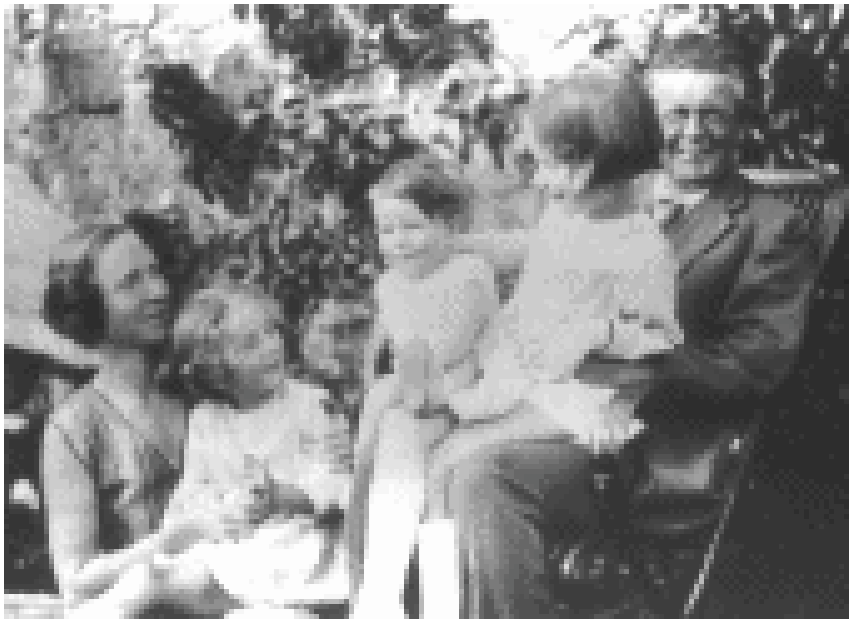
Section 7:
Cognitive Development

Objects and Agents

Cognitive Development
Jean Piaget - Child Psychologist



- **Albert Einstein:**

“a discovery so simple that only a genius could have thought of it.”

Piaget

- Begins his career working for Alfred Binet (Binet-Simon Intelligence Scale)
  - Piaget is more interested in *how* children perform intelligence tasks, rather than which ones they can successfully perform
  - Notices children of the same age tend to make the same mistakes, and offer the same reasoning for their errors

Piagetian Theory

- First to take children's thinking seriously
- Piaget is a serious **empiricist** (as opposed to a **nativist**)
  - Empiricism says we are born a blank slate, and is the more parsimonious account

Piagetian Theory

- Proposed that children were ‘little scientists’ who were constantly building and testing theories of the world
- Many of their theories are wrong:
  - things disappear when they are out of sight
  - big things float and small things sink
  - going faster can take more time

Piagetian Theory

- As children navigate the world, they adapt to new information
- Develop **schemas** and **scripts**
  - **Schemas** – concepts about objects
  - **Scripts** – concepts about events

Piagetian Theory

- As children navigate the world, they adapt to new information
- Develop schemas and scripts
- New information interacts with established schemas in one of 2 ways
  - **Assimilation** – interpreting events in terms of present schemas
  - **Accommodation** – modifying schemas to fit reality

Piaget's Stages of Cognitive Development

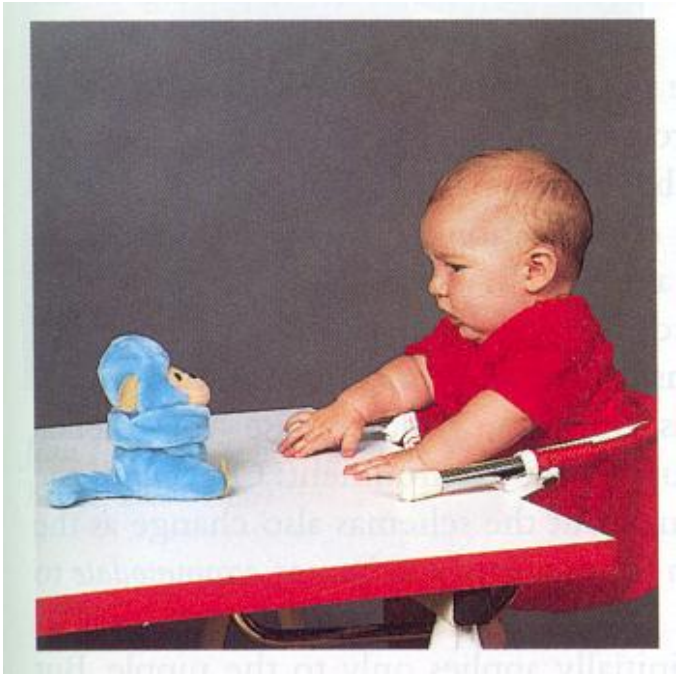
- Sensory-Motor Intelligence:
  - birth to 2 years
- Preoperational:
  - 2 to 7 years
- Concrete Operations:
  - 7 to 11 years
- Formal Operations:
  - 11 years and older

Sensory-Motor Stage (0-2 years)

- Piaget -- first few months, everything is transient and disconnected
  - "a blooming, buzzing mass of confusion"
  - No object permanence
  - No ability to form memories
  - A-not-B

Sensory-Motor Stage (0-2 years)

- Piaget -- first few months, everything is transient and disconnected
  - No object permanence



A-not-B effect

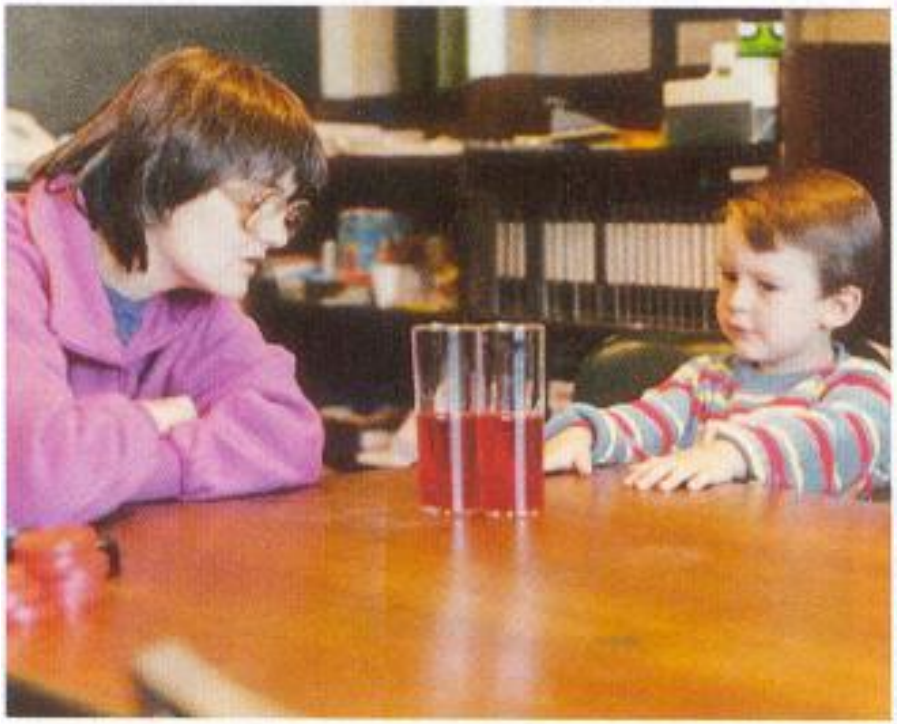
Piaget says: Children don't understand that the object's location changes, just an association between behavior and outcome

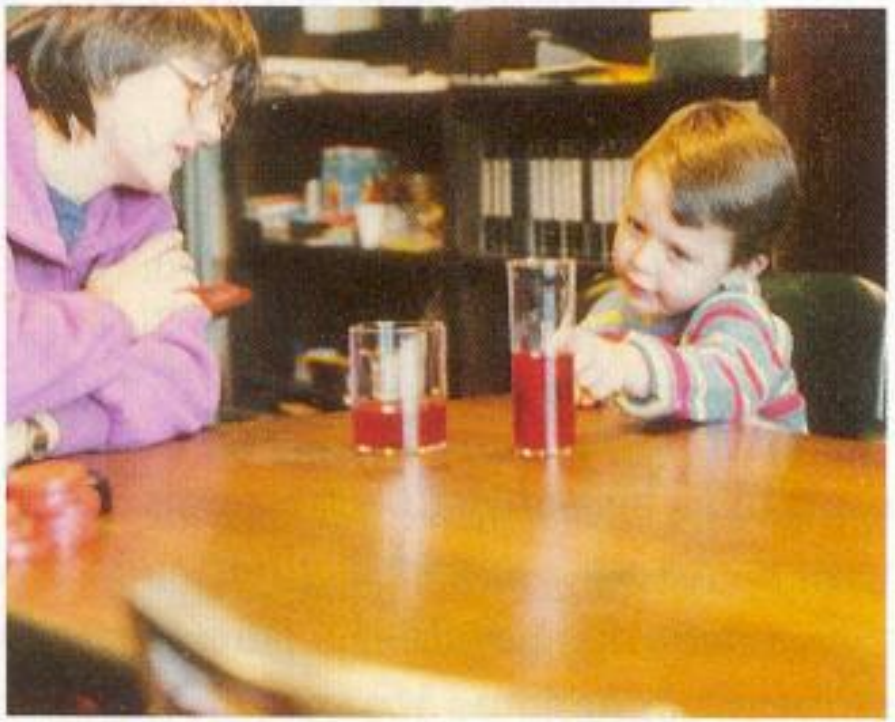
Video…

Preoperational Stage (2-7 years)

- Piaget:
  - Children unable to connect representations of the world into coherent whole
    - » Can't attend to more than 1 dimension of a situation
    - » Inability to conserve mass, number, volume
  - Children unable to take perspective of others
    - » Fail false belief tasks – we will come back to this

Conservation Tasks





Concrete Operations (7-11 years)
Formal Operations (11 and older)

- Piaget - by 7, children able to hold several representations and transform information
- Still only able to apply operations to concrete events - cannot form abstractions
- Developed in this stage:
  - ability to derive an abstraction and test it
  - ability to generate theories and test

Piaget's View of Cognitive Development

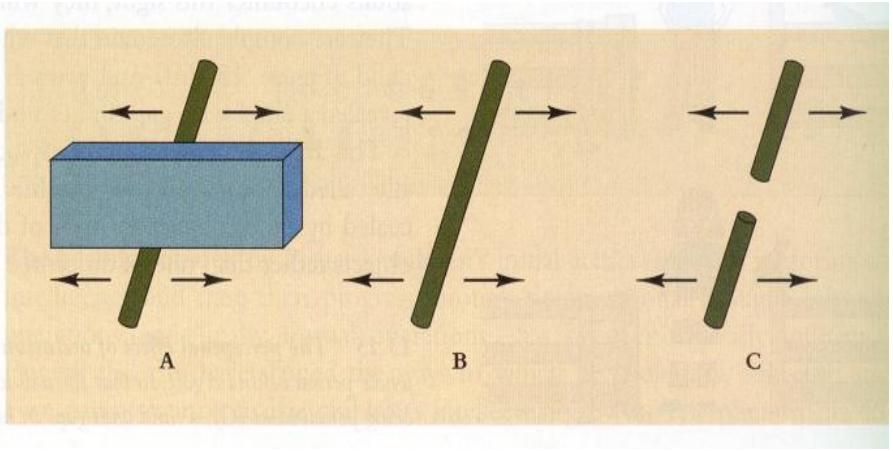
- **Empiricists** claim that the mental 'machinery' of adult and child the same - just fewer associations
- **Nativists** claim that categories of time, space, number, and causality innate
  - Experimental rejections of Piaget

Depth Perception – 6 Month Olds

- Visual cliff:
  - 3 feet drop
  - mother's call
- Results:
  - come when 'shallow,' not when 'deep'

Perception of Occluded Objects – 4 Month Olds

- Piaget argued that ability to 'see' occluded objects requires higher stage
- Empirical test:
  - 2 conditions: one rod and two rods
- Results:
  - 3-month-old babies look longer at C

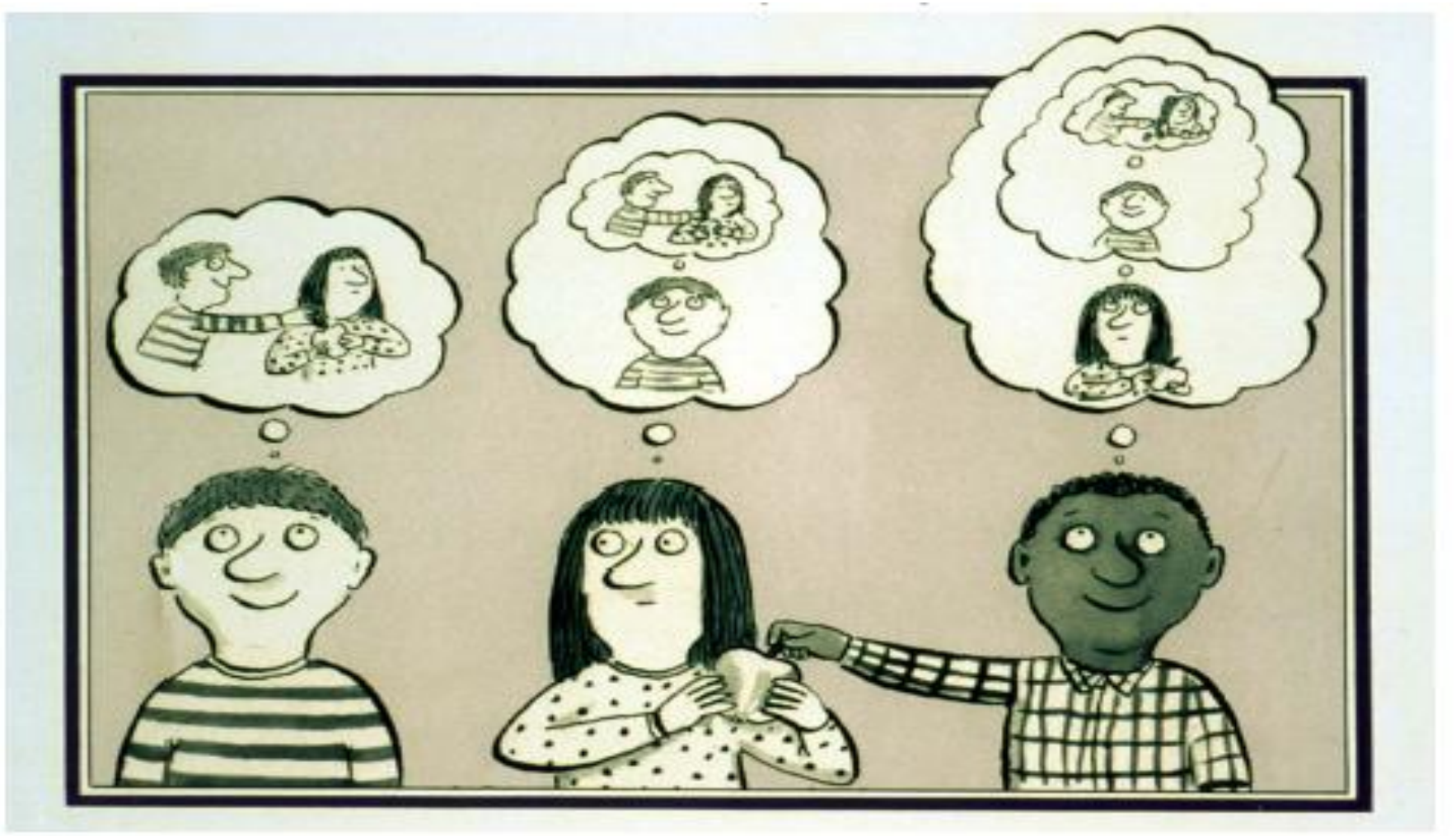


Empiricist Response

- Empiricists argue that this is learned…

Despite pitiful visual acuity in infancy

Social Cognition: Empiricists vs. Nativists



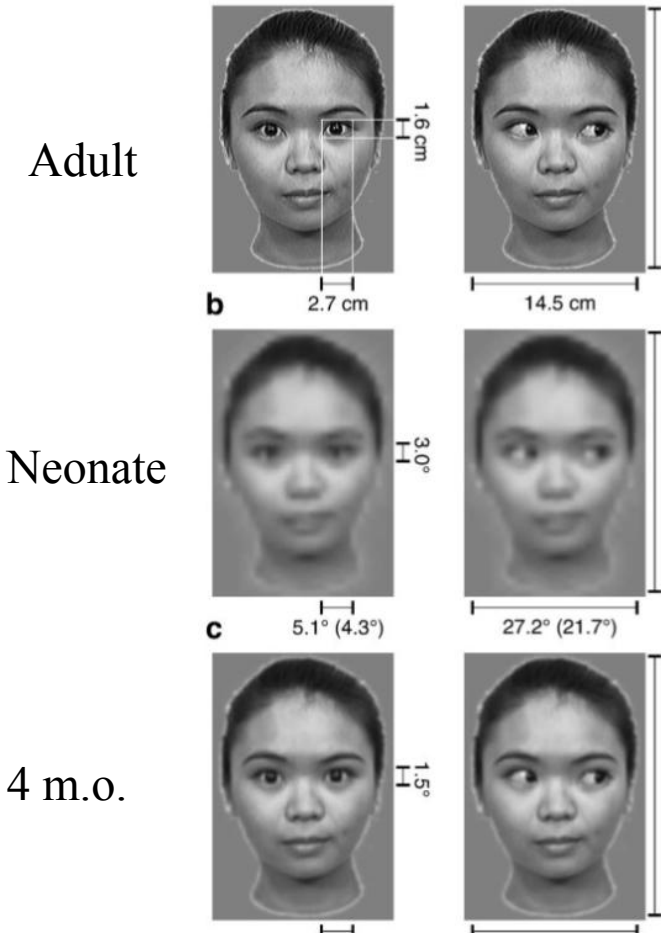
Innate Skills

Figure 2.4 *The arrangement of experimenter and infant in the replication of the Goren et al. study. Drawing by Priscilla Barrett.*

-newborns(!) will turn their heads further to follow a representation of a human face, than to other stimuli

4-Month-Olds Prefer Direct Gaze

Preference for direct gaze: Faronni et al., 2002

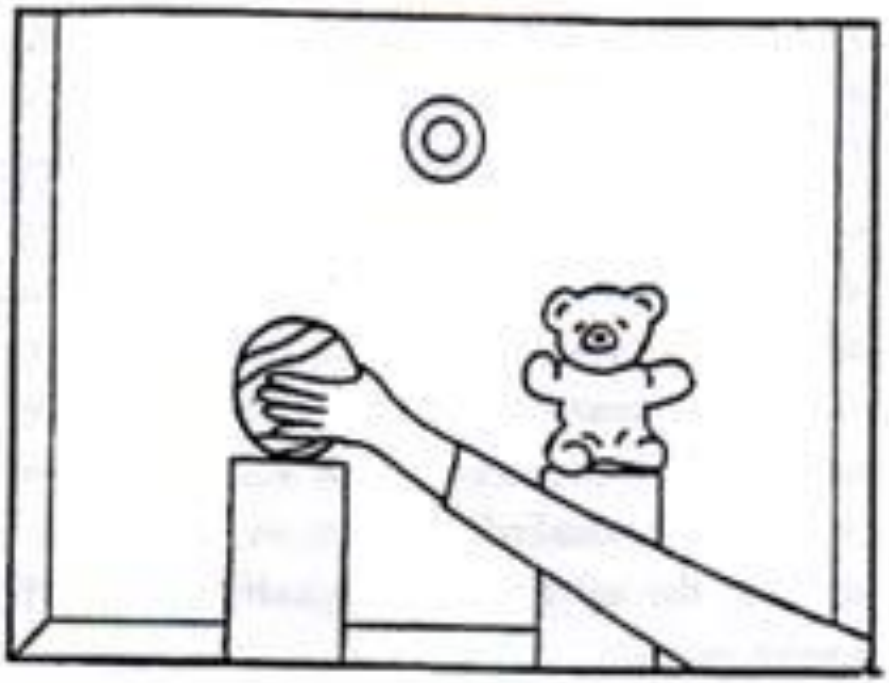


Newborns fixate longer, orient faster to direct gaze

ERPs show enhanced face processing for direct gaze (4 m.o.)

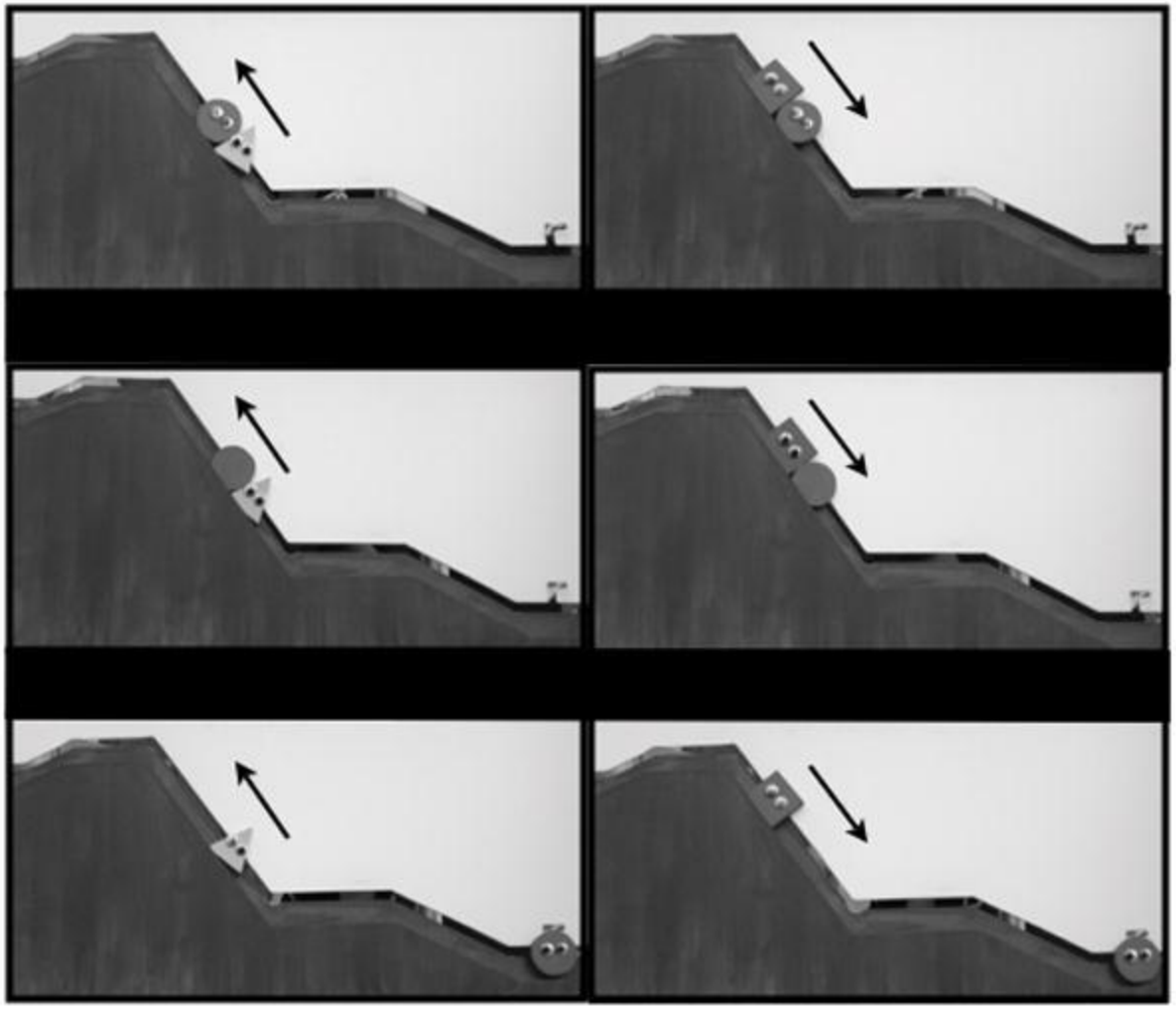
6-Month-Olds Infer Goals

(Woodward, 1998)



6-month-old infants are surprised when hand reaches for new object, not new location (opposite for inanimate reaching tools)

… And Prefer Helpers



10-Month-Olds Point

Pointing (10 m.o.), bringing objects into another's line of regard (Bates et al, 1979; Lempers et al., 1977)

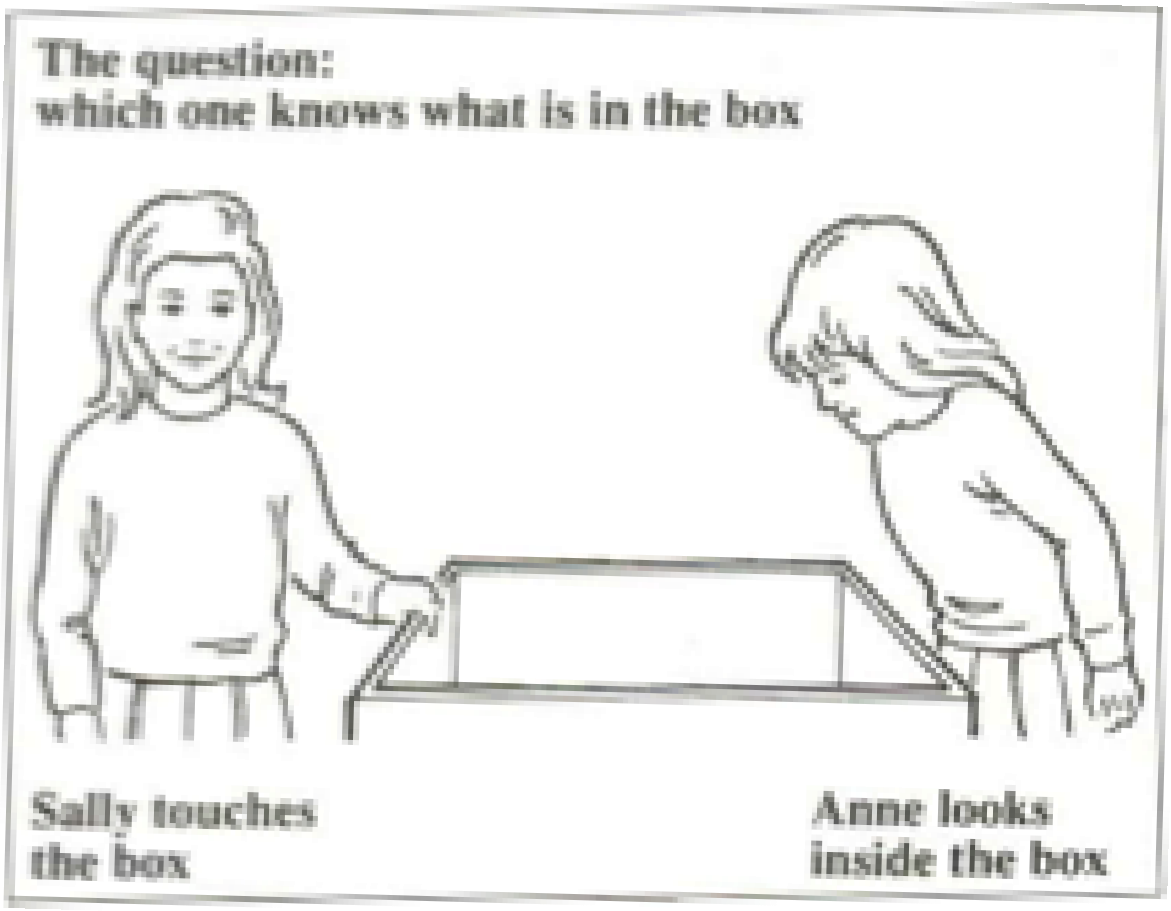
18-Month-Olds Lie/Pretend

Pretend Play: Comes about at 18-24 months
(Leslie, 1987)

Also in this window: understanding others have different desires from you

3 Year Olds Can Take Perspective

Seeing-leads-to-knowing Tasks: Around 3 years
(Pratt & Bryant, Baron-Cohen et al)



4 Year Olds Pass False Belief Tasks

Empiricist Perspective

- **Theory Theory:** Children solve this piece by piece, slowly figuring out how human beings work
- They each follow a similar process, so milestones show up around the same time
- Around age 4, they have finally figured out Theory of Mind
  - Addendum: Language is part of this process

Language changes thought: Theory of Mind

3 year old children understand :

"Johnny is thinking about his dog"

and

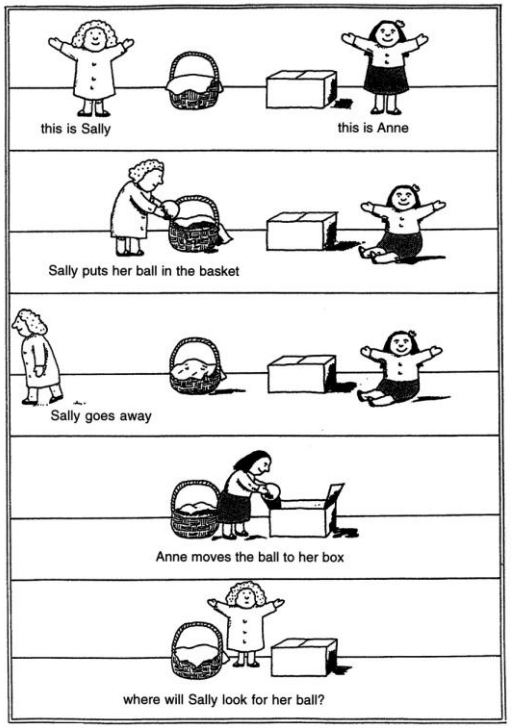
"Mary wants an apple"

Language changes thought: Theory of Mind

…but not: *"Sally thinks that her ball is in the basket."

Children come to pass false belief tasks when they come to master the syntax of embedded sentences.

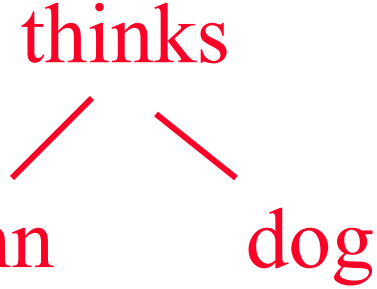
Hypothesis: false belief reasoning depends on natural language syntax.



How could language learning produce new conceptions of mind?

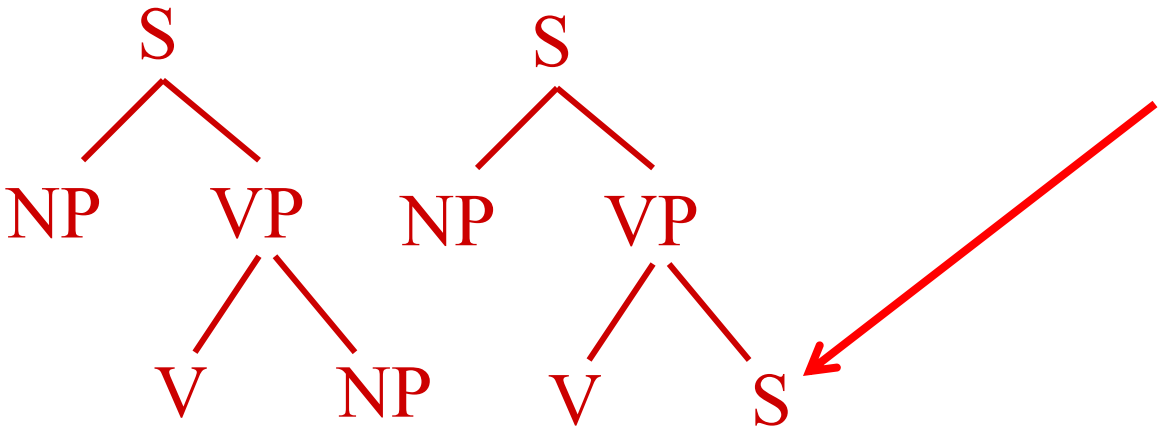
Understanding of persons:

John thinks about his dog.

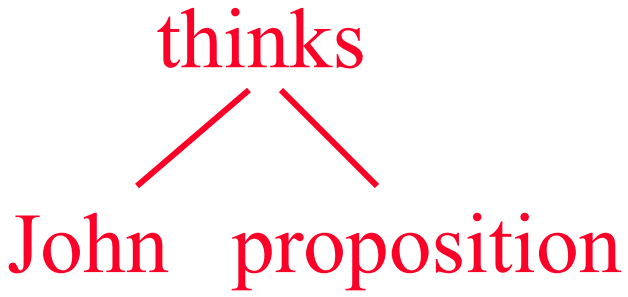


Learning English:

John thinks the leaf is green.



Constructed knowledge of propositional attitudes:



ToM and Language

Step 1. Child masters basic sentences: “Doggy chased the ball.” True sentences that match reality.

ToM and Language

Step 2. Child encounters discrepancy between sentences and reality; learns to recognize pretense, mistakes.

“Doggy chased the ball” [but it’s the cat!]

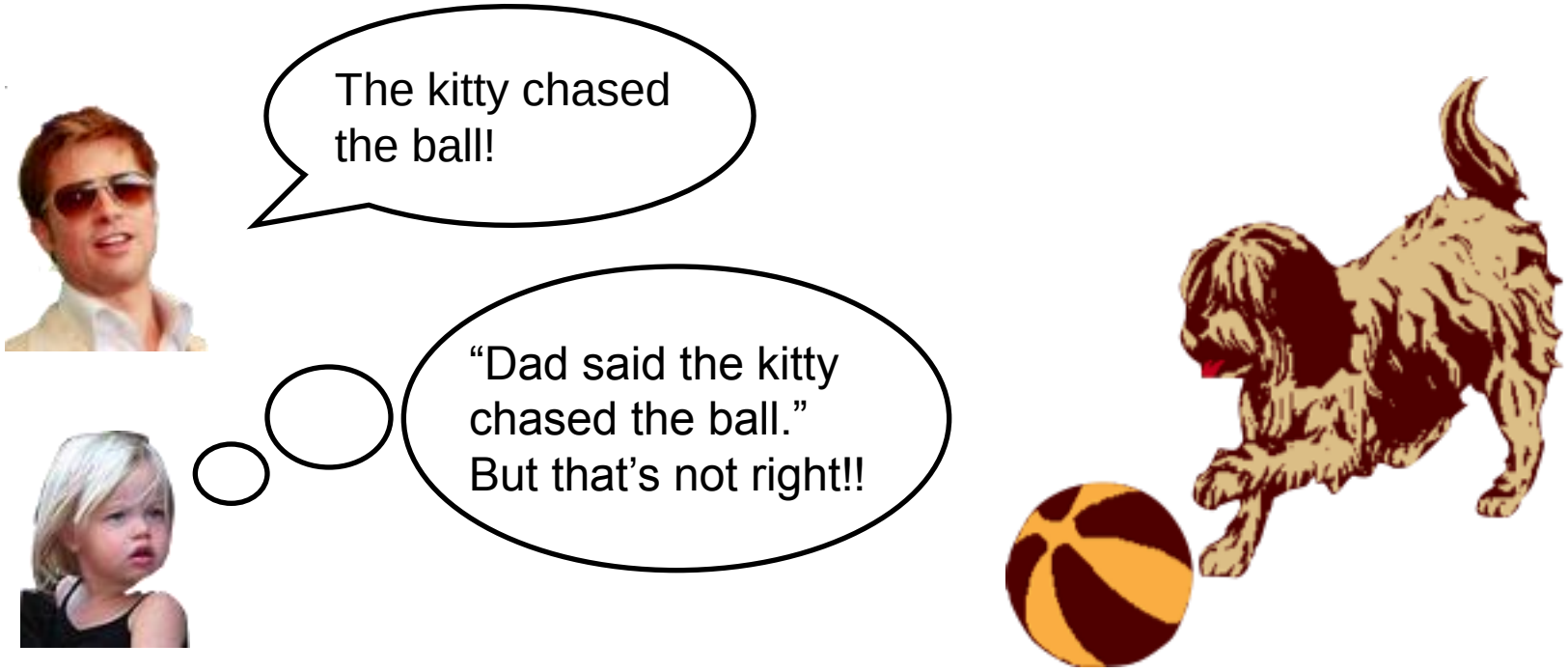
ToM and Language

Step 3: Child masters first embedded structures with communication/mental state/desire. Child acquires embedding syntax, but makes no accommodation of meaning within structure. Proposition inside the thought is always considered true.

"Brad said the doggy chased the ball."

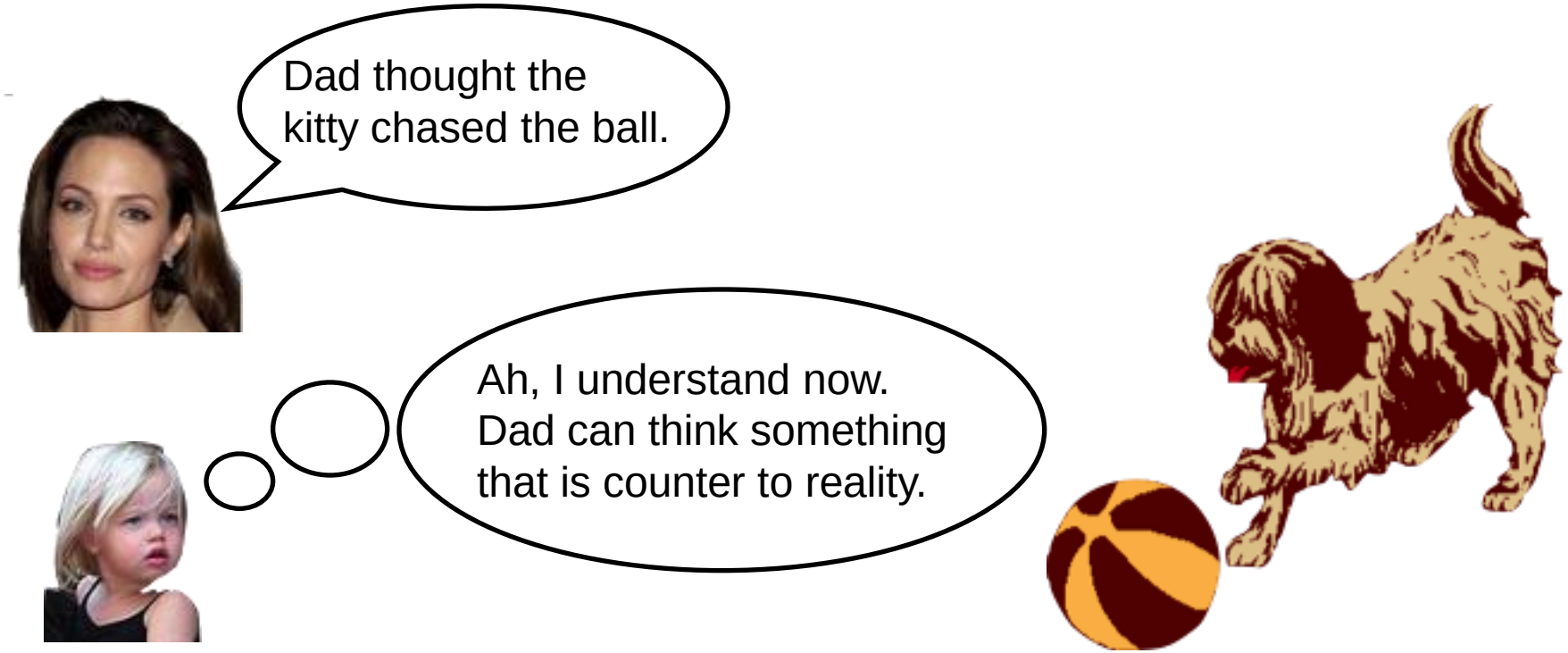
ToM and Language

Step 4. Child notices during communication verb sentences (e.g., said) that complement can be false; reports of lying, mistakes. Statements are overt, can be compared to reality.



ToM and Language

Step 5. Mastery of opacity understanding is extended to verbs of mental states (e.g., believe).



ToM and Language

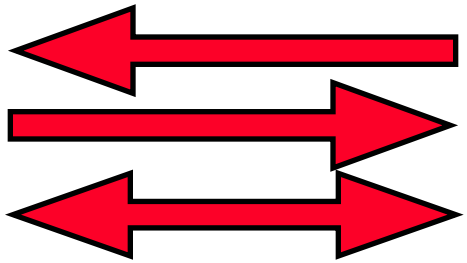
Between 3 and 4 years, children learn embedded syntax, and come to explicitly represent propositional attitudes in language.

These representations are central to explicitly viewing persons as having mental lives: representations of the world that are *distinct from reality*.

In order to understand propositional attitudes and pass a false belief task, children must be able to represent them. **Language scaffolds this.**

ToM and Language

1. Correlation between performance on ToM false belief task and ability to produce and comprehend sentence complements (de Villiers & Pyers, 1997, 2002)

Complements  False Belief

ToM and Language

- 2. These guys really struggle with false belief tasks
  - No exposure to language early on hurts ToM performance

ToM and Language

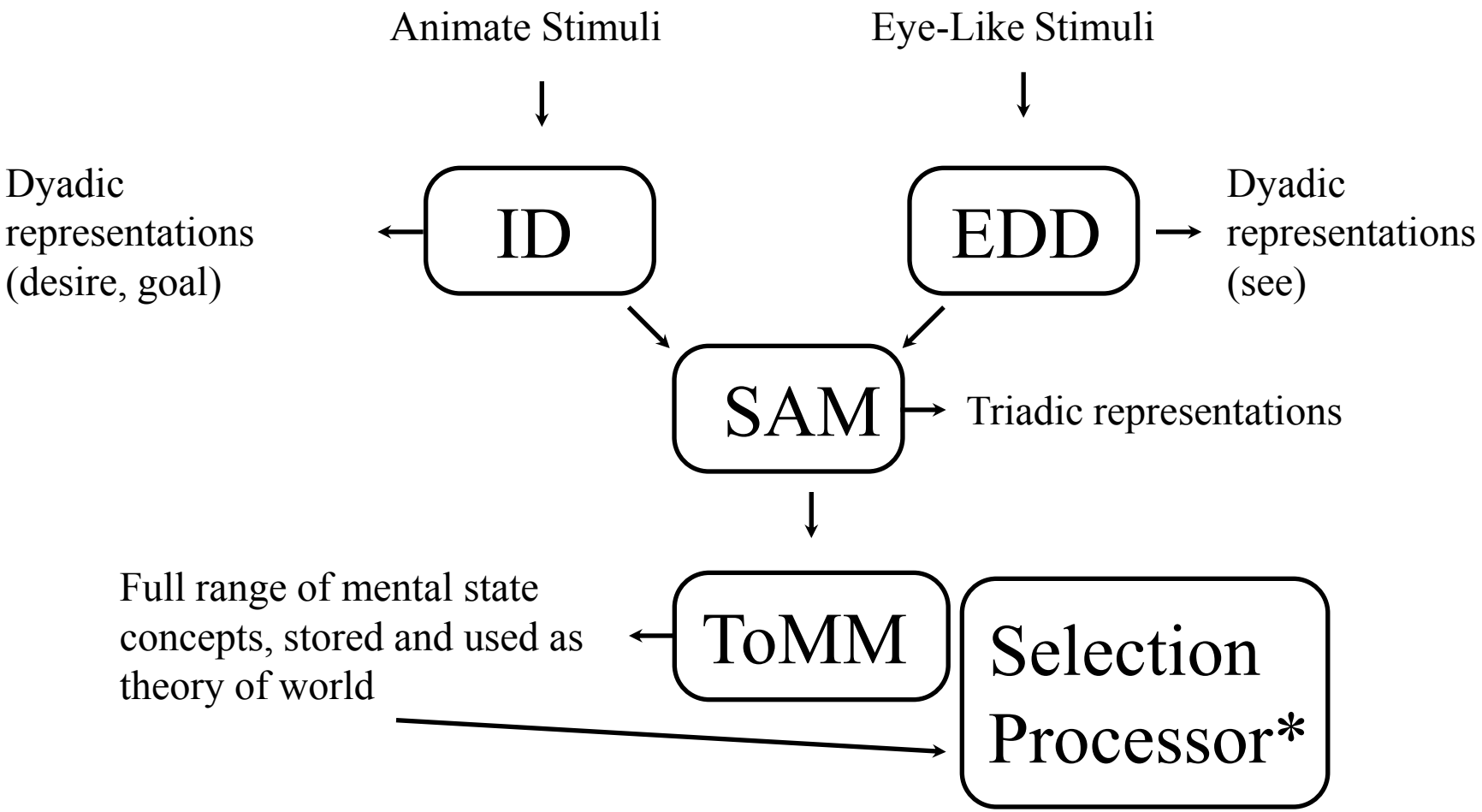
3. Deaf children raised by hearing parents exhibit delayed ToM (de Villiers, Pyers, Gale)

loving households,
normal IQs, all else equal
but language mismatched

A Nativist Theory: ToMM (Theory of Mind Module)

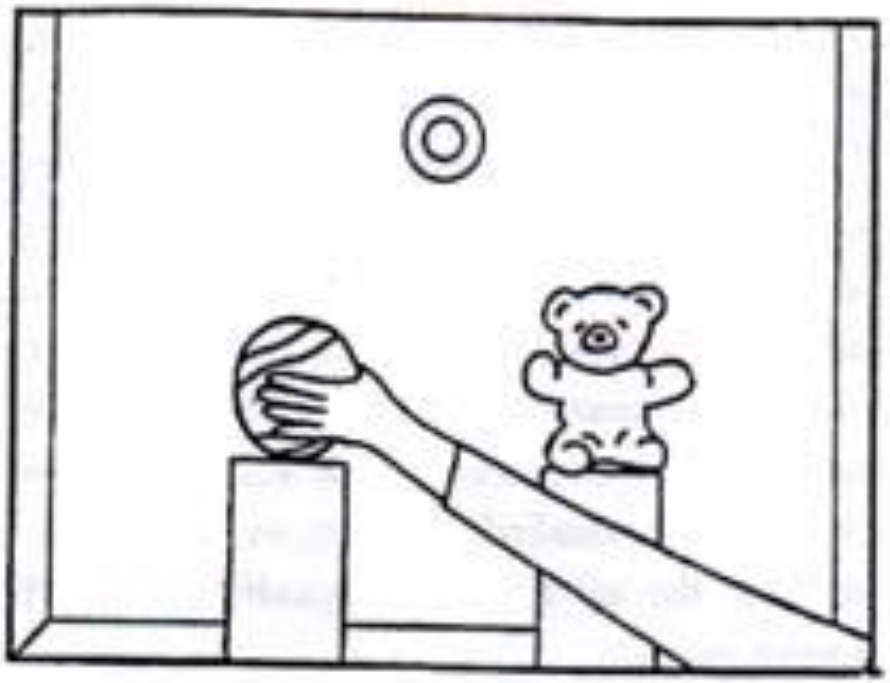
- **Theory Theory** is a highly empiricist account of how we learn about our social world
- A good nativist theory, **ToMM**, says we are born with a 'module' for reasoning about beliefs in our brain (Baron-Cohen, Leslie, Fodor)
- This module isn't able to function until around age 4, at which point children are able to think about others' thoughts

The Modular View



Evidence for ID (Intention Detector)

(Woodward, 1998)



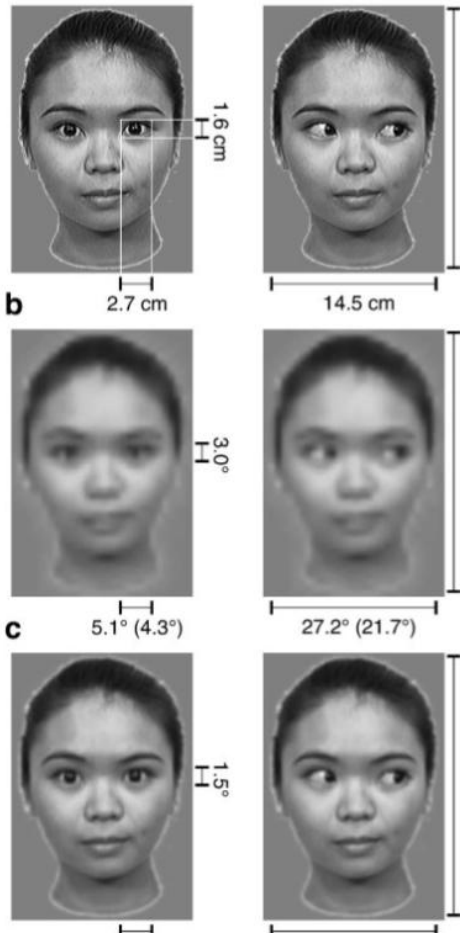
Infants assess goals by 6 months old

Evidence for EDD (Eye Direction Detector)

Adult

Neonate

4 m.o.



Infants prefer faces innately, respond to direct eye gaze by 4 months old, follow gaze by 9 months old

Evidence for SAM (Shared Attention Mechanism)

Infants follow your gaze/points and point to things by 10 months old

Baron-Cohen's Modularity

- All modules are innate, but rely on the right input to demonstrate their function
- EDD and ID can show off early
- SAM takes input from the two of them
- ToMM relies on input from SAM
  - So why is ToMM not showing up soon after SAM?

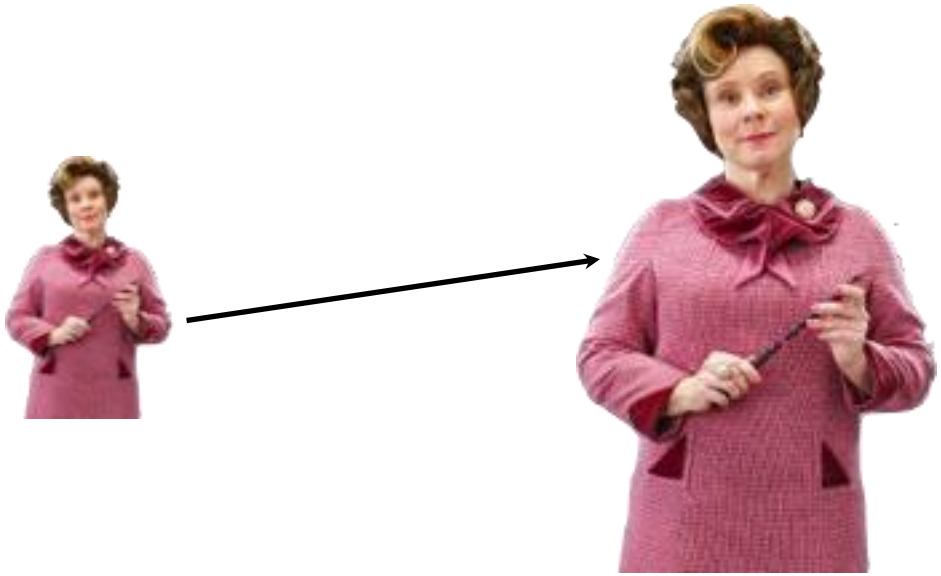
Selection Processor* (SP)

Analogous to (or perhaps *is*) the child's developing executive function

Helps child inhibit the true state of affairs, in order to choose the false (but mentally true) option

Selection Processor* (SP)

Some modularity theorists (e.g., Leslie) say this is the *main* developmental change, and ToMM exists and is largely innate



False Photograph Control: Executive Function (Zaitchik et al.)

Controls for executive function and for many linguistic and information processing demands of the task

Two characters interacting with an object

One character takes picture of object in location 1 (bed)

Object gets moved to location 2 (tub)

False Photograph Control: Executive Function

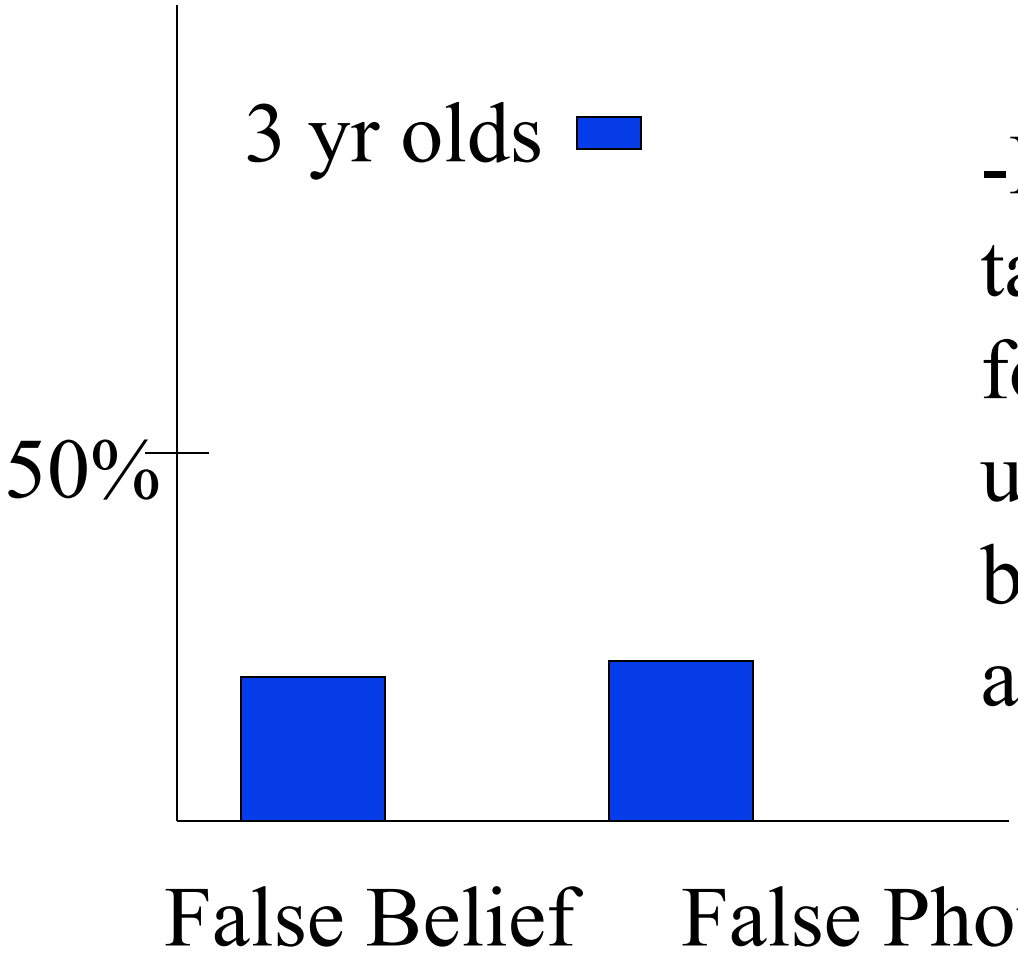
Test question: Where is the object in the photograph?

In the tub (actual state of world)

In the bed (photographic state of world)

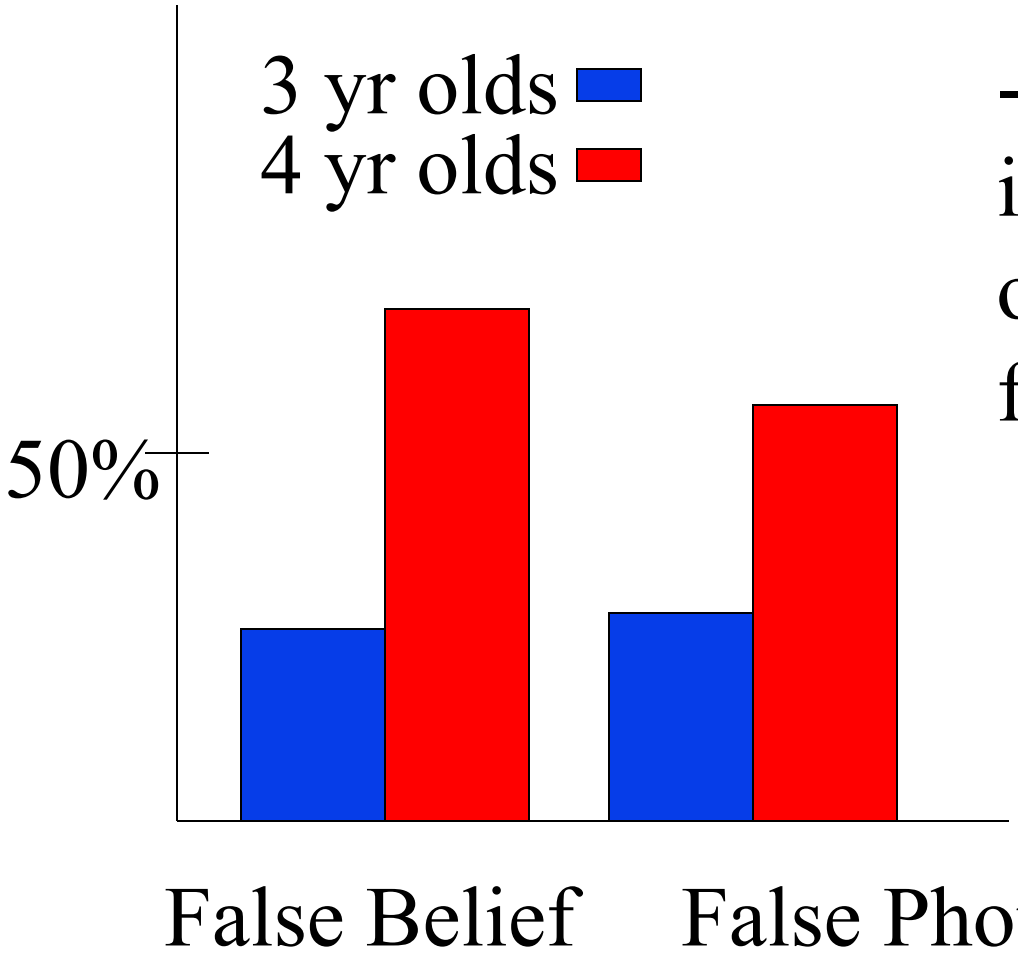
To get this right, must inhibit *actual* state of the world

False Photo Task



-Maybe the false belief task is just too tricky for young kids, w/ underdeveloped brains and cognitive architecture?

False Photo Task



-Comparable improvement on the false belief and false photo tasks

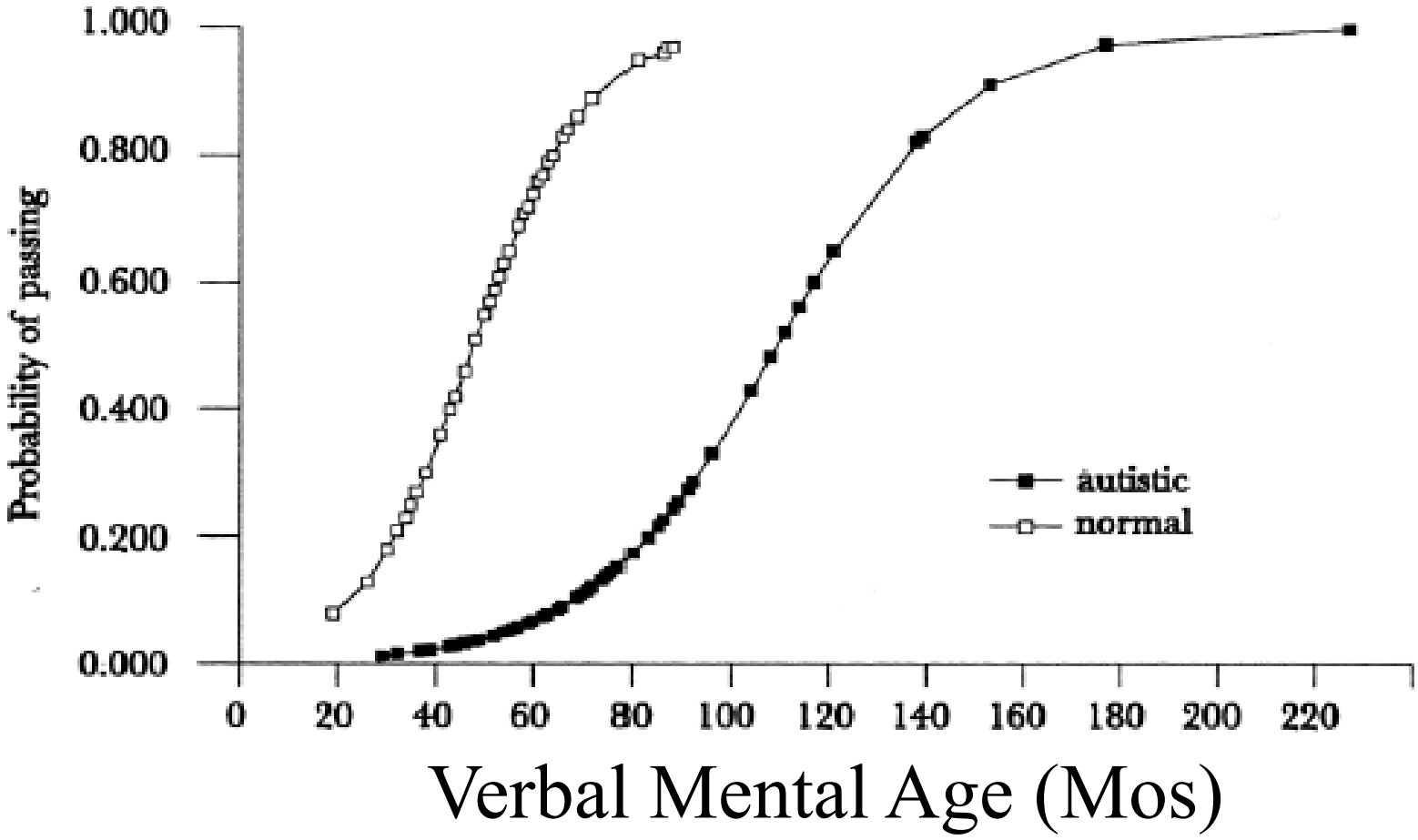
Evidence for a ToMM?

- So, why modularity?
  - Both theories explain the data, and empiricism is more parsimonious…
- We can't tell if children have a ToMM before age 4, because the tasks to assess it require too much executive function
  - Selection processor is under-developed
- Given the research on ToM development and language, what makes us think it still exists?

Autism

- Don’t develop normal social relationships
- Impaired communication & language development
  - problems with ‘I’ *vs* ‘you’
- Rigid behavior
  - lack of imagination (no pretend play)
  - repetitive behaviors
- **Fail false belief tasks**

Rates of False Belief Passing



Autism and ToMM

Dismal failures at classic false-belief tasks (compared to mental-age matched controls, or even Down's syndrome controls); only about 25% of high-functioning autistic adolescents pass

Two interpretations of data

Fundamental deficit in autism: Theory of mind

Fundamental deficit in autism: Executive function (Selection Processing (SP))

False Photograph Tasks

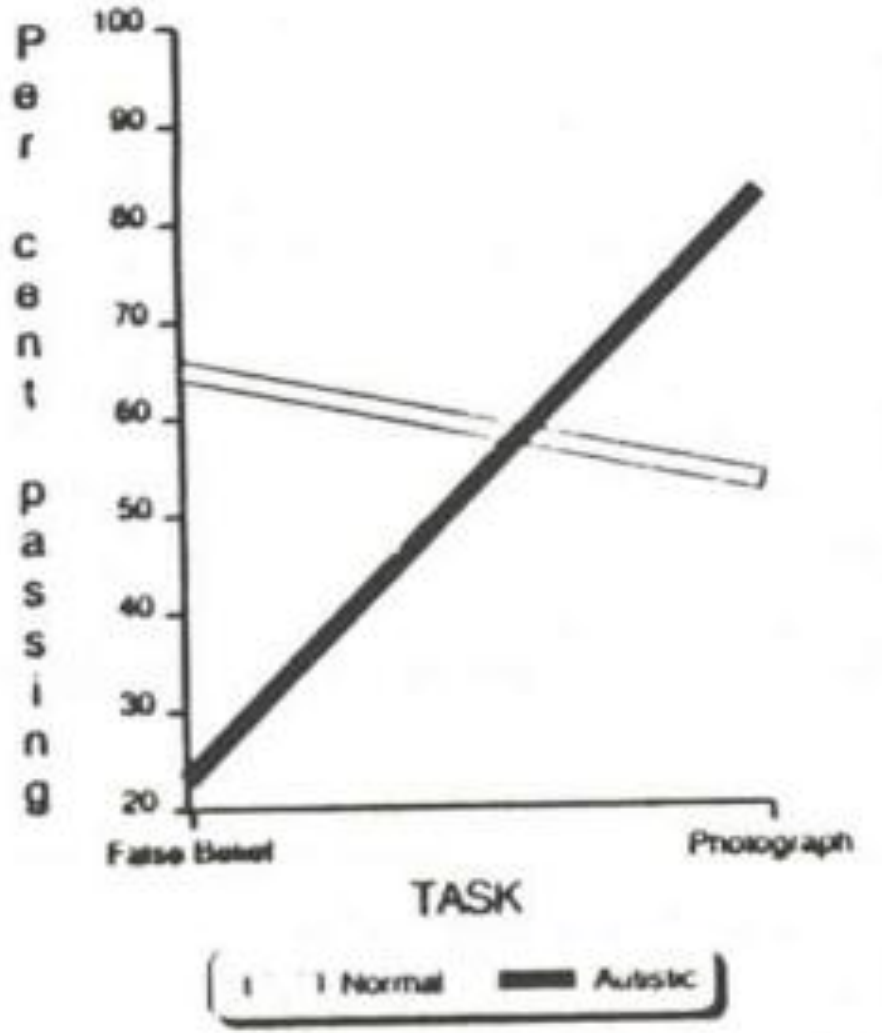
Alan Leslie's research

Normal children—age 4, verbal mental age, 4:8

Autistic children—age 11, verbal mental age 6:8

Tested both groups on false belief tasks, false photograph tasks

Results- False Photo Task

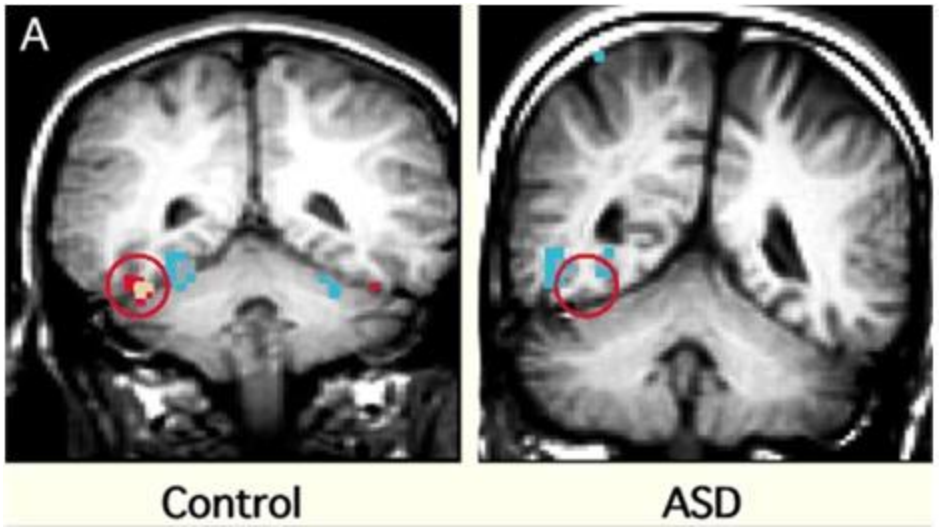


Nativism and Autism

- Although it's tempting to take the more parsimonious empiricist approach, there is clearly some piece of machinery in place that can malfunction in autism, which produces our theory of mind
- What might that machinery be?

ToMM in the Brain

- Fusiform face area?
  - Recent research shows that individuals with autism do *not* process faces the same way typical individuals do
    - » They are not worse at it, but they do not show activation in FFA, instead showing activation in various individual-specific regions

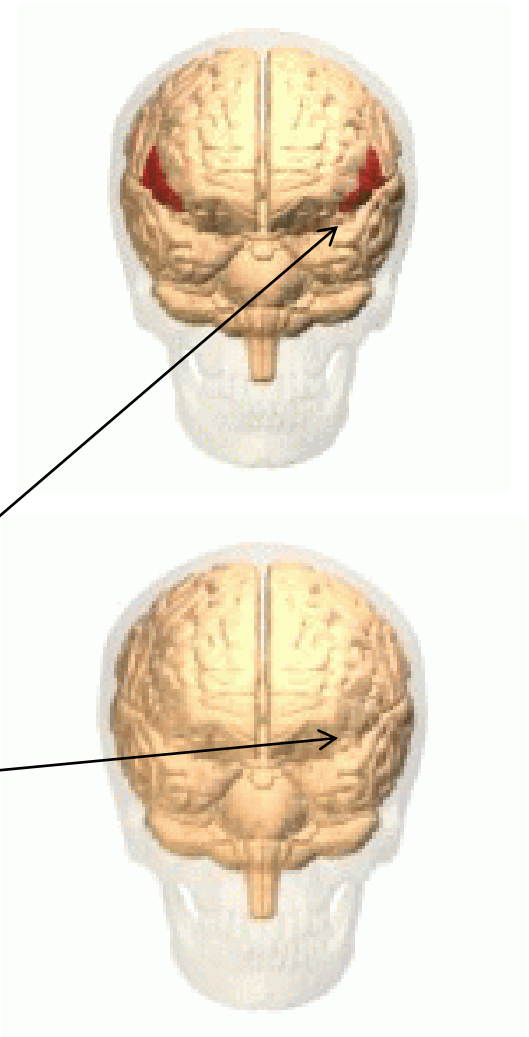


ToMM in the Brain

- Mirror neurons?
  - In the 1990s, researchers discovered neurons in macaques that fire both when executing an intentional action (e.g. grasping an object) *and* when watching someone else execute that action

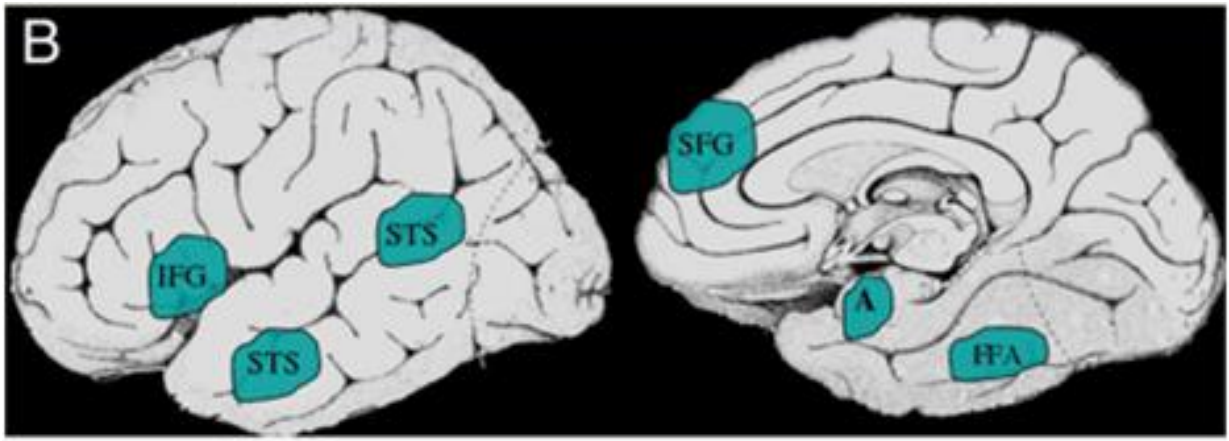
ToMM in the Brain

- These neurons exist in humans too, found mostly in the inferior frontal cortex and superior parietal cortex (and relying on visual input from the superior temporal lobe sulcus)



ToMM in the Brain

- Regions where we find reduced activity in autistic individuals vs. typical individuals



- Notice FFA, IFG and STS issues
-Also notice other more interior regions, like SFG and amygdala
-At present, conclusions are hard to draw…

Cognitive Development Summary

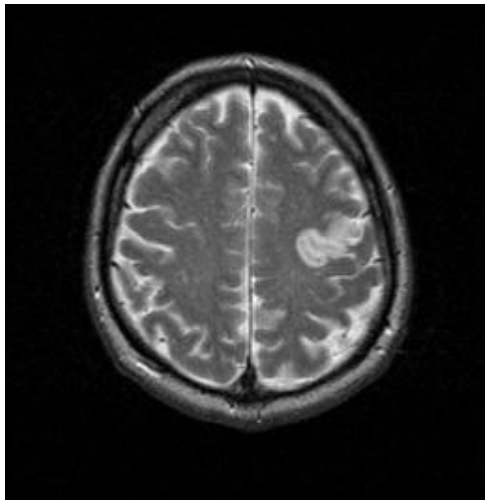
- From birth, children start building representations of objects
  - Some notions of space, time, object, causality seem to be in place from birth
- From birth, children start building representations of other humans
  - Some social expectations seem to be in place from birth
    - » Maybe ID, EDD, SAM and ToMM are there from the start, maybe less than that

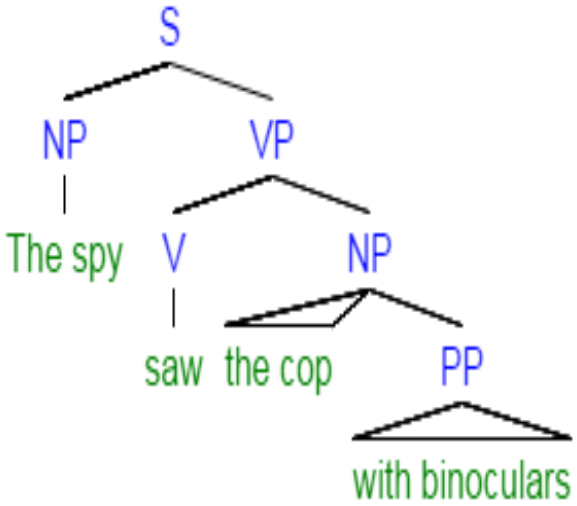
Cognitive Development Summary

- But we know there is some machinery that allows us to do theory of mind, because it appears to be missing in individuals with autism
  - The nature of that machinery is a wide open question…

Mega Summary!

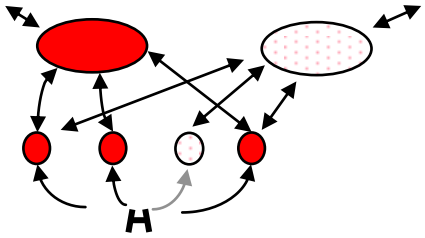
- The human brain processes tons of symbolic information on a massive probabilistic network
  - We need *lots* of domains and *lots* of levels of representation to do this

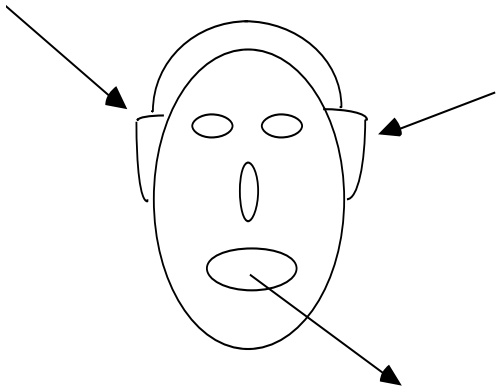


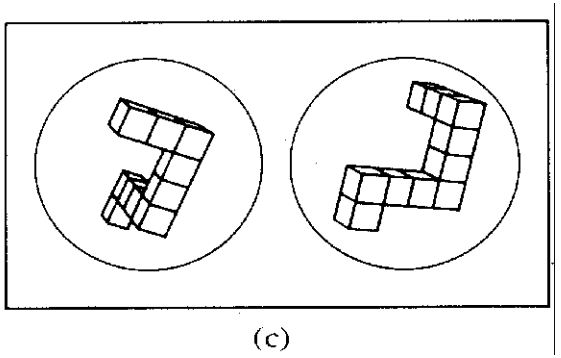


Mega Summary!

- The human brain uses bottom-up and top-down processing to process input
  - We can only process one stream of input at a time (mostly)
  - We turn most of that input into symbolic info, but keep some info in raw, perceptual form

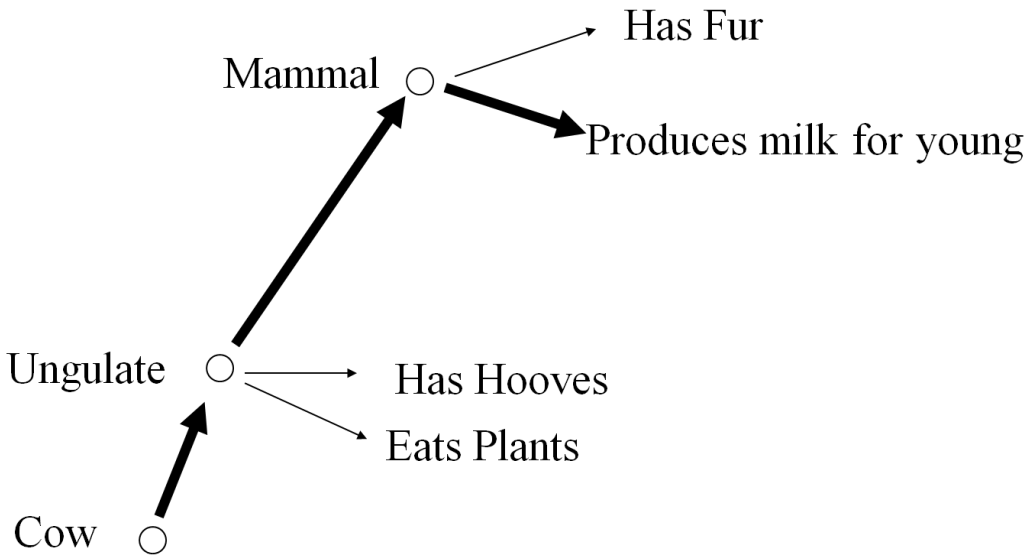






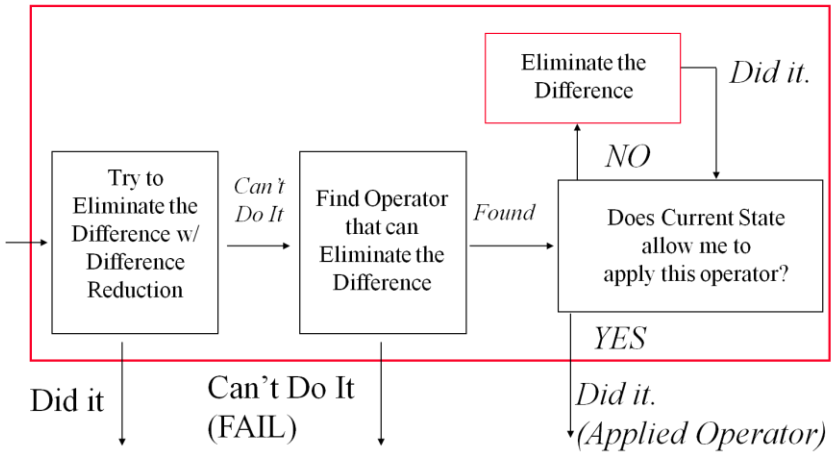
Mega Summary!

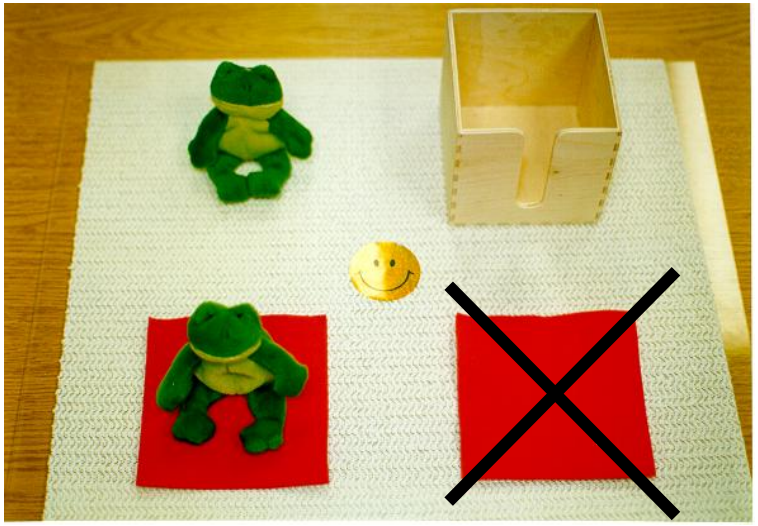
- The human brain uses this input and this network to build a huge, interconnected framework of symbolic knowledge
  - This framework relies on spreading activation



Mega Summary!

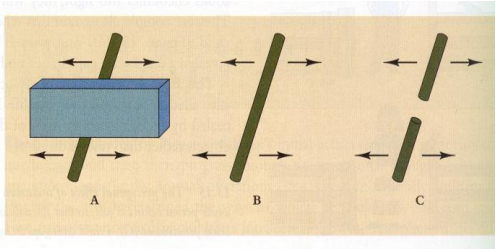
- The human brain uses this knowledge (and unique creative abilities) to deal with new information throughout life





Mega Summary!

- The human brain seems to get a head start, with some basic information already in the framework from the get-go…
  - Language, object, and social expectations



Mega Summary!

- The human brain is an amazing machine!!
  - We hope you think so too ☺