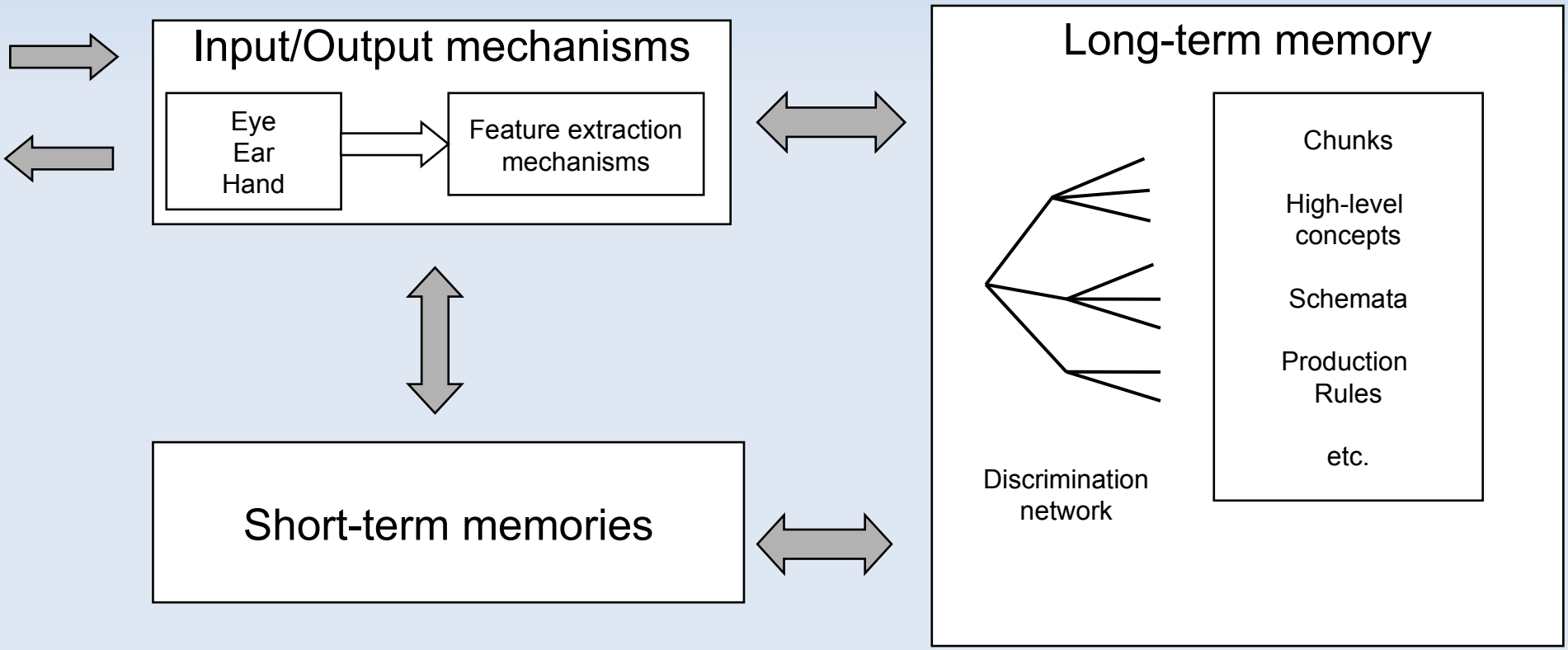
CHREST Tutorial

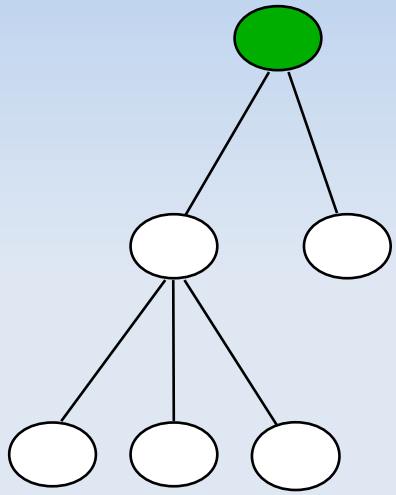
Overview of CHREST

Structure of EPAM/CHREST

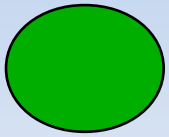


EPAM/CHREST

- Self-organising system
- Discrimination network
- Learns
  - by adding new nodes
  - by adding information to nodes
  - by adding new links between existing nodes



Learning in EPAM/CHREST



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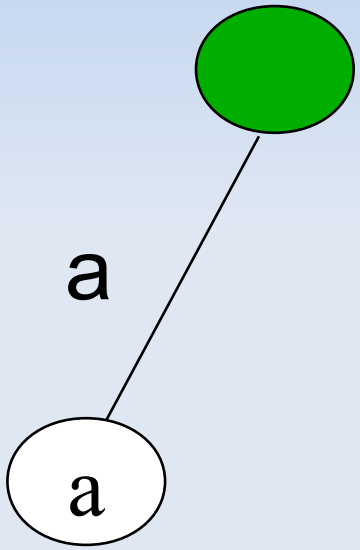

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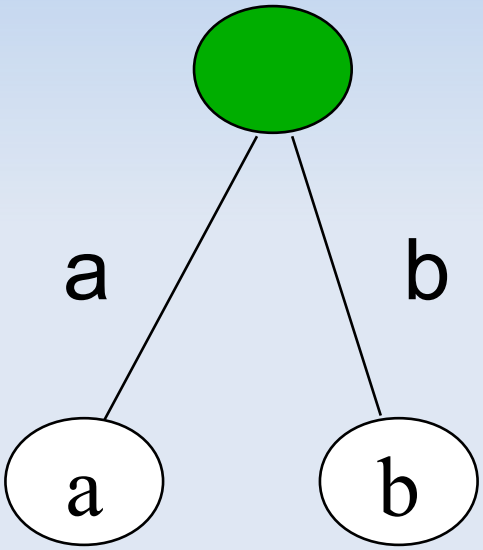

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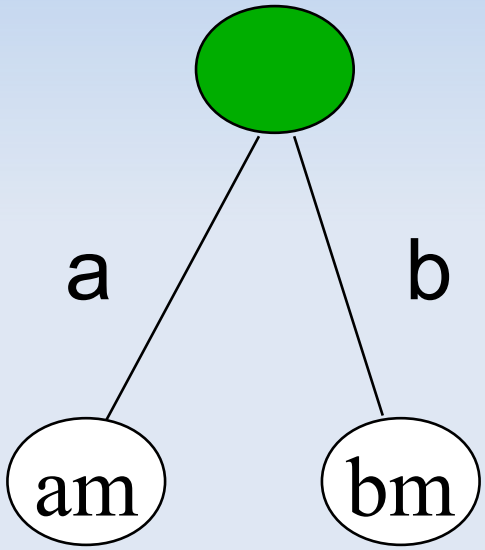

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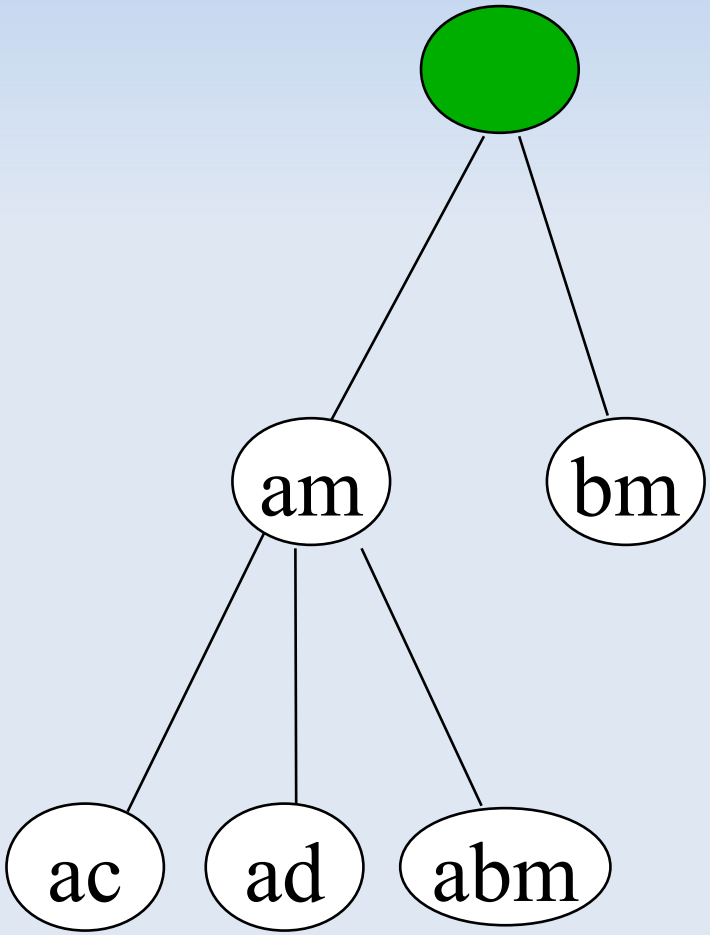

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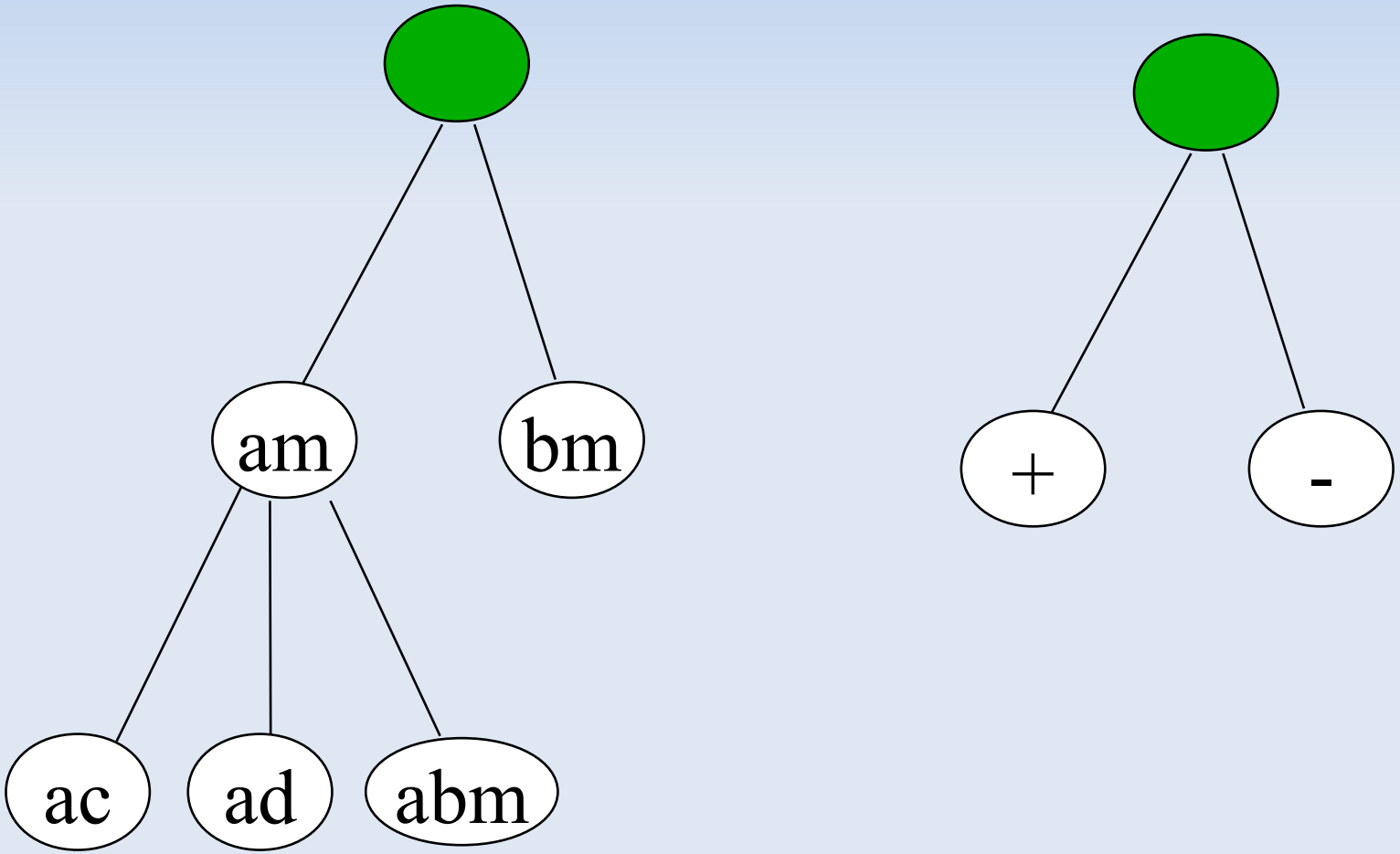

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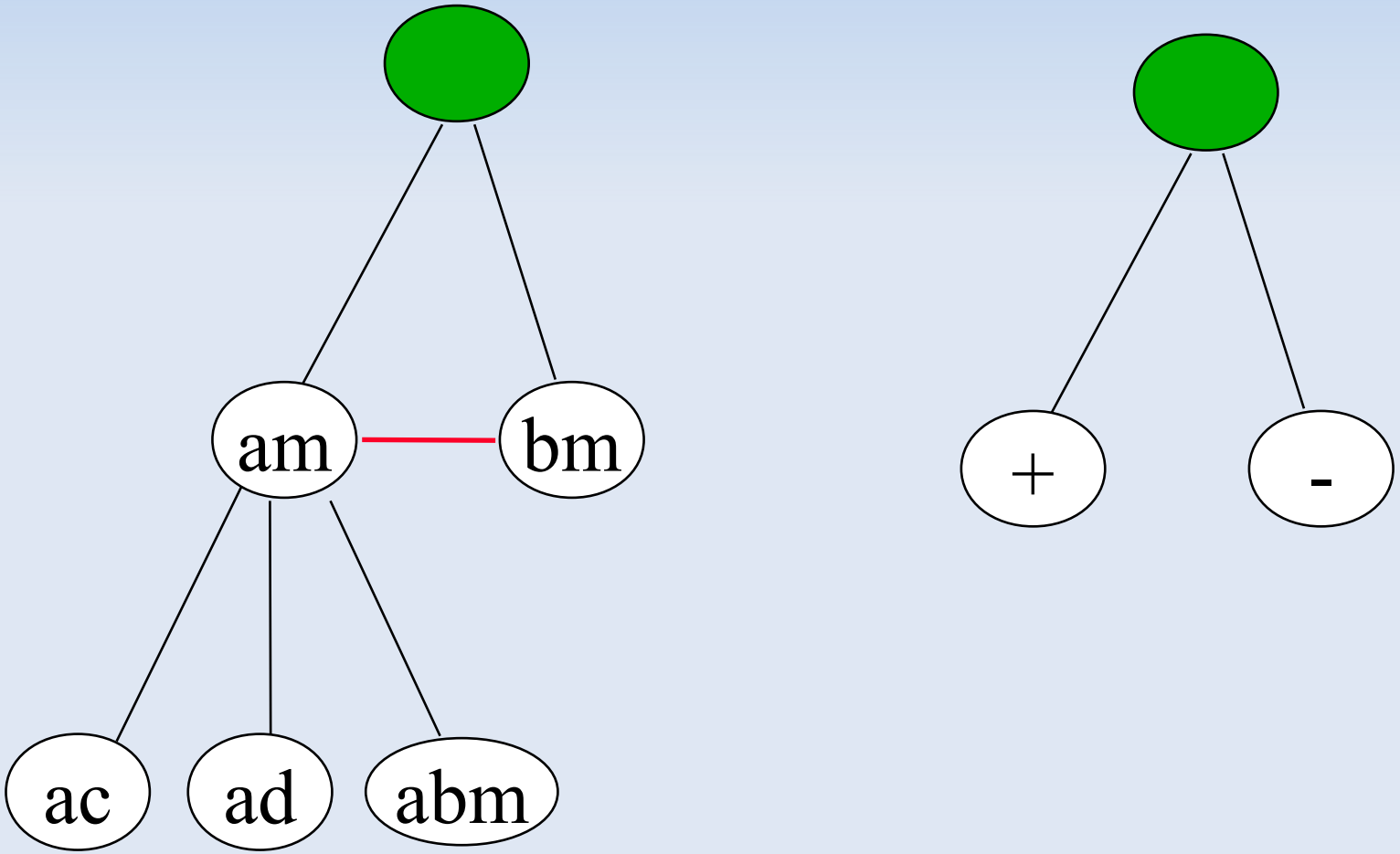

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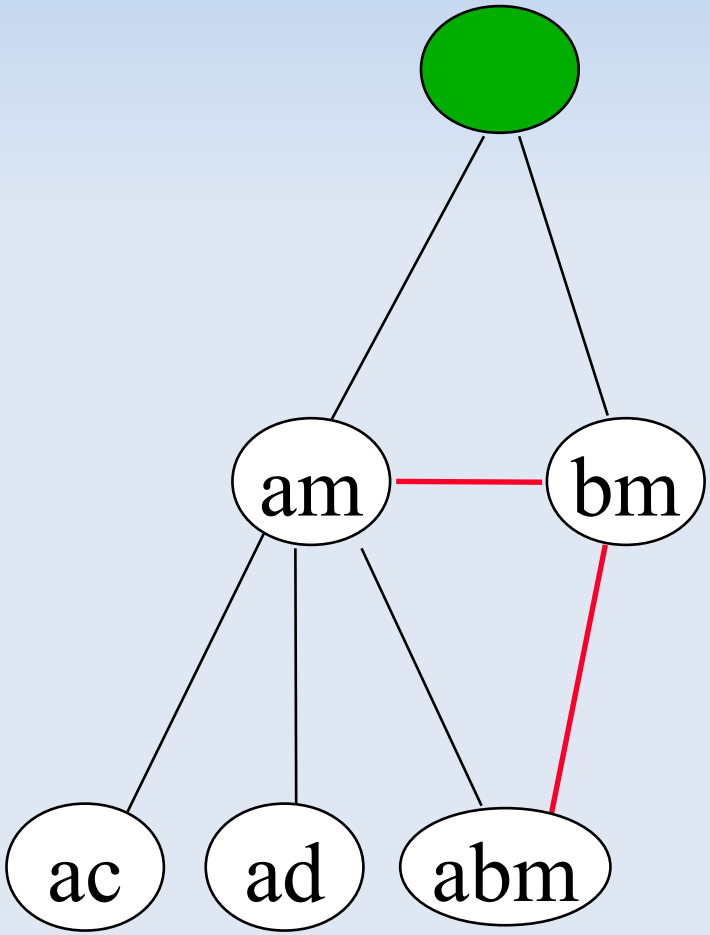

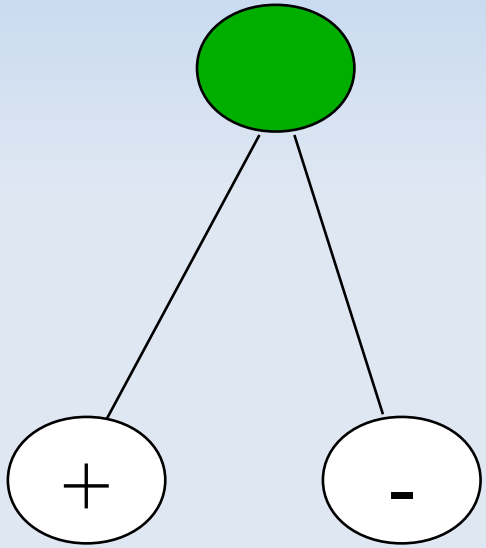

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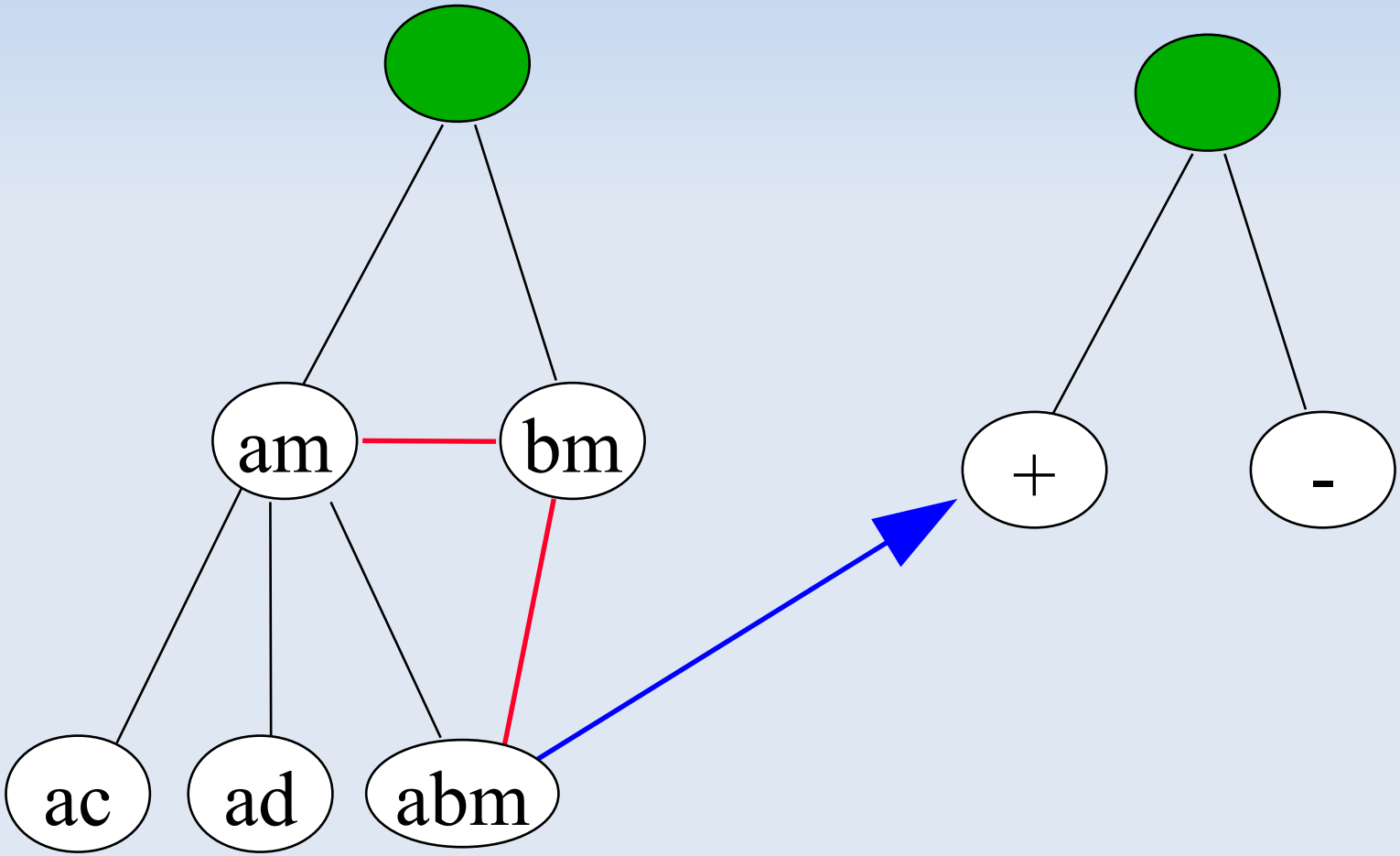
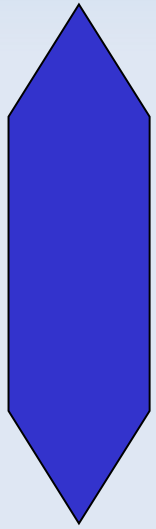


Cognitive Architectures

- The aim of a cognitive architecture is to capture a broad range of intelligent behaviours into one set of interlinked processes
- This is in contrast to a *model* which only looks at a single behaviour
- For example, we shall develop individual *models* of verbal learning and chess memory
- But the models will be developed within the CHREST *architecture*

Production systems
ACT-R Soar

Top-down



CHREST

Connectionism

Bottom-up

High Level Models of Mind

- Two broad approaches:
  - symbolic – loosely 'items in model relate to things we can think of'
  - subsymbolic / connectionist
- Under the symbolic heading:
  - production rule systems, like Soar and ACT-R are very important
  - discrimination network systems like CHREST

EPAM/CHREST

- EPAM/CHREST is the oldest cognitive architecture (50 years last year!)
- EPAM
  - Elementary Perceiver and Memoriser
  - created in 1959 by Edward Feigenbaum
  - second learning algorithm implemented on a computer
- CHREST
  - Chunk Hierarchy REtrieval STructures
  - developed in 1990s by Fernand Gobet

Assumptions in EPAM/CHREST

- Chunks (perceptual groups) are the basic units on which the system operates
  - Primitives (letters of the alphabet)
  - Groups of primitives (only after learning)
- Fixation of a chunk in LTM requires a definite amount of processing time per chunk (10 s)
- Immediate memory (4 chunks) stores material temporarily
- The central processing mechanism fixates any part of the stimulus to which it attends. Attention is modifiable by strategies, instruction, etc...

Development of EPAM/CHREST 1

- Early EPAM (1959-1962)
  - Developed by Feigenbaum and Simon
  - Focusses on Verbal Learning
- EPAM III (1963-1989)
  - Major refinement of theory
  - Still focus on Verbal Learning, but also Chess
  - Reflections on the methodology of cognitive modelling
- EPAM IV & V (1995-1997)
  - Extension to development of expertise
  - Deliberate practice and strategic knowledge

Development of EPAM/CHREST 2

- EPAM VI (2001)
  - The last version on EPAM worked on by Simon
  - Covers a wide range of data in verbal learning, memory, and concept formation
- CHREST (1992-today)

Linked Theories of Expertise

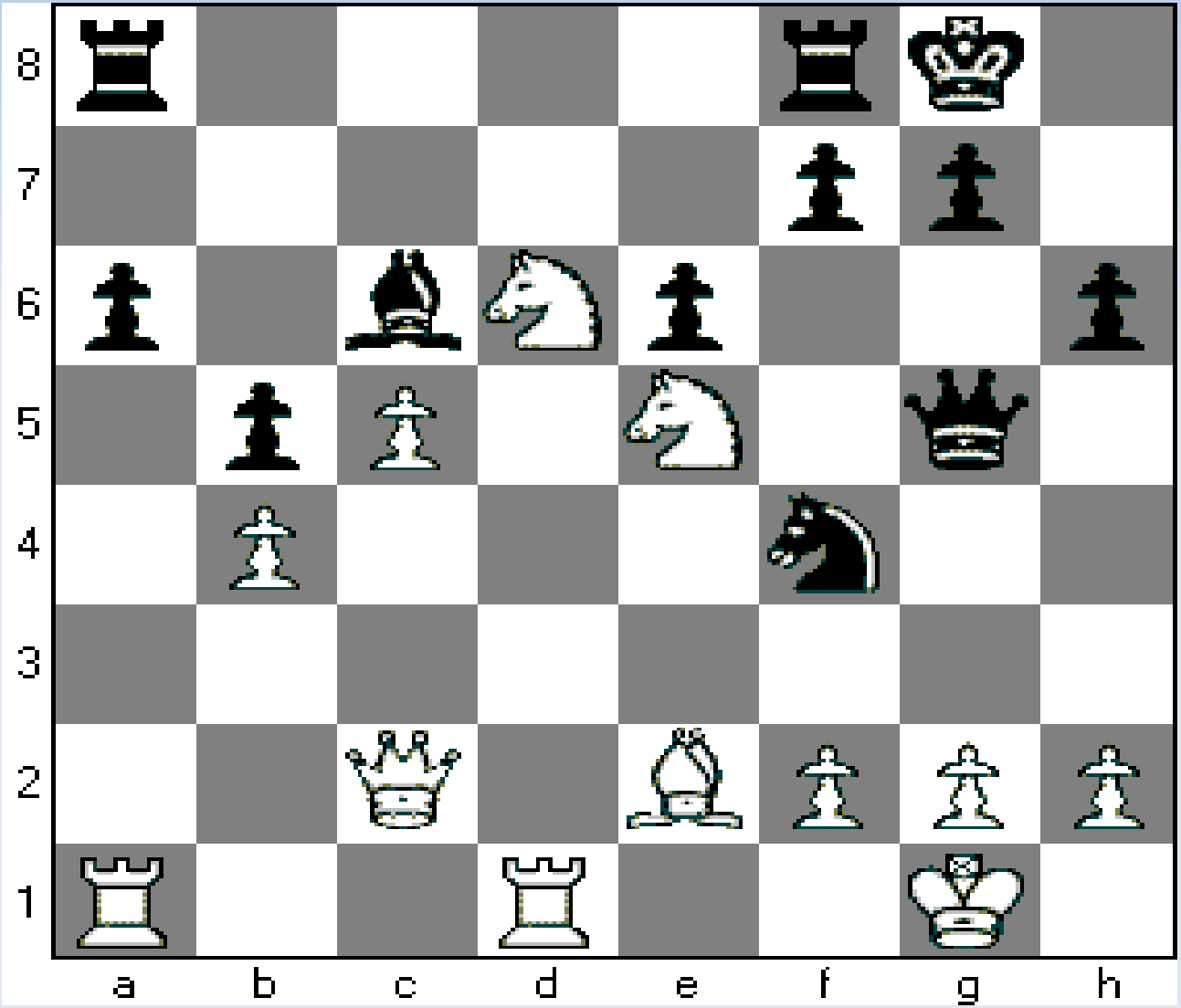
EPAM - Chunking Theory

CHREST - Template Theory

Experts' Memory

- Experts have an excellent memory for briefly presented items taken from their domain of expertise
- Typical for most domains of expertise
  - Sciences
  - Arts
  - Sports
  - Games

Test of Expertise: Recall



Test of Expertise: Recall

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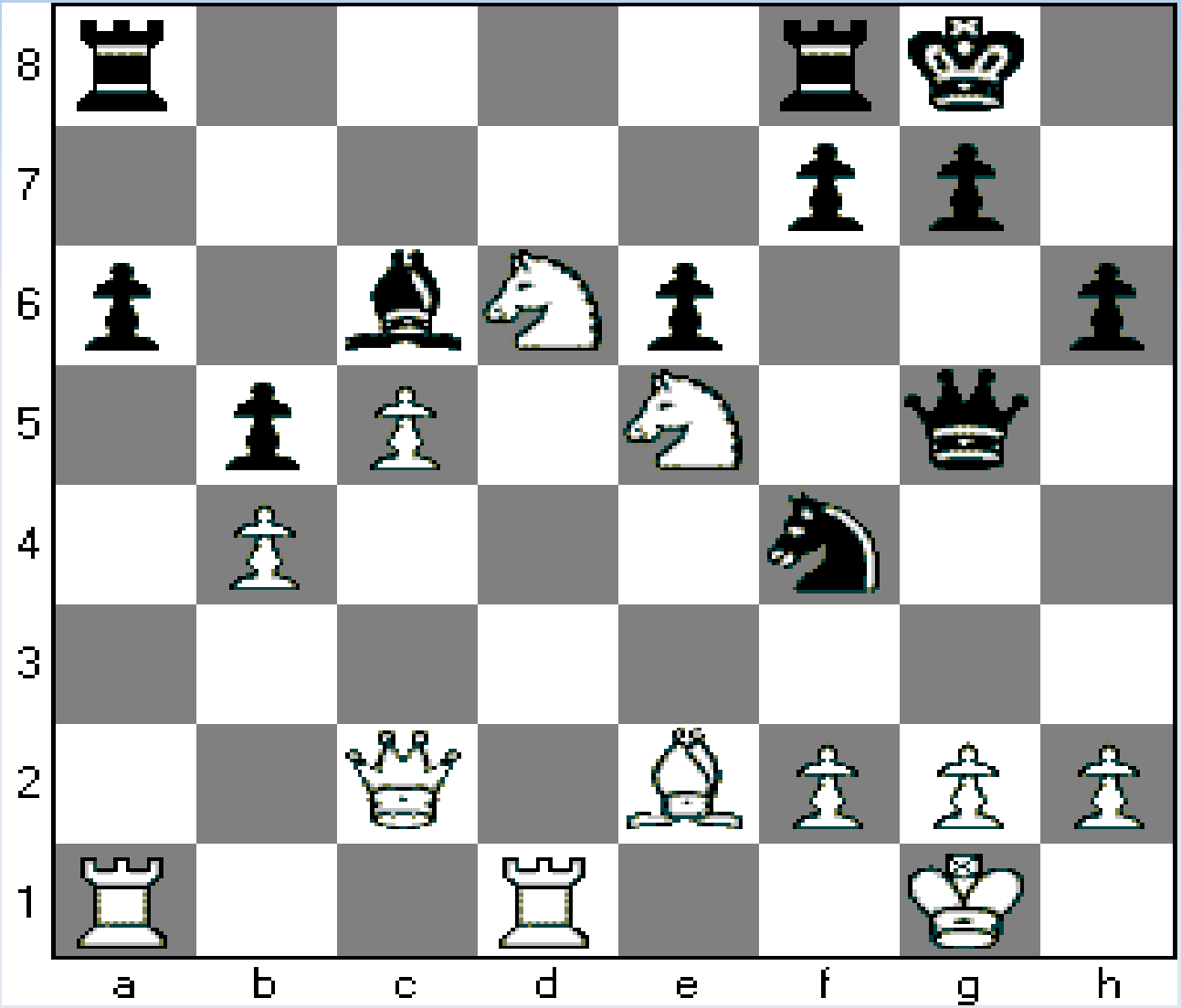
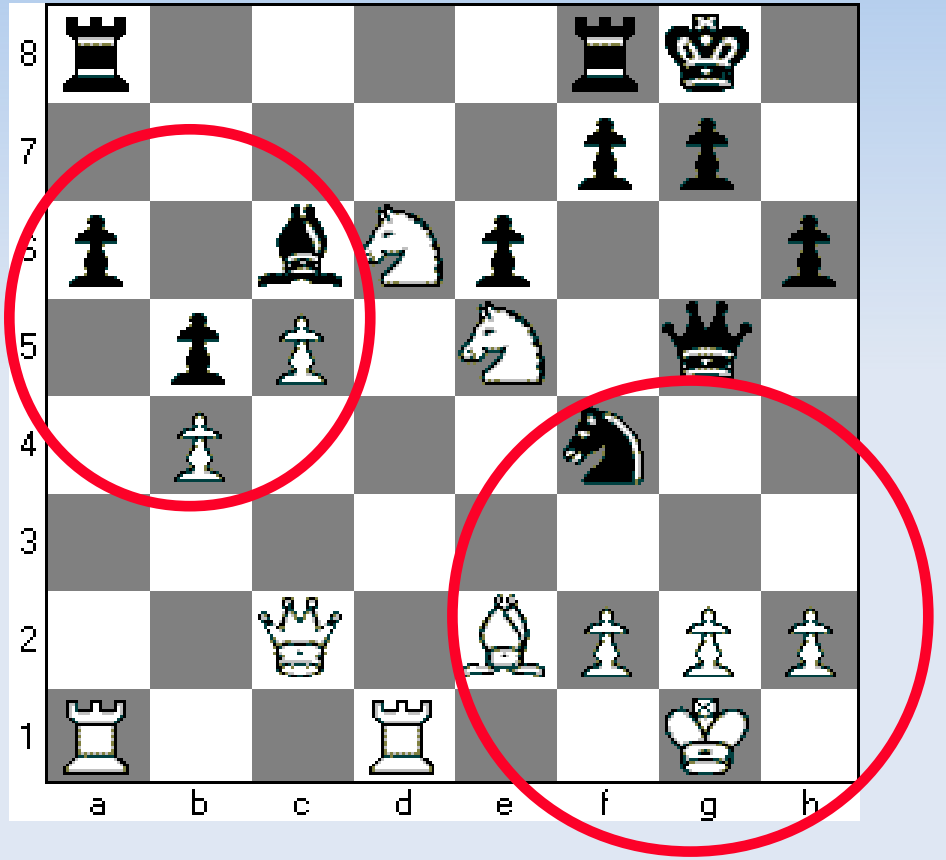
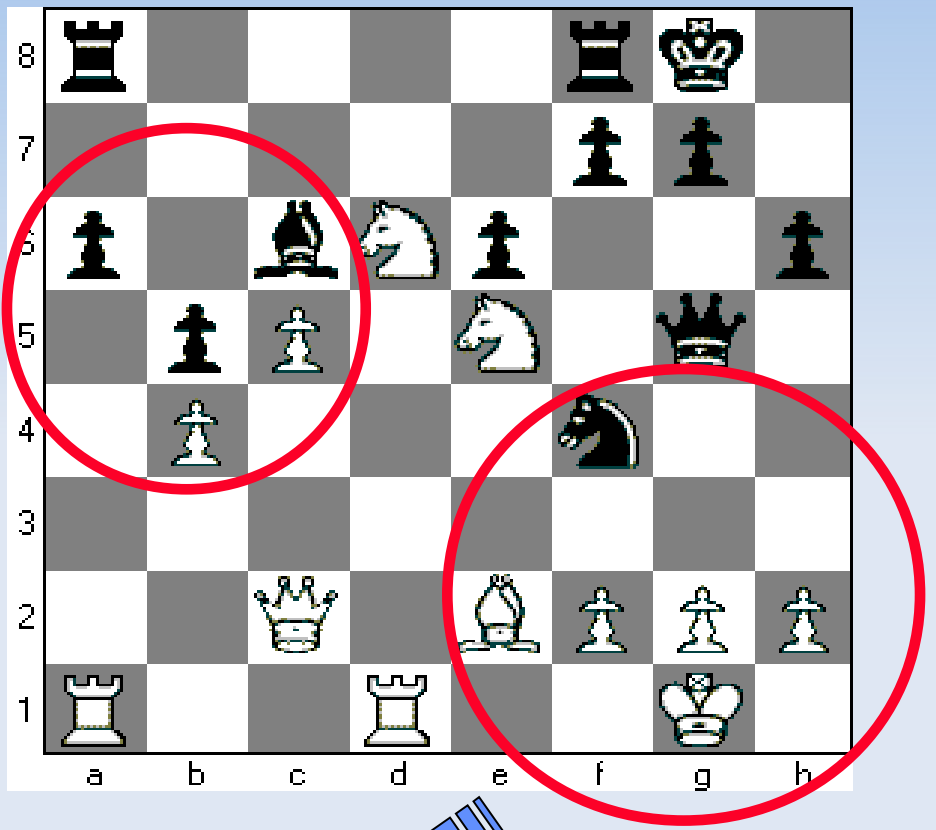


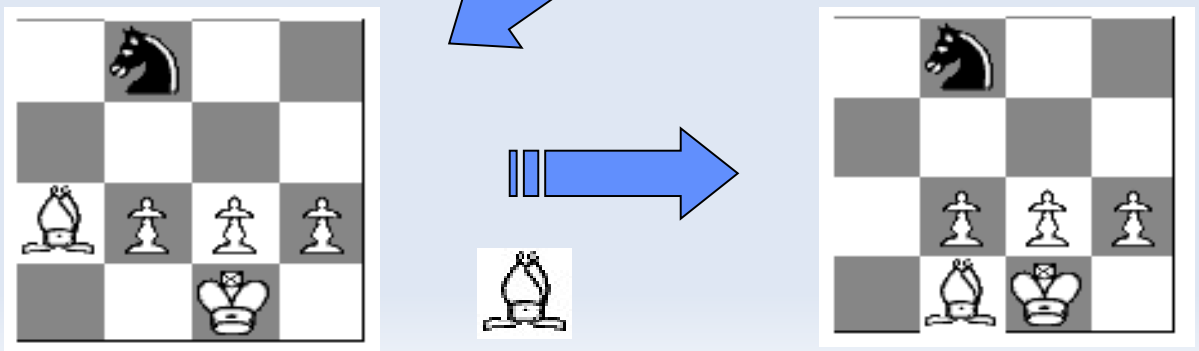
Chase and Simon's (1973) Chunking Theory

- Information in long-term memory is stored as a network of chunks
  - Each chunk is a familiar pattern that can be used as a unit
  - It takes about 8 seconds to create a chunk



Chunks and Moves





Template Theory (Gobet & Simon, 1996, 1998)

- Modification of the chunking theory
- Combines low-level with high-level aspects of cognition
- Chunks that recur often evolve into more complex data structures – templates
- Templates have slots allowing values to be encoded rapidly
  - slots for pieces, squares and chunks
  - slots for moves, evaluations, plans etc
- Templates are linked to other templates

Template Theory (II)

- (Visual) STM is limited to 4 chunks
- STM is dynamic: oldest chunks are updated by new incoming information
- The model uses the largest chunk recognised so far to direct eye movements

Emphasis on Learning

- Importance of input size (i.e., not limited to ‘toy’ domains)
  - In chess, ~50,000 positions used
  - In language acquisition, typically ~35,000 maternal utterances used; in one case, ~240,000 utterances
- This leads to large discrimination nets
  - 300,000 nodes for simulating memory of chess grandmasters

Domains Covered

- Verbal Learning and Child Language Learning
- Expertise
  - Chess memory and perception
  - Awele playing (African game)
  - Memory for computer programs
  - Problem solving in physics
- Concept formation
- Implicit learning (artificial grammars)
- Combination of low-level perception with expectations
- Role of multiple representations in physics
- Order effects in learning

Summary

- CHREST developed from EPAM model, over a period of 50 years
- Symbolic architecture, based on learning from real data
- CHREST is an implementation of the *template* theory of expertise