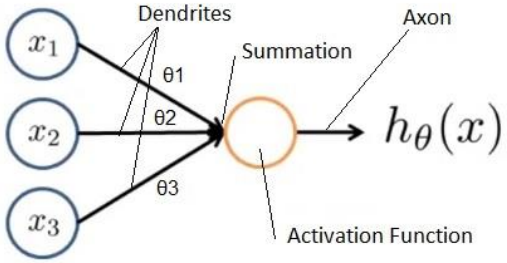
CHREST (Chunking Hierarchy REtrieval STructures)

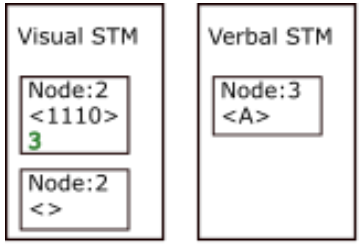


Why CHREST?

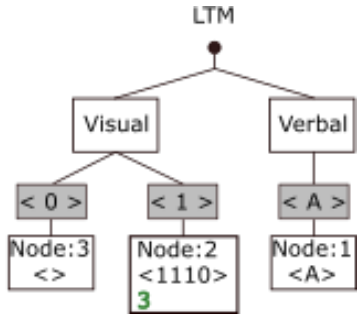

Soma
Nucleus
Nucleolus
Dendrites
Axon
Hillock


LTM
STM
ATTENTION


Dendrites
Axon
Summation
θ1
θ2
θ3
x_1
x_2
x_3
$h_\theta(x)$
Activation Function


Visual STM
Node:2
<1110>
3
Node:2
<>

Verbal STM
Node:3
<A>

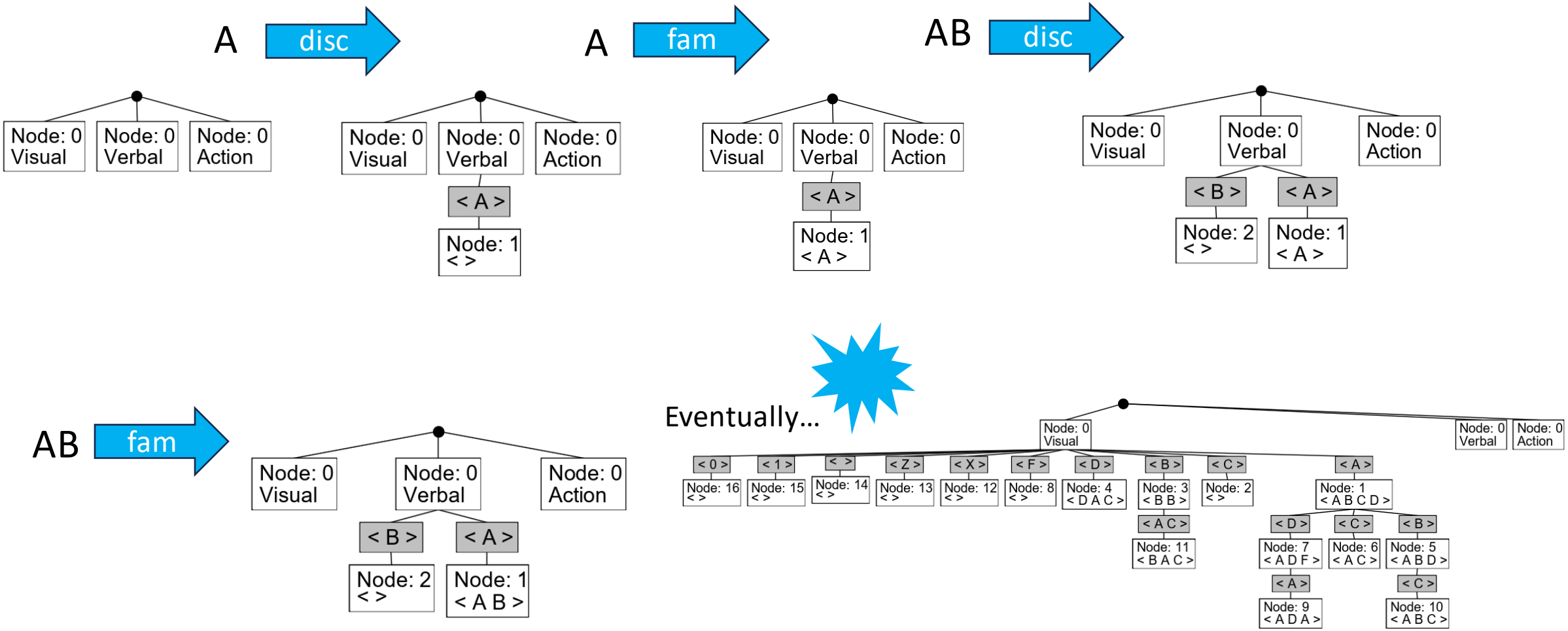

LTM
Visual
Verbal
< 0 >
< 1 >
< A >
Node:3
<>
Node:2
<1110>
3
Node:1
<A>

Chunking

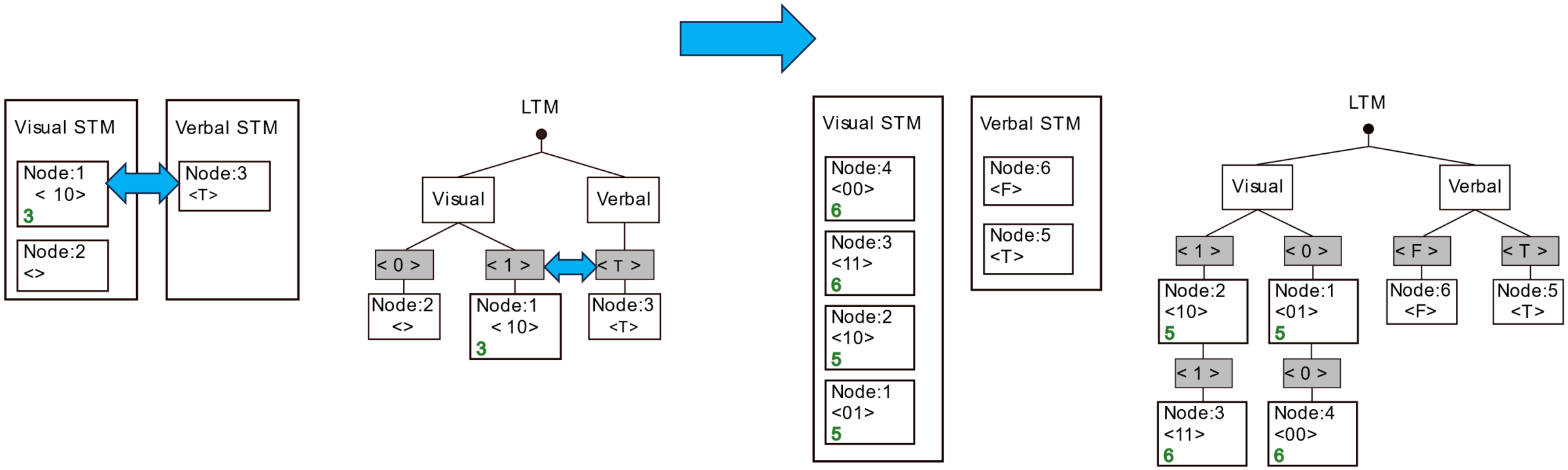
827608214703

121519562023

Unsupervised chunking: automatic discrimination and familiarisation



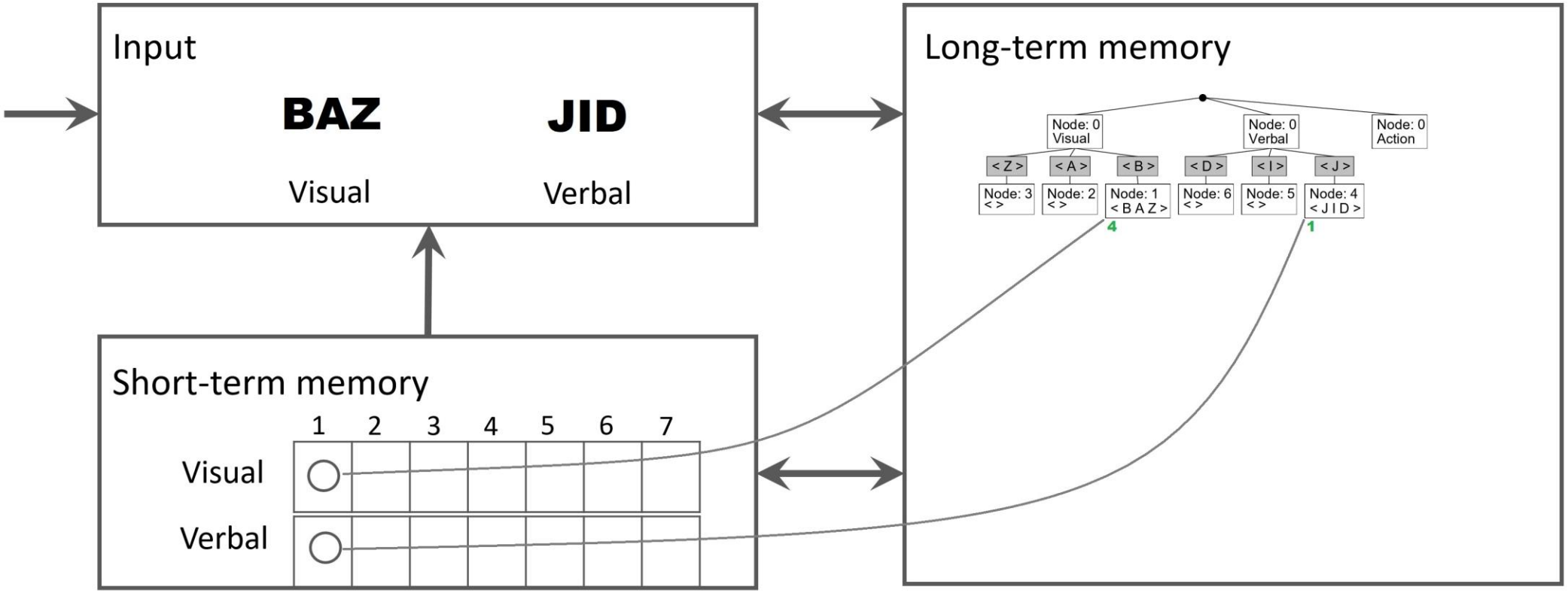
Supervised association learning: XOR



Verbal learning experiments

- Nonsense syllable learning
- Participants presented with CVC nonsense syllables
- Trials repeated until learning occurs
- Uncover laws of memory and learning
- Refine computer models through simulations

B A Z – J I D


Input
BAZ
JID
Visual
Verbal
Long-term memory
Node: 0
Visual
Node: 0
Verbal
Node: 0
Action
< Z >
< A >
< B >
< D >
< I >
< J >
Node: 3
< >
Node: 2
< >
Node: 1
< B A Z >
Node: 6
< >
Node: 5
< >
Node: 4
< J I D >
4
1
Short-term memory
1 2 3 4 5 6 7
Visual
Verbal

F E P - Y U F

H A J - P O B

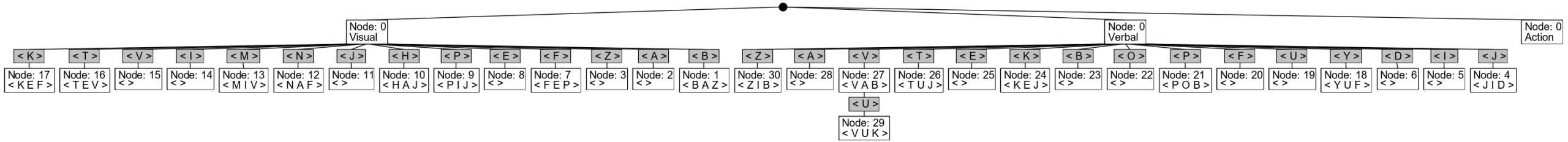
N A F - K E J

M I V - T U J

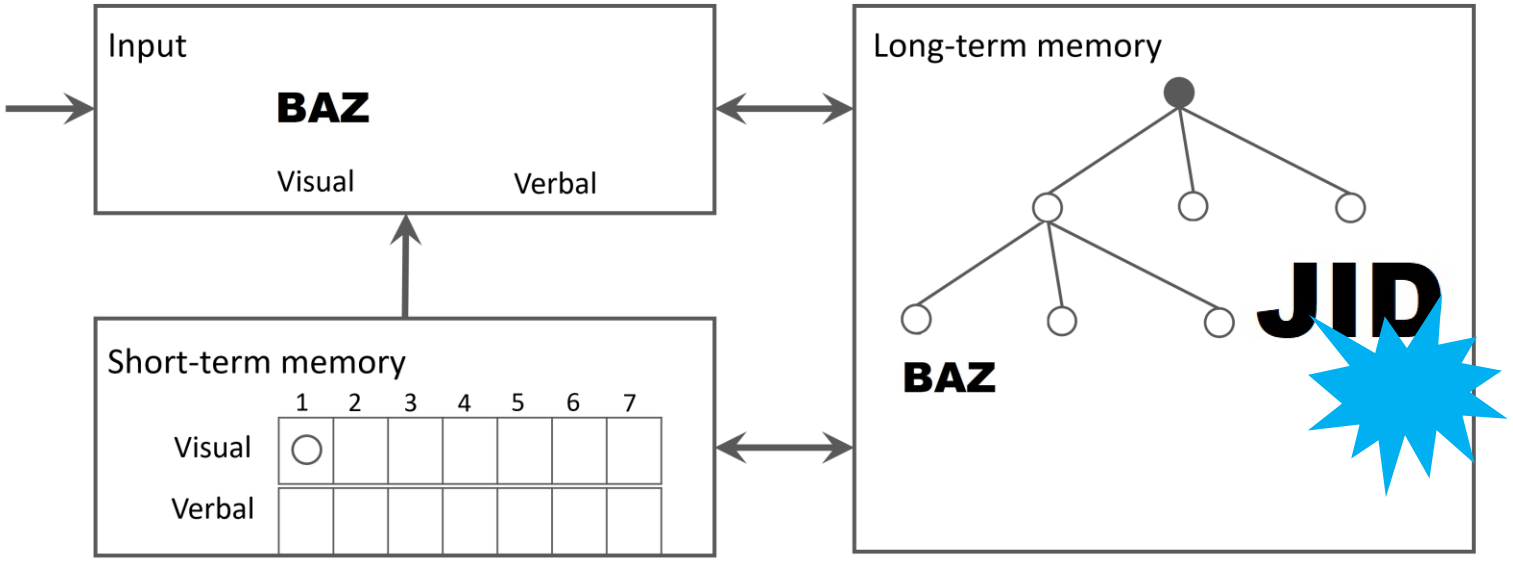
T E V - V A B

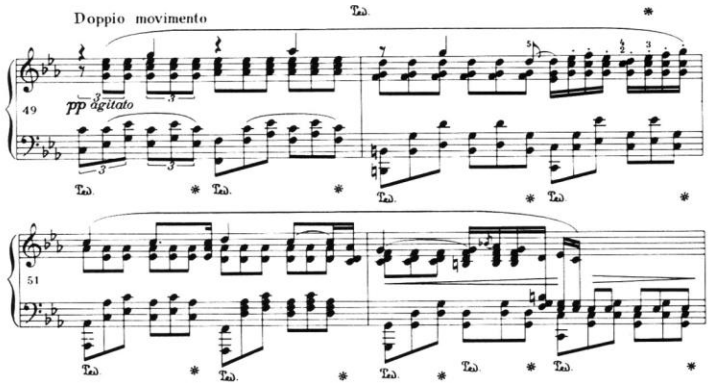
K E F - V U K

P I J - B I F

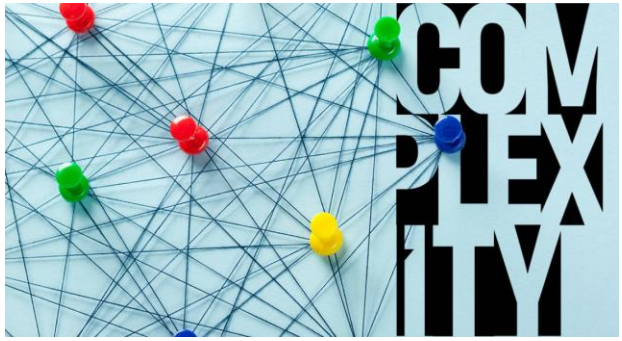


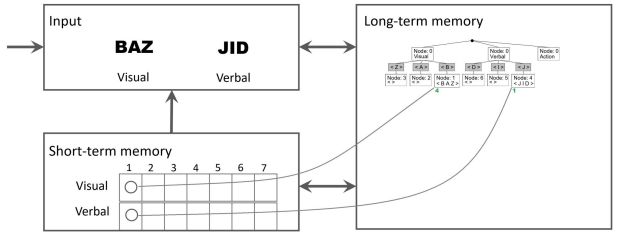
B A Z - ?

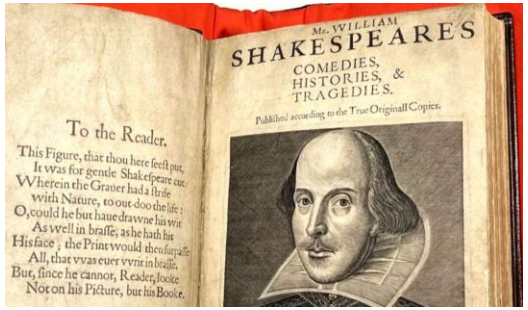

Input
BAZ
Visual
Verbal
Long-term memory
JID
BAZ
Short-term memory
1 2 3 4 5 6 7
Visual
Verbal


Doppio movimento
pp agitato
49
51

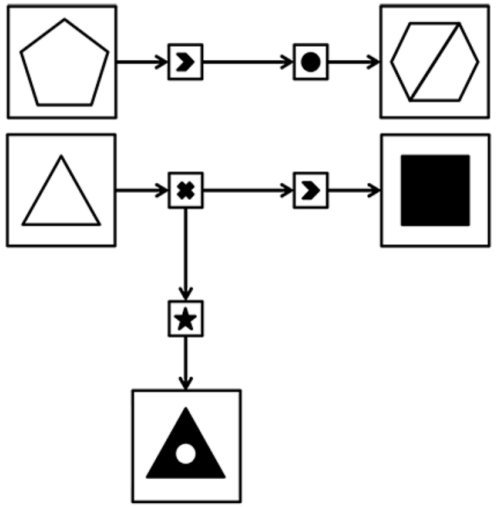

GRAMMAR


COM
PLEX
ITY


Input
BAZ
JID
Visual
Verbal
Long-term memory
Short-term memory
1 2 3 4 5 6 7
Visual
Verbal


Mr. WILLIAM
SHAKESPEARES
COMEDIES,
HISTORIES, &
TRAGEDIES.
Published according to the True Originall Copies.
To the Reader.
This Figure, that thou here seeſt put,
It was for gentle Shakeſpeare cut,
Wherein the Graver had a ſtrife
with Nature, to out-doo the life:
O, could he but haue drawne his wit
As well in braſſe, as he hath hit
His face; the Print would then ſurpaſſe
All, that was euer writ in braſſe.
But, ſince he cannot, Reader, looke
Not on his Picture, but his Booke.


STOP
BAR
BAR
BAR

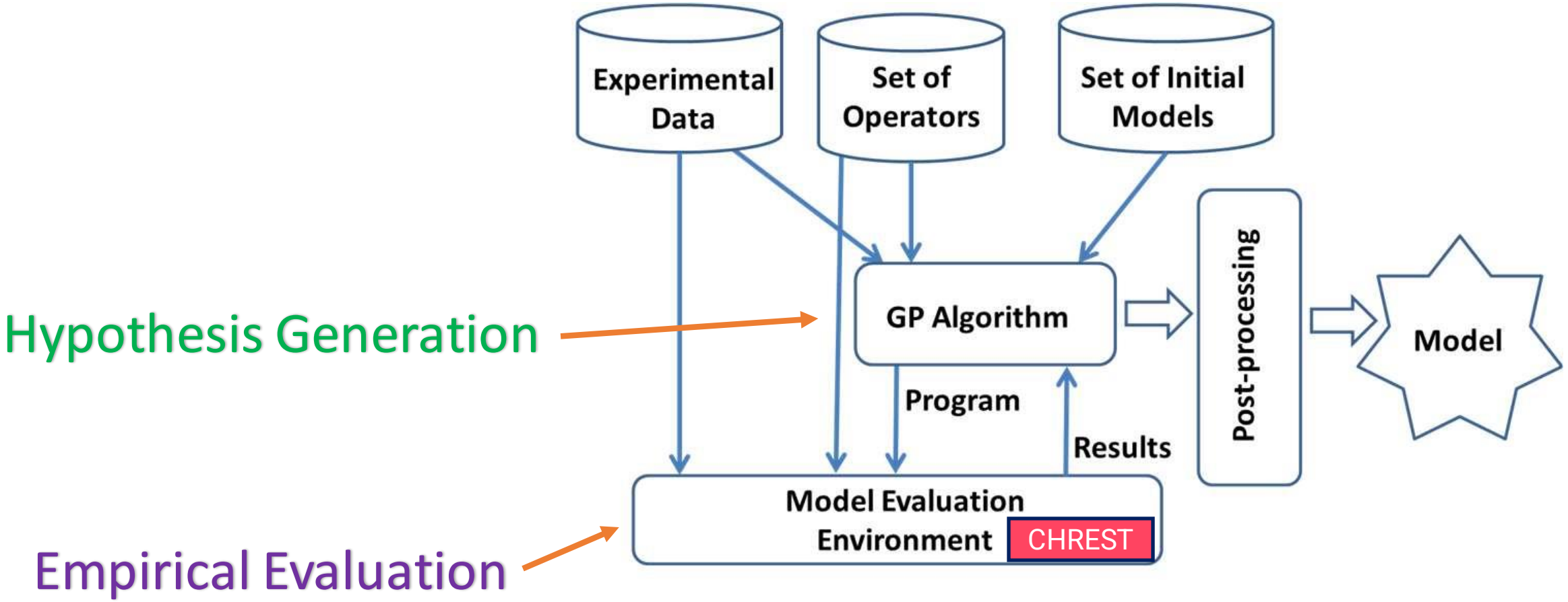


Summary

- CHREST is a general cognitive architecture
- Learns by chunking
- Has *general purpose learning* mechanisms

- Verbal learning – cognitive experiment paradigm
- Uncovers laws of human memory and learning
- Provides building blocks for designing formal cognitive architectures

Genetically Evolving Models of Science (GEMS)



GEMS Operators

Attention

Attend-Stimulus
Attend-Response
Wait

Short-term-memory

Put attended item in STM

LTM (CHREST)

Recognise-and-learn
Learn-and-link

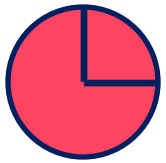
GEMS: Model Evaluation Environment

Short-term-memory

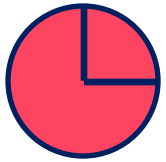
Slot 1

Slot 2

Clock



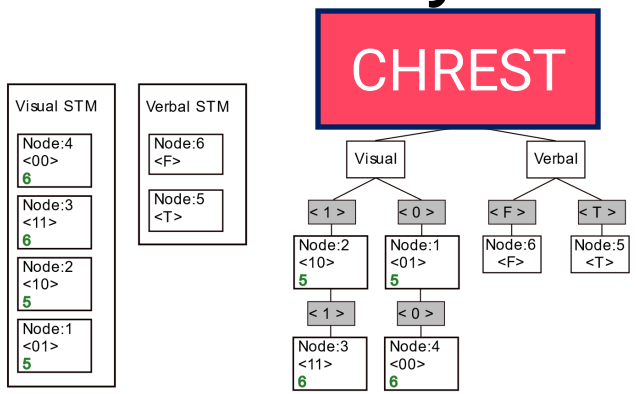
Learning Clock



Current

Slot

Long-term memory



Bugelski's Experiment: Constant Learning Time

K A R

W E H

Bugelski's Experiment: Constant Learning Time

C E Z

M U N

Bugelski's Experiment: Constant Learning Time

- Total time required to learn a paired-associate list is not affected by presentation rate

- Number of cycles/trials is inversely proportional to the presentation time

Bugelski's Experiment: Constant Learning Time

- List of non-sense syllables are presented until learned completely
- Stimulus presented for 2 seconds
- Response presented for n seconds
- 2 seconds wait before next stimulus appear
- No gap between trials

Constant Learning Time: Results

Presentation Time (sec)	People (trials)	GEMS (trials)
6	10.2	10
8	8.8	9
10	5.8	6
12	4.7	5
19	3.3	3

Constant Learning Time: Results

- GEMS able to generate models learning in the same number of trials
- GEMS models producing errors in recalling list

Underwood's Experiment: Intralist Similarity of Stimuli and Responses

- intralist similarity of stimuli effects learning rate
- intralist similarity of responses does not

Underwood Results

Intralist Similarity	People (trials)	GEMS (trials)
Low-Low	23.2	23
Low-Medium	22.4	22
Low-High	24.4	24
Medium-Low	25.5	25
High-Low	30.7	31

Summary

- GEMS can produce cognitive models for verbal learning
- CHREST acts as the Long-term memory for GEMS

Need further investigation:

- GEMS models producing a lot of errors. Need to compare it with human errors.
- A theory of short-term memory
- Integration of CHREST and GEMS short-term memories