

# **An algebraic approach to modeling interaction**

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# Background and Motivation

*Piaget's closed system that is also open to exchanges with the environment*

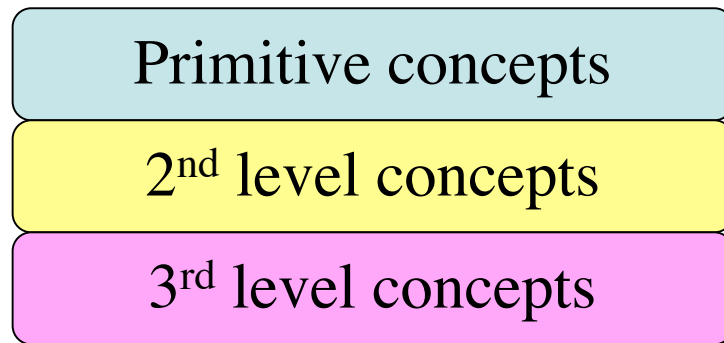
- “The opening is... the system of exchanges with the environment, but this in no way excludes a closure, in the sense of a cyclic rather than a lineal order.” (p. 155)
- “[The system is] necessarily circular, not merely hierarchical.” (p. 156)
- “A conceptual system, in fact (and a fortiori, a sensorimotor one, etc.), is a system such that its elements are inevitably supported by one another, while at the same time it is open to exchanges with the outer world.” (p. 157)

## *Closed system that is also open to exchanges with the environment*

- “One is compelled, in order to avoid making an explicit circle, to begin by positing ‘indefinable’ notions in such a way as to define those one needs to use... Now the choice of the indefinables and undemonstrables must of necessity remain arbitrary, in terms of the intentions of the system. In effect, there is thus no lineal order except by means of a process freely adopted in order to widen the circular order and to cut from within it the lineal series — still having no absolute starting point — that will be required if we are to demonstrate (relatively speaking) this or that consequence” (p. 157)

From *Biology and Knowledge* by Jean Piaget.  
Beatrix Walsh (trans.) Univ. of Chicago: 1971.

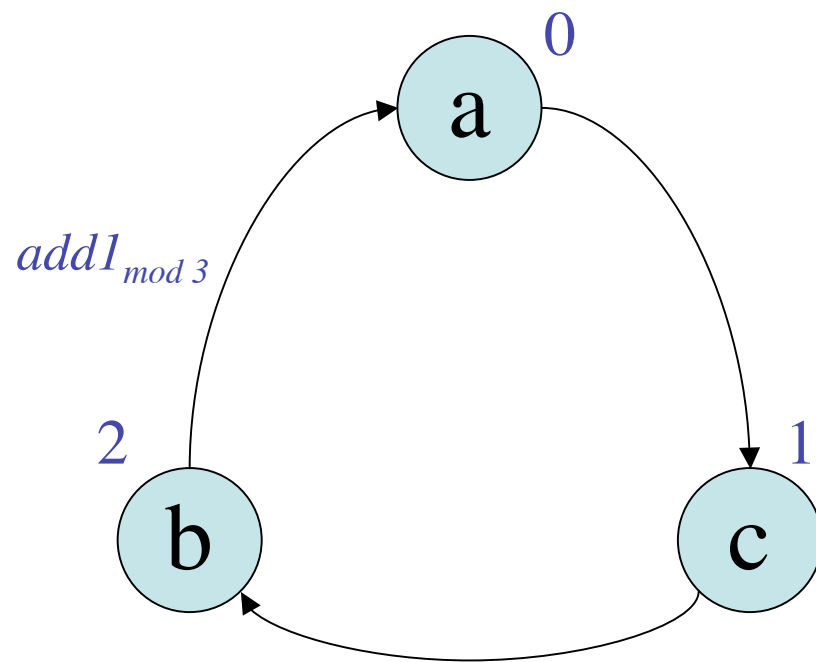
# Traditional approach to representation



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- Used in logic-based representations:
  - Define primitive concepts
  - Define 2<sup>nd</sup> level concepts
  - Define 3<sup>rd</sup> level concepts
  - ...

# Piaget's closed systems as algebras



*Any of these three objects can be chosen as a 'primitive'*

If 'b' is chosen as a primitive,

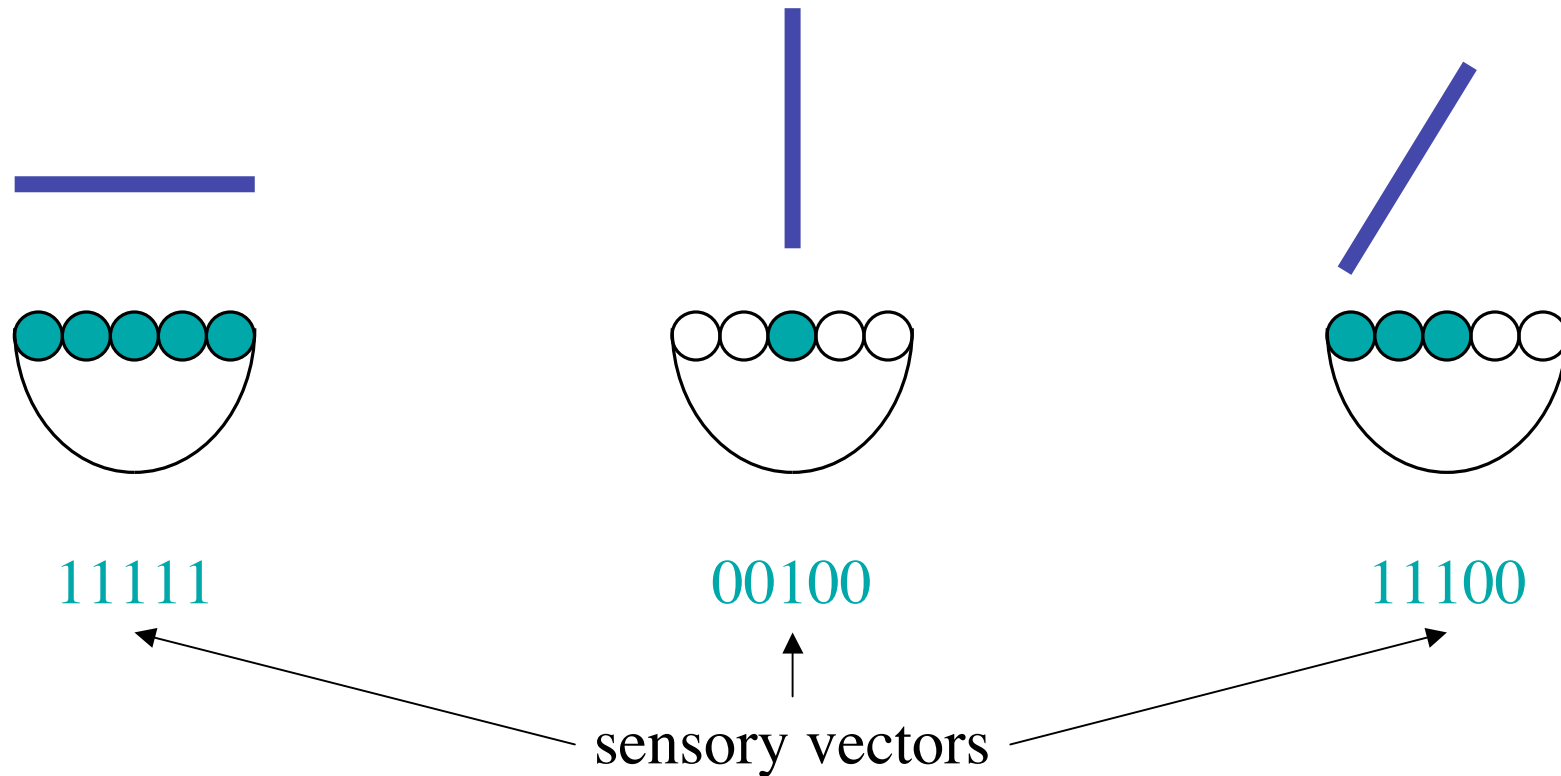
'a' becomes a 2<sup>nd</sup> level concept

'c' becomes a 3<sup>rd</sup> level concept

*The system admits of many choices of primitives!*

# A flatland microdomain: *Spinner*

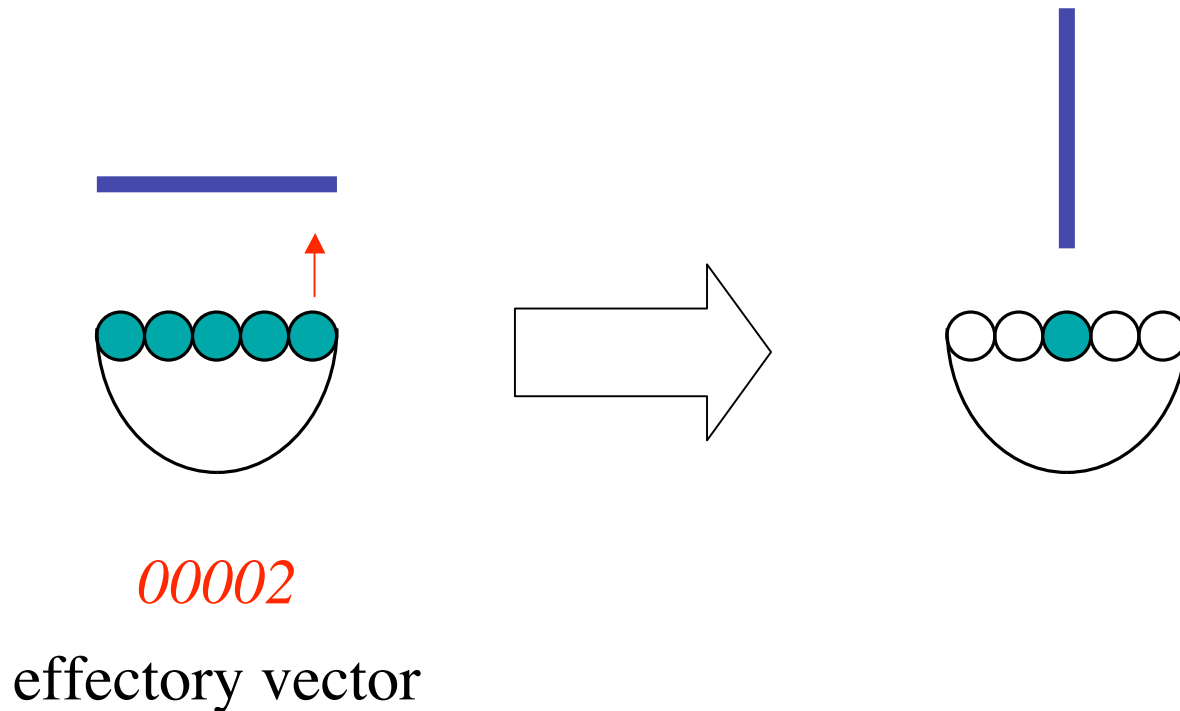
Sensory organ: an ‘eye’ of five cells



*Based on Indurkha (1992)*

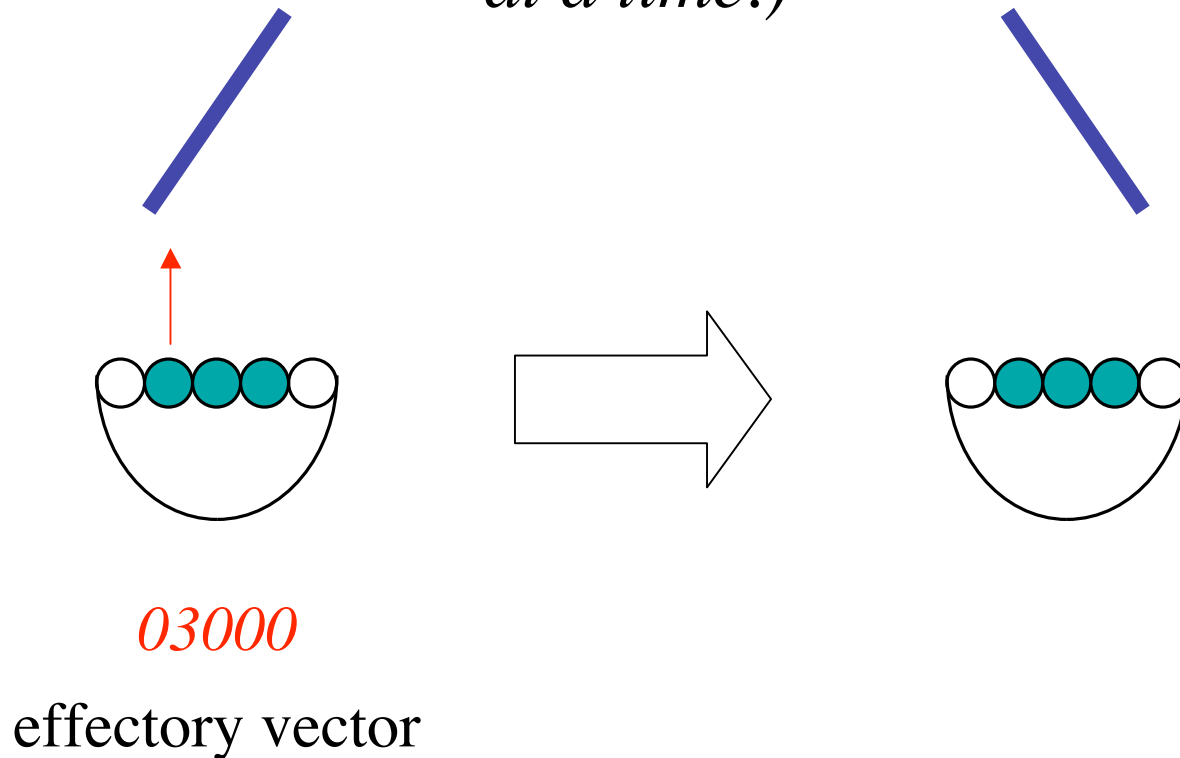
# Effector organ of *Spinner: 1*

*The cells double as actuators: Any of the five cells can emit a burst of air of strength 1, 2 or 3 (but only one cell at a time.)*



# Effector organ of *Spinner*: 2

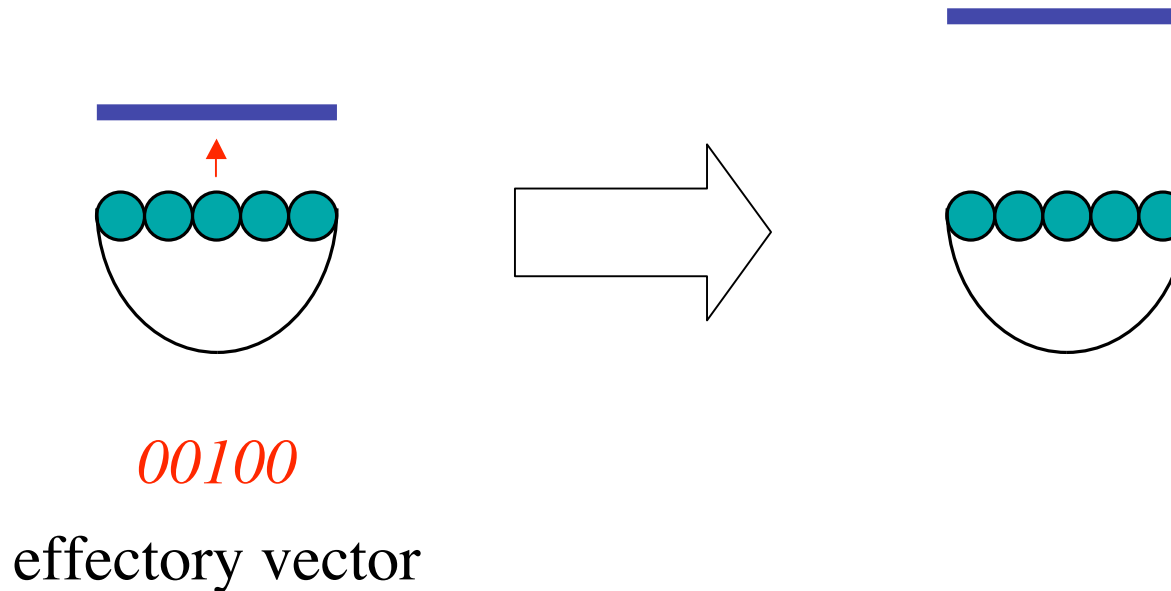
*The cells double as actuators: Any of the five cells can emit a burst of air of strength 1, 2 or 3 (but only one cell at a time.)*



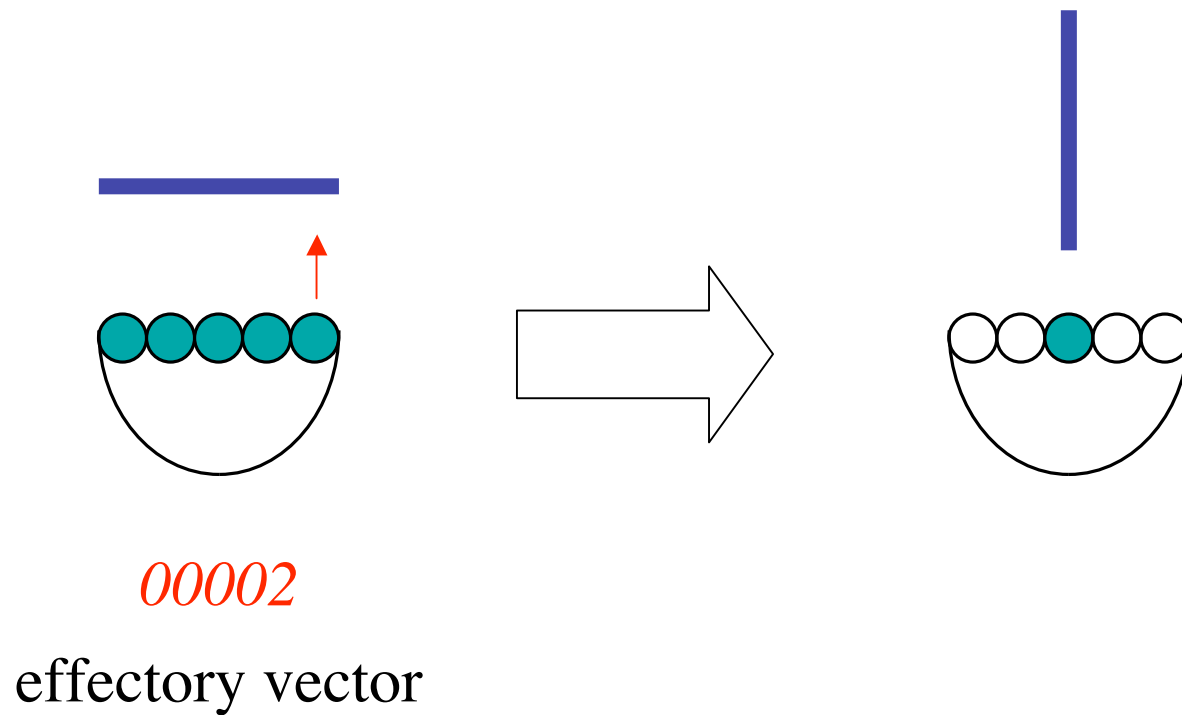


# Effectory organ of *Spinner*: 3

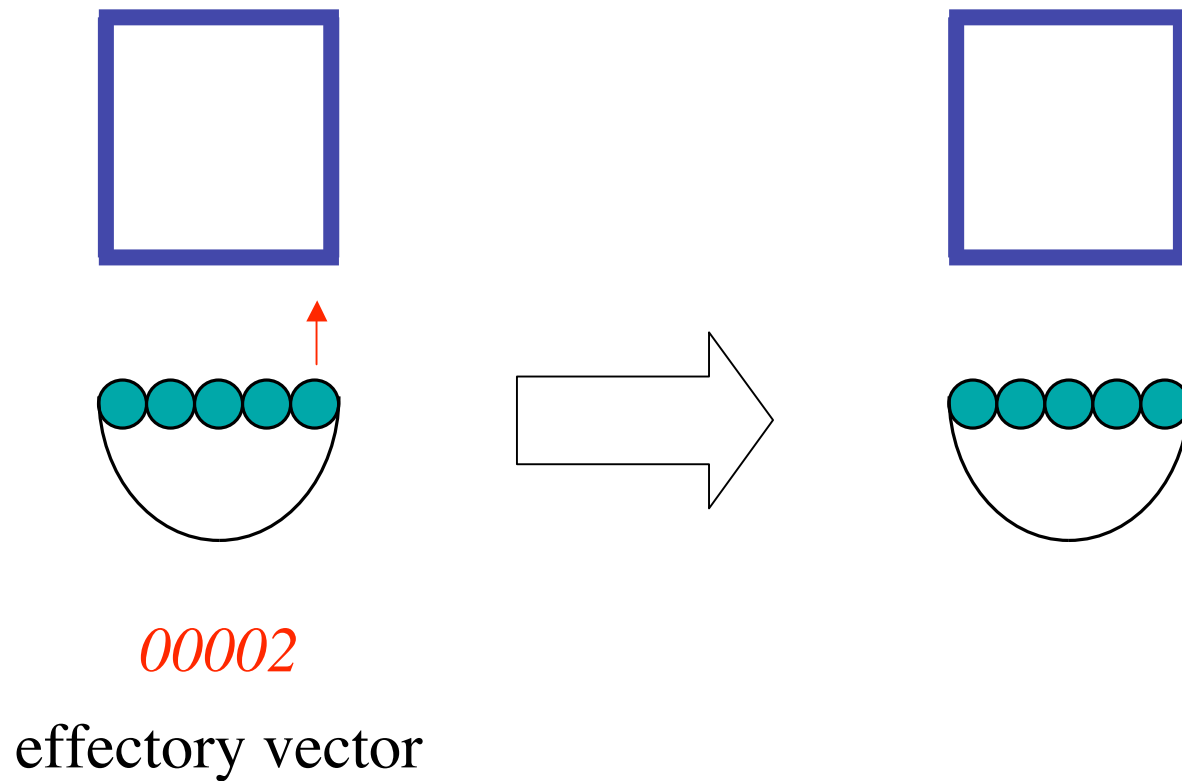
*The cells double as actuators: Any of the five cells can emit a burst of air of strength 1, 2 or 3 (but only one cell at a time.)*



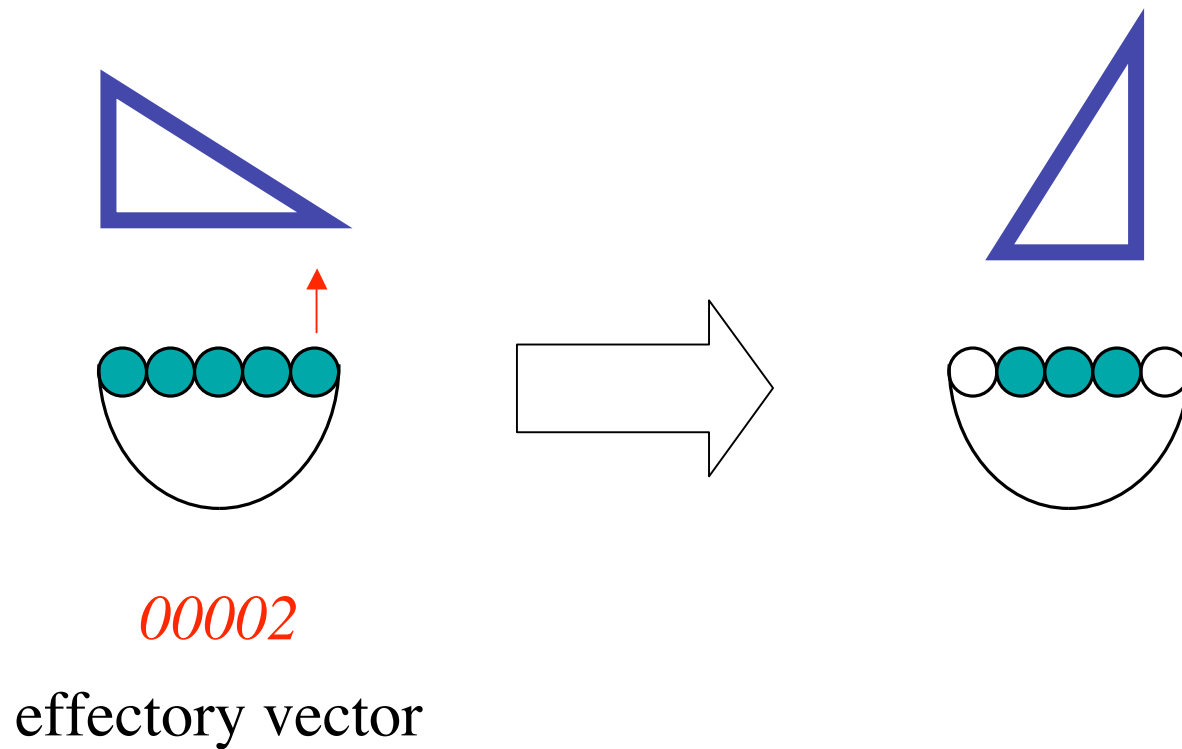
# Environmental grounding of operational structure: 1



# Environmental grounding of operational structure: 2

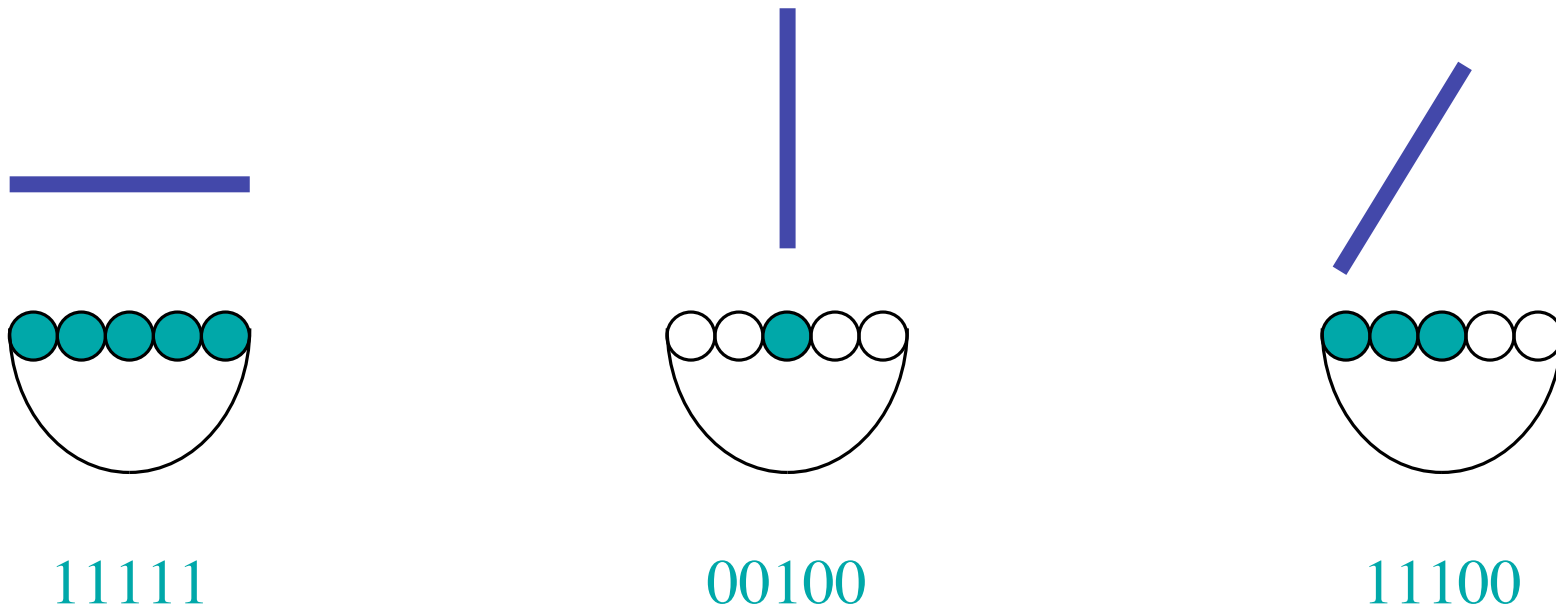


# Environmental grounding of operational structure: 3

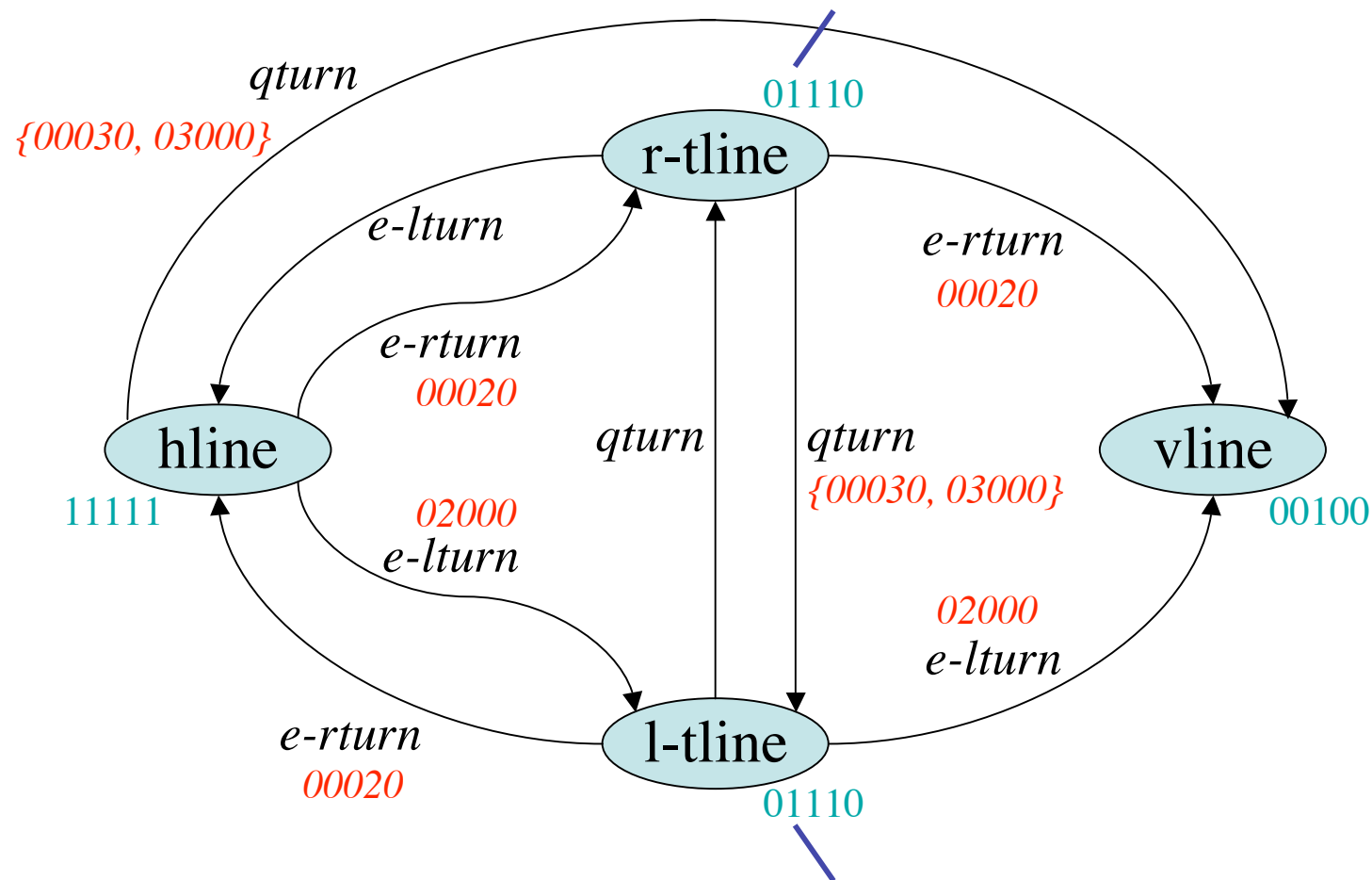


# Environment of *Spinner*

Straight lines (five unit long)



# A grounded concept network: *CN1*

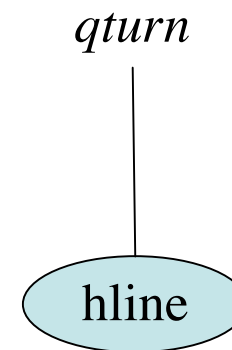
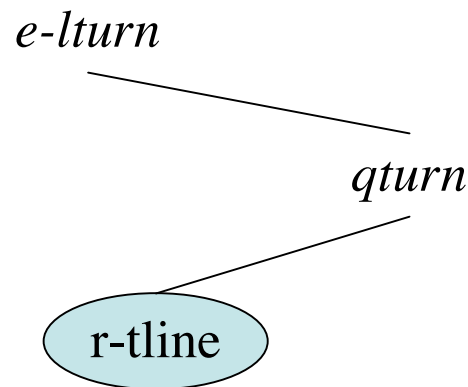
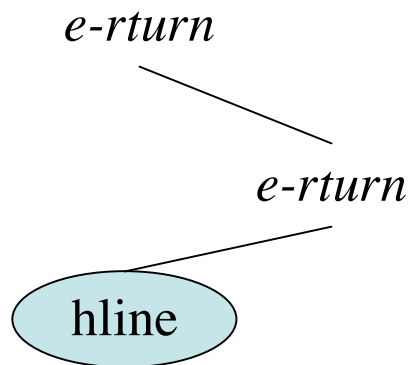


## *Comments on the grounded concept network CN1*

- The structure is operational, and can be learnt by trial and error.
- Certain concepts correspond to the same sensory vector (01110) but can be distinguished operationally.
- An operation can correspond to more than one action:  $qturn \rightarrow \{03000, 00030\}$

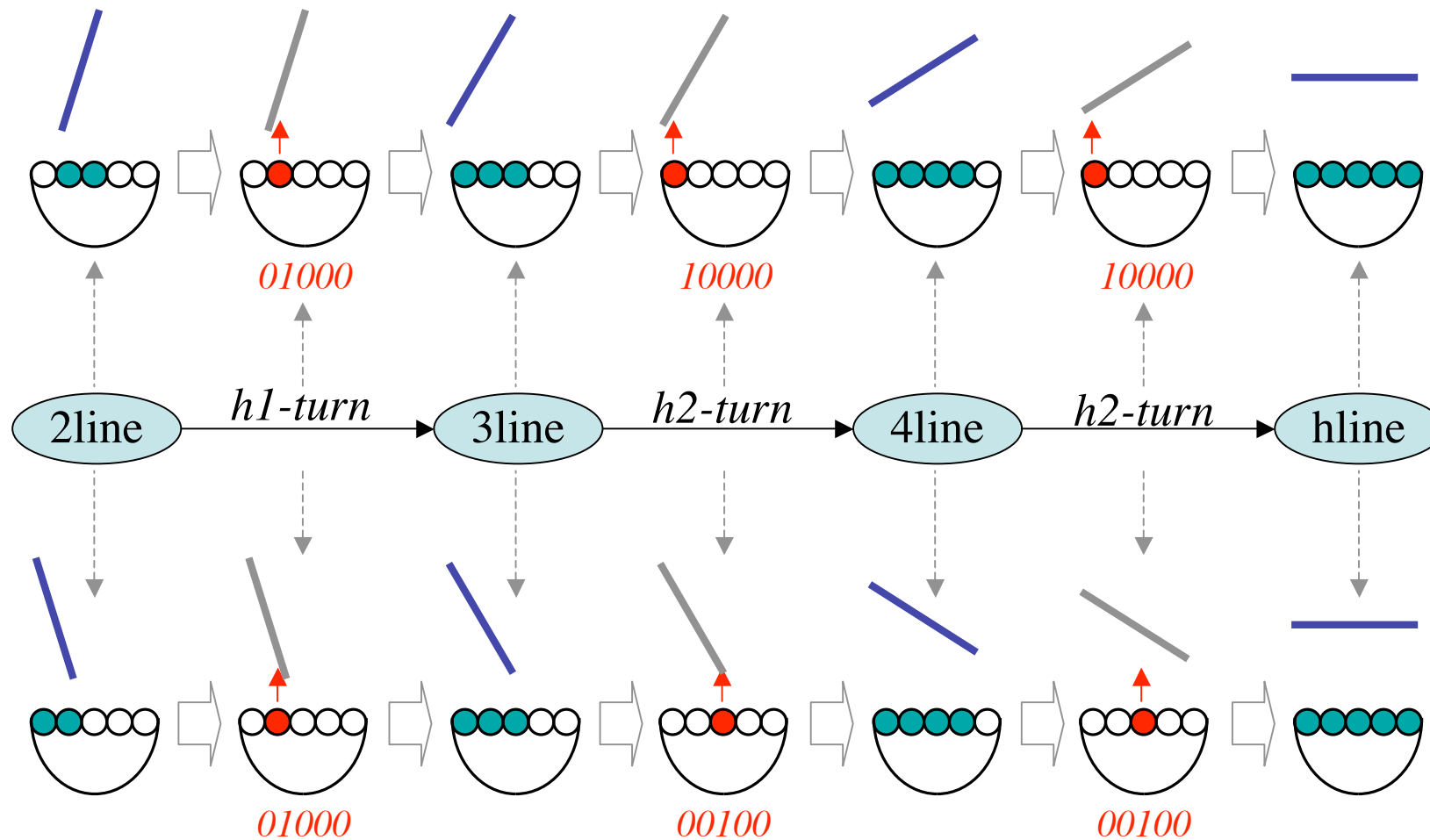
# Multiple descriptions of concepts

- A concept can have many descriptions in a concept network.
- A ‘description’ corresponds to an algebraic term.
- Example: some possible descriptions of the concept *v-line* as seen from CN1:





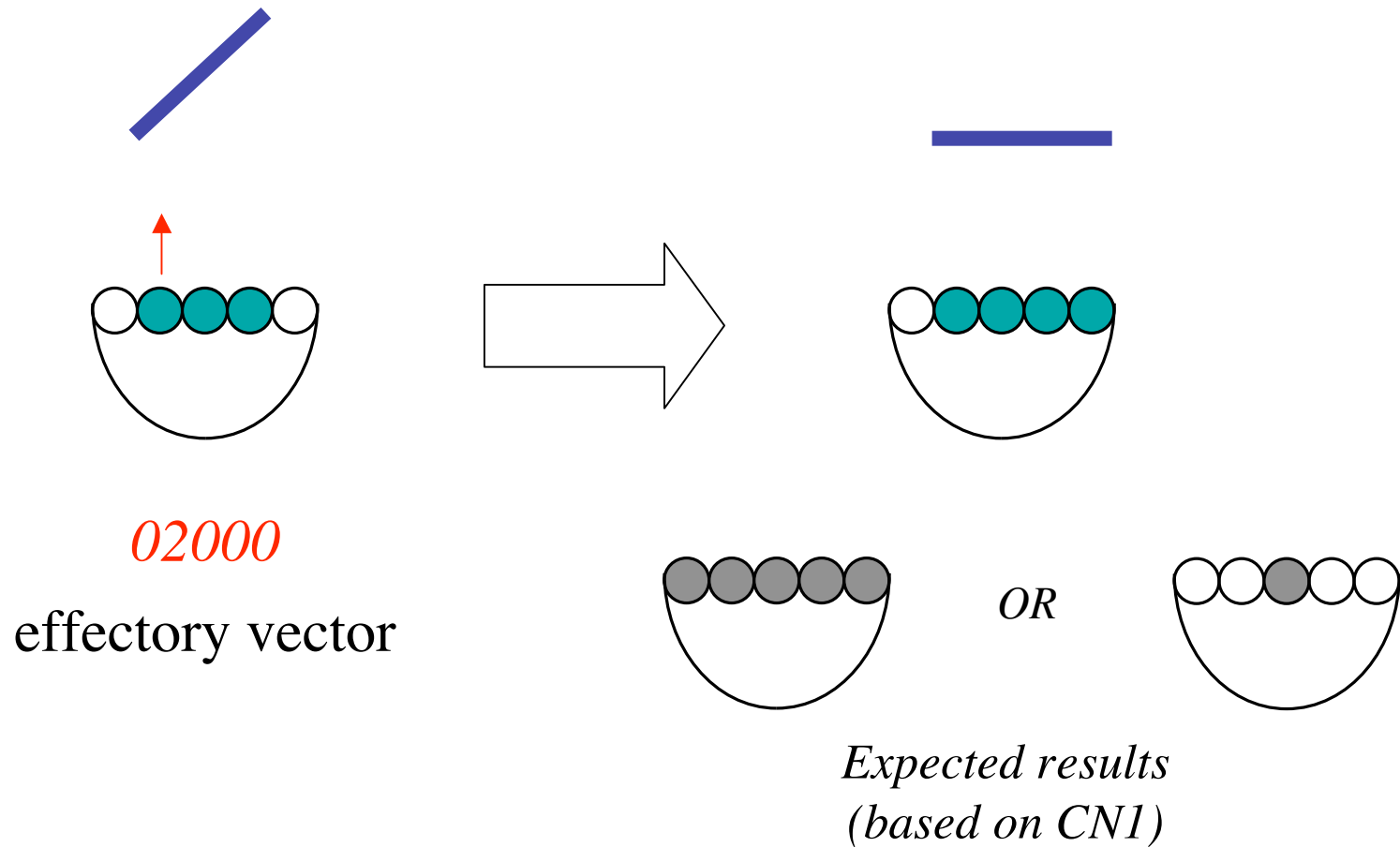
# Another concept network *CN2* with two different groundings



# Spinner in an alien environment

- The lines are 4 units long.
- Executing existing concept networks  
→ *system-detectable error*

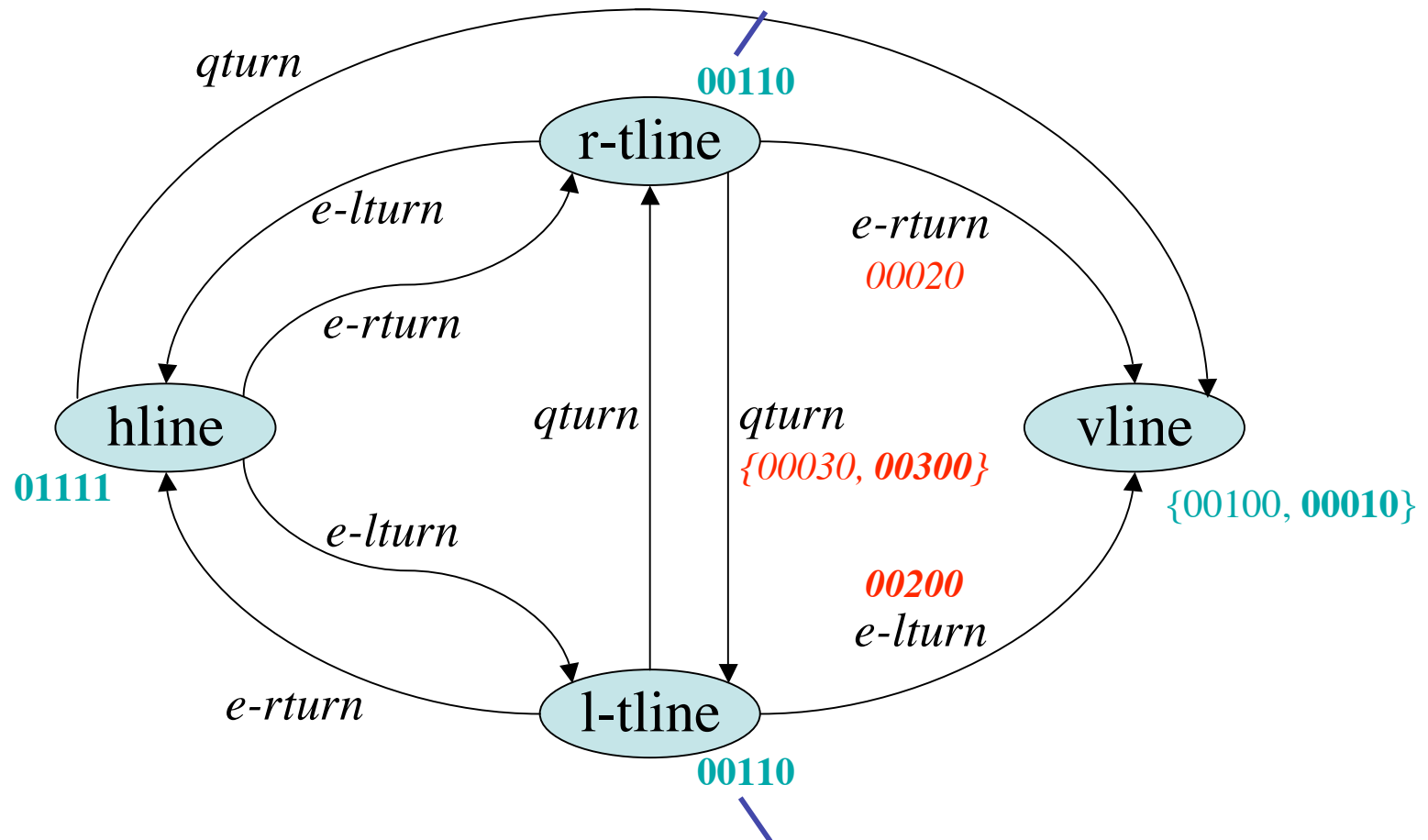
# Example of system-detectable error



# Two mechanisms of adaptation

- *Projection*: keep the structure of the concept network but change the correspondence.
- *Accommodation*: keep the ontology of the network the same but change the structure.

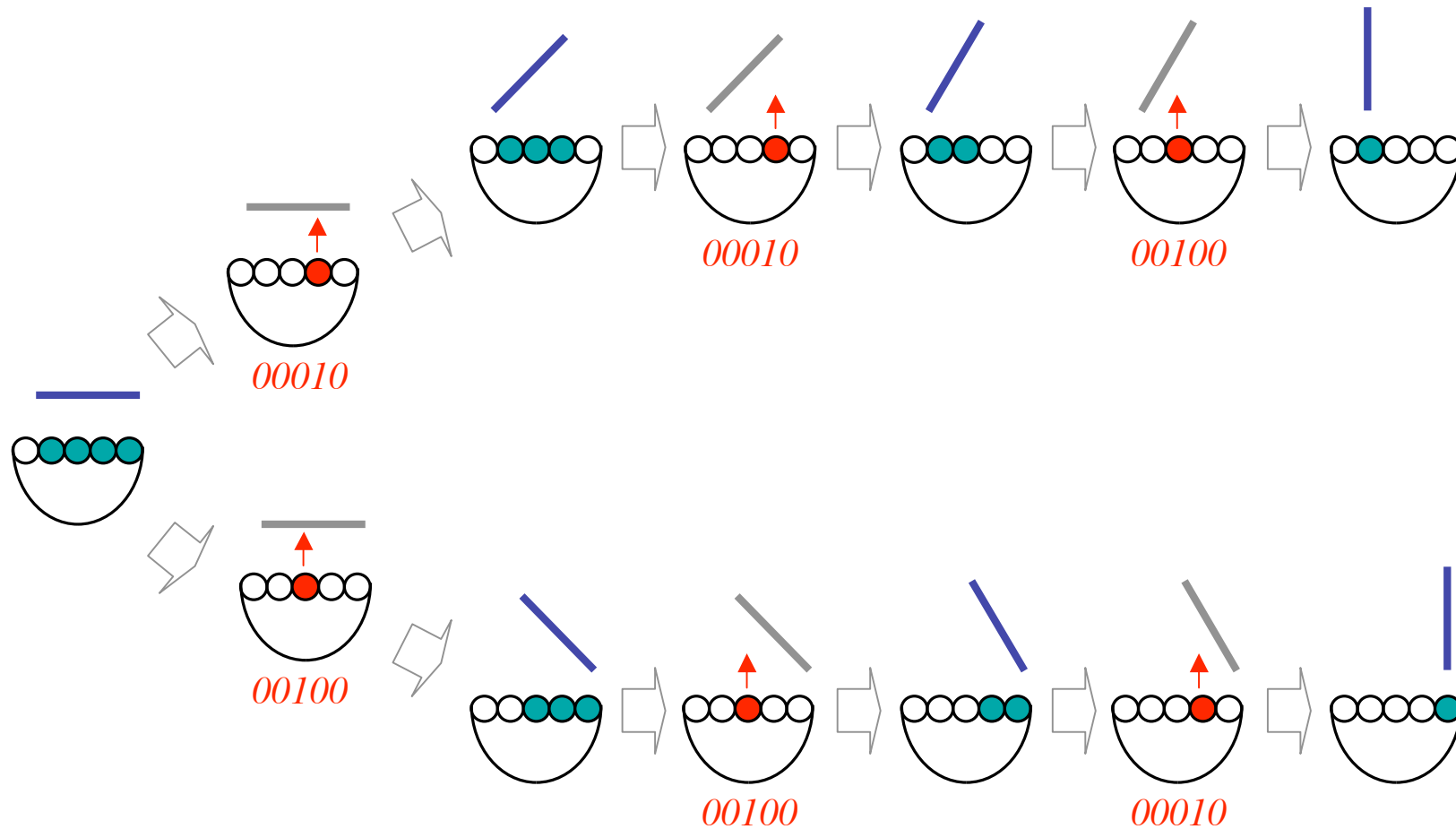
# Projecting *CNI* in the new environment



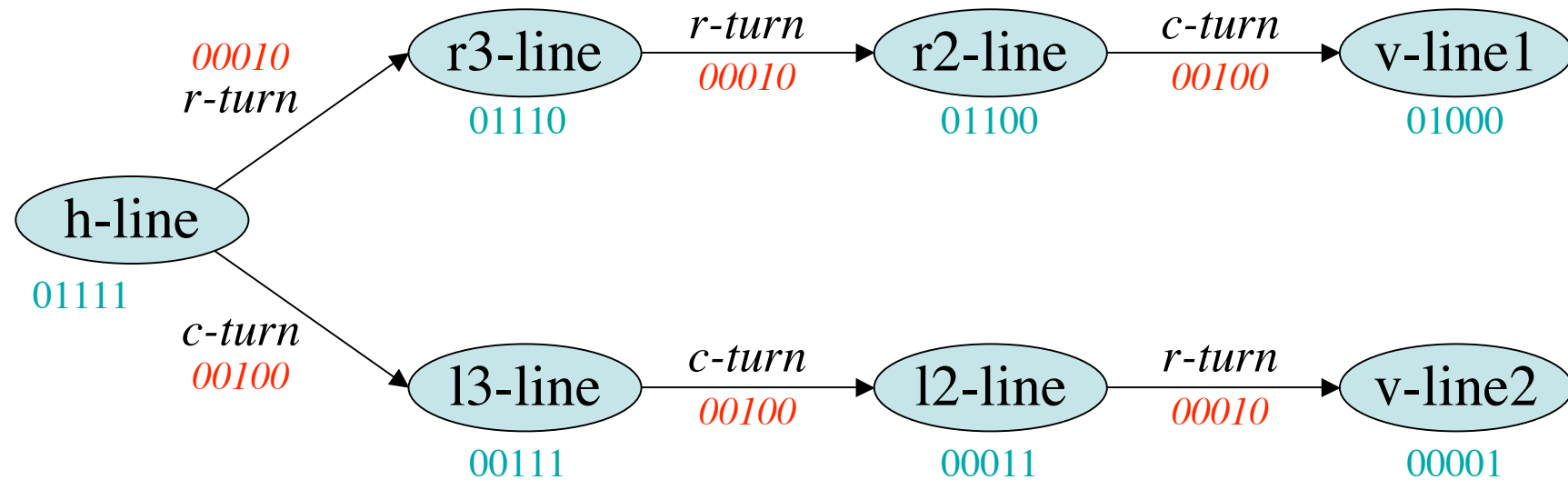
# Comments on projection

- A mechanism to recover from error by redefining the meaning of the terms.
- Quite pervasive in political debate, legal reasoning, science and even in mathematics (Lakatos.)
- Loosely corresponds to Piaget's assimilation.
- The environment plays a role by constraining the set of possible meanings.

# Accommodation: adapting the structure



# Generalizing the adapted structure into a concept network





# Comments on accommodation

- A mechanism to recover from error by changing the internal structure of the concept network to incorporate the error.
- Quite pervasive in science and mathematics (Lakatos), and sometimes used in other areas like political debate...
- The agent plays a role by fixing the ontology: by deciding what is relevant.

# Conclusions

- Algebra can be used to model operational structure of [grounded] concept networks.
- Circularity in the algebraic structure allows variability in choosing primitive concepts.
- Interaction allows system-detectable errors.
- Using projection and accommodation, the agent can recover from errors.
- Symbolic structures are consistent with interactionist theories.

## Part II

# *Creativity in Interpreting Poetic Metaphors*