

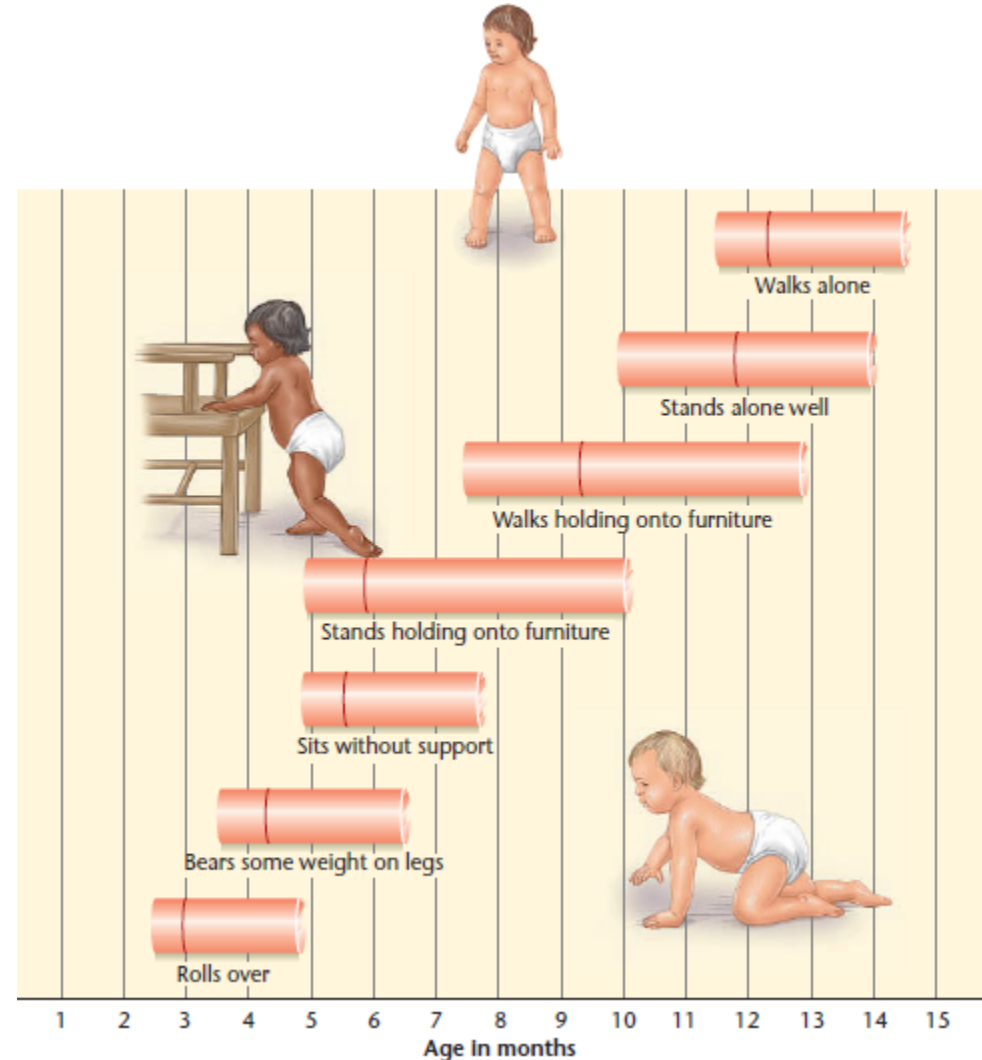
Intro. to Cognitive Science Cognitive Development

Adapted from Dr. Albert Ali Salah

Developmental stages

Behaviors at a stage

- organized around a dominant theme or a coherent set of characteristics,
 - qualitatively different from behaviors at earlier or later stages,
 - and all children go through the same stages in the same order.
- Environmental factors?
- Speed up or slow
 - Order is same



Critical periods vs. sensitive periods

Capacities of newborns

- William James suggested that the newborn child experiences the world as a “buzzing, blooming confusion”
 - Is it really?
- How to study infant/newborn capabilities?
 - Measure what?

Visual perception of newborn

- Low visual acuity
- Scan, prefer edges, complex patterns
- Facial preference



Developmental Theories

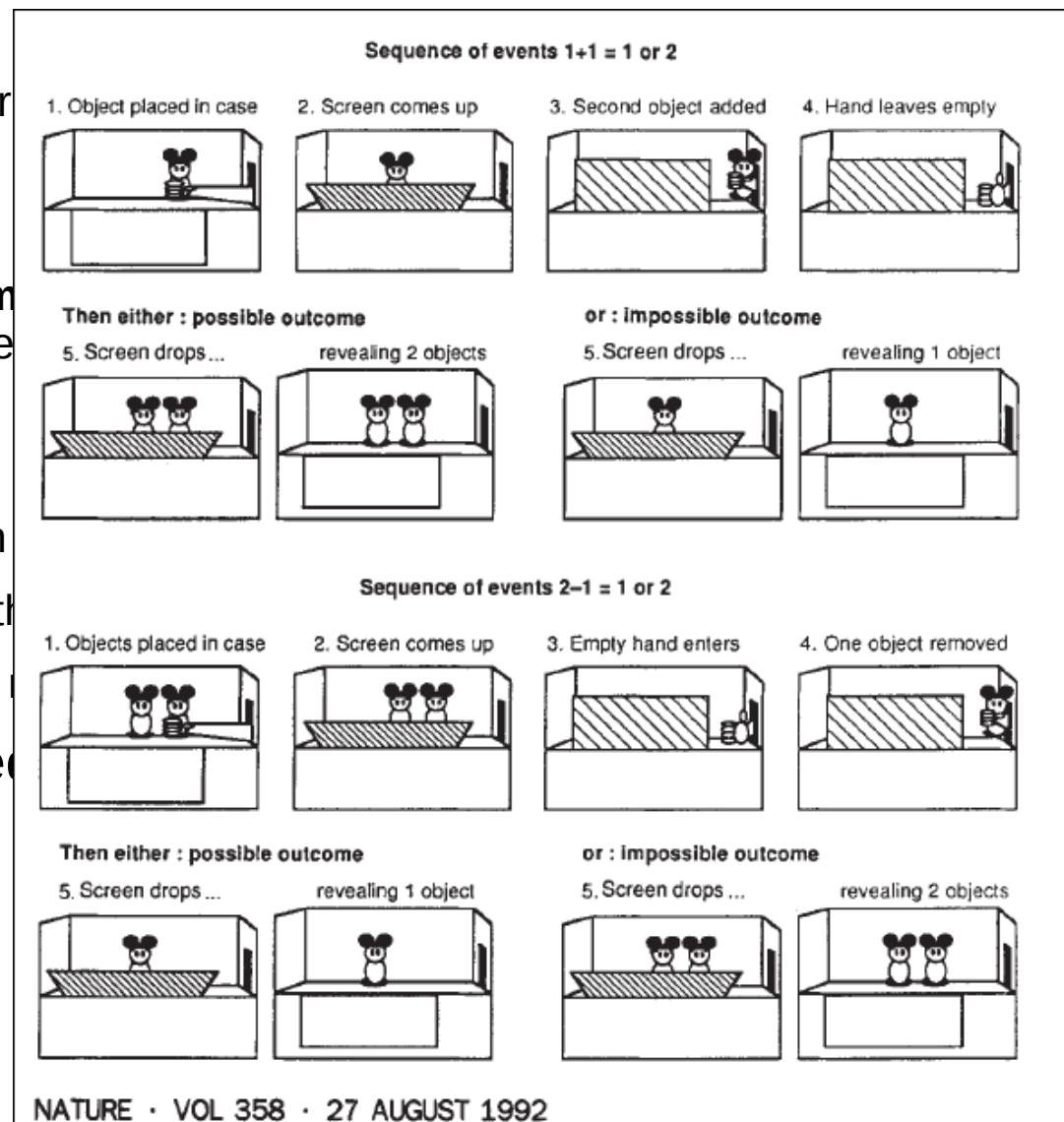
Developmental Theories and Nature informs DevRob field.

Nativist (Nature) Theories:

- ▶ Children are born with **innate, domain-specific** knowledge of the direct influence of the genes on the environment.

Examples:

- ▶ Chomsky (1956): children are born with innate knowledge of language.
- ▶ Leslie (1994): children are born with innate knowledge of physics.
- ▶ Wynn (1998): innate knowledge of arithmetic.
 - ▶ Look more to unexpected outcomes



Developmental Theories

Empiricist (Nurture) Theories:

- ▶ Importance of the **social and cultural environment and experience** on cognitive development.

Examples:

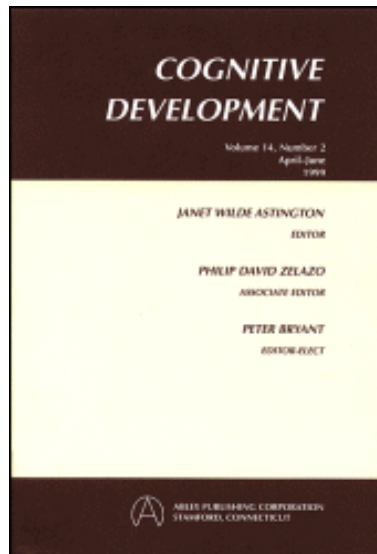
- ▶ **Tomasello** (2003) principle of constructivist and emergent development, whereby the child constructs her own language competence through interactions with others
- ▶ **Piaget's** (1971) **Epigenetics** (meaning?) theory, based on adaptation (assimilation and accommodation) with stage-like, qualitative progression.
- ▶ Thelen and Smith's (1994) dynamical systems theory of development. This considers complex, dynamics interaction of various neural, embodiment and environmental factors in the self-organization of cognitive strategies;

Influenced other fields interested in the study of intelligence, specifically in artificial intelligence and robotics. How?

Cognitive Development

Cognition – Mental processes by which knowledge is acquired, elaborated, stored, retrieved, and used to solve problems.

Cognitive Development – Refers to the changes that occur in children's mental skills and abilities over time.



Piaget's Theory of Cognitive Development



1896 – 1980

Piaget's Theory of Cognitive Development - Schema

Scheme – (Schema for singular, Schemata for plural)

An organized pattern of thought or action that one constructs to interpret some aspect of one's experience.

Represent the way that people organize and understand the things around them.

Piaget's Theory of Cognitive Development

Symbolic schemes – internal mental symbols that one uses to represent aspects of experience.

Cognitive operation – an internal mental activity that one performs on objects or thoughts.

Piaget's Theory of Cognitive Development

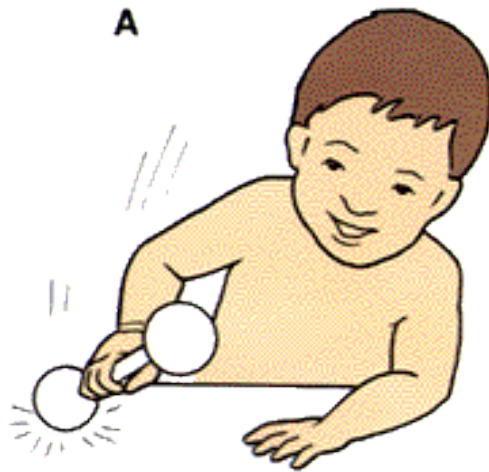
Assimilation – The process of interpreting new experiences by incorporating them into existing schemes.

Accommodation – The process of modifying existing schemes in order to incorporate or adapt to new experiences.

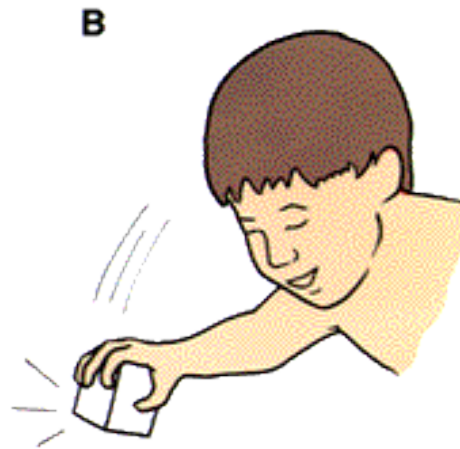
Quiz

- Give an assimilation/accommodation example from your experience

Piaget's Theory of Cognitive Development



Banging is a favorite **scheme** used by babies to explore their world . . .

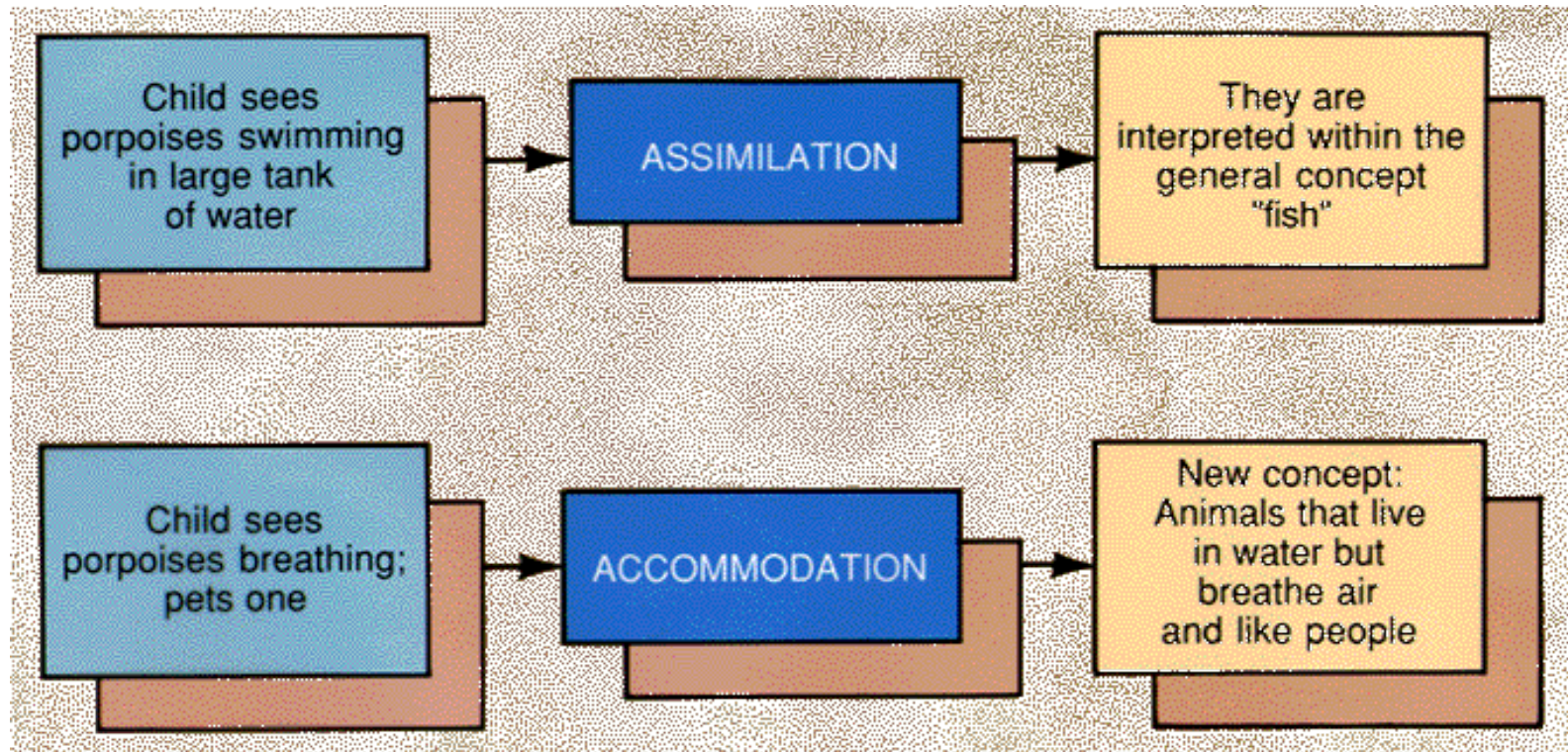


. . . And **assimilation** occurs when they incorporate new objects into the scheme.



Accommodation occurs when the new object doesn't fit the existing scheme.

Piaget's Theory of Cognitive Development



Piaget's Theory of Cognitive Development Stages

Piaget's Stages of Cognitive Development

Stage 1: Sensorimotor Stage (Birth-2yrs)

Stage 2: Preoperational Stage (2-7yrs)

Stage 3: Concrete Operations (7-11yrs)

Stage 4: Formal Operations (11-on)

Invariant developmental sequence!

Piaget's Theory of Cognitive Development

Sensorimotor stage

6 substages to Sensorimotor Stage:

Stage 1 (0-1mo) – Reflexes

Stage 2 (1-4mos) – Primary Circular Reactions

Stage 3 (4-8mos) – Secondary Circular Reactions

Stage 4 (8-12mos) – Purposeful coordination of secondary schemes

Stage 5 (12-18mos) – Tertiary Circular Reactions

Stage 6 (18-24mos) – Mental Solutions

Object permanence



Object permanence



Piaget's Theory of Cognitive Development

Sensorimotor stage

6 substages to Sensorimotor Stage:

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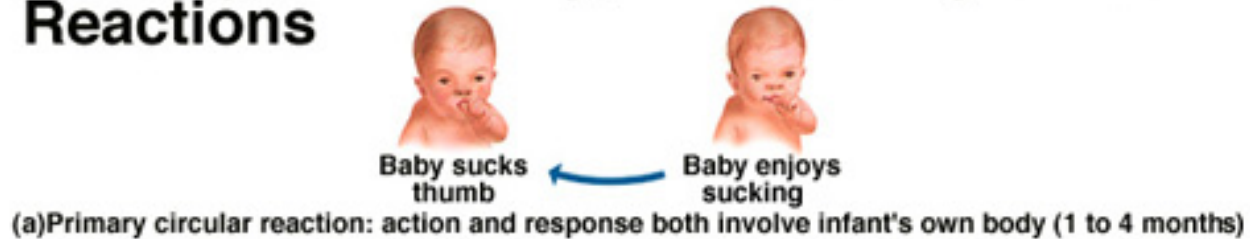
Stage 5 (12-18mos) – Tertiary Circular Reactions

Stage 6 (18-24mos) – Mental Solutions

Piaget's Theory of Cognitive Development

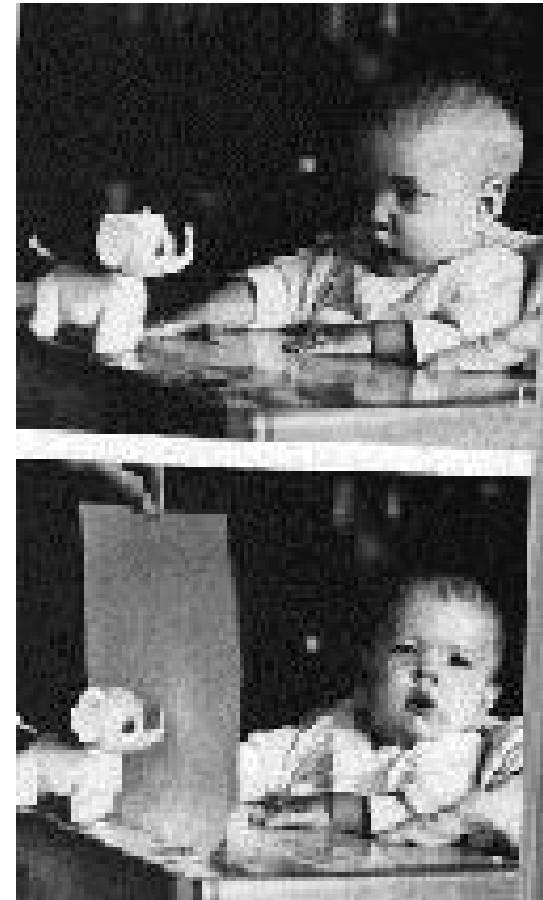
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Primary, Secondary, And Tertiary Circular Reactions



Piaget's Theory of Cognitive Development

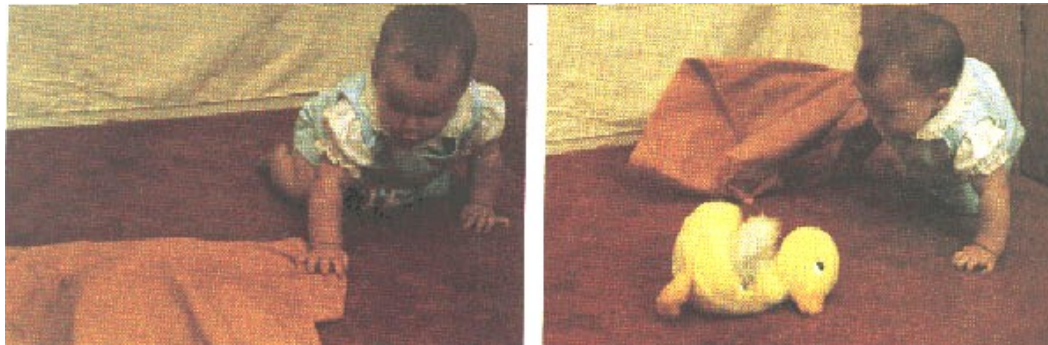
- Object Permanence: knowledge that an object continues to exist independent of our seeing, hearing, touching, tasting or smelling it!
- Stage 1 – Tracks, then ignores



Piaget's Theory of Cognitive Development

Object Permanence – knowledge that an object continues to exist independent of our seeing, hearing, touching, tasting or smelling it!

Stage 4 – Search for objects that disappear in last place found



Piaget's Theory of Cognitive Development

Object Permanence – knowledge that an object continues to exist independent of our seeing, hearing, touching, tasting or smelling it!

Stage 1 – Tracks, then ignores

Stage 2 – Looks where it disappeared

Stage 3 – Search for partially hidden

Stage 4 – Search for objects that disappear in last place found

Stage 5 – Follows series of visible displacements

Stage 6 – Fully developed

Piaget's Description of Sensorimotor Thought

**Ability to
organize and
coordinate
sensations
with physical
movements**

**Is nonsymbolic
through most
of its duration**

**Consists of
six substages
of cognitive
development**

**Object
permanence
develops**

Piaget's Theory of Cognitive Development

Piaget's Stages of Cognitive Development

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Stage 4: Formal Operations (11-on)

Piaget's Theory of Cognitive Development

Preoperational Stage

The Preoperational Stage: 2-7 Years, Preconceptual Period (2-4 Years)

A. Accomplishments

1. Symbolic Function



Piaget's Theory of Cognitive Development

Preoperational Stage contd'

The Preoperational Stage: 2-7 Years, Preconceptual Period (2-4 Years)

A. Accomplishments

1. Symbolic Function
2. Pretend Play





Piaget's Theory of Cognitive Development

Preoperational Stage Errors

The Preoperational Stage: 2-7 Years, Preconceptual Period (2-4 Years)

A. Accomplishments

1. Symbolic Function
2. Pretend Play

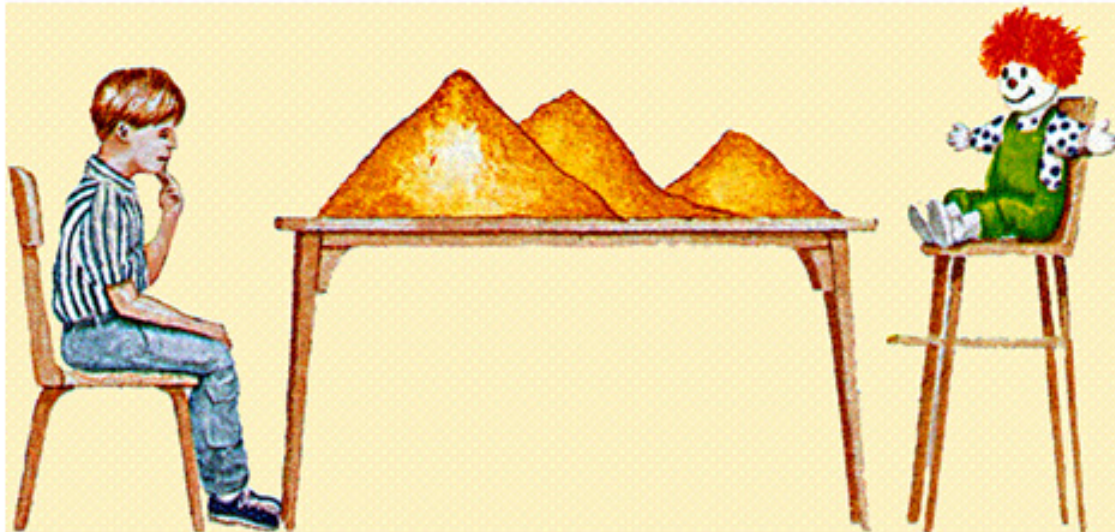
B. Errors

1. Animism, artificialism
2. Precausal or Transductive reasoning
3. Egocentrism

Piaget's Theory of Cognitive Development

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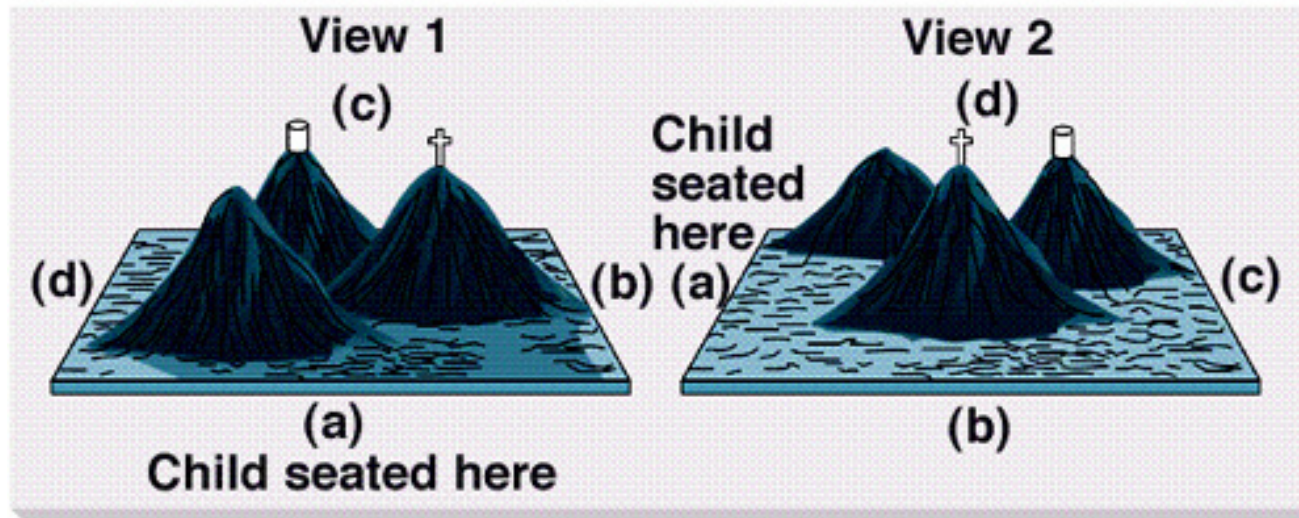
Piaget's Mountain Task



Piaget's Theory of Cognitive Development

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Three Mountain Task Perspective



Piaget's Theory of Cognitive Development

Curiosity

The Preoperational Stage: 2-7 Years, Intuitive Period (4-7 Years)

A. Accomplishments

1. Curiosity

B. Errors

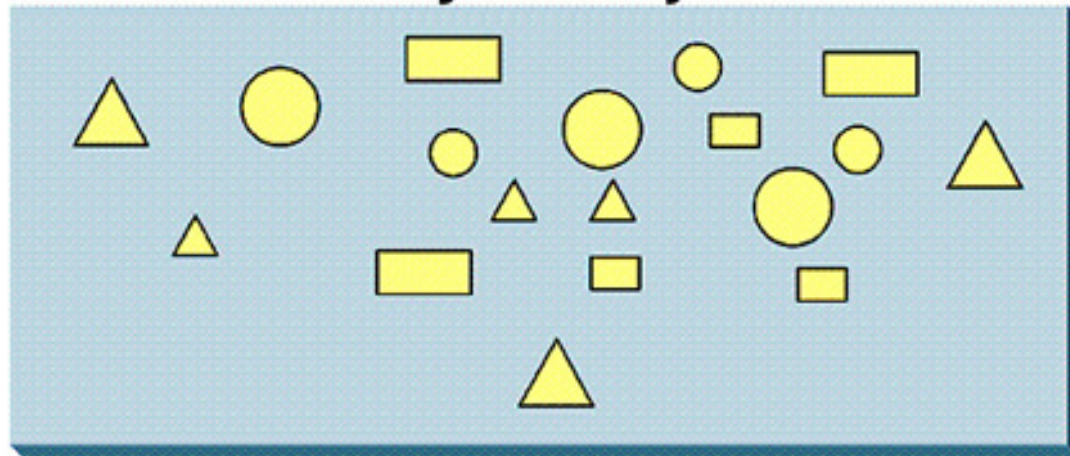
1. Centration
2. Conservation
3. Irreversibility
4. Class inclusion
5. Transitive Inference



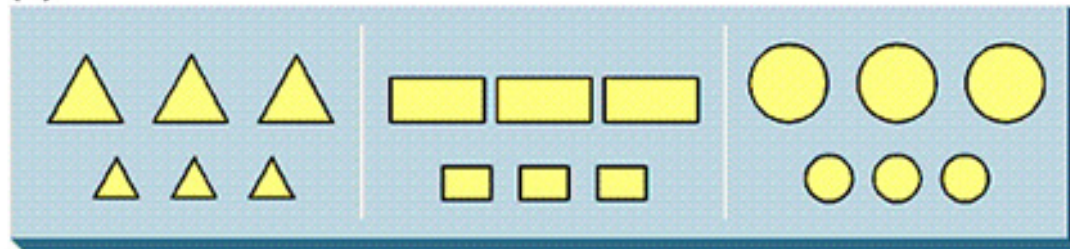
Piaget's Theory of Cognitive Development

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Array of Objects



(a)



(b)

Piaget's Theory of Cognitive Development

1. Conservation of mass

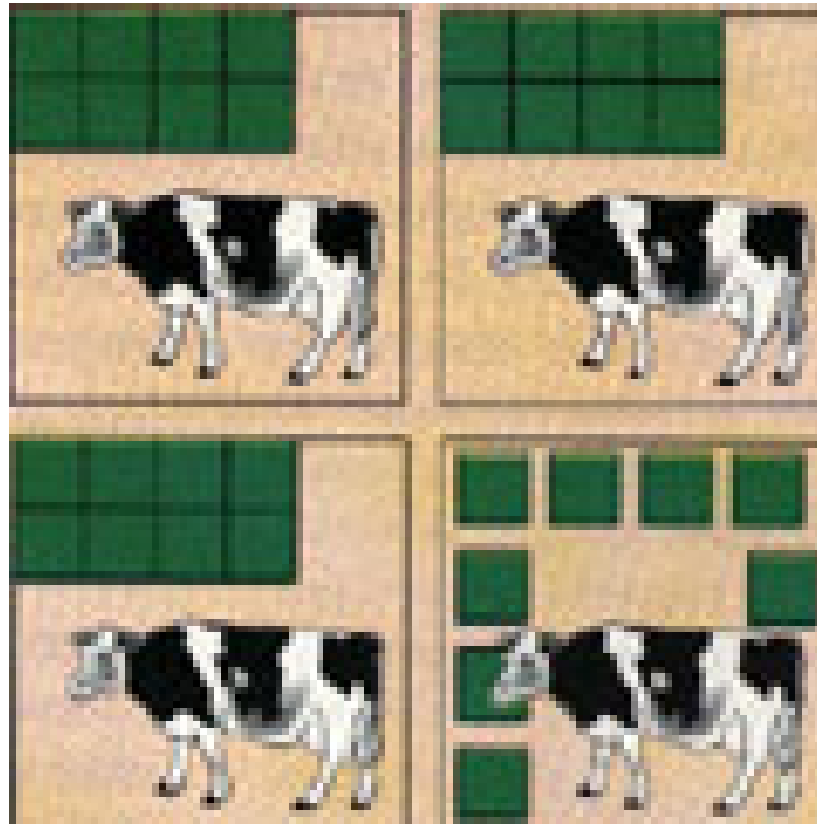


The experimenter presents two balls of clay.



The experimenter rolls one ball into a "sausage" and asks the child whether they still contain the same amount of clay.

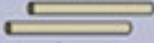
Piaget's Theory of Cognitive Development



Piaget's Theory of Cognitive Development



Piaget's Theory of Cognitive Development

Type of conservation	Initial presentation	Manipulation	Preoperational child's answer
Number	 Two identical rows of objects are shown to the child, who agrees they have the same number.	 One row is lengthened and the child is asked whether one row now has more objects.	Yes, the longer row.
Matter	 Two identical balls of clay are shown to the child. The child agrees that they are equal.	 The experimenter changes the shape of one of the balls and asks the child whether they still contain equal amounts of clay.	No, the longer one has more.
Length	 Two sticks are aligned in front of the child. The child agrees that they are the same length.	 The experimenter moves one stick to the right, then asks the child if they are equal in length.	No, the one on the top is longer.
Volume	 Two balls are placed in two identical glasses with an equal amount of water. The child sees the balls displace equal amounts of water.	 The experimenter changes the shape of one of the balls and asks the child if it still will displace the same amount of water.	No, the longer one on the right displaces more.
Area	 Two identical sheets of cardboard have wooden blocks placed on them in identical positions. The child agrees that the same amount of space is left on each piece of cardboard.	 The experimenter scatters the blocks on one piece of cardboard and then asks the child if one of the cardboard pieces has more space covered.	Yes, the one on the right has more space covered up.

Preoperational Thought's Characteristics

**More symbolic
than sensorimotor
thought**

**Inability to engage
in operations; can't
mentally reverse
actions; lacks
conservation
skills**

**Egocentric
(inability to
distinguish
between own
perspective and
someone else's)**

**Intuitive rather
than logical**

Piaget's Theory of Cognitive Development

Piaget's Stages of Cognitive Development

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Stage 4: Formal Operations (11-on)

Piaget's Theory of Cognitive Development

Concrete Operations – Concrete Operations

Stage 3: Concrete Operations (7-11yrs)

A.Accomplishments

- 1.Logical Reasoning
- 2.Reversibility
- 3.Seriation
- 4.Transitivity



Piaget's Theory of Cognitive Development

Stage 3: Concrete Operations (7-11yrs)

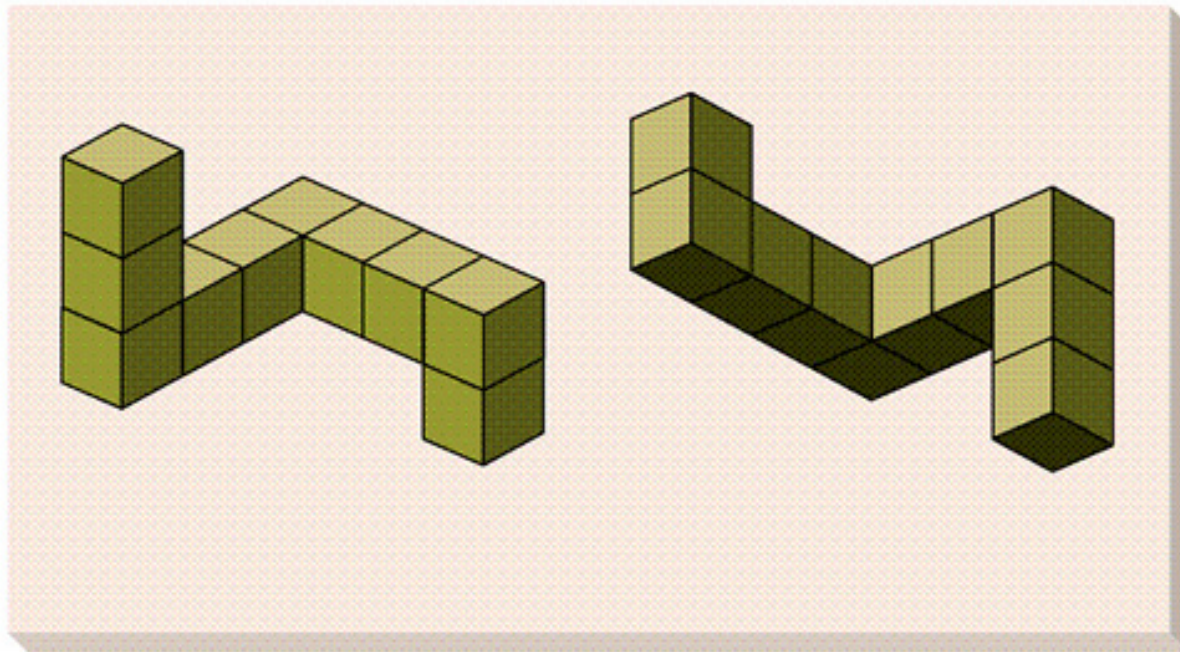
A.Accomplishments

- 1.Logical Reasoning
- 2.Reversibility
- 3.Seriation
- 4.Transitivity

Piaget's Theory of Cognitive Development

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Cubes Used to Study Mental Rotation Abilities



Characteristics of Concrete Operational Thought

Can use
operations,
mentally
reversing
action; shows
conversation
skills

Logical
reasoning
replaces
intuitive
reasoning; but
only in concrete
circumstances

Not abstract
(can't imagine
steps in
algebraic
equation,
for example)

Classification
skills -- can
divide things
into sets and
subsets and
reason about
their
interrelations

Piaget's Theory of Cognitive Development

Piaget's Stages of Cognitive Development

Stage 1: Sensorimotor Stage (Birth-2yrs)

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Piaget's Theory of Cognitive Development

Stage 4: Formal Operations (11-on)

- Mental actions performed on ideas and propositions.
- Can reason logically about hypothetical processes and events that may have no basis in reality.

Characteristics of Formal Operational Thought

Abstract

Adolescents think more abstractly than children. Formal operational thinkers can solve abstract algebraic equations, for example.

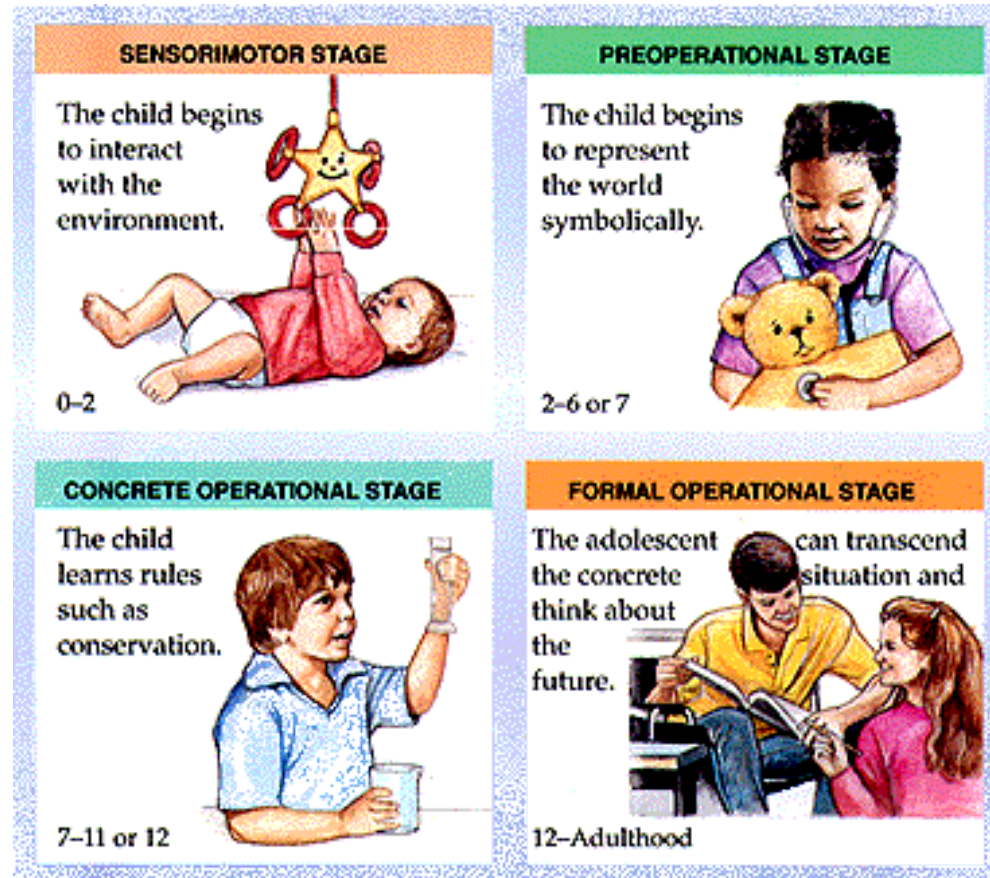
Idealistic

Adolescents often think about what is possible. They think about ideal characteristics of themselves, others, and the world.

Logical

Adolescents begin to think more like scientists, devising plans to solve problems and systematically testing solutions. Piaget called this type of logical thinking hypothetical-deductive reasoning.

Piaget's Theory of Cognitive Development

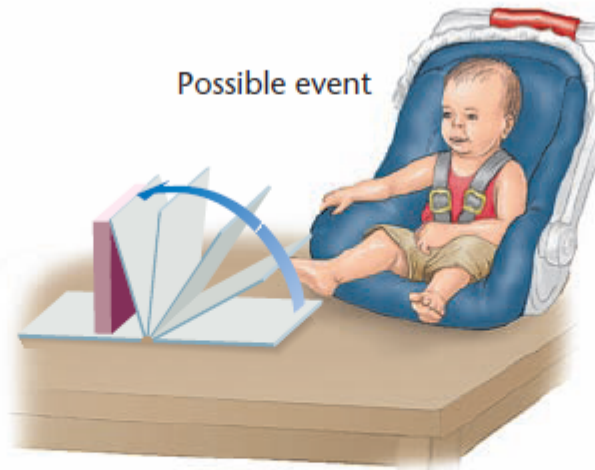


Evaluating Piaget

- Underestimated abilities
- Competence/performance



a) Habituation event
Infants are shown a rotating screen until they no longer attend to it.



b) Test events
In these test events, a box is placed where it can be hidden by the screen. The infants then see either a possible event (the screen rotates until it would hit the box and then returns to its starting position) or an impossible event (the screen appears to pass right through the box). Infants attend more to the impossible event, indicating that they realize that the hidden box still exists.

Evaluating Piaget

- Underestimated abilities
- Competence/performance
- Stages (abandon?)
- How do they progress?
- Ignored social & cultural influences

Vygotsky's Sociocultural Perspective



Sociocultural Theory – Vygotsky's perspective on cognitive development, in which children acquire their culture's values, beliefs, and problem-solving strategies through collaborative dialogues with more knowledgeable members of society.

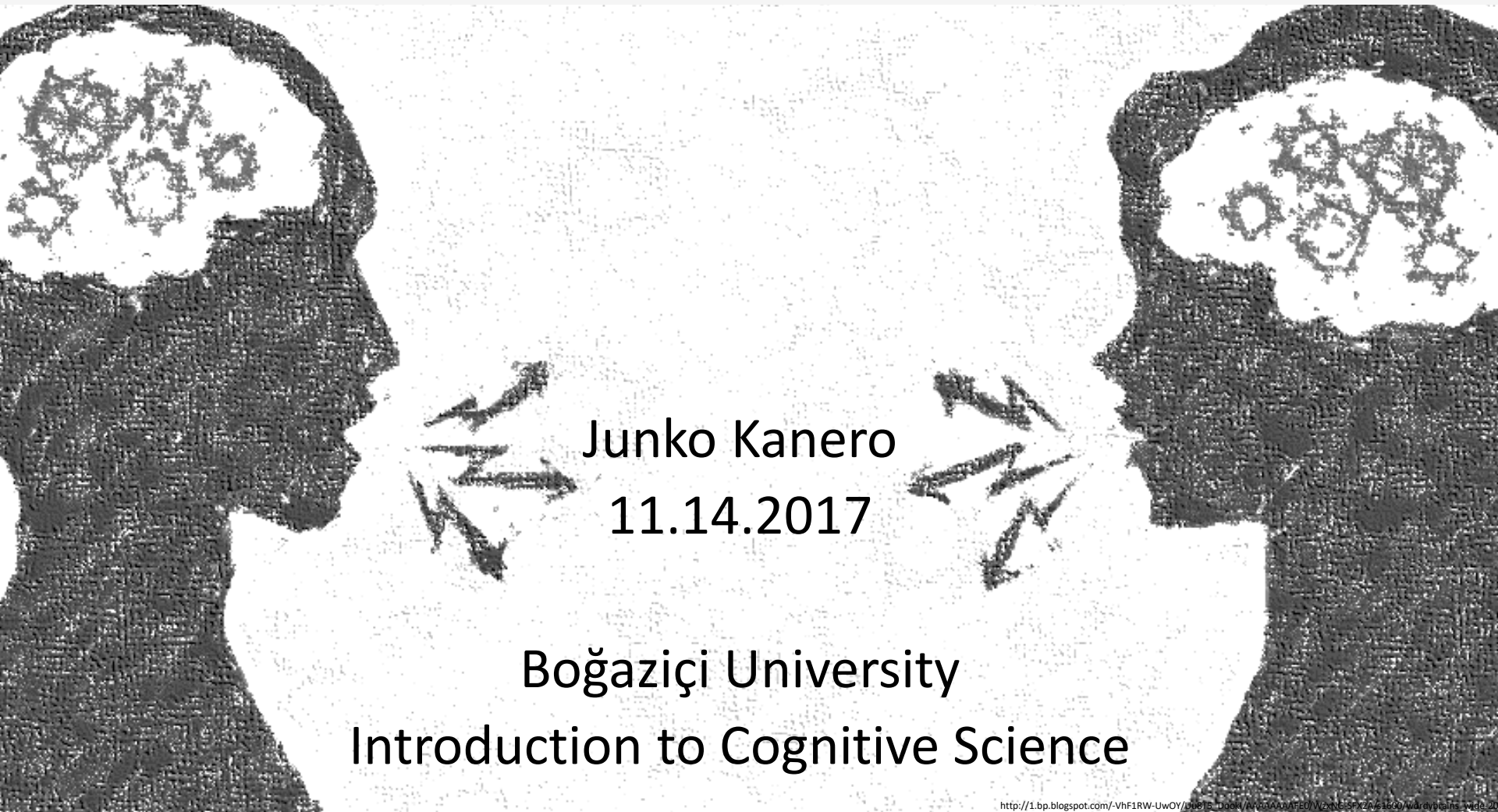
Culture influence

- By providing the opportunity for specific activities: water conservation for a child in desert
- By determining the frequency of certain activities: Dancing skills for Norwegian vs. Balkan children.
- By how they relate different activities
- By controlling the child's role in the activity

Theory of mind



Cognitive Development



Junko Kanero
11.14.2017

Boğaziçi University
Introduction to Cognitive Science

Questions for Developmental Psychologists

“Children from an initially equivalent base, end up controlling often very differently structured languages.”

(Bowerman & Levinson, 2001, p.10)

**What state do
children start
from?**

**What state do
children need to
get to? And
how?**

Questions for Developmental Roboticians

“Children from an initially equivalent base, end up controlling often very differently structured languages.”

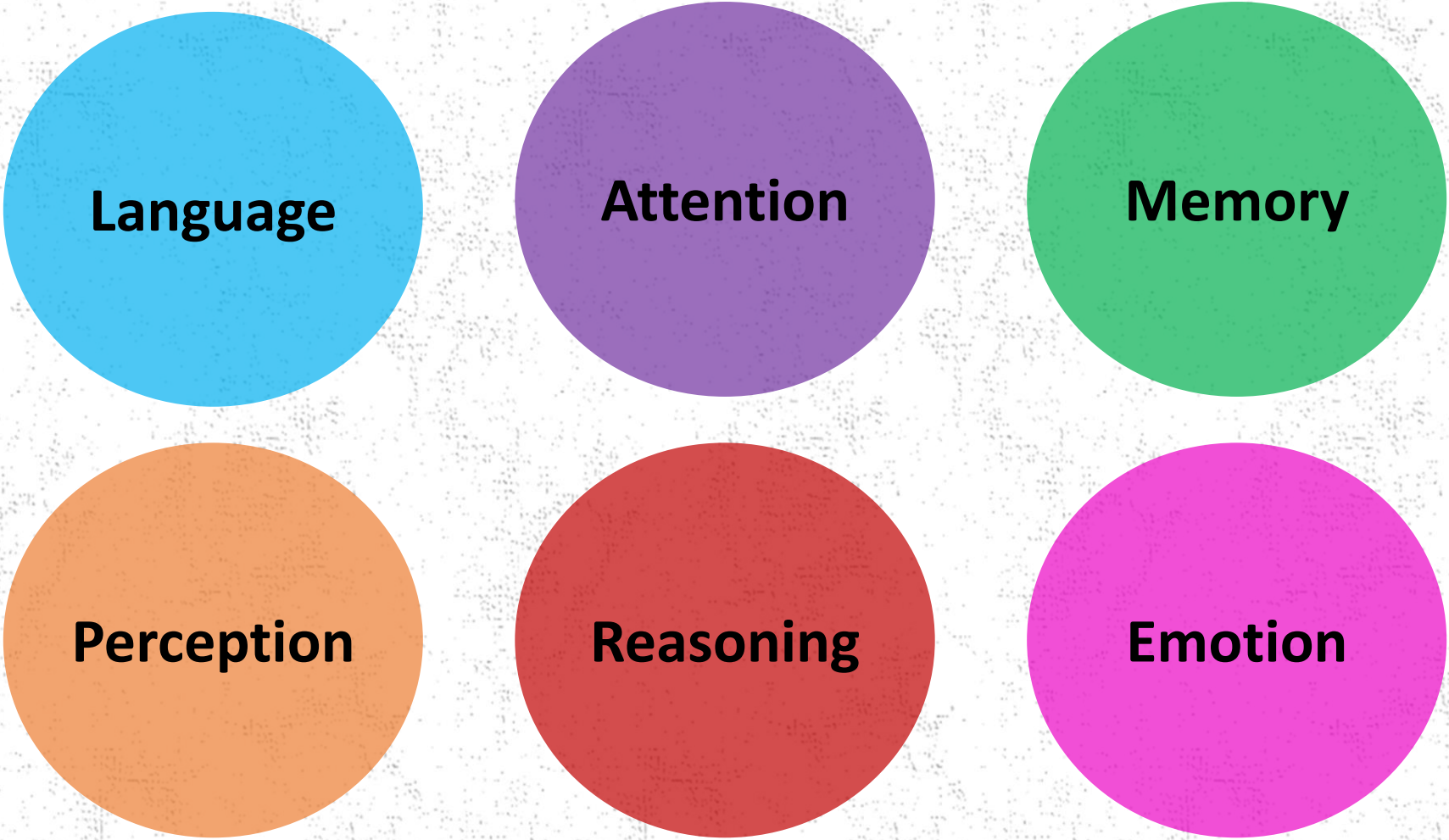
(Bowerman & Levinson, 2001, p.10)

**What state
should robots
start from?**

**What state do
robots need to
get to? And
how?**

Section 1:
**Brief Overview of
Developmental Cognitive Science**

Topics in Cognitive Science



Language

Attention

Memory

Perception

Reasoning

Emotion

How do we access baby mind?

Behavioral measures

- Sucking rate
- Eye gaze
- Head turn



How do we access baby mind?

Behavioral measures

- Sucking rate
- Eye gaze
- Head turn



How do we access baby mind?

Behavioral measures

- Sucking rate
- Eye gaze
- Head turn



How do we access baby mind?

Behavioral measures

- Sucking rate
- Eye gaze
- Head turn

Physiological measures

- Heart rate
- EEG, MEG, NIRS



Habituation Paradigm

1. Present Stimulus A over and over again until the infant gets bored, i.e., habituated
 2. Presented Stimulus B
- If the infant regains their attention, i.e., dishabituated, that indicates that the infant...
 - remembers Stimulus A
 - can distinguish between Stimuli A and B
 - *Novelty preference*

Preferential Looking Paradigm

1. Simultaneously present Stimulus A and Stimulus B
 2. Measure how long the infant looks at each one of the stimuli
- If the infant looks longer at Stimulus A than Stimulus B, that indicates that the infant...
 - can distinguish between Stimuli A and B
 - *Novelty preference or Familiarity preference*

Piaget and His Problems

- Weak starting points
- Transition mechanisms too general
- Not enough study of social and cultural interaction
- Knew little about the brain
- Uninterested in individual differences and atypical development

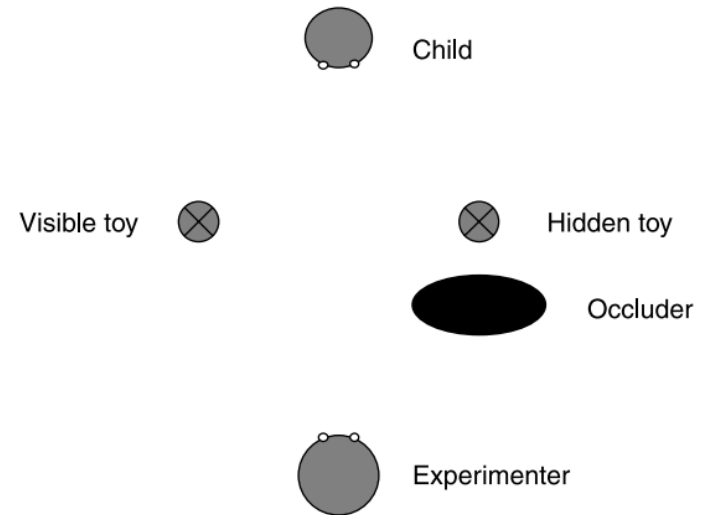
Problem 1: Weak Starting Points

- Toddlers and babies have more abilities than Piaget thought—there are strong starting points for development

Egocentrism



Borke (1975)



Moll & Tomasello, (2006)

Object Permanence

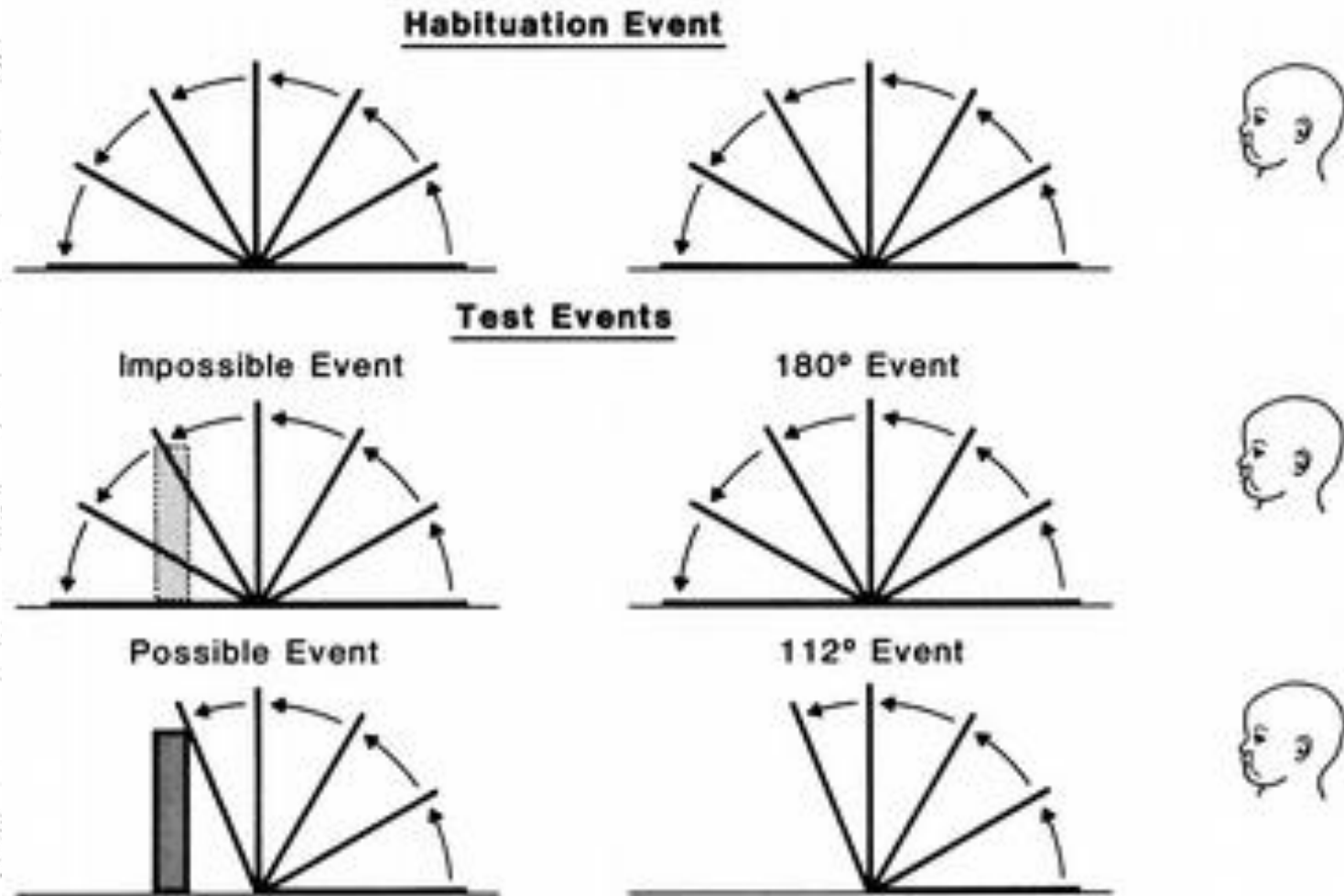
Piaget: “Develop by 8 months”



Object Permanence: Baillargeon (1987)



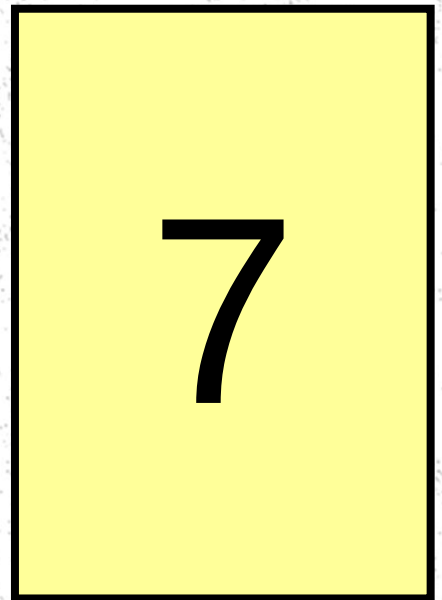
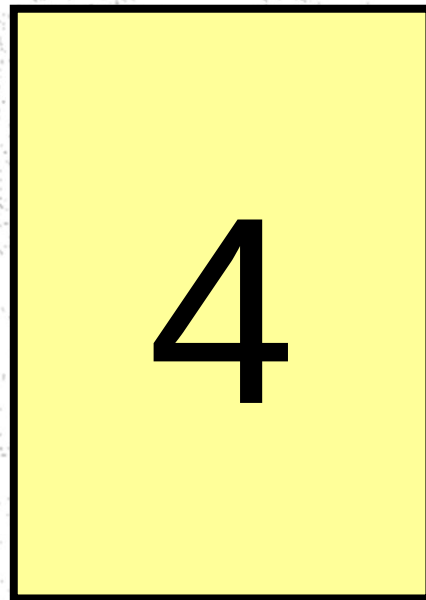
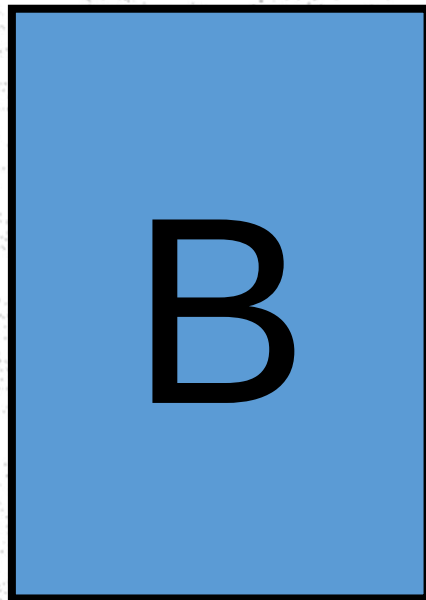
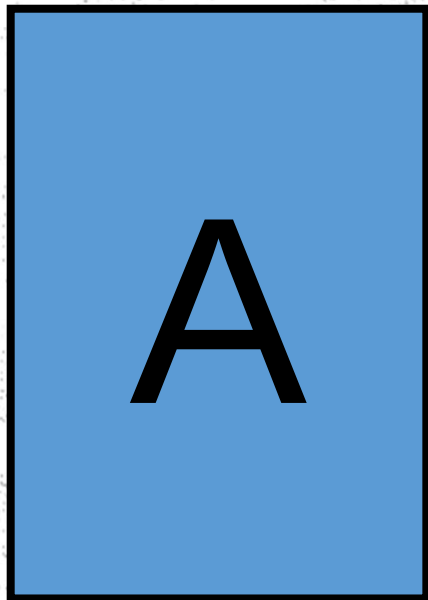
- 3½ month years old





The Wason Card Problem

- There is a deck of four cards that have a letter on one side and a number on the other. They are on the table with different sides facing up
 - Statement : *If a card has a vowel on one side, then it has an even number on the other side.*
- Which cards do you have to flip over to verify that the statement is true?



The Wason Card Problem

- Each card contains a person's age on one side, and what the person is drinking on the other side.
- Statement : "If a person is drinking a beer, then that person is at least 21 years of age" is true?
→ Which cards do you have to flip over to verify that the statement is true?

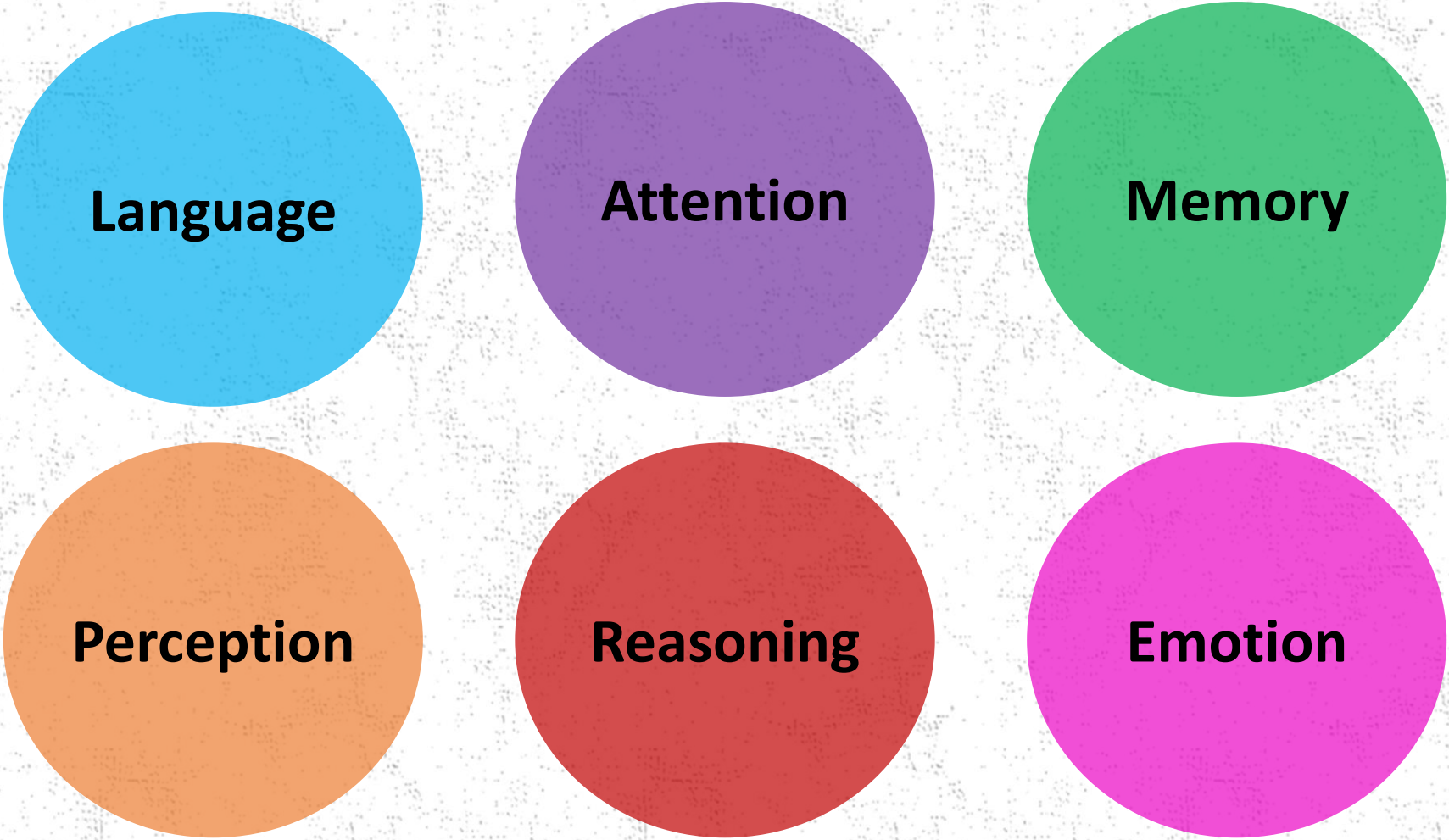
Drinking
beer

Drinking
juice

22
years
old

16
years
old

Topics in Cognitive Science



Language

Attention

Memory

Perception

Reasoning

Emotion

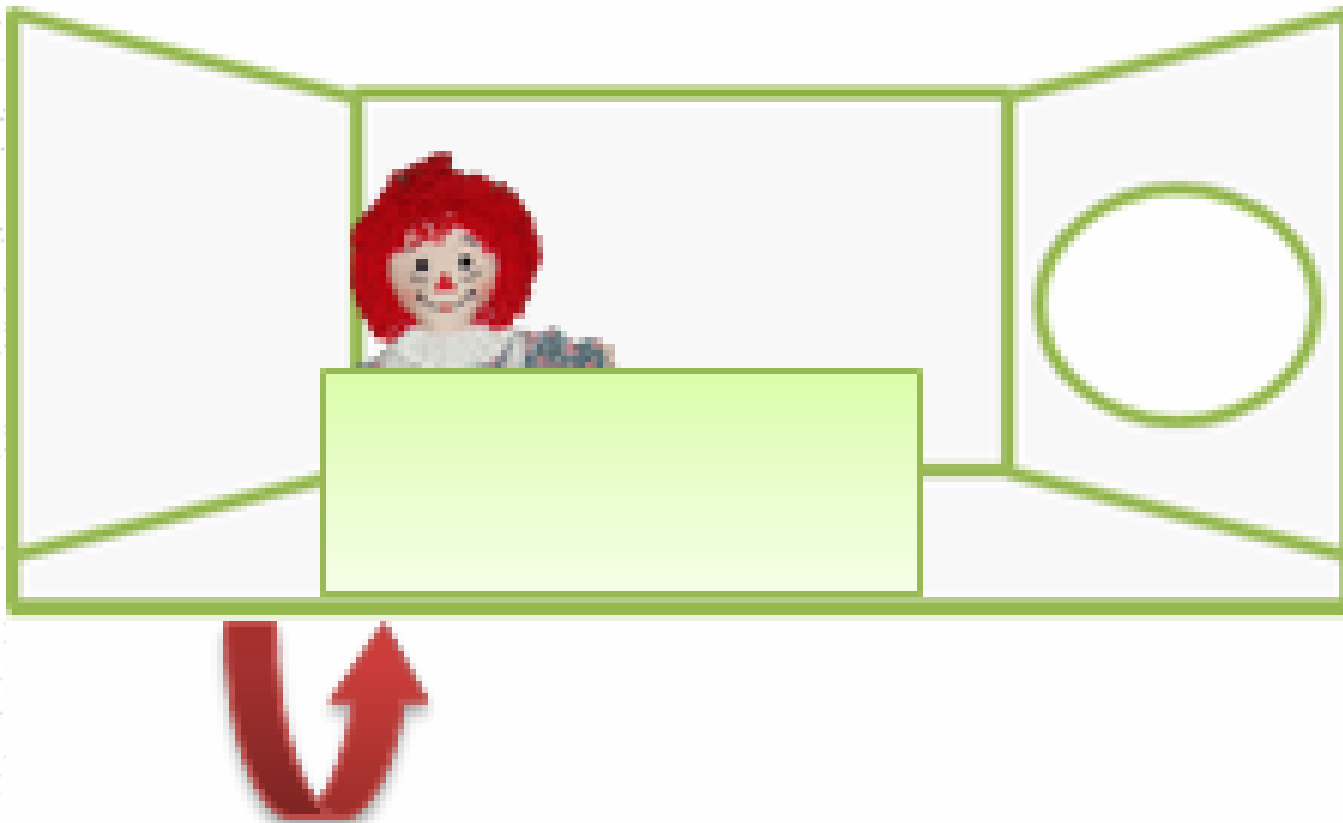
Reasoning

Baby math: Wynn (1992)



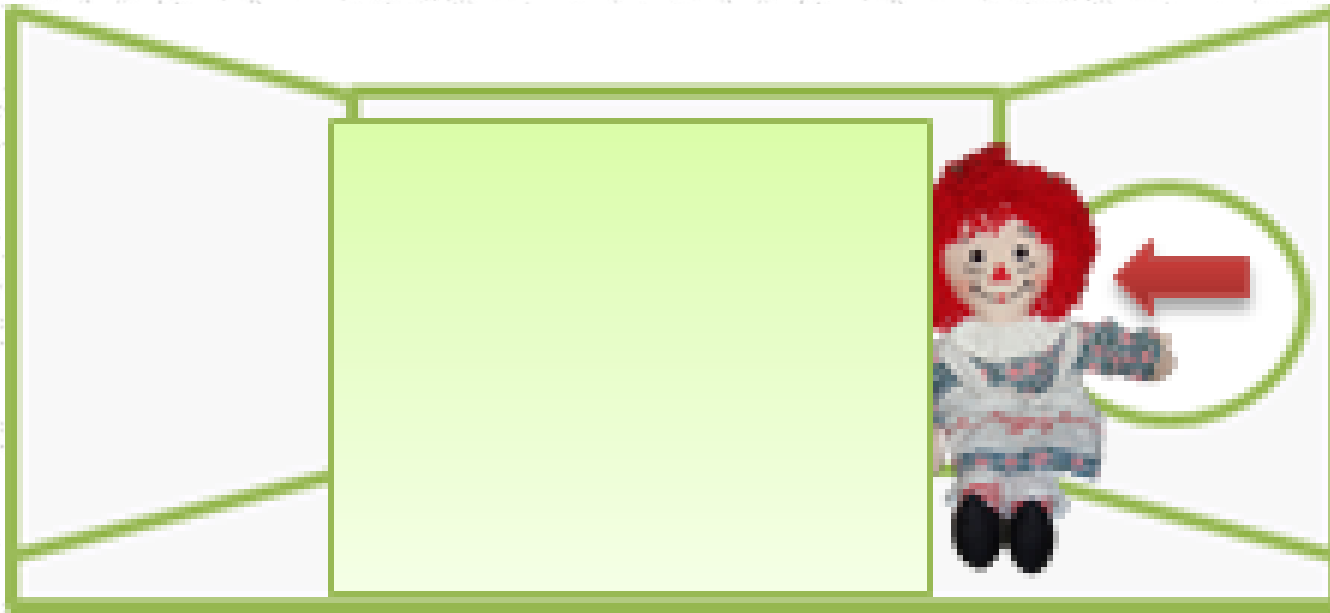
Reasoning

Baby math: Wynn (1992)



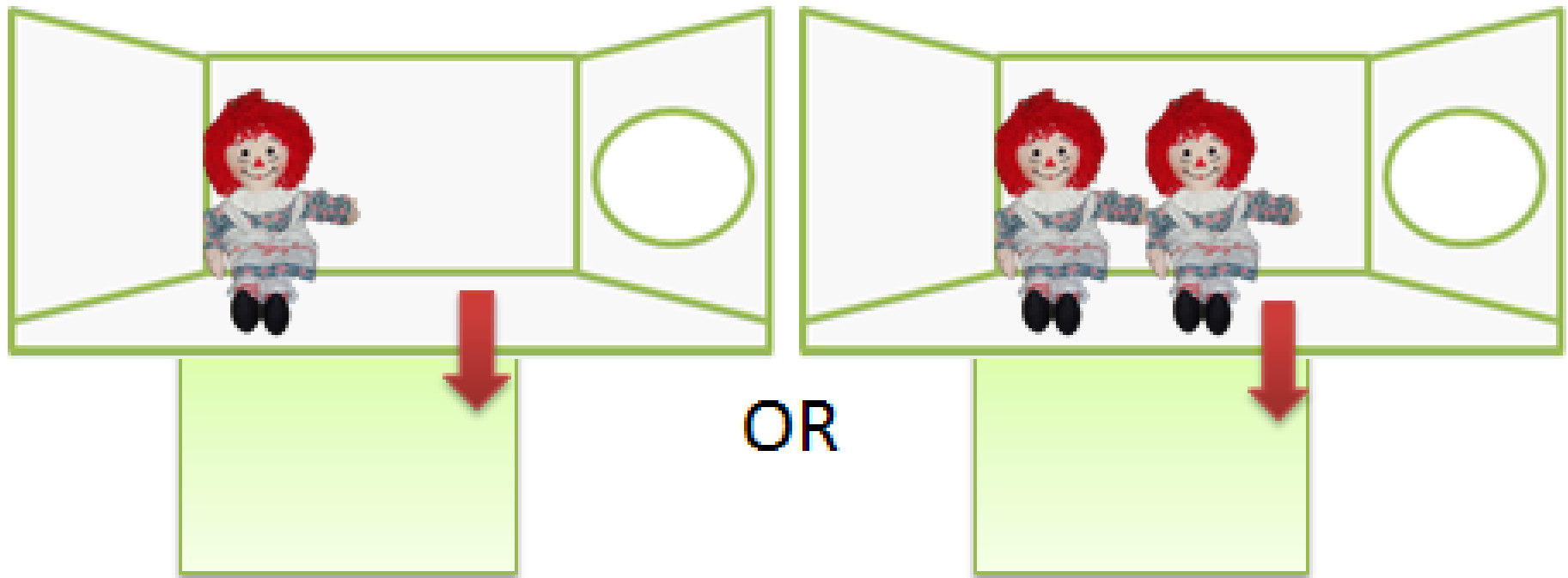
Reasoning

Baby math: Wynn (1992)



Reasoning

Baby math: Wynn (1992)



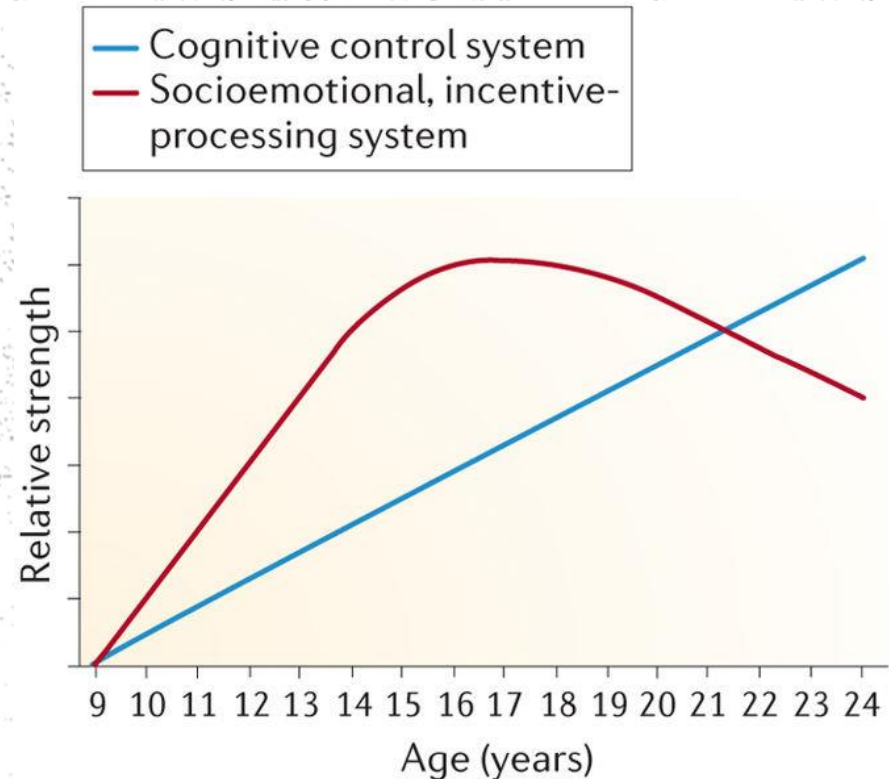
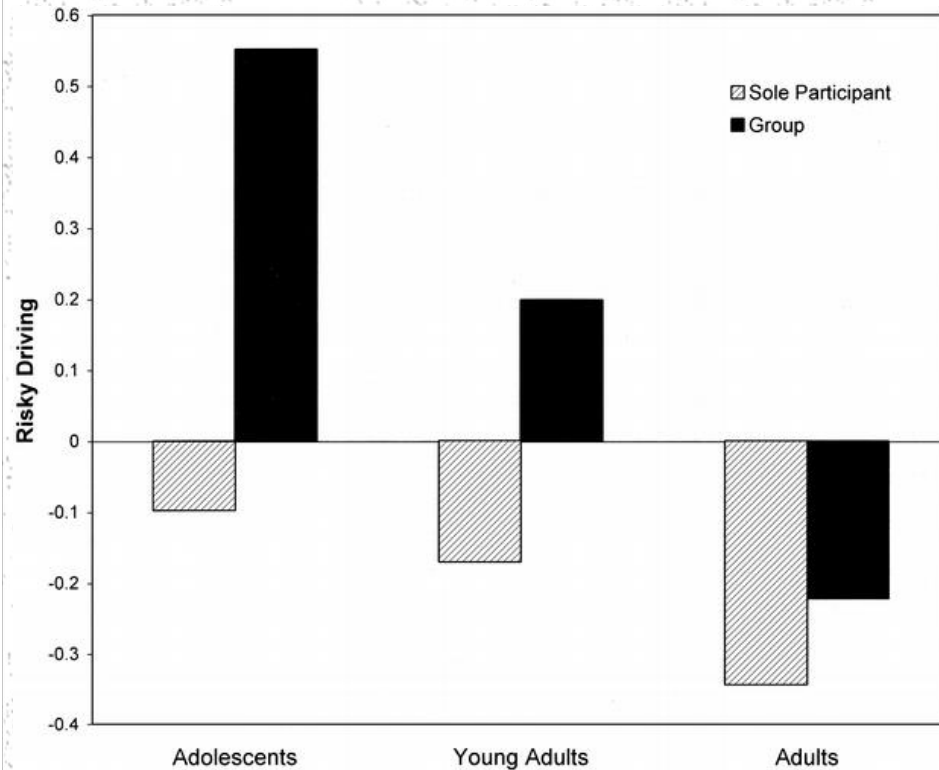
Causality

- By 6 months...
 - Infants discriminate a causal collision event from non-causal collision event
(e.g., Carey, 2009; Cohen & Amsel, 1998; Cohen & Oakes, 1993; Göksun, et al., 2010; Leslie & Keeble, 1987; Muentener & Carey, 2010; Oakes, 1994; Shultz, 1982; see also Rakison & Krogh, 2012; see also Michotte's, 1963/1946).
- By 7 months...
 - Infants expect caused motion to be initiated by animate agents
(Saxe, Tenenbaum, & Carey, 2005; Saxe, Tzelnic, & Carey, 2007; see also Kanero, et al., 2014).
- By 8 months...
 - infants also differentiate between causal and non-causal events in which the effect is a change of state (e.g., breaking) (Muentener & Carey, 2010).

Reasoning

Adolescence

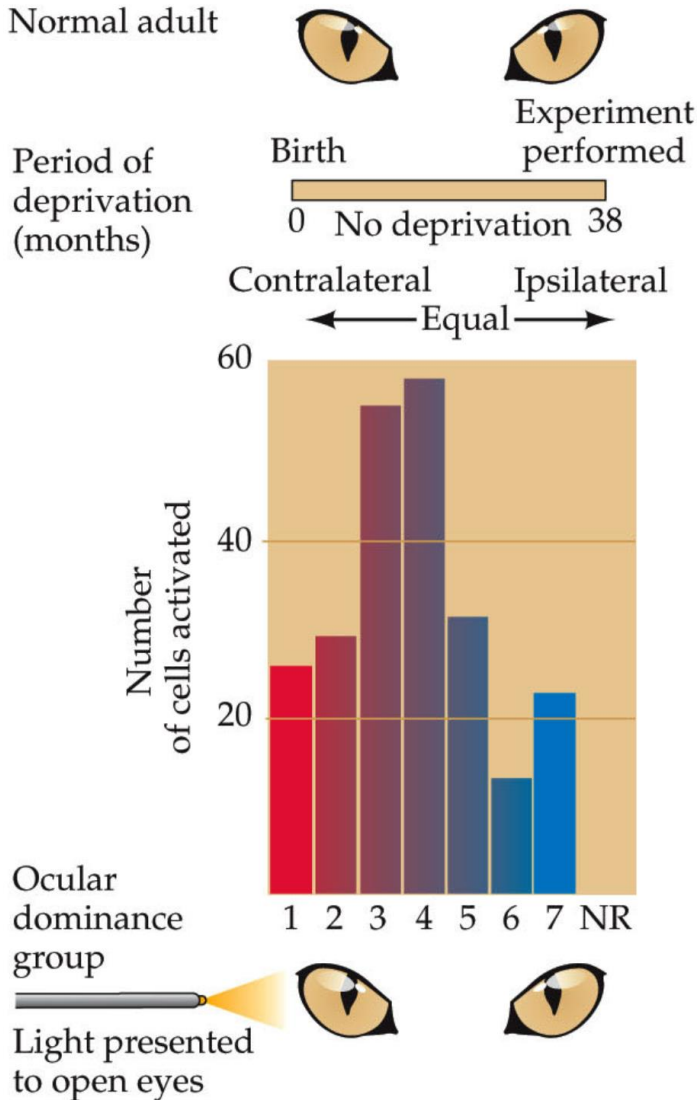
Gardner & Steinberg (2005)



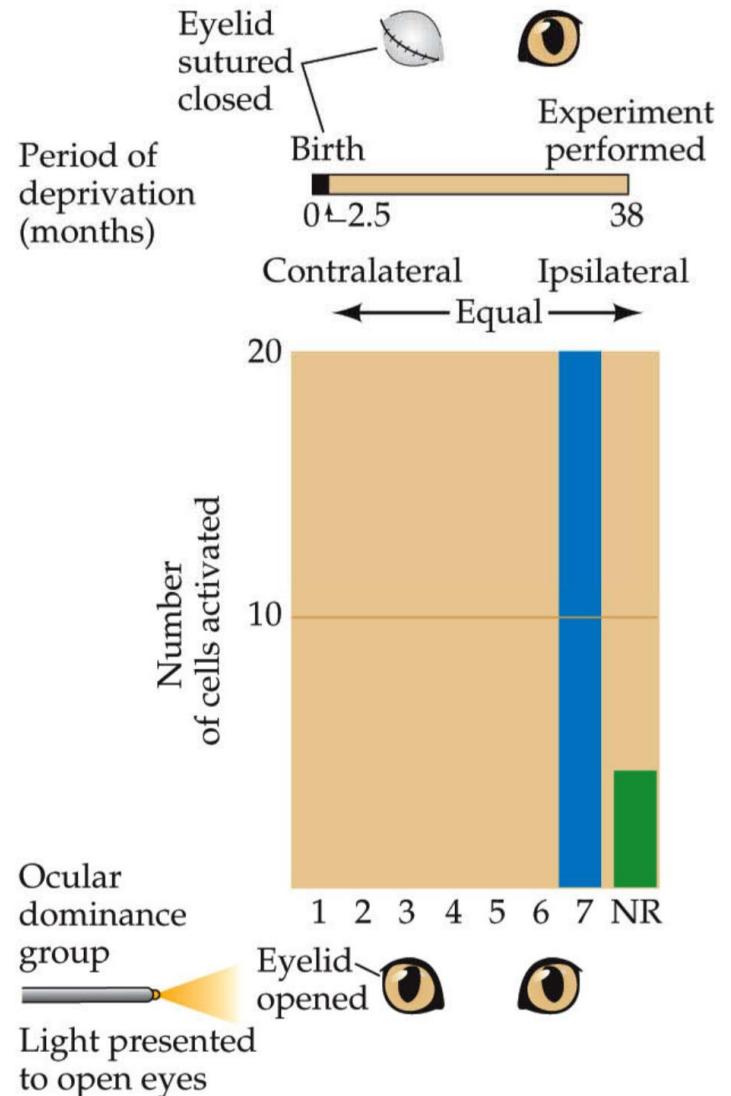
Steinberg (2013)

Vision: Critical Period

(A) Normal adult



(B) Monocular deprivation in kitten



Perception

A.



Face



Scrambled



Blank

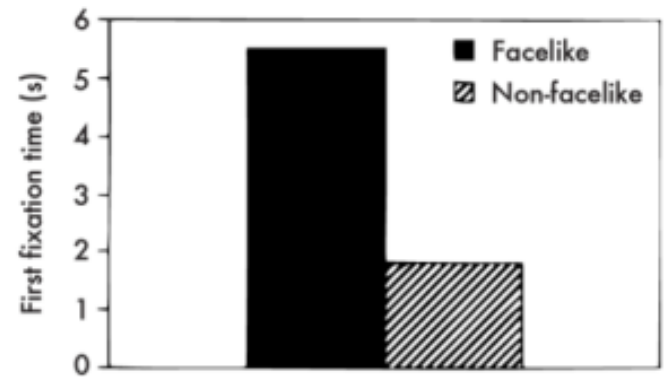
B.



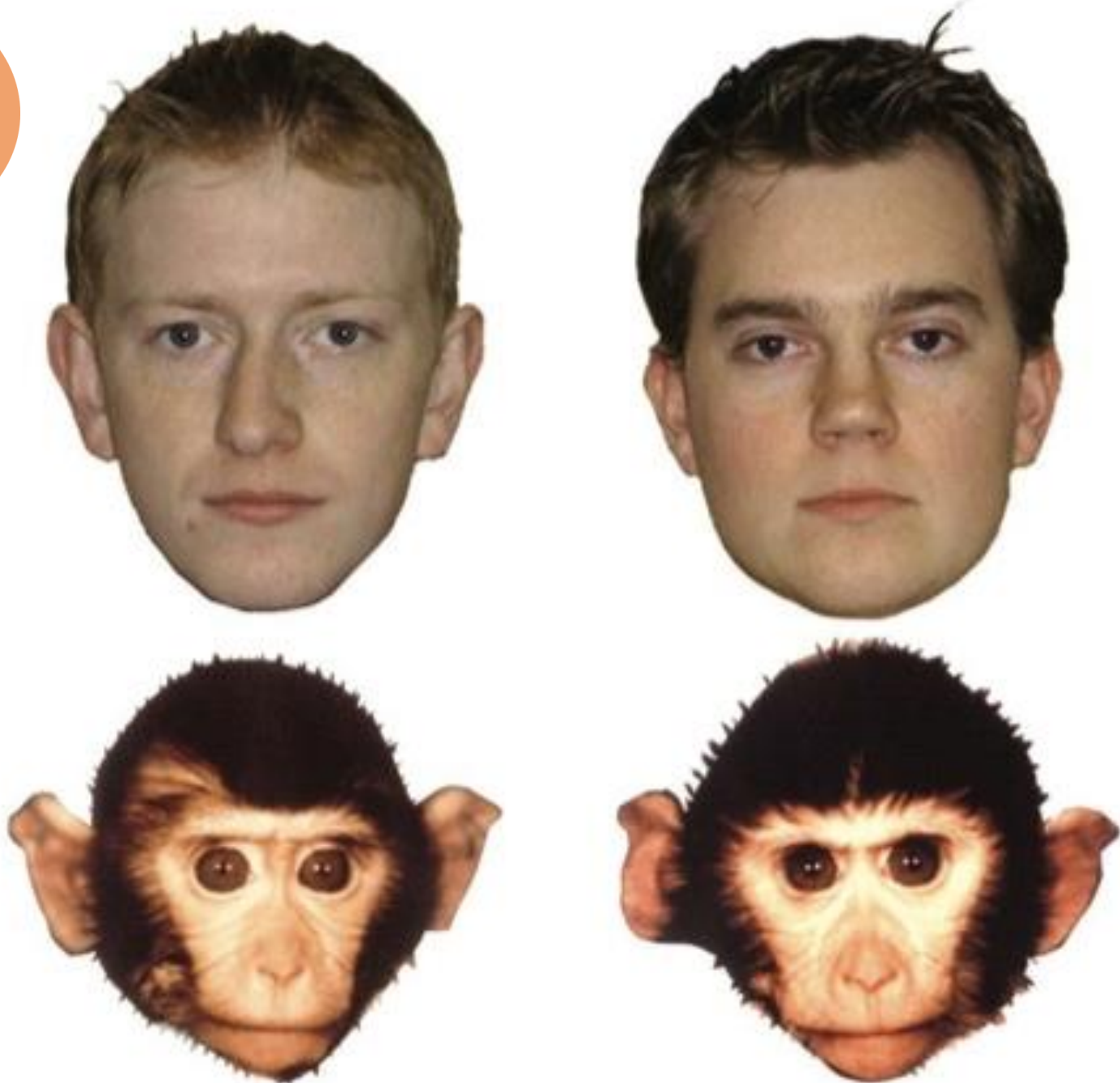
Facelike



Non-facelike



Perception



Pascalis, de Haan, & Nelson (2002)

Memory

Memory

Long-term memories

Declarative:

Things you know that you can tell others

Episodic:
Remembering your first day in school

Semantic:
Knowing the capital of France

Procedural:

Things you know that you can show by doing

Skill learning:
Knowing how to ride a bicycle

Priming:
Being more likely to use a word you heard recently

Conditioning:
Salivating when you see a favorite food

Memory

Rovee-Collier (1997, 1999)



Fig. 2. A 3-month-old during training in the mobile task and during a retention test. During training (a), the infant's kicks move the mobile by means of the ankle ribbon that is connected to the mobile hook. During baseline and all retention tests (b), the ankle ribbon and the mobile are connected to different hooks so that kicks cannot move the mobile.

Memory

Rovee-Collier (1997, 1999)

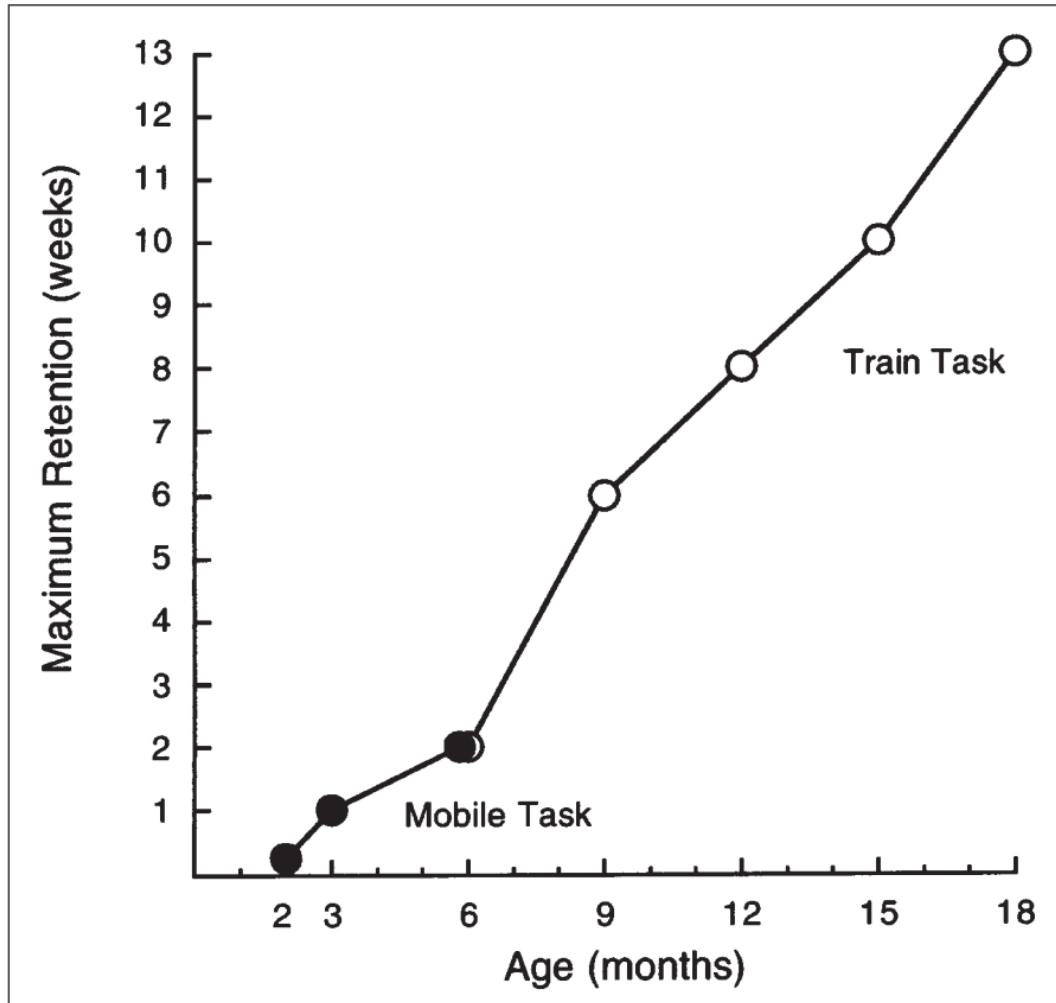


Fig. 4. Maximum duration of retention over the first 18 months of life. Filled circles show retention on the mobile task, and open circles show retention on the train task; 6-month-olds were trained and tested in both tasks.

Episodic/Autobiographic Memory

- Infantile amnesia
- The “reminiscence bump”

