
A CASE STUDY: EXPLORING MINDREADING

PRETEND PLAY AND METAREPRESENTATION

METAREPRESENTATION, AUTISM, AND THEORY OF MIND

THE MINDREADING SYSTEM

UNDERSTANDING FALSE BELIEF

MINDREADING AS SIMULATION

THE COGNITIVE NEUROSCIENCE OF MINDREADING



PRETEND PLAY AND METAREPRESENTATION



PRETEND PLAY

- Self-directed: drink from an empty cup, eat from a spoon with nothing on it
- Other-directed: pretending a toy vehicle makes a sound, a doll is saying something
- Object substitution: pretending a banana is a phone, Imaginary friends

Pretend play engages fairly sophisticated cognitive abilities. Child should be able to represent objects and properties not perceptible in the immediate environment

ALAN LESLIE: BASICS OF INFANT PRETENSE

Pretending a banana is a telephone:

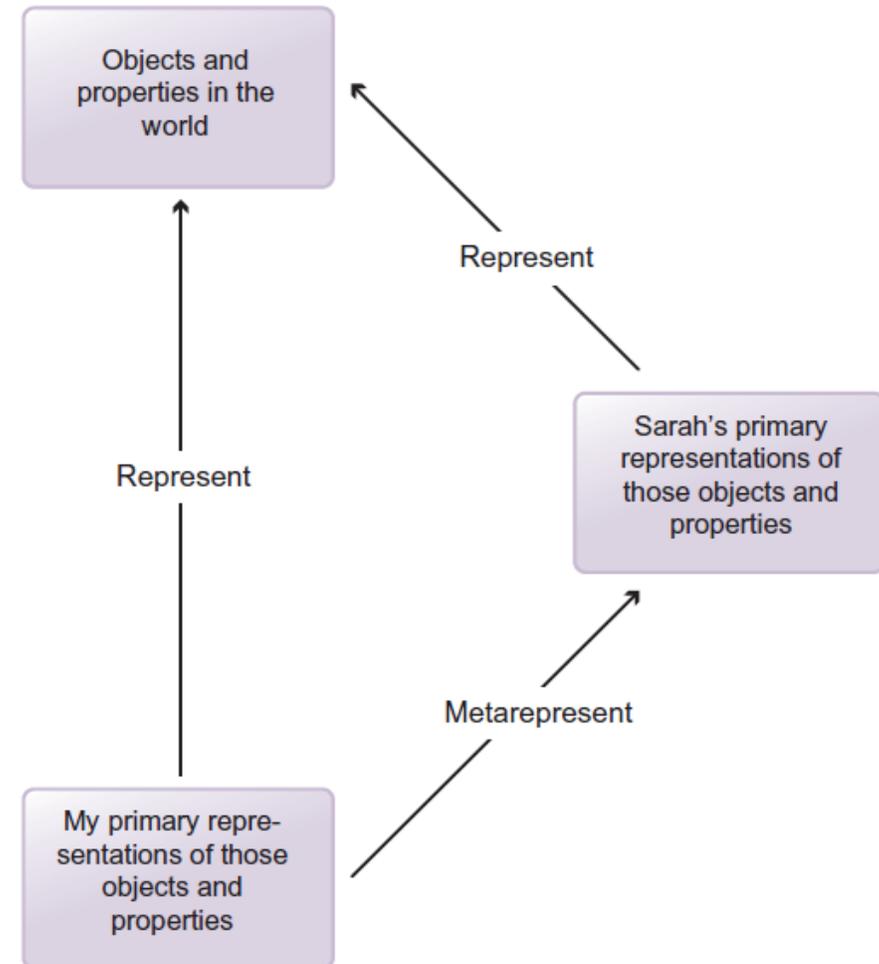
- Pretend play in the infant depends crucially on how the infant represents the world (and hence on her primary representations).
- We cannot explain what is going on in pretend play simply with reference to the infant's primary representations (primary representation and pretend representation contradict each other)
- The pretend representations must preserve their ordinary meanings in pretend play

Parallel between how representations function in pretend play and mind reading. Pretend representations are quarantined from ordinary primary representations.

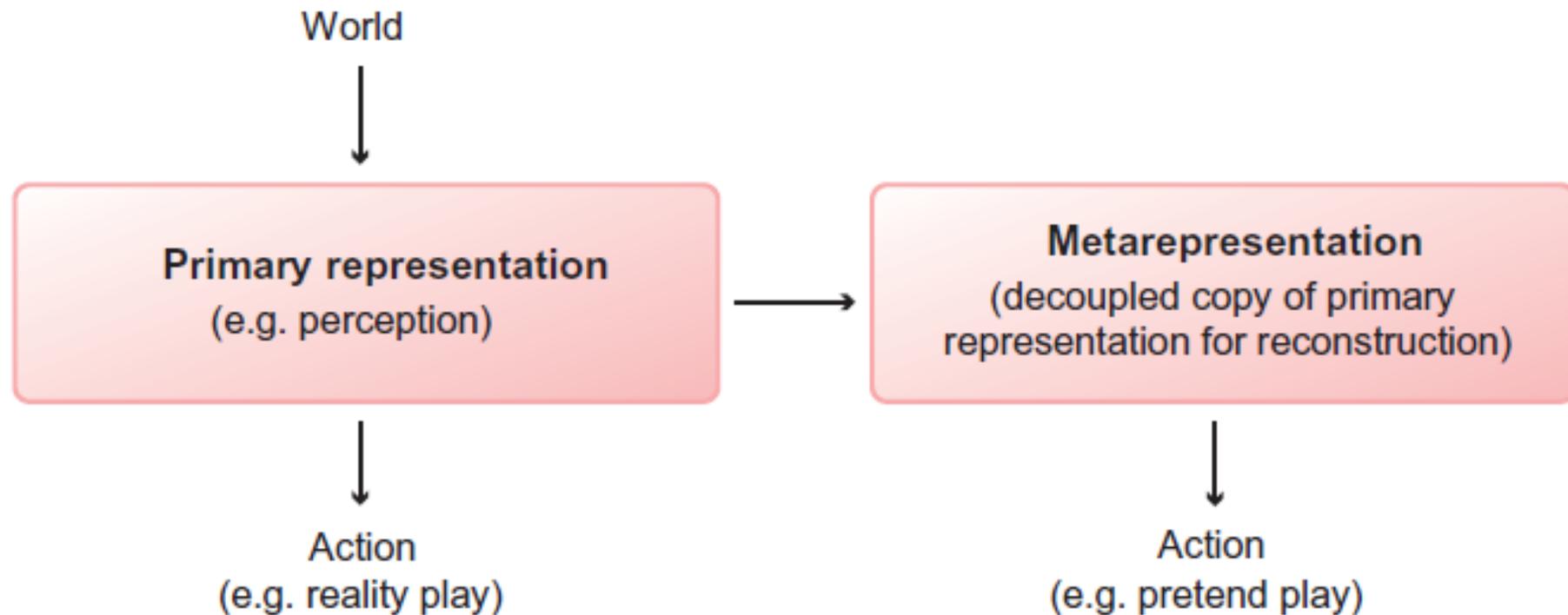
Ex) "Sarah believes that the world is flat." – Sarah's state of mind, not mine.

METAREPRESENTATION

- “Sarah believes that the world is flat.”
- This sentence is not about the world anymore. It is more about Sarah’s state of mind – Decoupling
- Leslie argues, the mechanism that decouples primary representations from their usual functions in the context of pretend play is exactly the same mechanism that decouples primary representations from their usual functions in mindreading



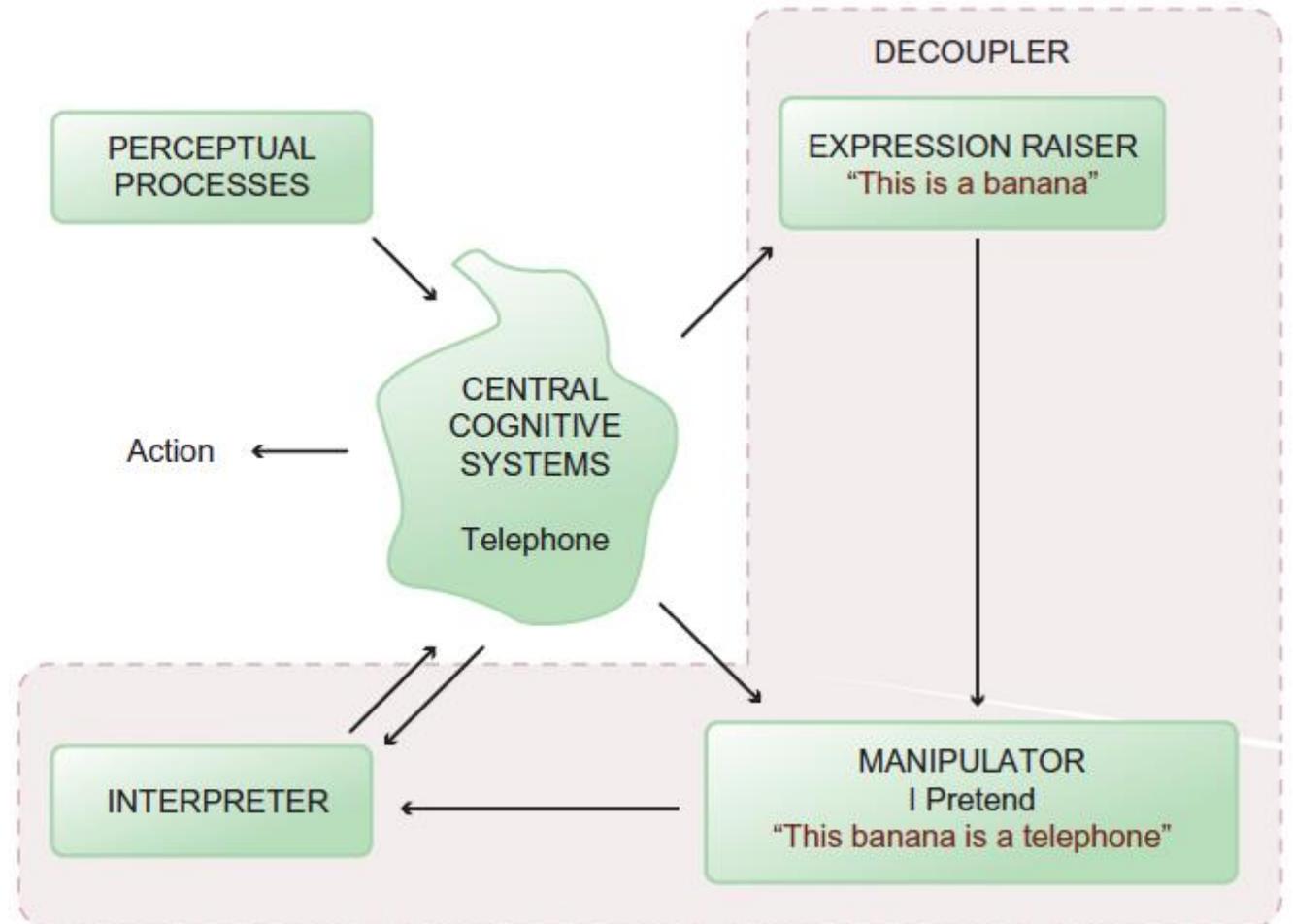
LESLIE'S MODEL OF PRETEND PLAY



Physical symbol system hypothesis

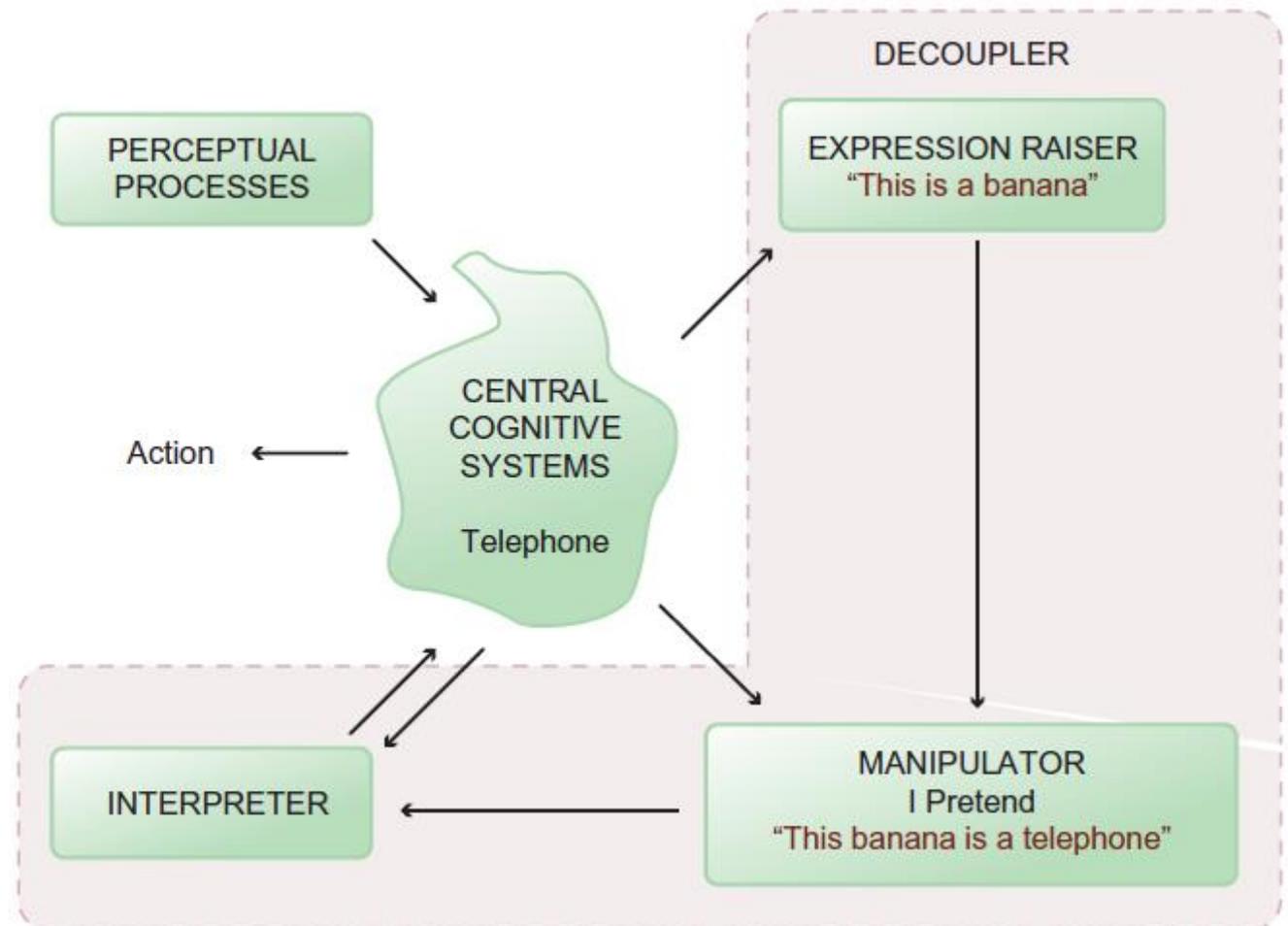
PRETEND OPERATION

- I PRETEND “*This banana: it is a telephone.*”



THE LINK TO MINDREADING

- Other operation – BELIEVE, DESIRE, HOPE, FEAR, etc.
- Agent BELIEVES “It is raining.”





METAREPRESENTATION, AUTISM, AND THEORY OF MIND



AUTISTIC CHILDREN AND PRETEND PLAY

- Autism involves deficits in social understanding, social coordination, and communication.
- However, autistic subjects can have high IQs.
- It is known that they are pretty bad at pretend play (used as a diagnostic tool)
- <https://www.youtube.com/watch?v=9MWMYuFKhtE>

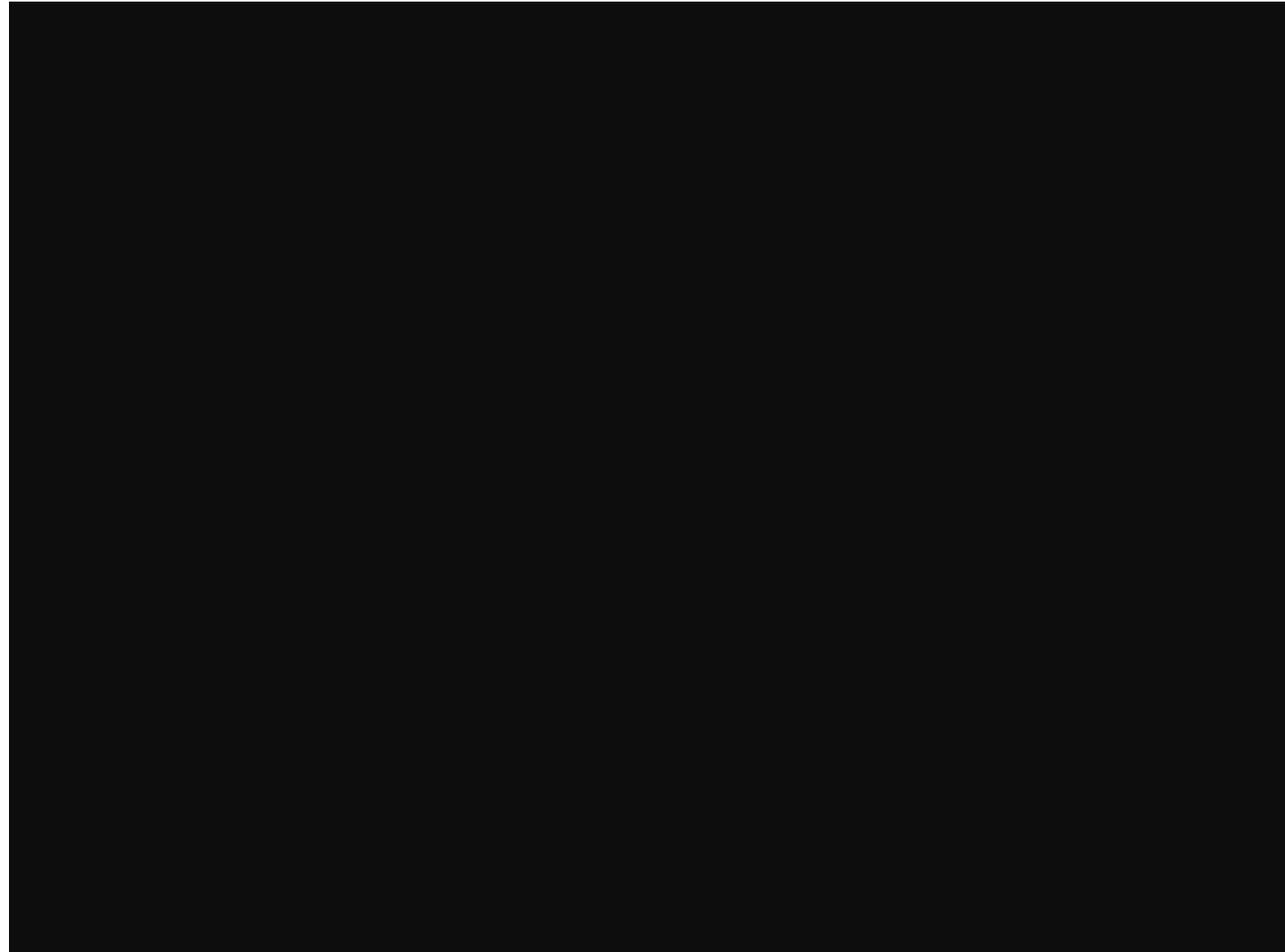
BARON-COHEN, LESLIE, AND FRITH 1985 STUDY

- Actual ages
 - Normal group: 3;5 ~ 6 years
 - Down syndrome group: 7 ~ 17 years
 - Autistic group: 6 ~ 16 years
- Autistic group was pretty bad at **false belief test**

TABLE 12.1 The three groups studied in Baron-Cohen, Leslie, and Frith 1985

POPULATION	MEAN VERBAL MENTAL AGE	MEAN NONVERBAL MENTAL AGE
Normal group	4;5	4;5
Down syndrome group	2;11	5;1
Autistic group	5;5	9;3

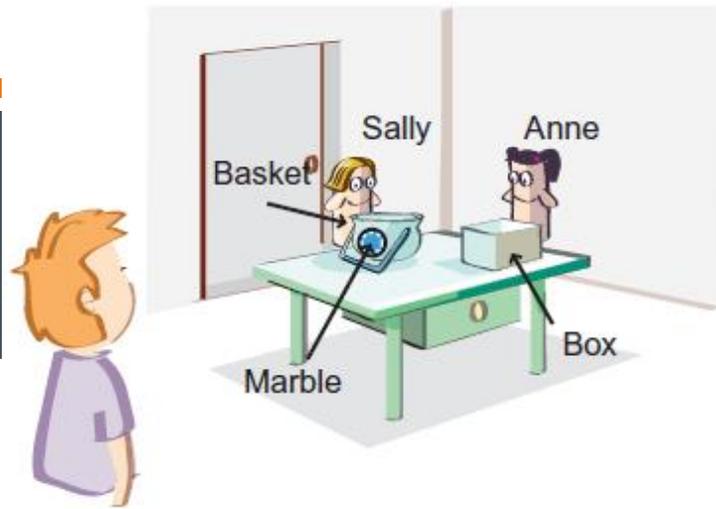
FALSE BELIEF TEST



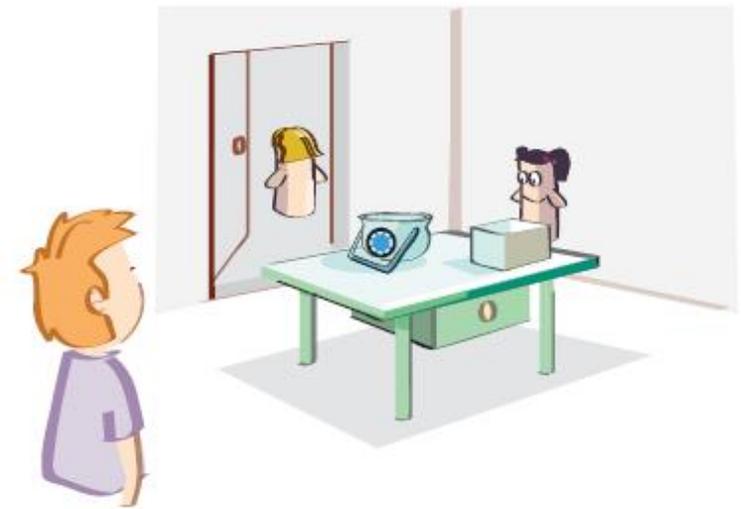
FALSE BELIEF TEST



FALSE BELIEF TEST



(a) Sally places her marble in basket.



(b) Exit Sally.

The Belief question

“Where will Sally look for her marble?”

The Memory question

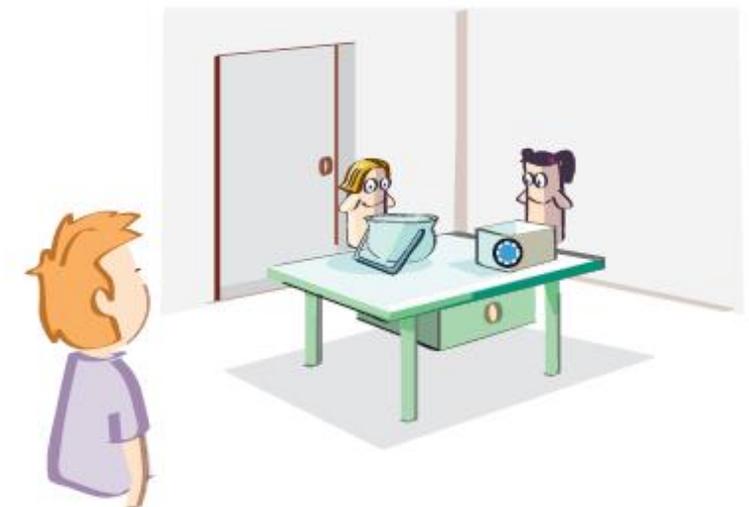
“Where was the marble in the beginning?”

The Reality question

“Where is the marble really?”



(c) Anne transfers Sally's marble to box.



(d) Re-enter Sally. The experimenter asks:
Where will Sally look for the marble?

FALSE BELIEF TEST

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For the memory question and the reality question, all three groups did pretty well.

For the belief question, normal and down syndrome group did pretty well (85 and 86 % correct answers).

However, autistic group did poorly on this question. Eighty percent of the autistic children failed the belief question!

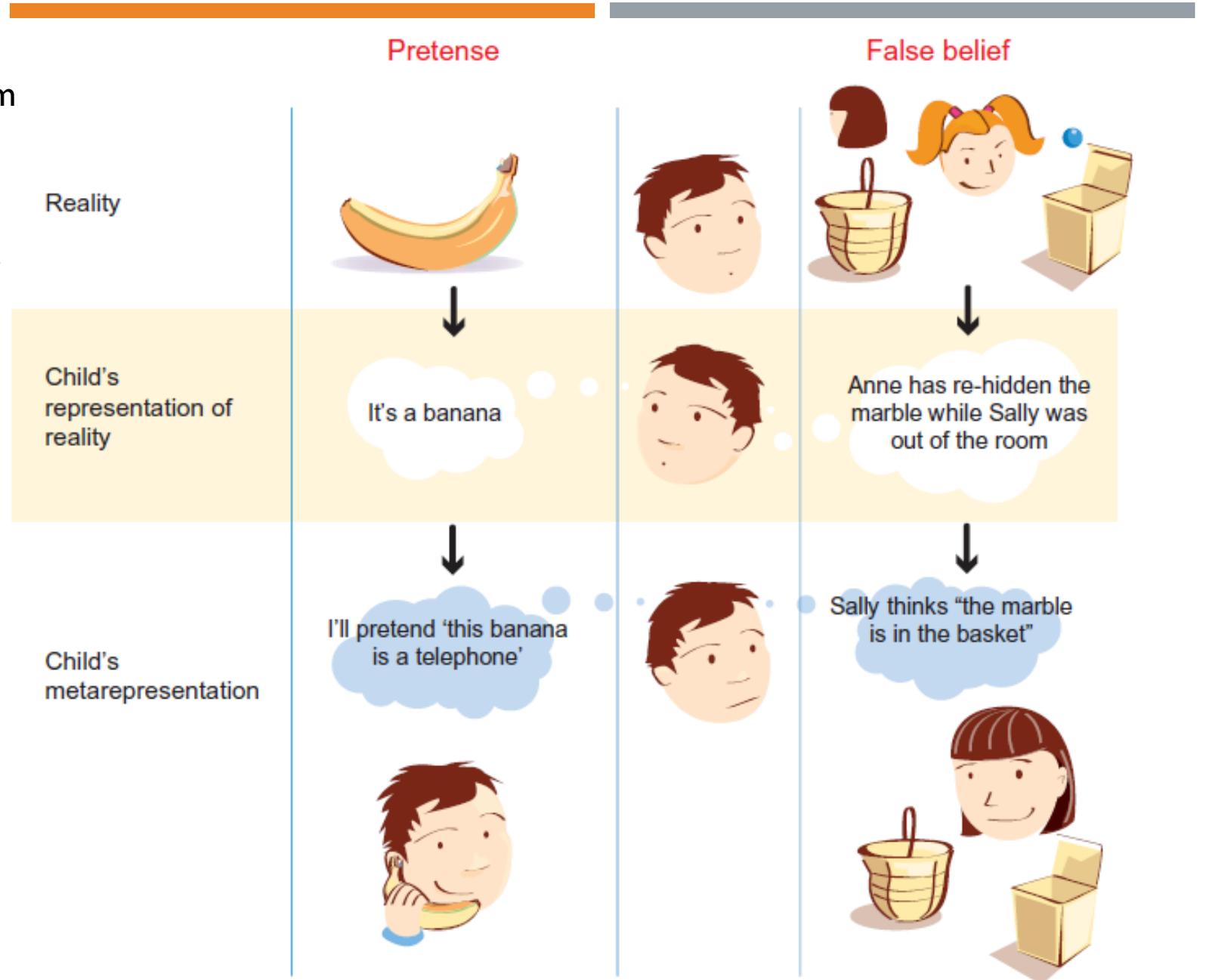
- > Autistic children fail to employ a theory of mind.

Autistic children's failure might come from inability to represent mental states.

They are bad at both pretend play and false belief. This might be because of their lack of mental representation.

Sally BELIEVES "The marble is in the basket."

AUTISM AND METAREPRESENTATION



PRETEND PLAY AND FALSE BELIEF TEST

Pretend play (PRETEND operation) emerges during the second year of life. However, children do not typically pass the false belief test (BELIEVES operation) until they are nearly 4 years old. **Why?**

Onishi and Baillargeon (2005) Test using habituation reveals that 15 months old infant can pass the false belief test.

-> Implicit understanding of false belief!

Distinction between implicit and explicit understanding of false belief



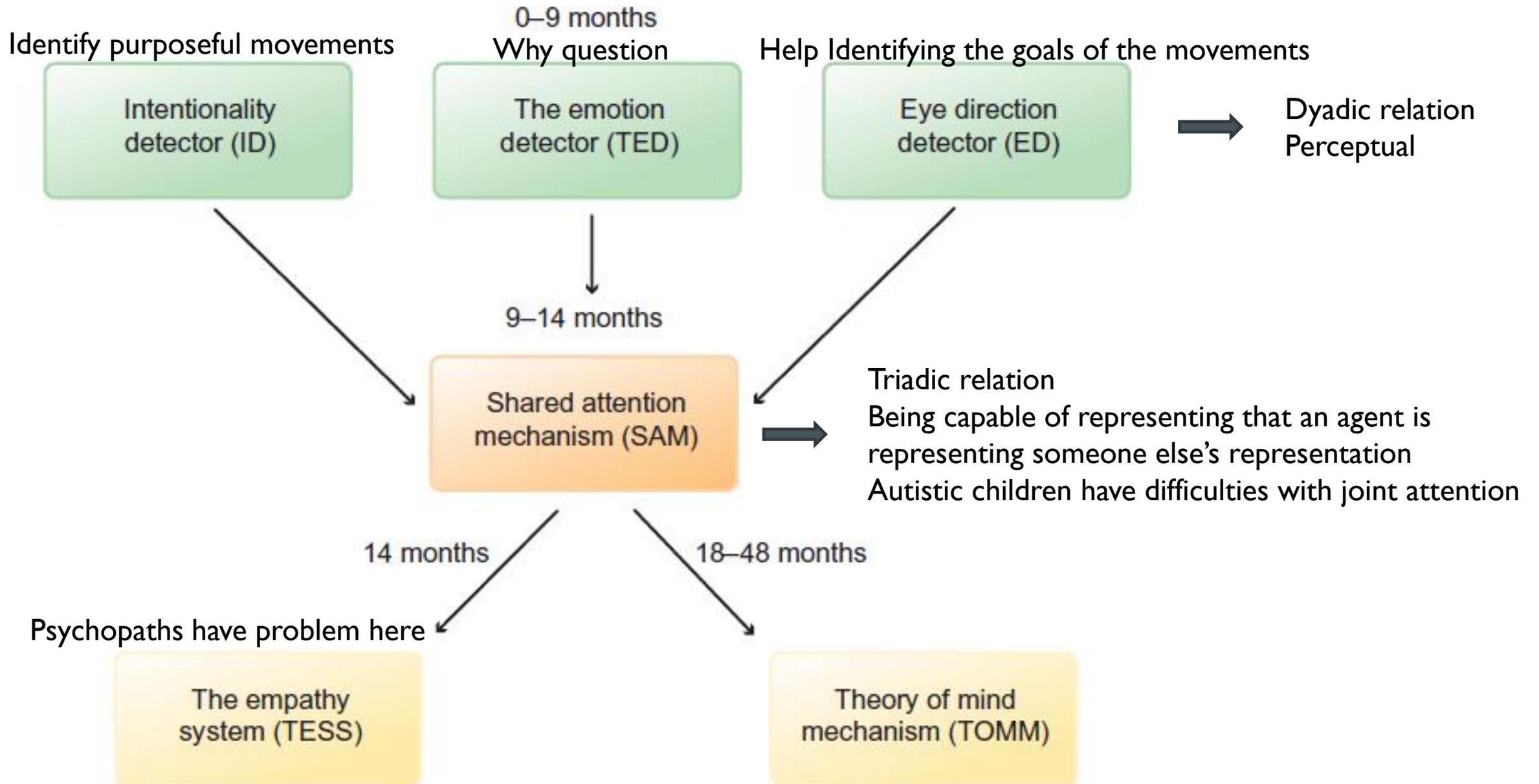
THE MINDREADING SYSTEM



TWO SETS OF QUESTIONS

- Are the mindreading skills of normal human children built on a foundation of more primitive cognitive abilities?
 - If so, then what does this tell us about the architecture of the mind?
 - What can we learn from the developmental progression of normal human children about the origins and causes of mindreading deficits such as those suffered by autistic children?
-
- What is it about understanding belief that makes it so hard for young children to perform the false belief task?
 - Are there alternative explanations of why it takes so long for young children to understand the possibility of false beliefs?

BARON-COHEN'S MODLE OF THE MINDREADING SYSTEM



WHY IS IT SO HARD FOR YOUNG CHILDREN TO PASS THE FALSE BELIEF TEST?

- The evolution of TOMM begins at around 14 months (pretend play) and is not complete until the child is around 4 years old (false belief test). Why it takes that long?
- I PRETEND “It is raining.”
- Mother BELIEVES “It is raining.”
 - They seem to have identical structure but the latter takes longer time to complete



UNDERSTANDING FALSE BELIEF



THE FALSE BELIEF TEST

- Two different abilities are required
 - The ability to attribute true beliefs to someone else
 - Attributing true beliefs is the default setting of the theory of mind mechanism.
 - The ability to attribute false beliefs
 - The young children should learn to inhibit the default setting.

THE SELECTION PROCESSOR HYPOTHESIS

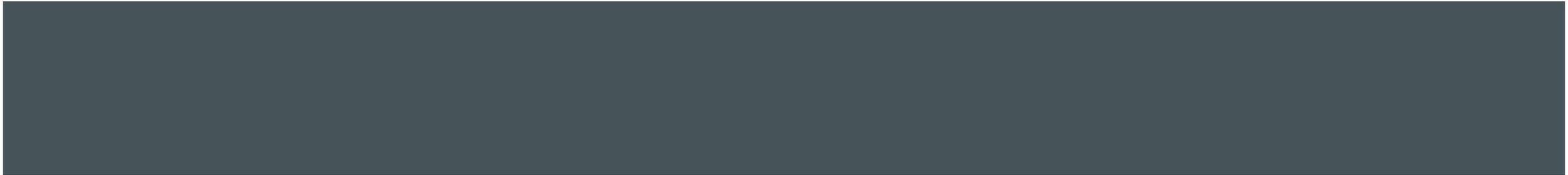
1. The selection process is set up to favor true beliefs
 - Two candidates
 - Sally BELIEVES “The marble is in the basket” (the false belief candidate)
 - Sally BELIEVES “The marble is in the box” (the true belief candidate)
2. The child knows that Sally did not see the marble being moved from the basket to the box.
3. The selection process’s default setting needs to be overridden
 - Leslie et al. think that young children fail on the false belief task because they are not able to inhibit the selection processor’s default bias
 - TOMM is in place from the pretend play stage
 - Limiting factor is a general capacity for executive control
 - This hypothesis can be tested by a false belief task with increased executive control component in it

AVOIDANCE-DESIRE (LESLIE AND POLIZZI, 1998)

1. Sally is asked to place food in one of two boxes
2. But there is a sick kitten in one of the boxes
3. Sally wants to avoid putting the food into the box with the kitten in it
 - ***Avoidance-desire***
4. Two conditions: true belief and false belief
 - Moving kitten from Box A to Box B either 1) in front of Sally or 2) without Sally seeing
 - Children all pass the true and false belief test
 - Over 90% children pass the true belief + avoidance-desire test
 - Only 14% children pass the false belief + avoidance-desire test
 - Double inhibition places much higher demands on the selection processor than ordinary false belief tasks.



MINDREADING AS SIMULATION



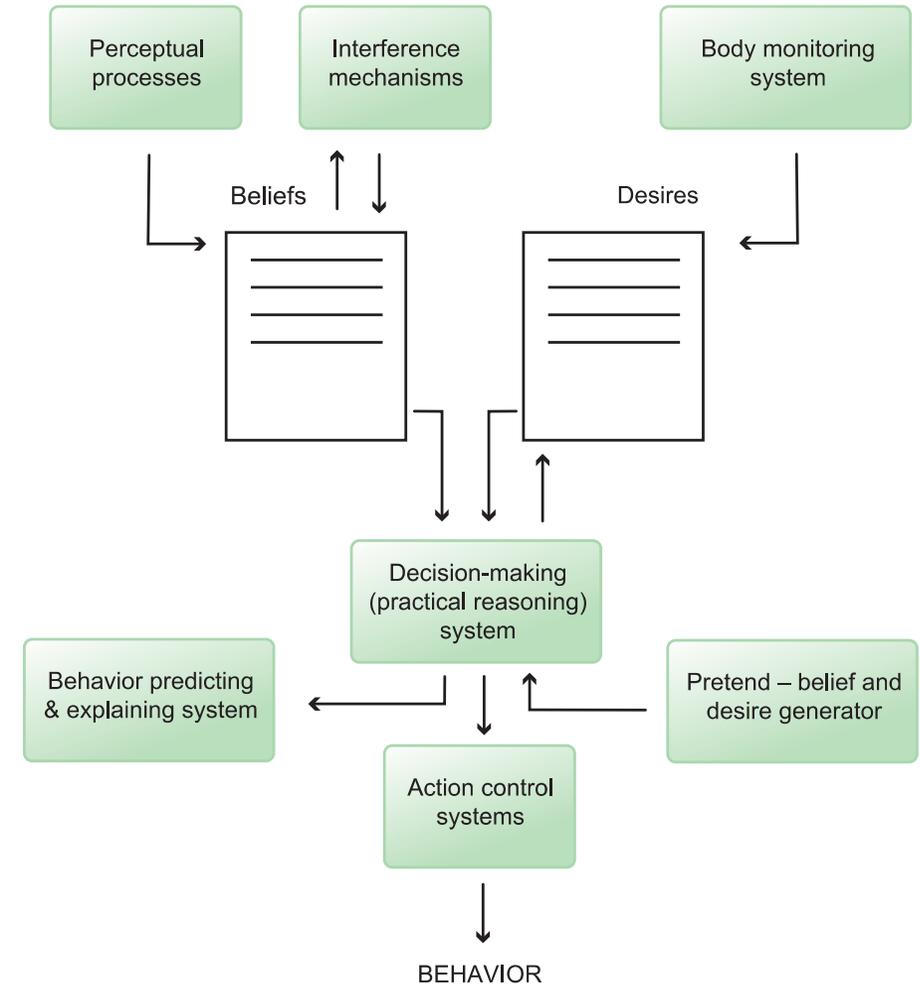
MINDREADING AS SIMULATION

- Leslie and Perner's view: 'theory of mind' exploits dedicated, domain-specific information processing.
- Alternative view: there is no specialized theory of mind mechanism. Instead, theory of mind processing is carried out by the very same systems that are responsible for ordinary decision-making and for finding out about the world.
- We use our own decision-making processes to run a simulation of what would happen if we ourselves had those beliefs and desires.

STANDARD SIMULATIONISM

Two basic principles

1. We understand the psychological states of others by analogy with our own psychological states.
2. We have a special self-monitoring mechanism for keeping track of our own psychological states. (introspection or inner sense)



RADICAL SIMULATIONISM

- World-directed approach rather than mind-directed approach
- Standard simulationism: I can only simulate another person by forming pretend beliefs and pretend desires (metarepresentations, simulating another person's desires and beliefs)
- Radical simulationism: The simulator is thinking about ***the world*** from the perspective of the person being simulated

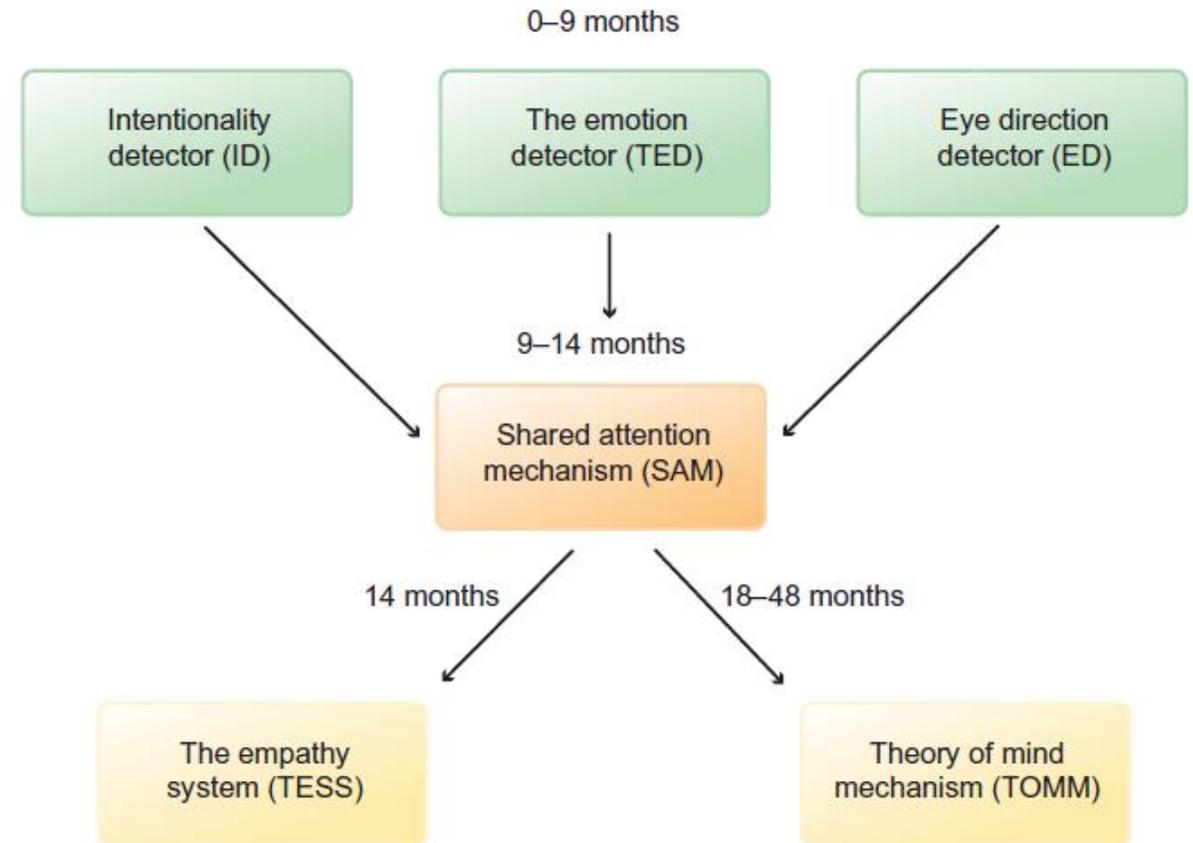


THE COGNITIVE NEUROSCIENCE OF MINDREADING



THEORY OF MIND MECHANISM

- Baron-Cohen's model
- Question 1: Is there any evidence at the neural level for the existence of a TOMM?
- Question 2: Is there evidence at the neural level that low-level mindreading is a process of simulation involving co-opted systems?
 - ID, TED, ED
- Question 3: Is there evidence at the neural level that high-level mindreading is a process of simulation involving co-opted systems?
 - Beliefs, Desires, and other psychological states

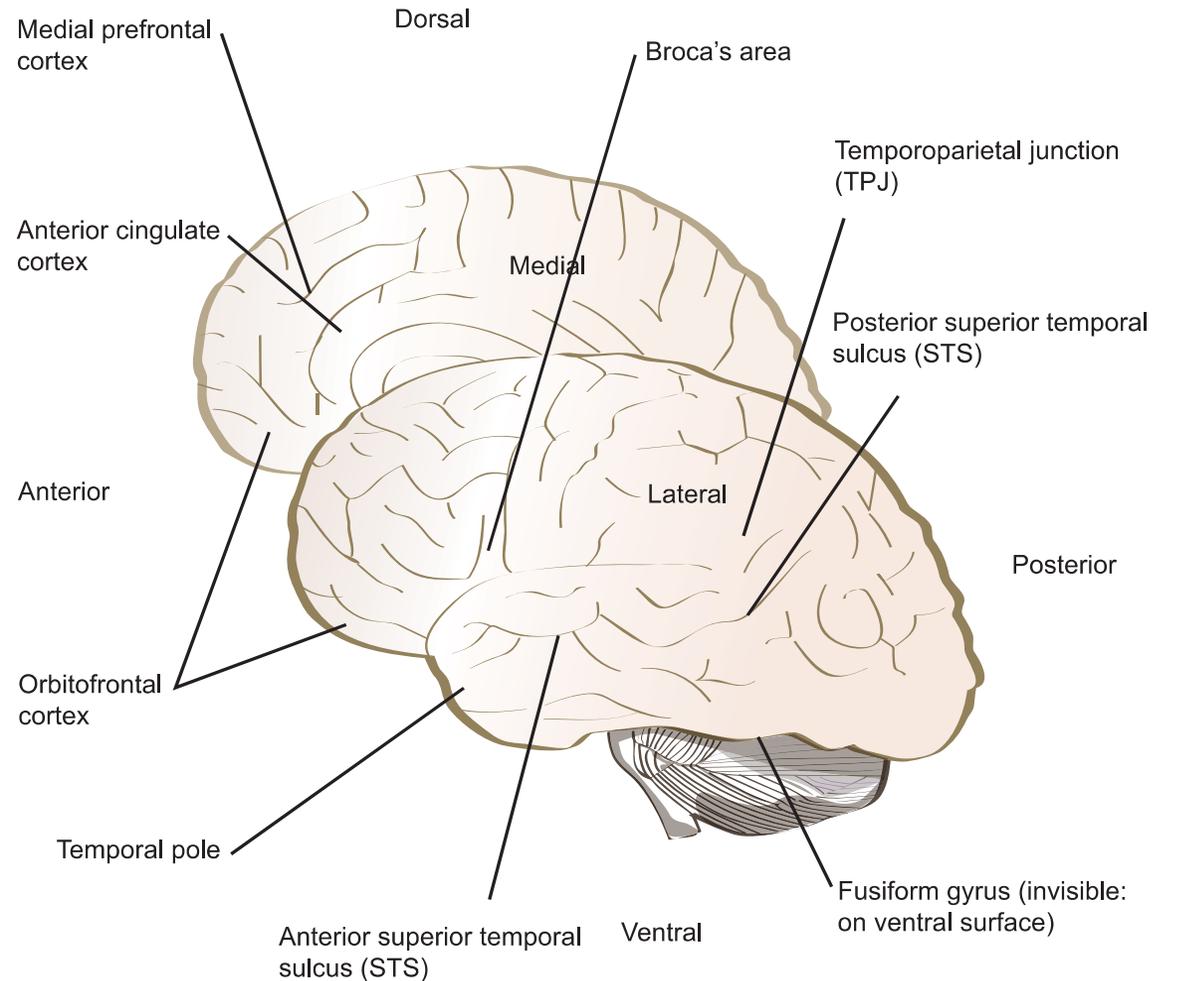


NEUROIMAGING EVIDENCE FOR A DEDICATED THEORY OF MIND SYSTEM?

- Experiments for testing evidence for a dedicated theory of mind system?
 1. They show increased activity in response to information-processing tasks that require the subject to attribute beliefs
 - A candidate TOMM region should show increased activation both for false belief and true belief tasks
 2. These increased activation levels are specific to tasks involving belief attribution-as opposed, for example, to reflecting demands on general reasoning, or the fact that people are involved
 - The neural systems are engaged in domain-specific processing (should control domain-general processing, for example, language or working memory)

POTENTIAL AREAS FOR THEORY OF MIND

- medial prefrontal cortex
- anterior cingulate cortex
- orbitofrontal cortex
- temporal pole
- Broca's area
- anterior superior temporal sulcus
- fusiform gyrus
- temporoparietal junction
- posterior superior temporal sulcus



I. AREAS ACTIVE BOTH FOR FALSE BELIEF AND TRUE BELIEF

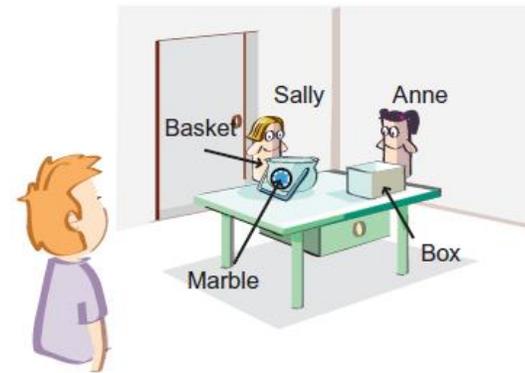
- Rebecca Saxe and Nancy Kanwisher
 - Medial prefrontal cortex (MPFC)
 - Superior temporal sulcus (STS)
 - Temporoparietal junction (TPJ)

2. RULING OUT DOMAIN-GENERAL INFORMATION PROCESSING

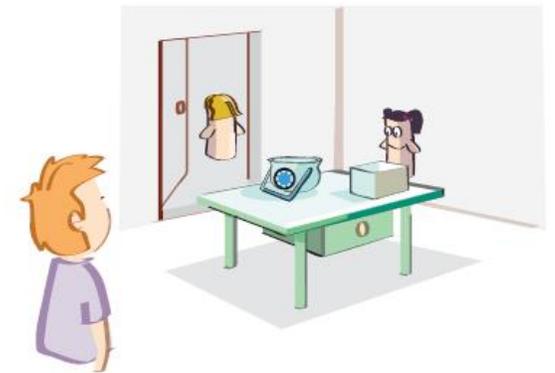
- The problem of hidden cause: we identify hidden causes when we attribute beliefs to other people
 - Non-psychological hidden cause scenario: ***hidden causes condition***
 - The beautiful ice sculpture received first prize in the contest. It was very intricate. Unfortunately, the temperatures that night hit a record high for January. By dawn, there was no sculpture.
 - The night was warm and dry. There had not been a cloud anywhere for days. The moisture was certainly not from rain. And yet, in the early morning, the long grasses were dripping with cool water.
- Activation due to general reasoning about false representations
 - ***False photograph task (taking photograph instead of Sally leaving the room)***

2. RULING OUT DOMAIN-GENERAL INFORMATION PROCESSING

MPFC, STS, and TPJ showed significant activation



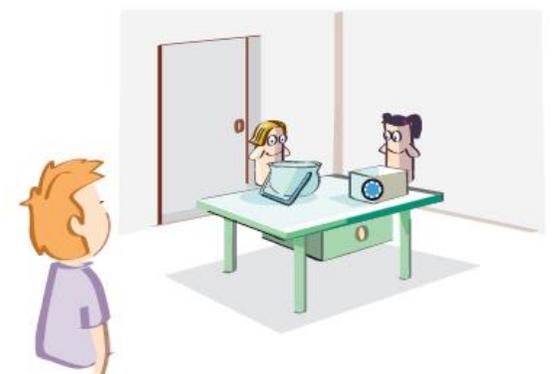
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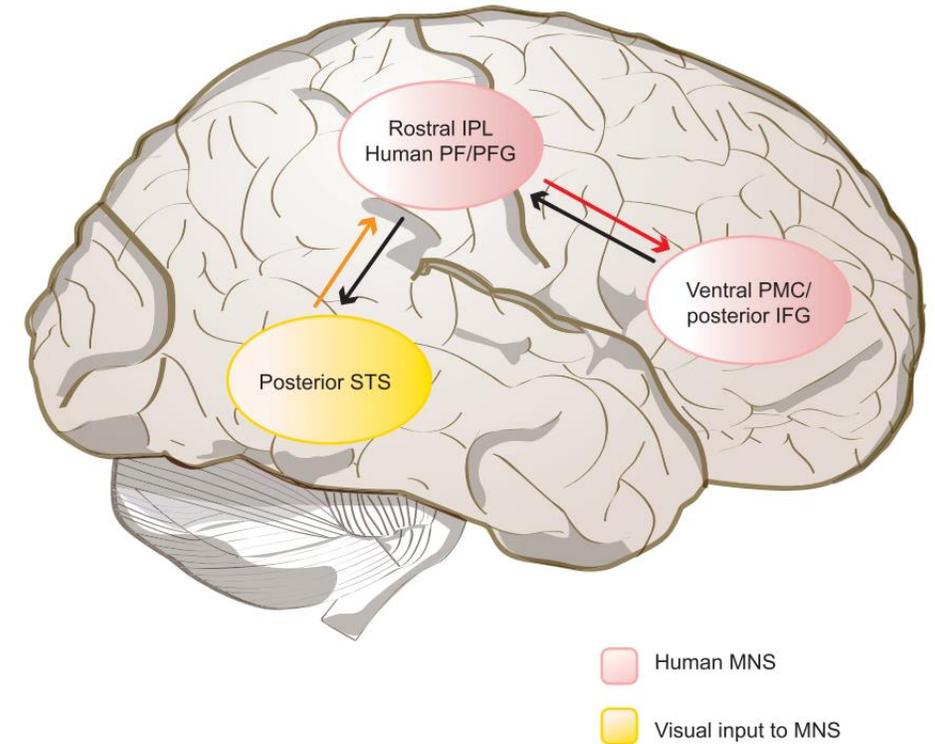


NEUROSCIENTIFIC EVIDENCE FOR SIMULATION IN LOW-LEVEL MIND READING?

- Usage of co-opted mechanisms
- The emotion detector
- The very same mechanism that mediates the experience of a particular emotion is recruited when the subject recognizes that emotion in someone else
 - Fear: case of S. M. (amygdala damage). She knows what fear is, but she cannot experience it. Also, she was bad at identifying fear from facial expression. Psychopathic patients are known to have smaller amygdala.
 - Anger: low dopamine level (Sulpiride); worse in recognizing anger from facial expression
 - Disgust: case of N.K. (insula damage): problem in experiencing and recognizing disgust
- Mirror neurons (Giacomo Rizzolatti): candidate system for **the emotion detector system, the empathy system, and the intentionality detector**

MIRROR NEURON SYSTEM

- The emotion detector
- The empathy system
- The intentionality detector
 - Mirror neurons fire even when the monkey cannot see the final stages of the action (Umiltà et al.)



- A representative example for the dual purpose structure (simulationist approach to mindreading)
 - Brain regions that serve both first-person and third-person roles.

MIRROR NEURONS



NEUROSCIENTIFIC EVIDENCE FOR SIMULATION IN HIGH-LEVEL MIND READING?

- Activation of MPFC by self-reflection tasks
 - Perceptual (“Is this adjective written in italics?”), self-directed (“Does this adjective describe you?”), or other-directed (“Does this adjective describe the President?”) – greatest activation in MPFC for the self-directed questions
- Mitchell et al. 2005
 - Presentation of photographs of other people and asked questions about them
 - Mindreading questions: “How pleased is this person to have their photograph taken?”
 - Other questions: “How symmetrical is this person’s face?”
 - After a short delay: “How similar they thought the other person was to themselves?”
 - MPFC activation was greater at mindreading questions and high similarity rate.