NEURAL NETWORK MODELS OF COGNITIVE PROCESSES

LANGUAGE LEARNING

OBJECT PERMANENCE

LANGUAGE LEARNING

INFORMATION PROCESSING MODEL FOR LANGUAGE LEARNING

1. Language is a rule-governed activity
   - Noam Chomsky's transformational grammar
2. Does not mean that language learning and understanding involve manipulation of symbol structures according to rules.

LANGUAGE LEARNING IN NEURAL NETWORKS

1. Children displays a very typical trajectory in language acquisition
   - For example, making similar types of errors at similar stages of learning
2. Neural network researchers tested if their models can reproduce these characteristic patterns.

THE CHALLENGE OF TENSE LEARNING

First stage: a small number of very common words in the past tense

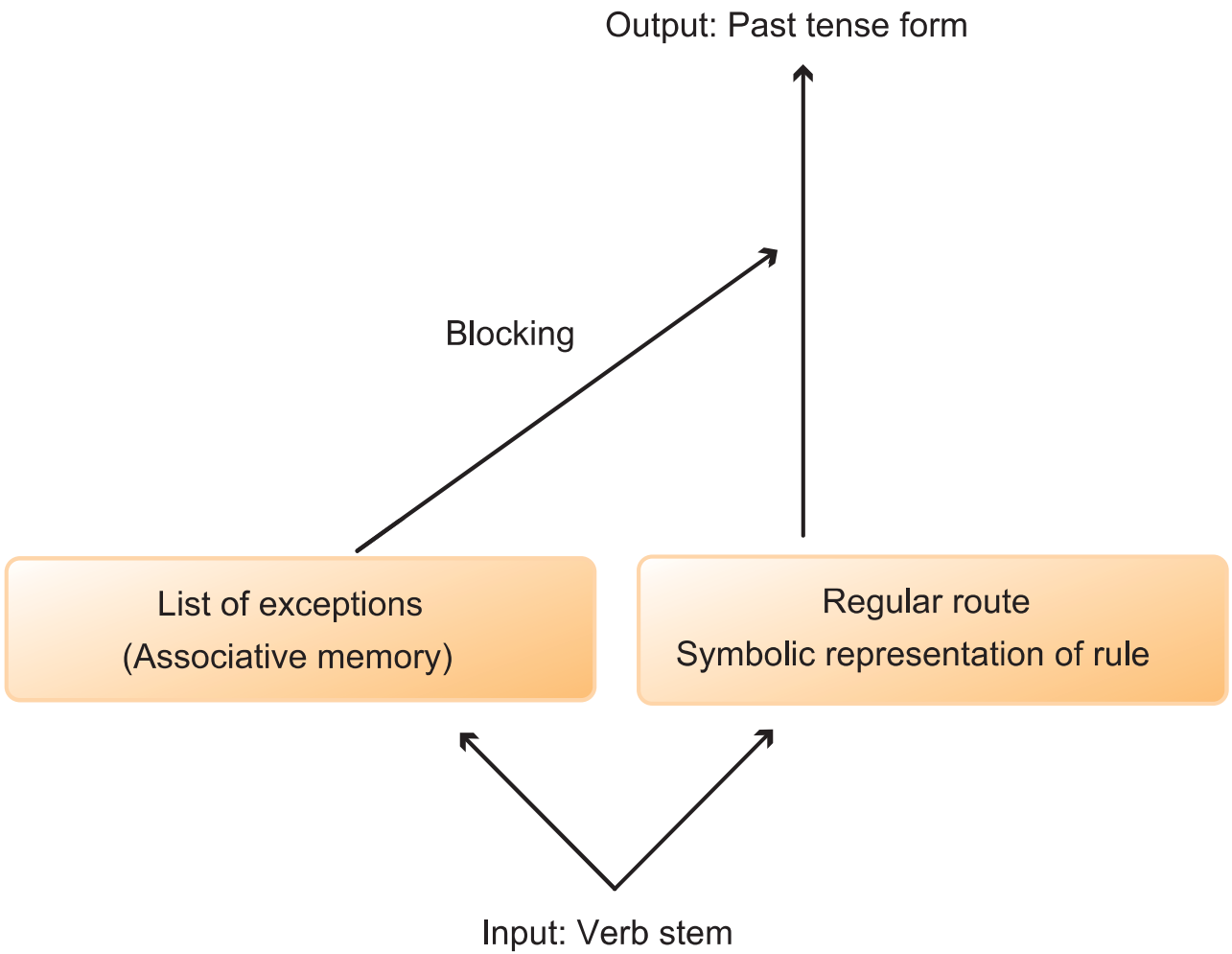
Second stage: application of the regular past tense ending of '-ed' on the irregular past tense verb (over-regularization errors).

Third stage: cease to make the over-regularization errors and regain their earlier performance on the common irregular verbs.

TABLE 9.1 The stages of past tense learning according to verb type

	STAGE 1	STAGE 2	STAGE 3
Early verbs	Correct	Over-regularization errors	Correct
Regular verbs		Correct	Correct
Irregular verbs		Over-regularization errors	Improvement with time
Novel		Over-regularization errors	Over-regularization errors

STEVEN PINKER & ALAN PRINCE MODEL



Two competitive information-processing routes

The symbolic component: not sensitive to phonological form of the verb

Associative memory: sensitive to the phonological form of the verb

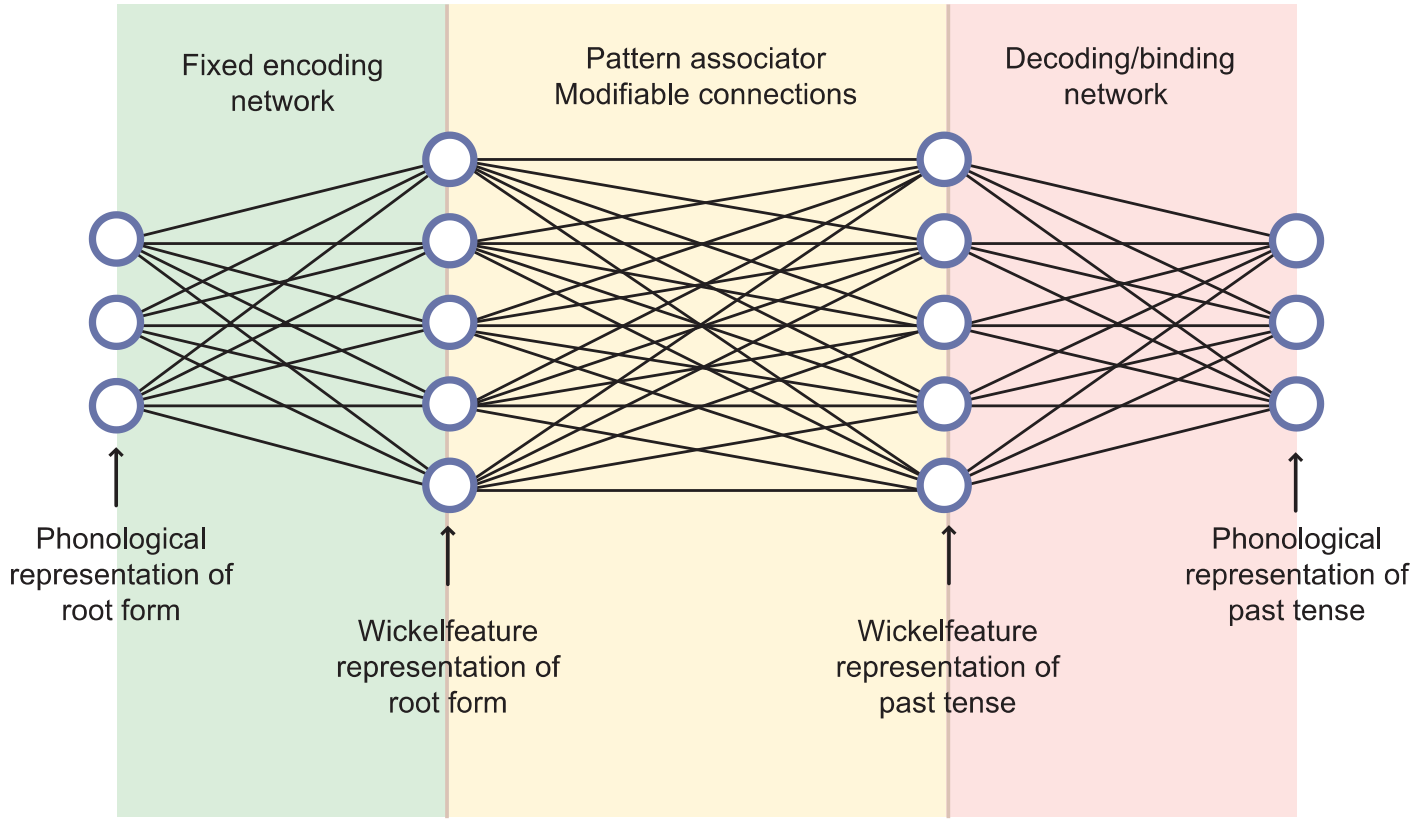
The symbolic route is the default setting

However, strong enough signal from associative memory can override the default setting

Reinforcement through experience makes the alternative signal strong

NEURAL NETWORK MODELS OF TENSE LEARNING

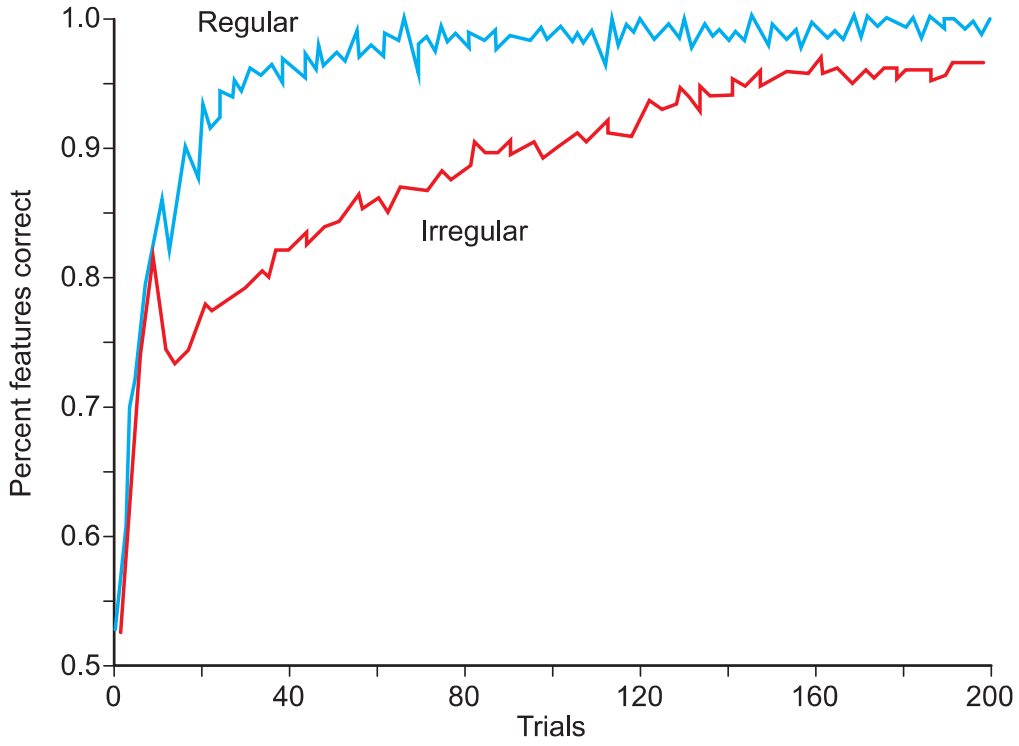
- Rumelhart and McClelland model (1986)



1. Training on 10 high-frequency verbs
   - 10 cycles
2. Training on 410 medium-frequency verbs
   - 190 cycles (410 medium + 10 high)
3. Testing on 86 low-frequency verbs

NEURAL NETWORK MODELS OF TENSE LEARNING

- Rumelhart and McClelland model (1986)



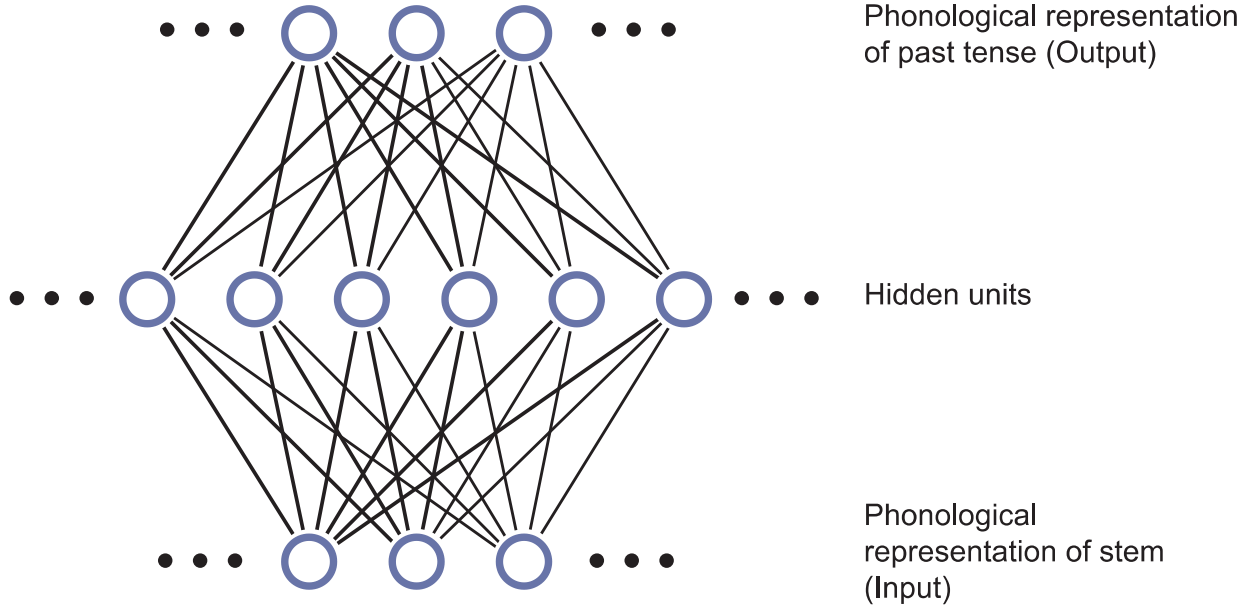
Appearance of Over-regularization

Used the perceptron convergence rule

Critiques

NEURAL NETWORK MODELS OF TENSE LEARNING

- Plunkett and Marchman (1993)



It contains hidden layer

Backpropagation learning algorithm was used

1. Training on 20 verbs
   - 50% regular and 50% irregular
2. Gradually increase the vocabulary size
3. 90% of regular verbs in total vocabulary
   - Similar with the percentage in English
4. Still showed over-regularization

LANGUAGE LEARNING

OBJECT PERMANENCE

INFANT DEVELOPMENT

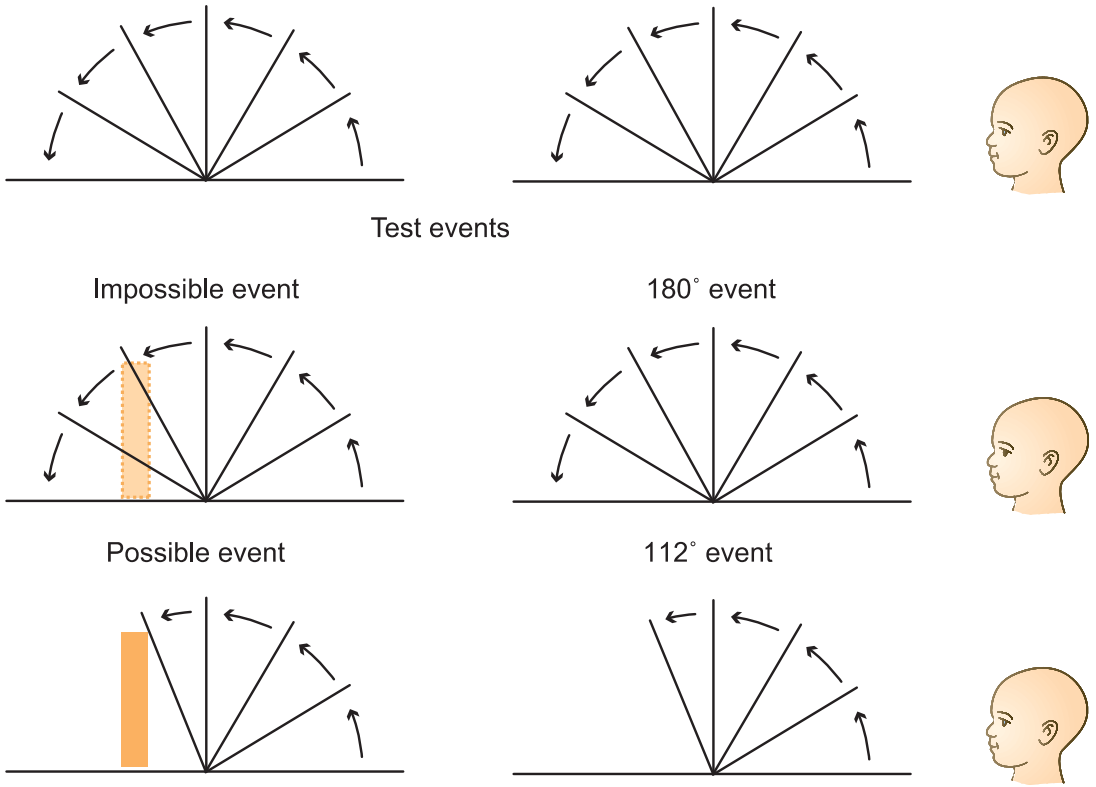
- William James: what it is like to be a newborn infant - ‘a blooming, buzzing, confusion’
- Jean Piaget: Infants are born highly egocentric and it is not until the end of the sensori -motor stage (~2 years old) that they fully appreciate the distinctions between self an d other, between the body and other physical objects.

- However, the modern developmental psychologist thinks that even very young infants inhabit a highly structured and orderly perceptual universe.
  - ***Dishabituation paradigm! – violation of expectation***

OBJECT PERMANENCE

DISHABITUATION PARADIGM (VIOLATION OF EXPECTATIONS)

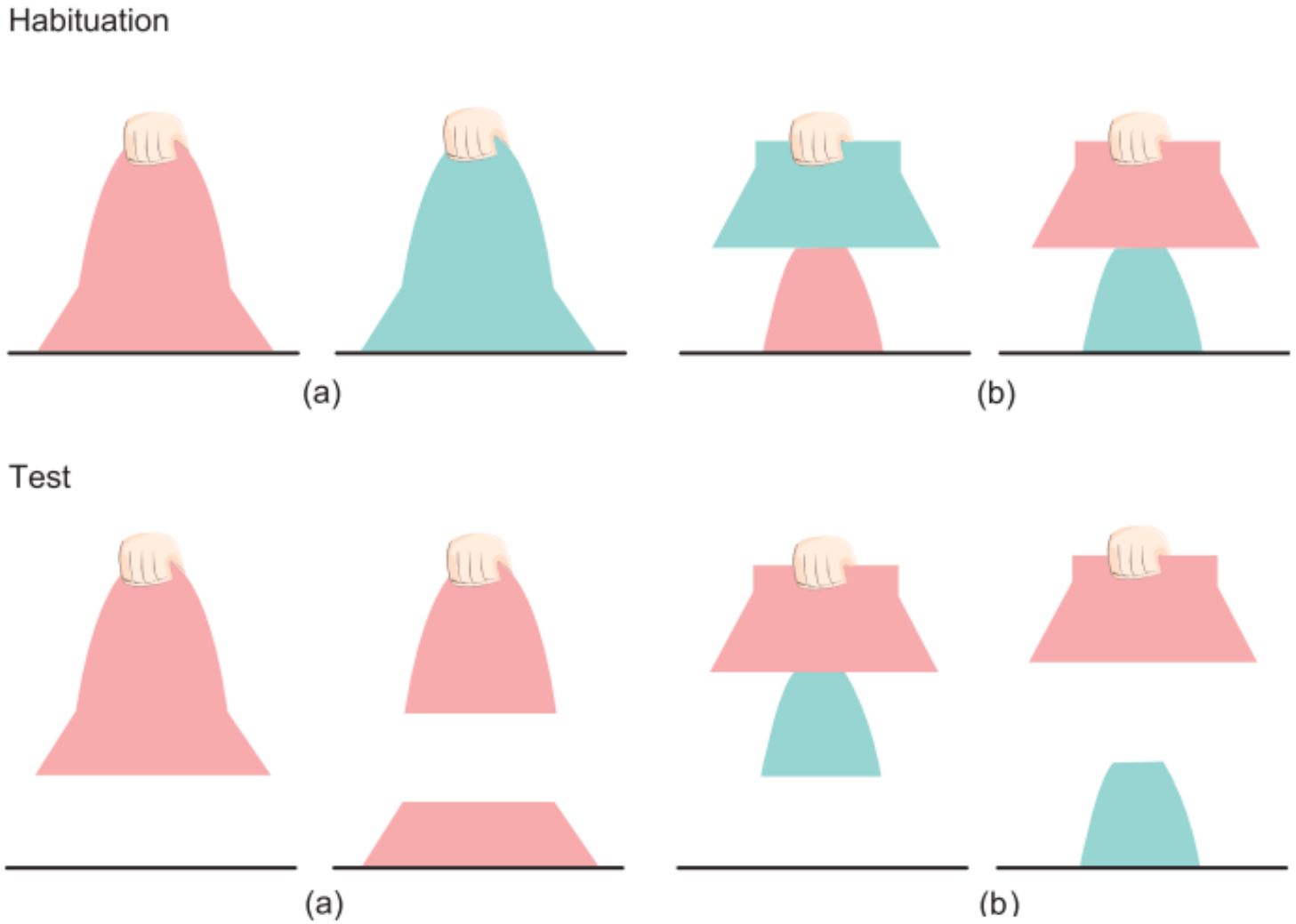
- Renee Baillargeon "drawbridge experiment"
- 4.5 months infant looked the impossible event l onger
- Traditional view (Jean Piaget) says that object pe rmanence appears around 8~9 months!
- They have expectations about how objects shou ld behave. – *folk physics*



RENEE BAILLARGEON

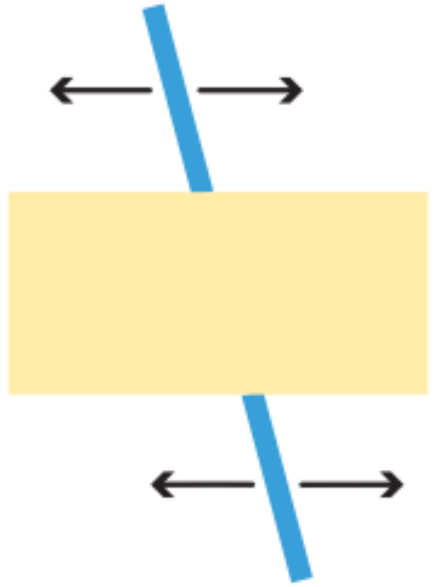
LIZ SPELKE (INFANT FOLK PHYSICS)

1. Principle of cohesion

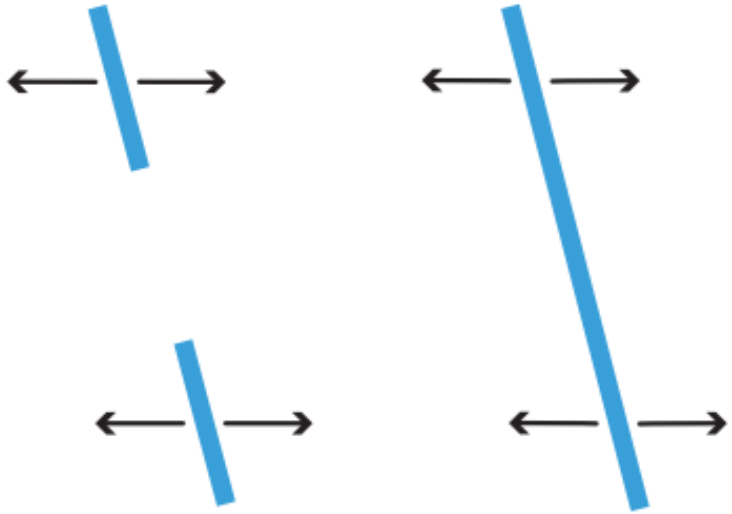


LIZ SPELKE (INFANT FOLK PHYSICS)

2. Principle of contact

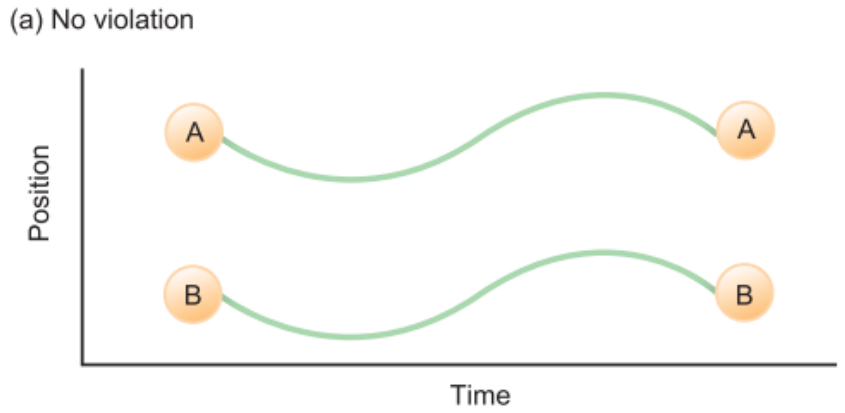


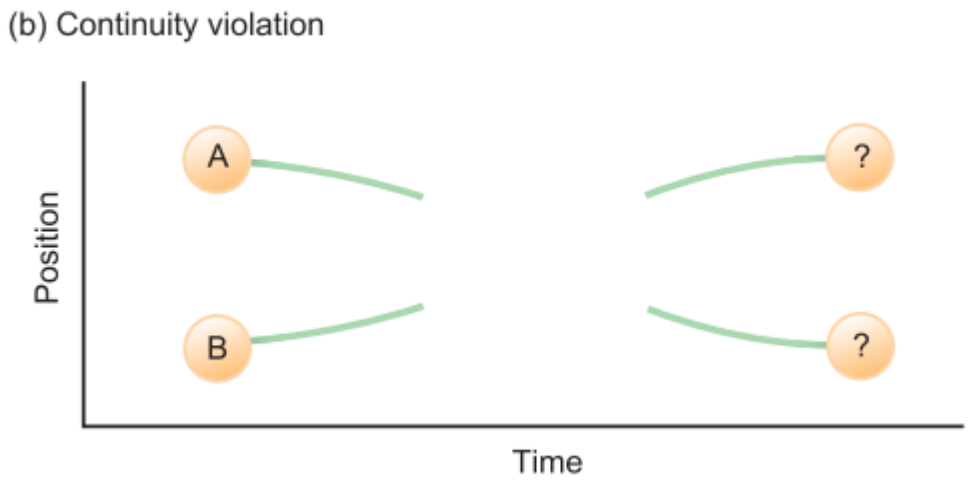
Test

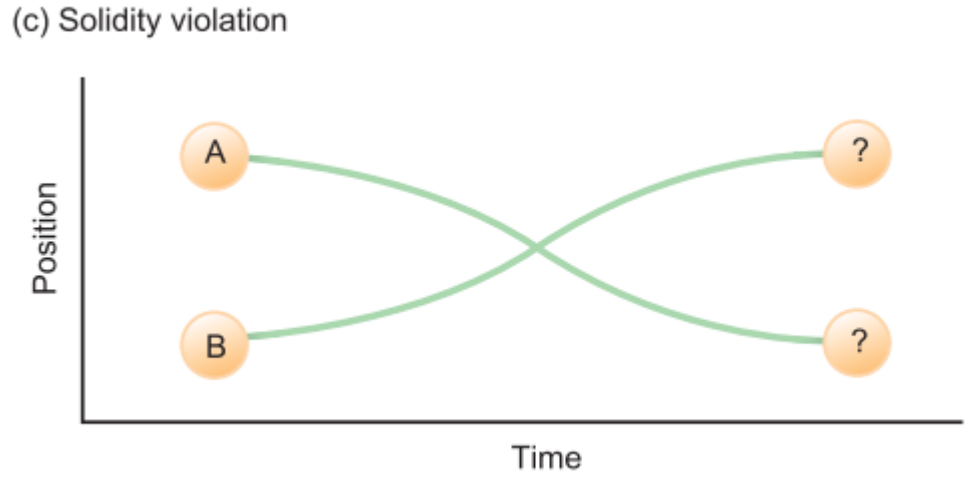


LIZ SPELKE (INFANT FOLK PHYSICS)

3. Principles of continuity, solidity







Infants tend to put more weight on spatiotemporal continuity than on featural continuity

INFANT FOLK PHYSICS

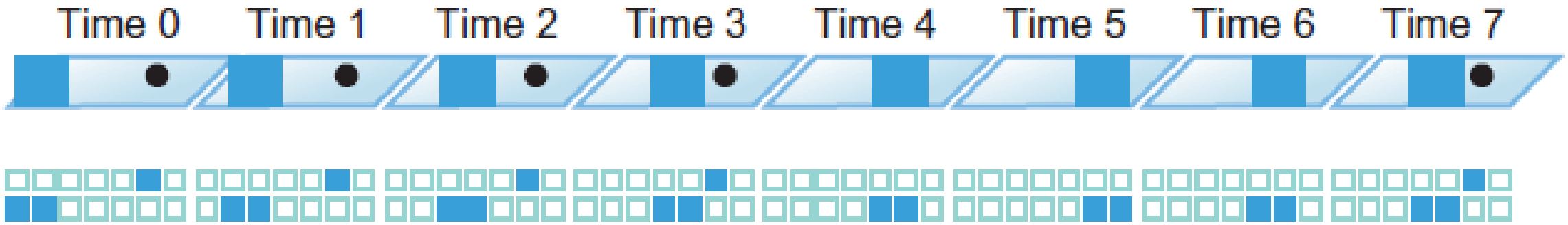
- Basic principles of infant folk physics might be symbolically represented
- These symbolically represented principles allow the infants to compute the probable behavior of the objects in the dishabituation experiments.
  - Physical symbol system

- Simulating infant folk physics using neural network models.

NEURAL NETWORK MODELS OF CHILDREN'S PHYSICAL REASONING

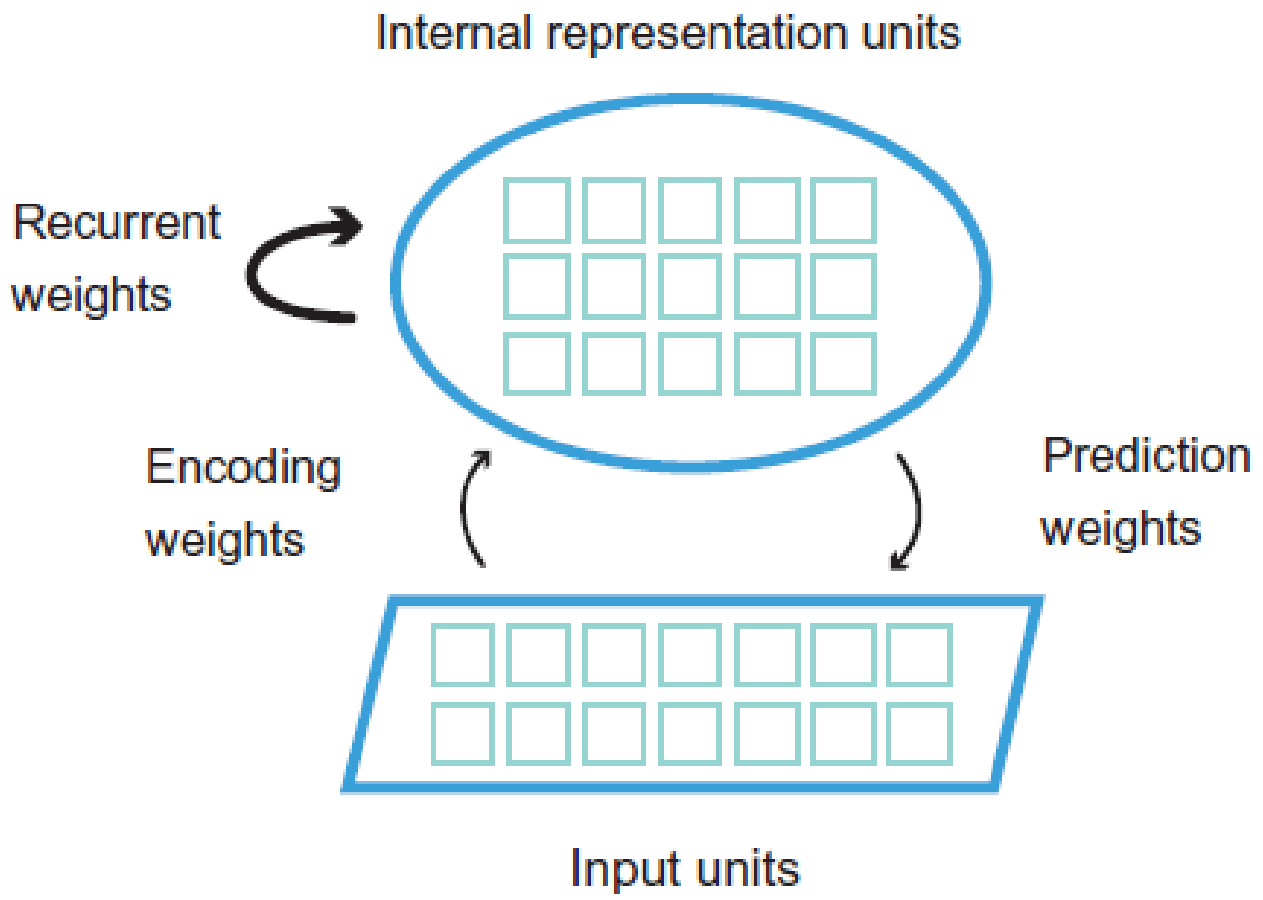
1. The dishabituation experiments show that human infants are sensitive to certain basic physical principles.
2. However, it does not mean that the knowledge is stored in the form of theoretical principles.
3. It might have been stored in graded patterns of neural connections that evolve as a function of experience.

MODELING OBJECT PERMANENCE



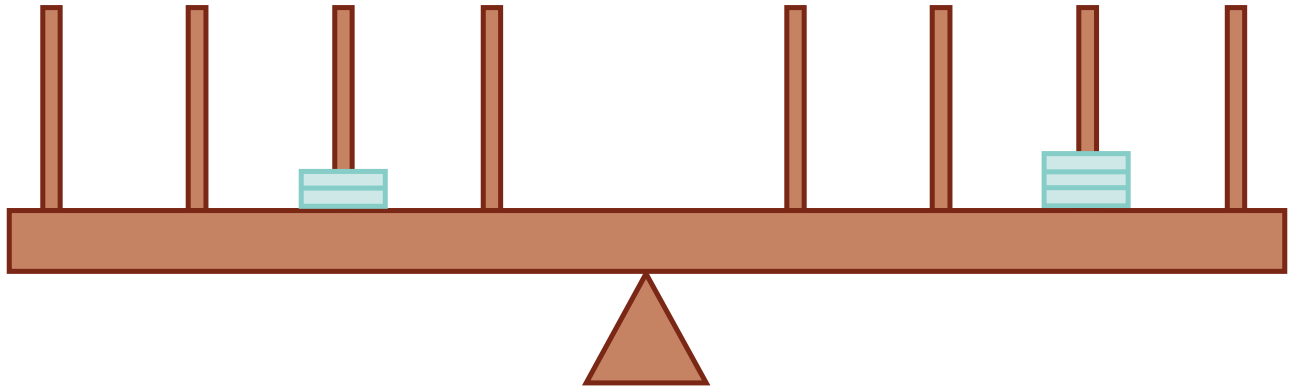
MODELING OBJECT PERMANENCE

Recurrent connections!



MODELING THE BALANCE BEAM PROBLEM

How children solve the balance beam problem? (WHISPER)



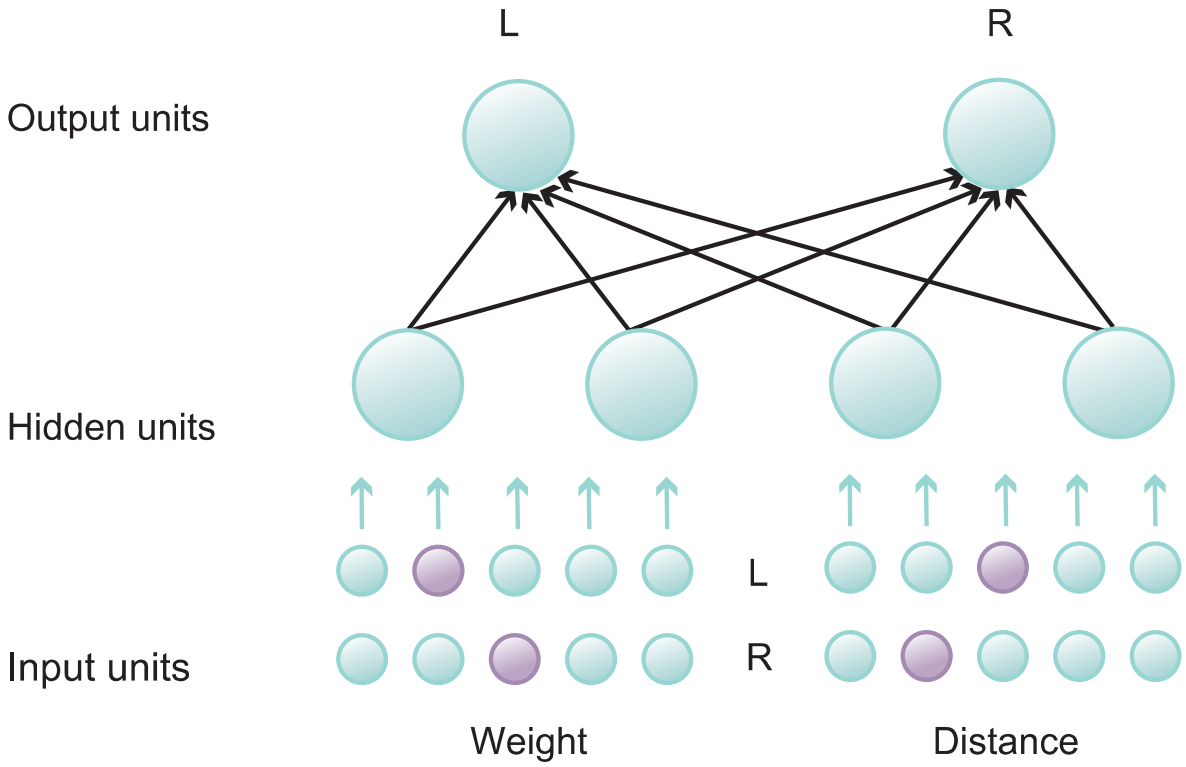
Stage 1: The side with the greatest number of weights will go down regardless of other factors

Stage 2: When the weights on each side of the fulcrum are equal, the side on which the weights are furthest away will go down

Stage 3: Downwards force is a function both of weight and of the distance from the fulcrum (they only manage to do this when the two sides differ in respect either to weight or to distance, but not both)

Stage 4: Acquires a general competence for balance beam problem (adolescence)

MODELING THE BALANCE BEAM PROBLEM



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THREE LEVELS: PHYSICAL SYMBOL SYSTEM VS. ARTIFICIAL NEURAL NETWORK

The computational level: A general characterization of the information-processing task

The algorithmic level: Identifies a particular algorithm

The implementational level: How the algorithm is realized in the system

Algorithmic level vs. Implementational level???

THREE LEVELS: PHYSICAL SYMBOL SYSTEM VS. ARTIFICIAL NEURAL NETWORK

The physical symbol system: An algorithmic level account

How about the artificial neural network? Implementation level account? Algorithmic level account?

Fodor: Cognition should be understood in terms of the rule-governed transformation of abstract symbol structures!

What do you think? ➡

1. Either artificial neural networks contain representations with separable and recombinable components, or they do not.
2. If they do contain such representations, then they are simply implementations of physical symbol systems.
3. If they do not contain such representations, then they cannot plausibly be described as algorithmic information processors.
4. Either way, therefore, artificial neural networks are not serious competitors to the physical symbol system hypothesis.