

Intro to Behavioral Neuroscience (B)

Lecture 11: Social Interaction

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<https://youtu.be/Kz-f2sWhaHY>

Lecture video at above link.

Today: Social Interaction

Social Interaction:

- 1) Theory of mind (understanding the mental states of others) – false belief test
- 2) Mirror neurons
- 3) Helping others: altruism
- 4) Cooperation: Prisoner's dilemma
- 5) A disorder of social function: autism

Social Interaction



Among animals and also compared to the closest relatives, the great apes, homo sapiens is special:

humans use complex language for communication, develop reusable tools, clothes, construct architecture, engage in economic exchange, organize governments, and worship higher entities.

Social interaction

Some researchers (see Tomasello et al., 2005) believe that the immense cognitive skills of homo sapiens are based on adaptations focused on one central feature: social cognition.

Social cognition allowed for successful cooperation, learning, and teaching, and thus creation of civilization.



Social interaction

Components of the social brain:

- Stable and coherent sense of self.
- Theory of mind (understanding the mental states of others).
- Capability of living with other humans, keeping good relationships, suppressing destructive emotional expression.
- Perceiving threats (either from own or different social group).



Theory of Mind – False Belief Test

Theory of mind (also referred to as mentalizing) is the capability to understand the mental state of others.

A test for theory of mind is the **false belief test**:

Maxi eats half the chocolate and puts the rest into the kitchen cupboard. Then he goes away to play. His mother comes in and finds the chocolate in the cupboard. She puts it into the fridge and leaves.

When Maxi comes back, where will he look for the chocolate bar?



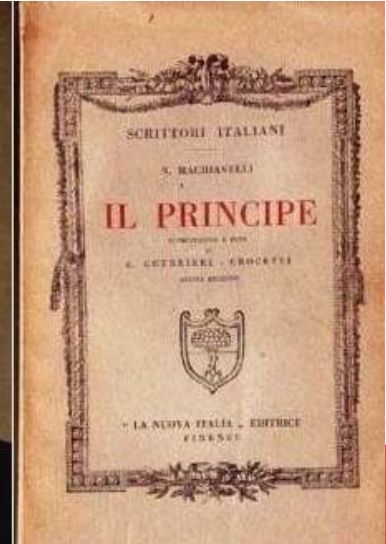
Where will Maxi look for his chocolate? (From the collection of Uta Frith.)

The "False Belief" Test: Theory of Mind

Theory of Mind – False Belief Test

If we understand the mental states of others, we know what they know/think and what they don't know:

- If they don't know something that we know, we may be motivated to teach them. If we always assume that others know what we know, then there is no motivation for teaching → no civilization.
- The dark side is that this knowledge helps us to deceive others.



Theory of Mind – False Belief Test

Children from around the age of 4 years develop a theory of mind, they start to answer correctly in the false belief test (“Maxi will look into the cupboard”). Before that age, they respond according to their own knowledge (“Maxi will look into the fridge”).

Children with autism are impaired in this task.

Full theory of mind capabilities have not been found in nonhuman animals, but it is debated whether great apes have it (see Kuperavice et al., Science, 2016).

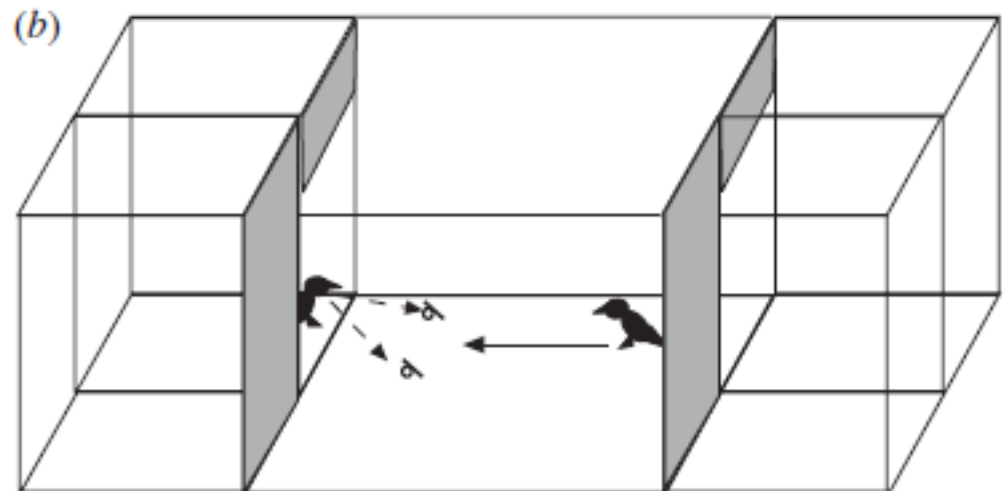
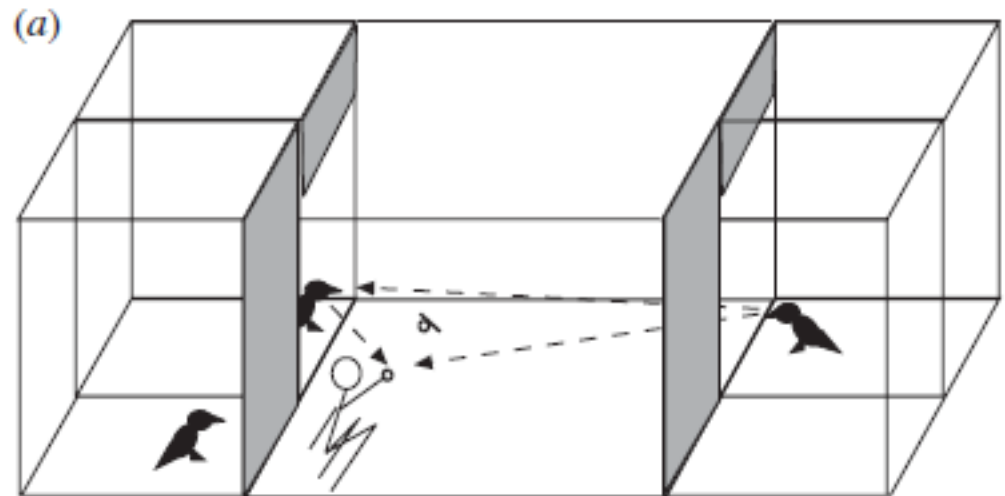
A modified test, the knower-guesser paradigm has suggested that some animals, i.e., nonhuman primates such as chimpanzees, macaque monkeys, and birds such as corvids and ravens, can understand the perceptual viewpoint of others.

Knower-Guesser Paradigm

In this paradigm, a human experimenter caches food in the view of two ravens.

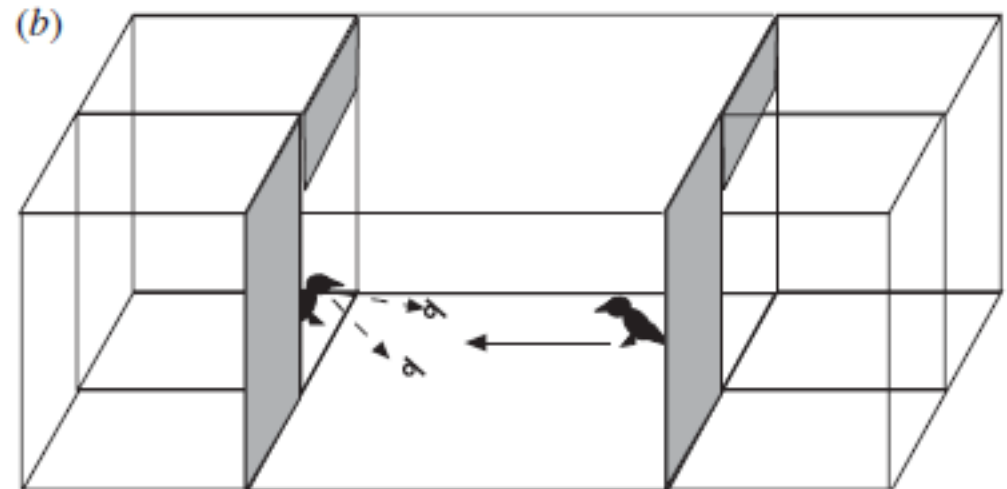
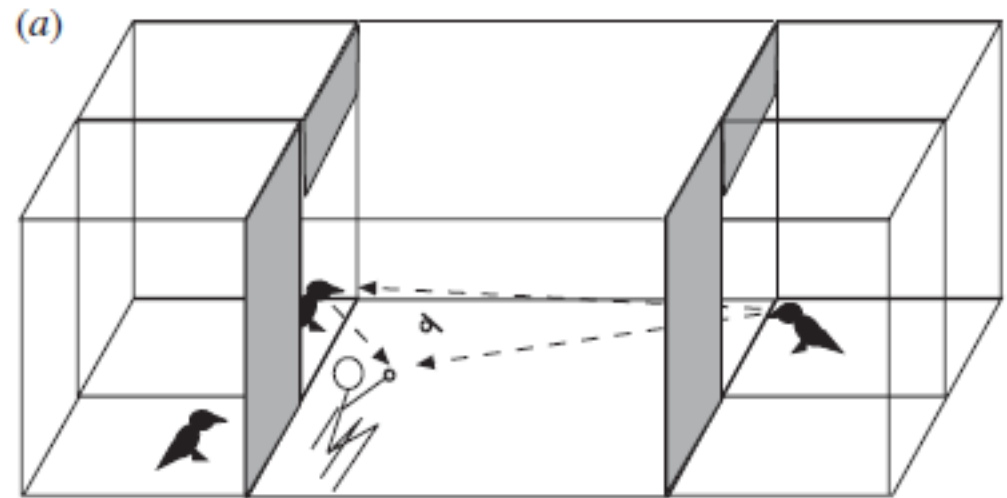
For example, the focal bird (right in a) observes the human experimenter to make two caches.

There are two competitors:
one is uninformed (lower left in a), it didn't observe the human experimenter;
one is partially informed, it saw the human experimenter making one cache (lower one in the middle).



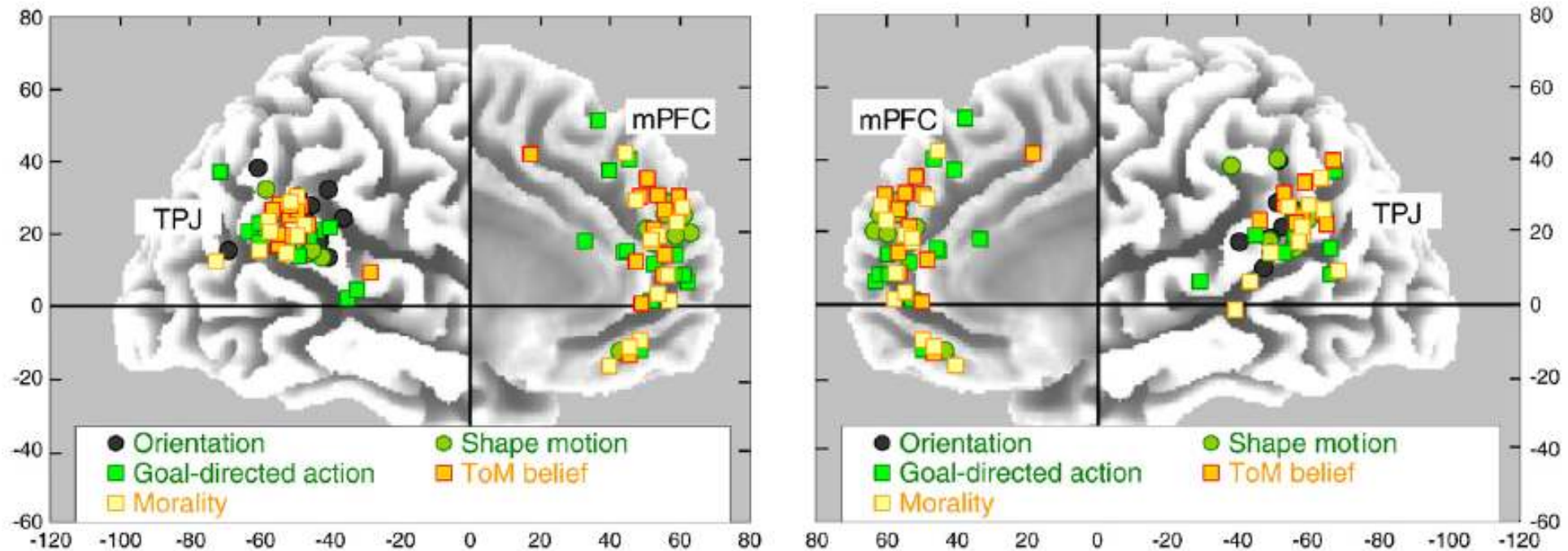
Knower-Guesser Paradigm

When the focal bird (right) is released before the partially informed observer, it will rush to the cache that was observed by the competitor. It knows what the competitor has perceived.



Theory of Mind in the brain?

Van Overwalle, NeuroImage, 2009



This meta-analysis of ~200 fMRI studies shows that two main areas are involved in theory of mind (ToM) belief tasks: the TPJ (temporo-parietal junction) and the mPFC (medial prefrontal cortex).

Theory of Mind in the brain

Theory of Mind (ToM) belief task (Mitchell et al., Cerebral Cortex, 2009):

“Jenny put her chocolate away in the cupboard. Then she went outside. Alan moved the chocolate from the cupboard into the fridge. Half an hour later, Jenny came back inside.” After 10 s, this text was replaced with the question, “Jenny expects to find her chocolate in the 1) fridge or 2) cupboard”

Morality judgment task (Prehn et al., SCAN, 2008):

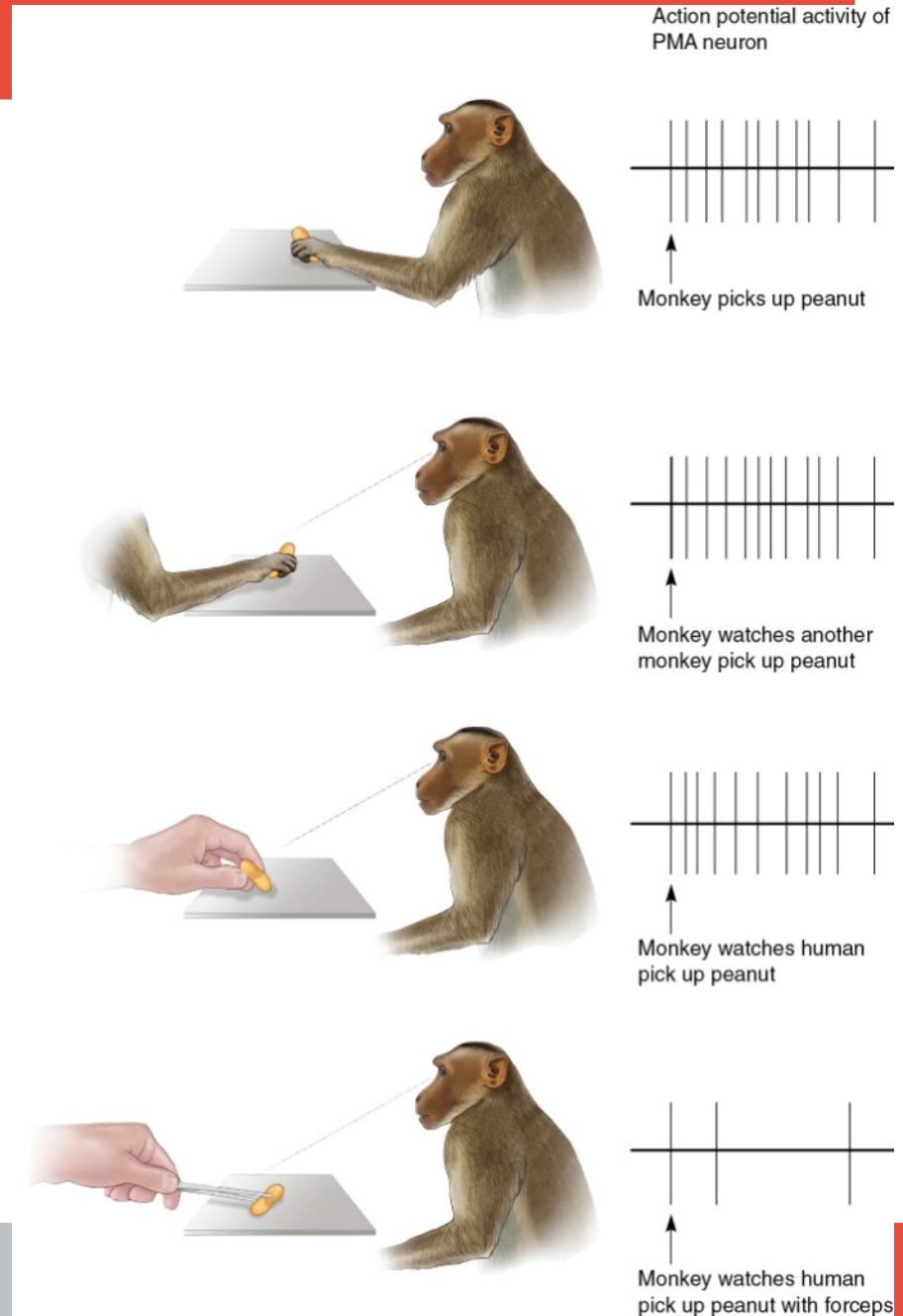
		Violation
Socio-normative judgment	First sentence	A uses public transportation [A fährt mit der S-Bahn]
	Second sentence	He smashes the window [Er wirft das Fenster ein]
Grammatical judgment	First sentence	B goes to a restaurant [B geht in ein Restaurant]
	Second sentence	He order a starter [Er bestellen eine Vorspeise]
		Non-violation
		A uses public transportation [A fährt mit der S-Bahn] He looks out of the window [Er sieht aus dem Fenster]
		B goes to a restaurant [B geht in ein Restaurant] He orders a starter [Er bestellt eine Vorspeise]

Mirror Neurons

Mirror neurons were first described in macaque ventral premotor cortex.

Premotor cortex is involved in the planning of movements (such as grasping food). Neurons in premotor cortex encode specific complex movements (such as “move arm to right”). They fire before and during movement execution.

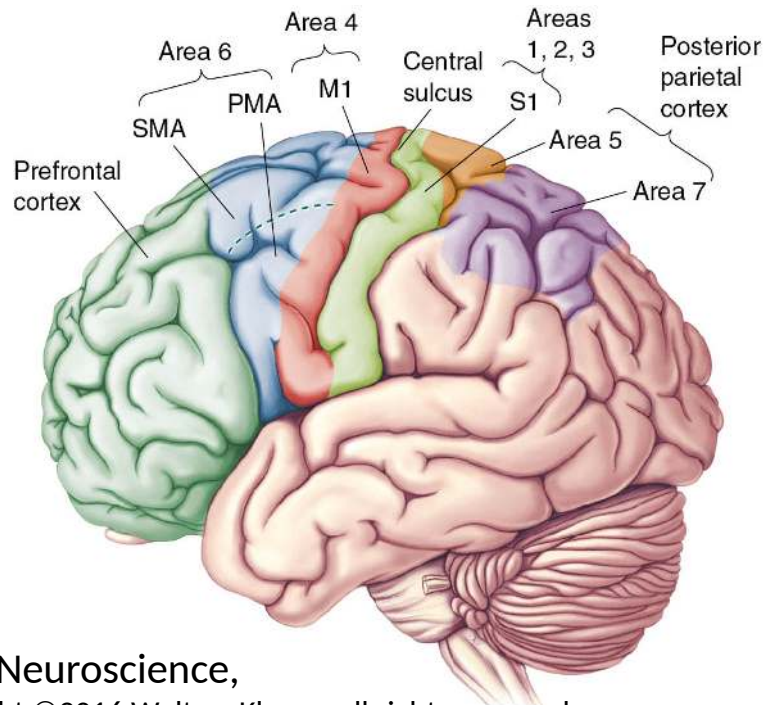
Mirror neurons are specific neurons that are active both when the monkey performs a movement (“pick up peanut”), or when somebody else performs the same movement.



Mirror Neurons

Human brain

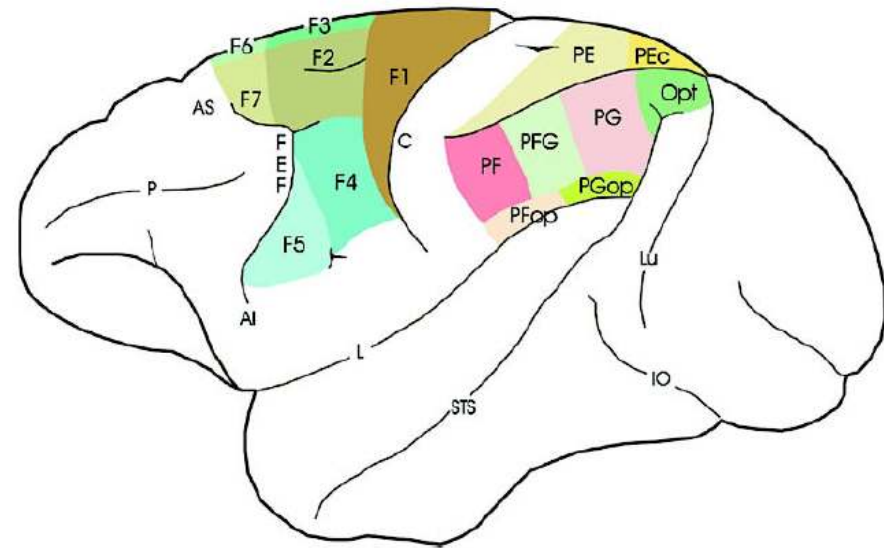
PMA: premotor area



Bear, Neuroscience,
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Macaque brain

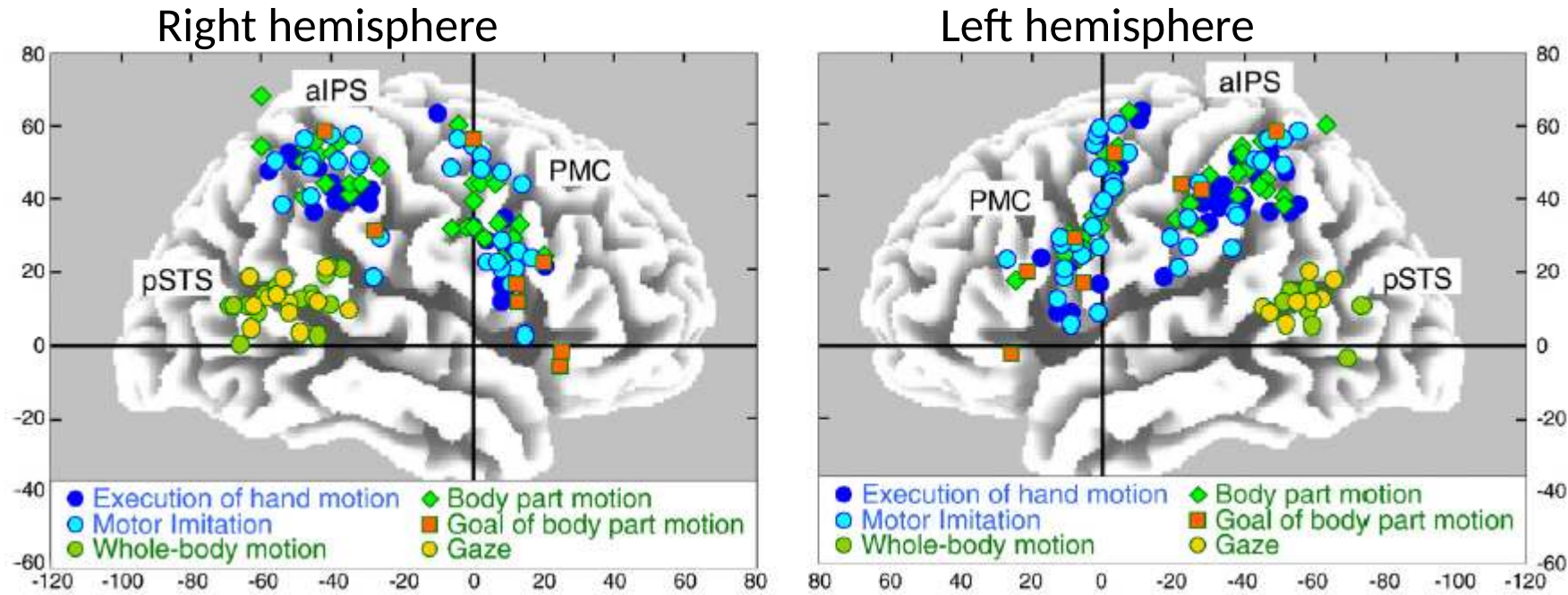
Mirror neurons found in F5



Rizzolatti and Craighero, 2004

Mirror neurons respond to interactions between an effector (hand or mouth) and an object (e.g., “grasping a peanut”) and do not respond to object alone. Some mirror neurons also respond to sounds of an action. They have been reported not only in F5 (premotor cortex), but also superior temporal sulcus (STS), and parietal cortex (area PF).

Mirror Neurons in Humans

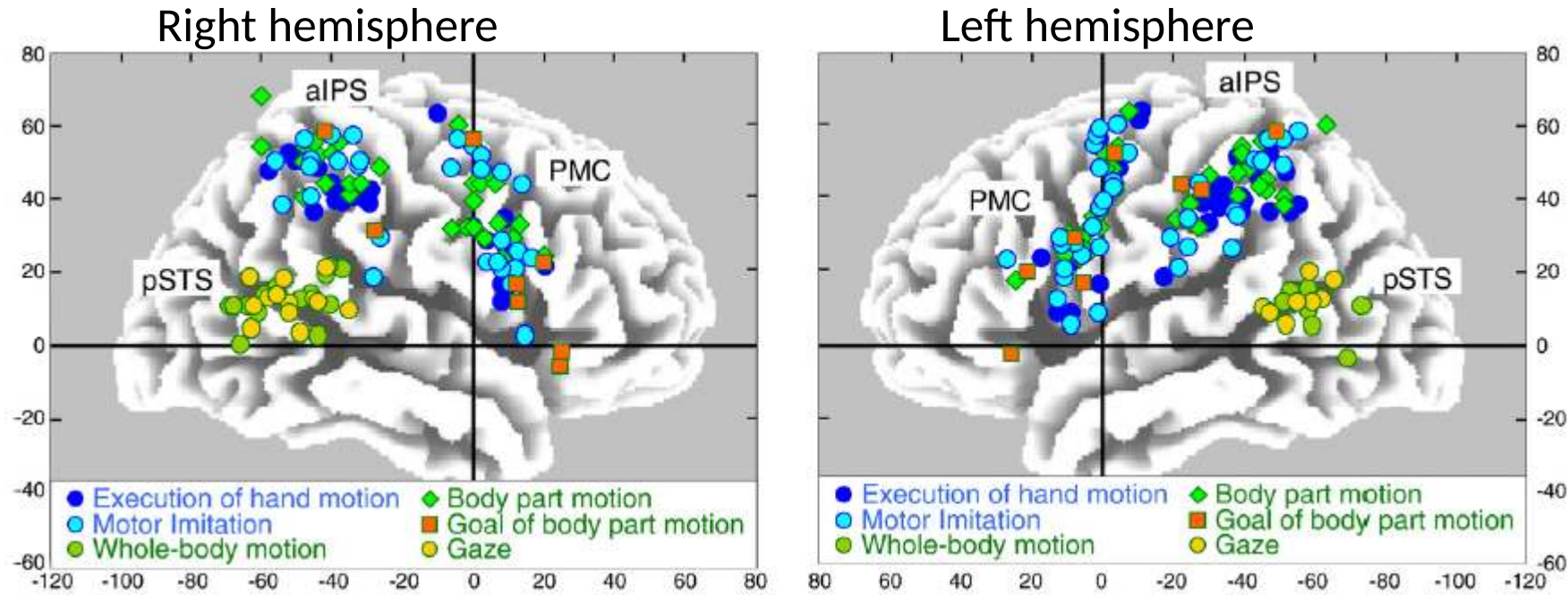


Van Overwalle, NeuroImage, 2009

This meta-analysis of ~200 fMRI studies shows that humans also seem to possess a mirror neuron system: in particular the premotor cortex (**PMC**) and the anterior intraparietal sulcus (**aIPS**) are active during execution of hand motion (own hand), observing body part motion (of others), and motor imitation.

The posterior superior temporal sulcus (pSTS) is activated during perception of whole-body movement and gaze motion.

Mirror Neurons in Humans



Van Overwalle, NeuroImage, 2009

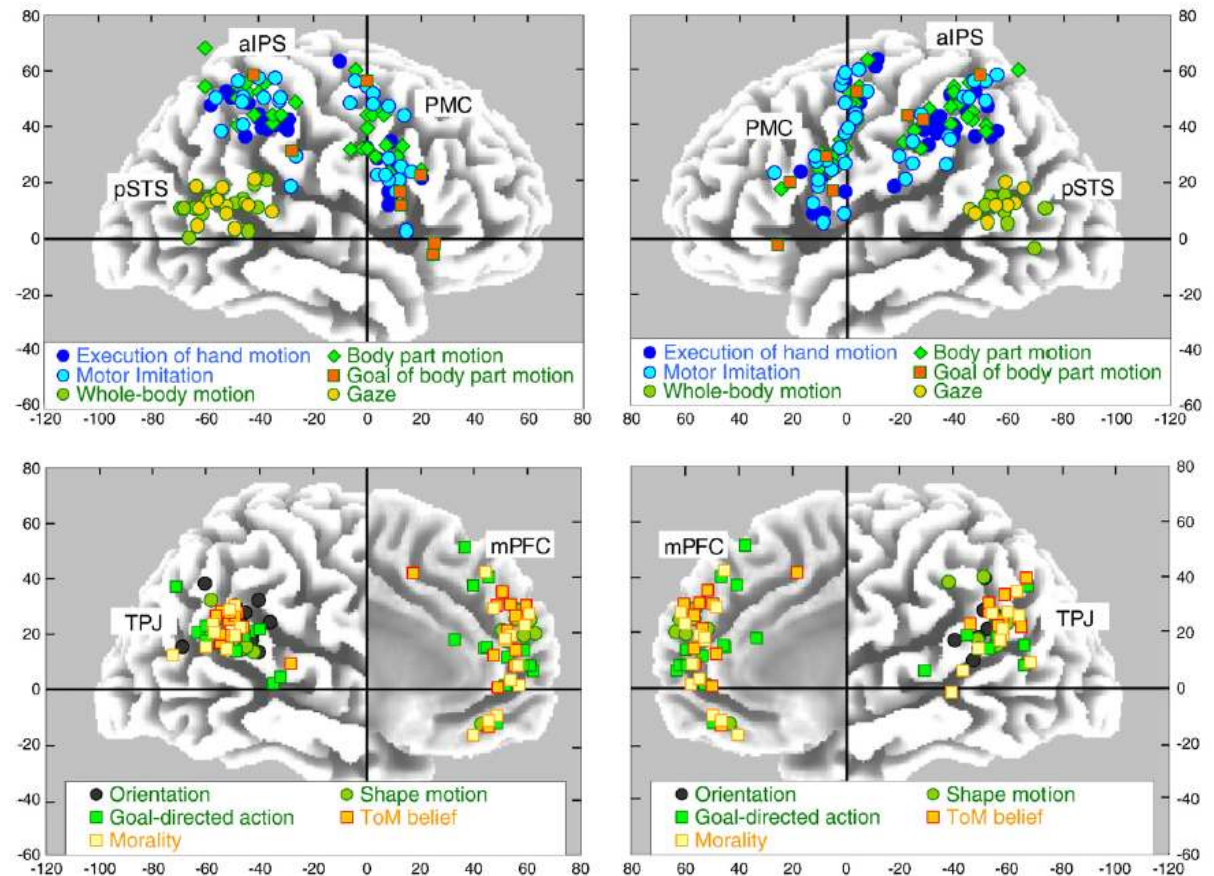
Van Overwalle suggests that multimodal sensory information (visual or auditory) when observing movement of others' body parts is transmitted to aIPS and PMC. In aIPS, body part movement and object/context information is integrated. In PMC, movements are compared to one's own movement repertoire.

Mirror Neurons in Humans

Van Overwalle, NeuroImage, 2009

According to this meta-analysis, the mirror system and the mentalizing (theory-of-mind) system are not located in the same brain regions.

However, these two complimentary systems might underlie social cognition (understanding the intentions and mental states of others).



Altruism: helping others

Already from the age of 14-18 months, infants help others without being rewarded. For this, they have to understand the intention of others, be empathetic and have to be motivated to be altruistic. Chimpanzees show helping to some degree.

Out-of-reach



A person accidentally drops an object on the floor and unsuccessfully reaches for it.

Physical Obstacle



A person wants to put a pile of books into a cabinet, but she cannot open the closed doors because her hands are full.

However, some recent studies (Barragan and Dweck, PNAS, 2014) challenge this: when a reciprocal game is played before the situation in which help is needed, 1-2 year old children help, but not when a non-reciprocal game is played.

Reciprocal game: taking turns when playing with a ball.

Nonreciprocal game: experimenter and child have their own ball.

The Prisoner's Dilemma

Two suspects are picked up by the Secret Police:

Prisoner A is interrogated, he faces 1 years of prison (for doing nothing).

The police offers him a deal: he can incriminate prisoner B and he will be free (0 years of prison for prisoner A, 10 years for prisoner B).

Prisoner B is offered the same choice: if he incriminates prisoner A, he will walk free, but prisoner A gets 10 years.

If both incriminate each other, they both get 5 years each.



The Prisoner's Dilemma: Humans

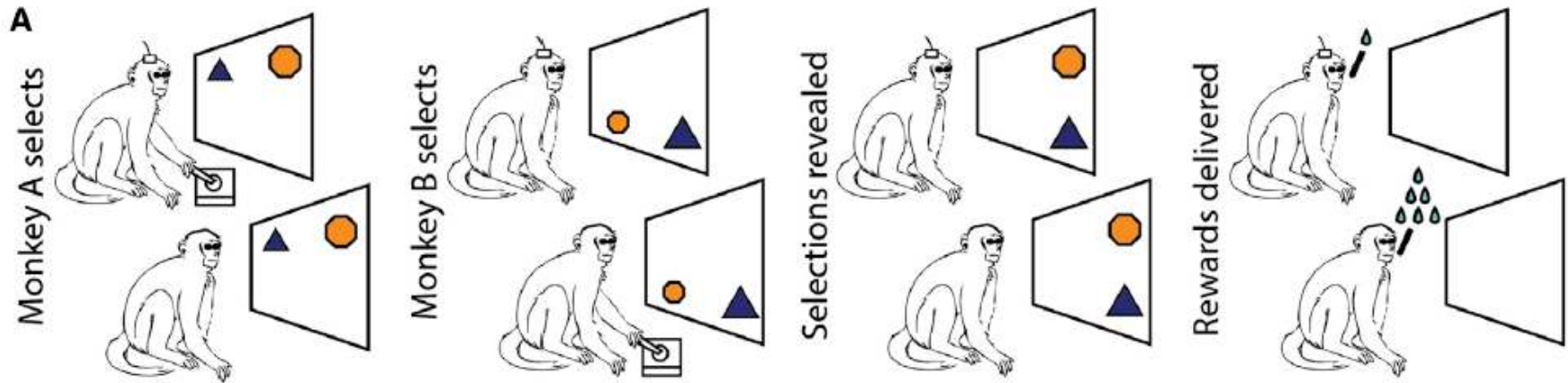
For both prisoners, to defect (to incriminate the other prisoner) is the best strategy in terms of self-interest: if Person B cooperates, it is better for Person A to defect (result: 0 years); if Person B defects, it is better for Person A to defect (result: 5 years instead of 10).









		Person A	
		Cooperate	Defect
Person B	Cooperate	A: 1 year B: 1 year	A: 0 years B: 10 years
	Defect	A: 10 years B: 0 years	A: 5 years B: 5 years

However, when humans play the game, they cooperate more than expected, because cooperation leads to a better outcome than defect by both players.

Furthermore, if the game is repeated with the same players, they can react to the other player, e.g., playing 'tit-for-tat' (if one player has defected in the previous game, the other player might defect in return).

The Prisoner's Dilemma: Macaques



Monkey A \ B Monkey		Cooperate	Defect
			
Cooperate	 		
Defect	 		

Macaque monkeys were trained in a Prisoner's dilemma task: they chose either a hexagon or a triangle and could see the other, but not the other's choice before they have chosen.

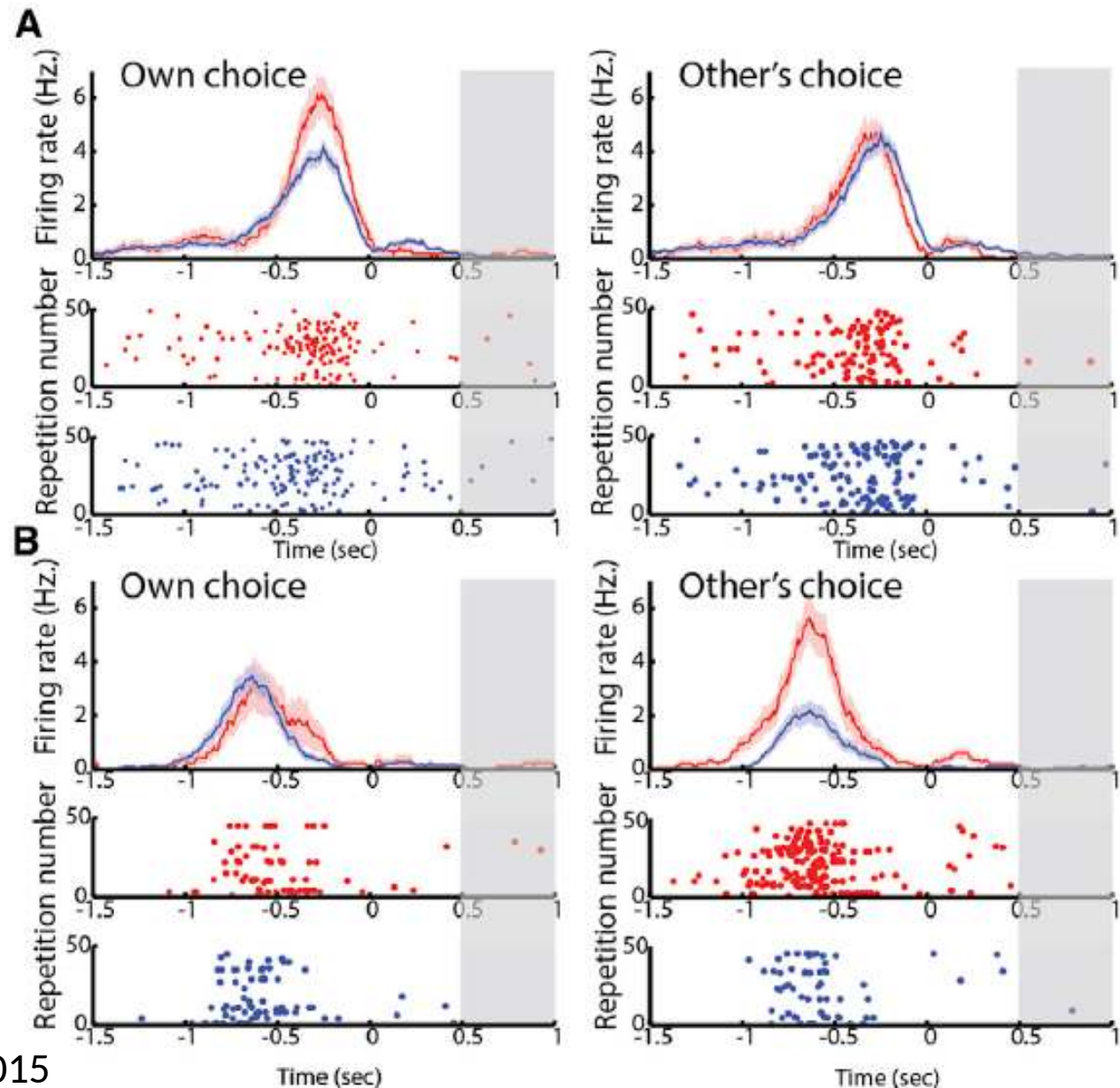
Reward was juice given according to the payoff matrix on the left. The four monkeys defected in 65.3% of the 1,346 trials and cooperated in 34.7%.

The Prisoner's Dilemma in the brain

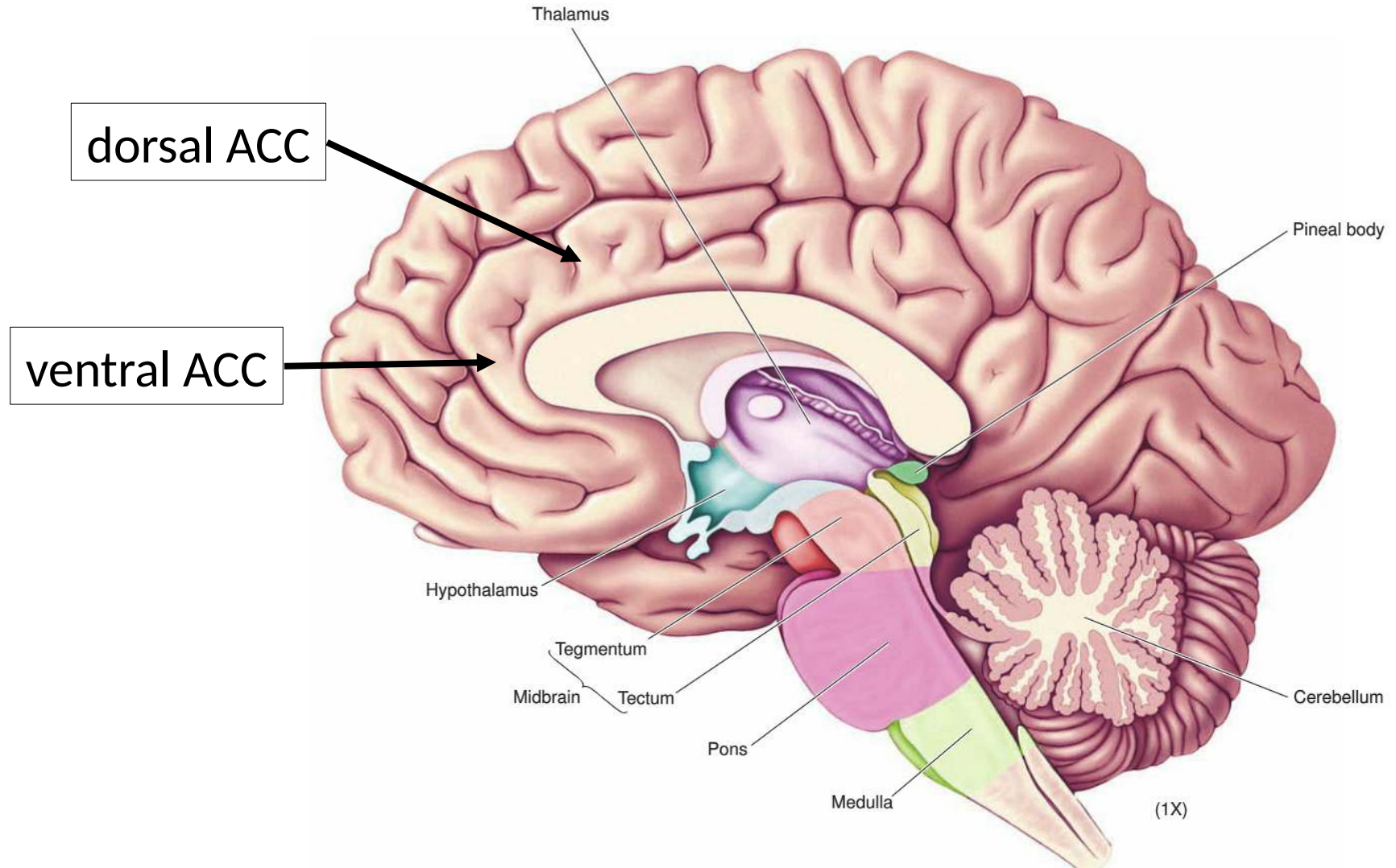
Some neurons in the dorsal part of the anterior cingulate cortex (dACC) fired according to the monkey's own choice (A: more firing when the monkey will cooperate).

A distinct set of dACC neurons fired predicting the other monkey's choice (B: more firing when other monkey will cooperate).

Such a prediction was based on the other monkey's previous behavior.



ACC in Humans



Autism Spectrum Disorder (ASD)

Autism:

- 1) Reduced ability to interpret emotions and intentions of others
- 2) Deficits in social interaction and communication
- 3) Restriction of interests (preoccupation with a single object or activity)

Asperger's syndrome:

Mild form of ASD with preserved cognitive and linguistic functions.

Autism spectrum disorder (ASD) – a new definition (DSM-V) includes both autism and Asperger's syndrome.

ASD affects boys 4 times more than girls.

Genetic influence:

Siblings of an ASD child have a chance of 5% for ASD.

Monozygotic twins of an ASD child have a chance of 60% for ASD.

Autism Spectrum Disorder

Autism:

- Diagnosed before an age of 3 years
- Late language development
- Often no social smile as infant, not cuddly
- No immediate response when own name is heard
- Aversion to changes in their environment
- Impairments in false belief task
- Do not understand metaphors or take utterances always literally
- Often cognitive impairment



Savant Abilities

While often impaired in cognitive abilities, many individuals with ASD show domains in which they are very good: jigsaw tasks, rote memory, etc. Some are exceedingly good at something: savant abilities.



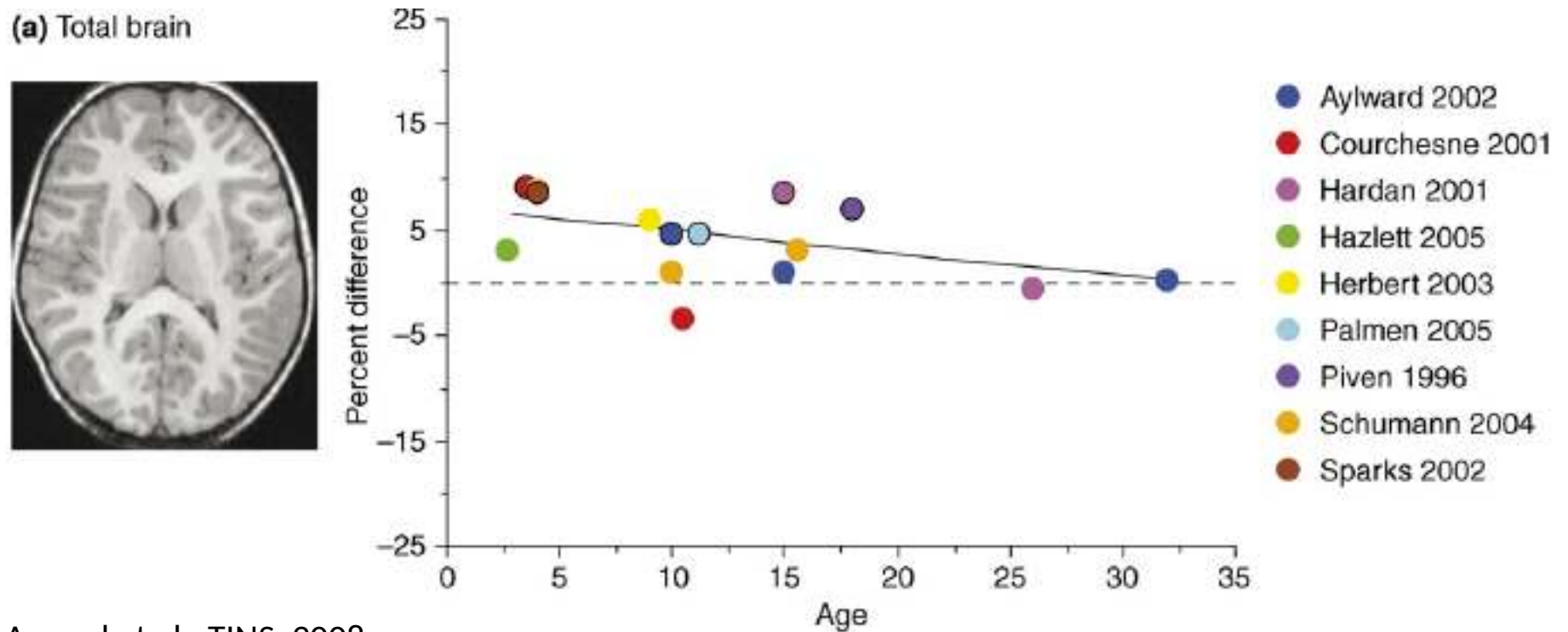
Temple Grandin designs livestock equipment.

Drawing by Gilles Trehin of a virtual city



ASD: causes?

Some studies indicate that individuals with ASD show enlarged brains in their early childhood, in particular white matter.

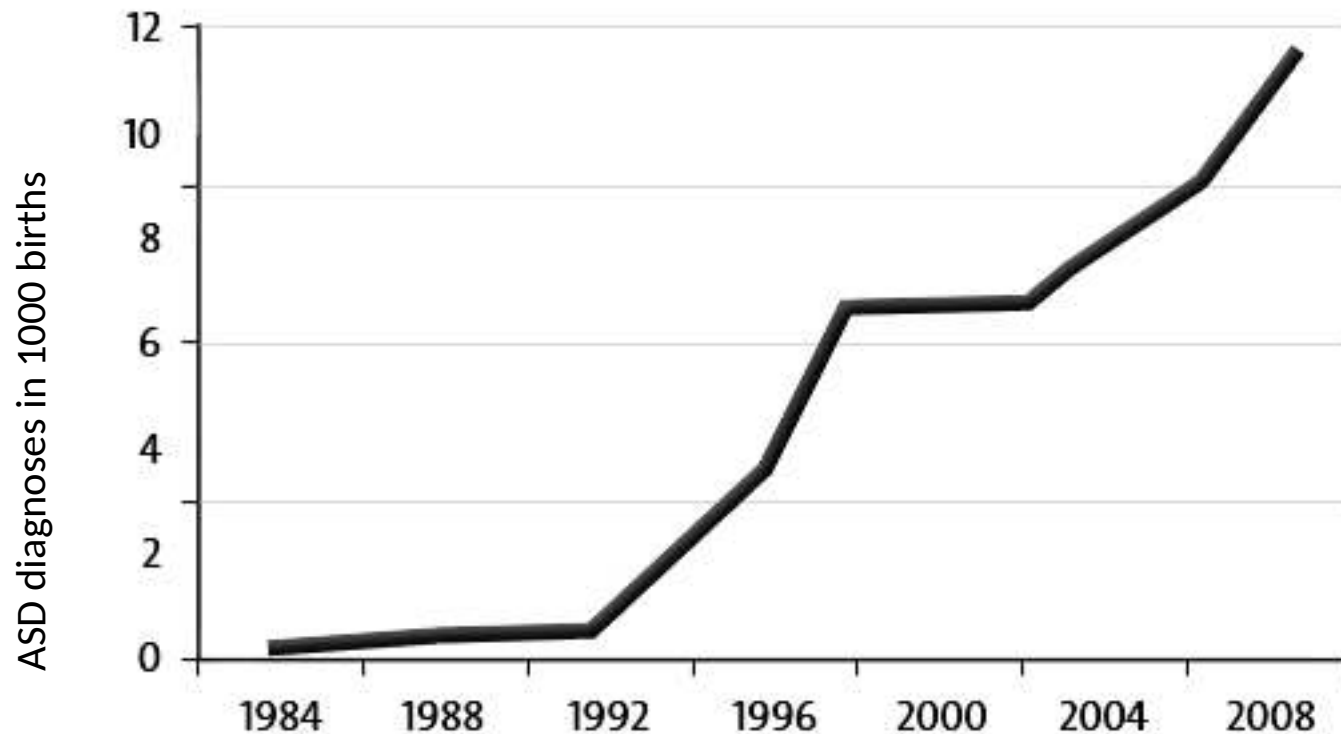


Amaral et al., TINS, 2008

Increasing rate of ASD?

Increase in diagnosis of ASD:

In the 1990 about 1 in 1000 children were diagnosed with ASD, currently that number rose up to 12 in 1000 (USA).



This may reflect both increased sensitivity and changes in diagnosis, but also an increase in the disorder frequency.

ASD: therapies

Behavior therapy: aims at improving behavior with reinforcement and contingent aversive techniques, often in intensive one-to-one training situations in their home.

- to eliminate self-injurious behavior
- to improve emotional control
- to improve fundamental social skills
- to improve language skills



From Autism speaks: Applied Behavior Therapy



AUTISM SPEAKS™
It's time to listen.

Summary: Social Interaction

- 1) Theory of mind: understanding the mental states of others; false belief test, knower-guesser paradigm
- 2) Mirror neurons
First observed in macaque premotor cortex, in human neuro imaging studies found in premotor cortex and anterior intraparietal sulcus.
- 3) Helping others: altruism
- 4) Cooperation: Prisoner's dilemma
- 5) A disorder of social function: autism
Deficits in interpreting other's emotions/intentions, deficits in communication, restricted interests.