Wired to be Social

Discoveries in Brain Functioning and their Implications for the Evolution of Social Intelligence

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- All of my lectures in PDF files
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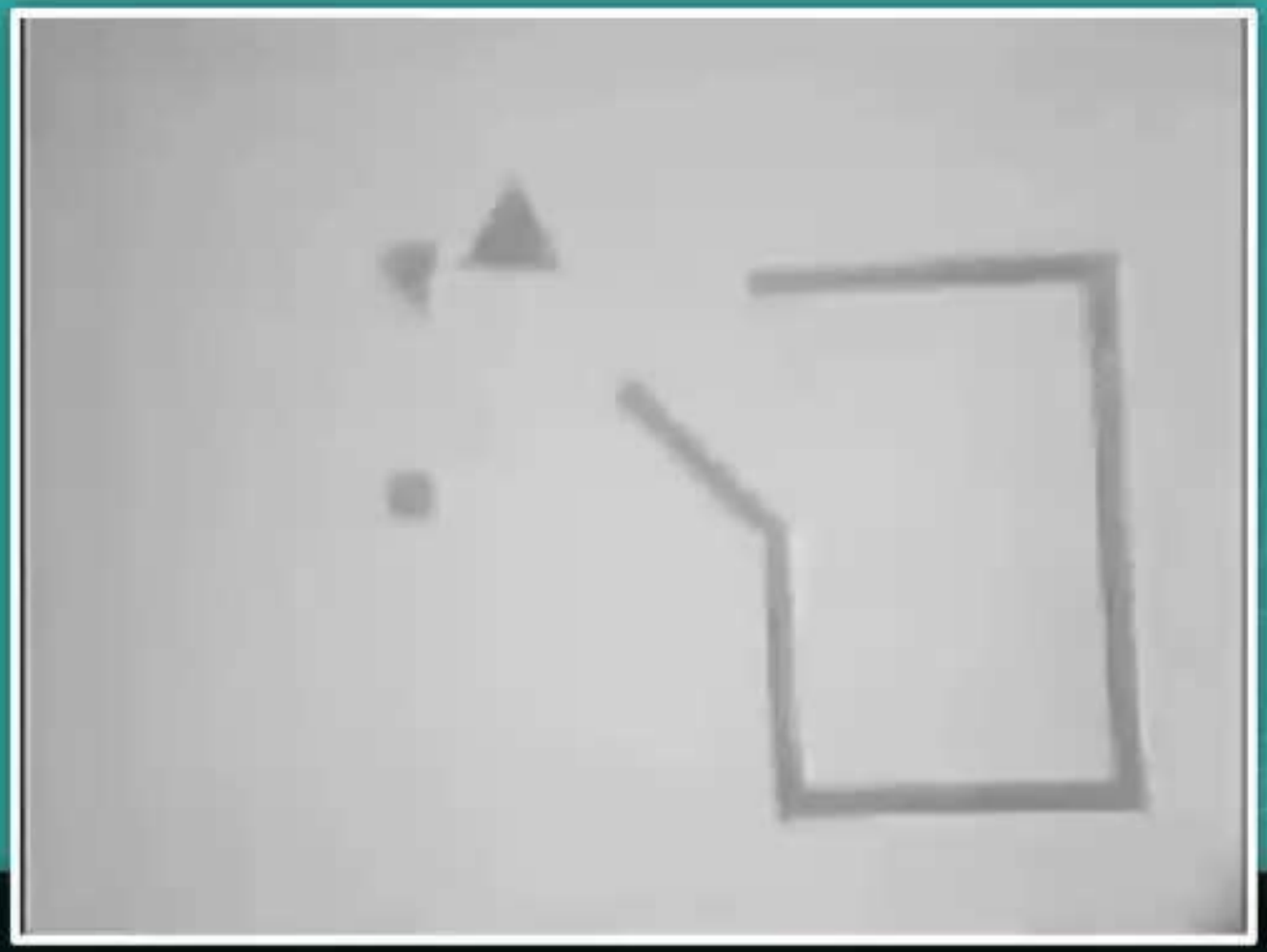
Social Objects: We perceive sociality



HEIDER & SIMMEL (1944) "AN EXPERIMENTAL STUDY OF APPARENT BEHAVIOR"

American Journal of Psychology 57, 234-259

NORMAL CONTROL SUBJECT

"I saw a box, like a room, that had an opening to it. There was a large triangle chasing around a smaller triangle, and a circle...got into the box, or the room, and hid. And the big triangle chased the little triangle around. Finally he went in, got inside the box to go after the circle, and the circle was scared of him...but manoeuvred its way around and was able to get out the opening, and they shut it on him. And the little circle and the little triangle were happy that they got that, the big one, caught. And they went off on their way, and the big triangle got upset and started breaking the box open."

Wired to be Social

- Newborns come into the world wired to socially interact.

This little gesture encapsulates millions of years of primate brain evolution

Infants a few minutes old will stick out their tongues at adults doing the same thing. Hard wired for imitation?

Empathic Rat:

Busting friend out of jail & sharing chocolate

“Empathically motivated pro-social behavior” exhibited. Basis unclear.
Rats recognize their peers' pain—show emotional contagion (mimic emotional behavior)

Inbal Ben-Ami Bartal, Jean Decety, Peggy Mason ,2011

Scientific research says real source of happiness:

Harvard Study of Adult Development: Longest Prospective Study

- 75 year prospective study (724 men; 60 still alive; & 2000 children; 4 directors) – Group 1 (sophomores at Harvard); Group 2 (disadvantaged Boston teenagers); every 2 years reexamined

- Conclusion: Good relationships keep us happier and healthier
  - Social relationships (family, friends, community) are really good for us
  - Loneliness kills: isolation is toxic (less happy, health declines earlier in midlife, brain declines sooner, die sooner); 1 in 5 Americans

Harvard study

- Quality of close relationships count; living in conflict with no affection is toxic, & worse than divorce; warm relationships are protective

- Those who were most satisfied in their relationship at age fifty were most healthy at age 80

- Physical pain is magnified if in unhappy relationships

- Being in securely attached relationship (can depend on the other, even if bicker a lot) in your 80s is protective of brain and memory functioning

Social Cognition - Perception

- Face perception
  - Face identification
  - Facial expression
- Eye gaze
- Prosody
- Biological motion
- Dynamic emotion

It takes a lot of brain abilities to be social

- Visual face recognition
- Emotional recognition: visual and auditory
- Memory for faces
- Memory for relationships
- Ability to manipulate information about a set of relationships
- Judgments about intentions of others
- Eye gaze and hand intent recognition
- Empathy
- Desire to be in social group
- Appropriate social responding
- Ability to inhibit behavior
- Language: Ability to listen and to talk
- Fast processing of all of these functions

New Couples fMRI Machine:
Brain Areas sync when we interact

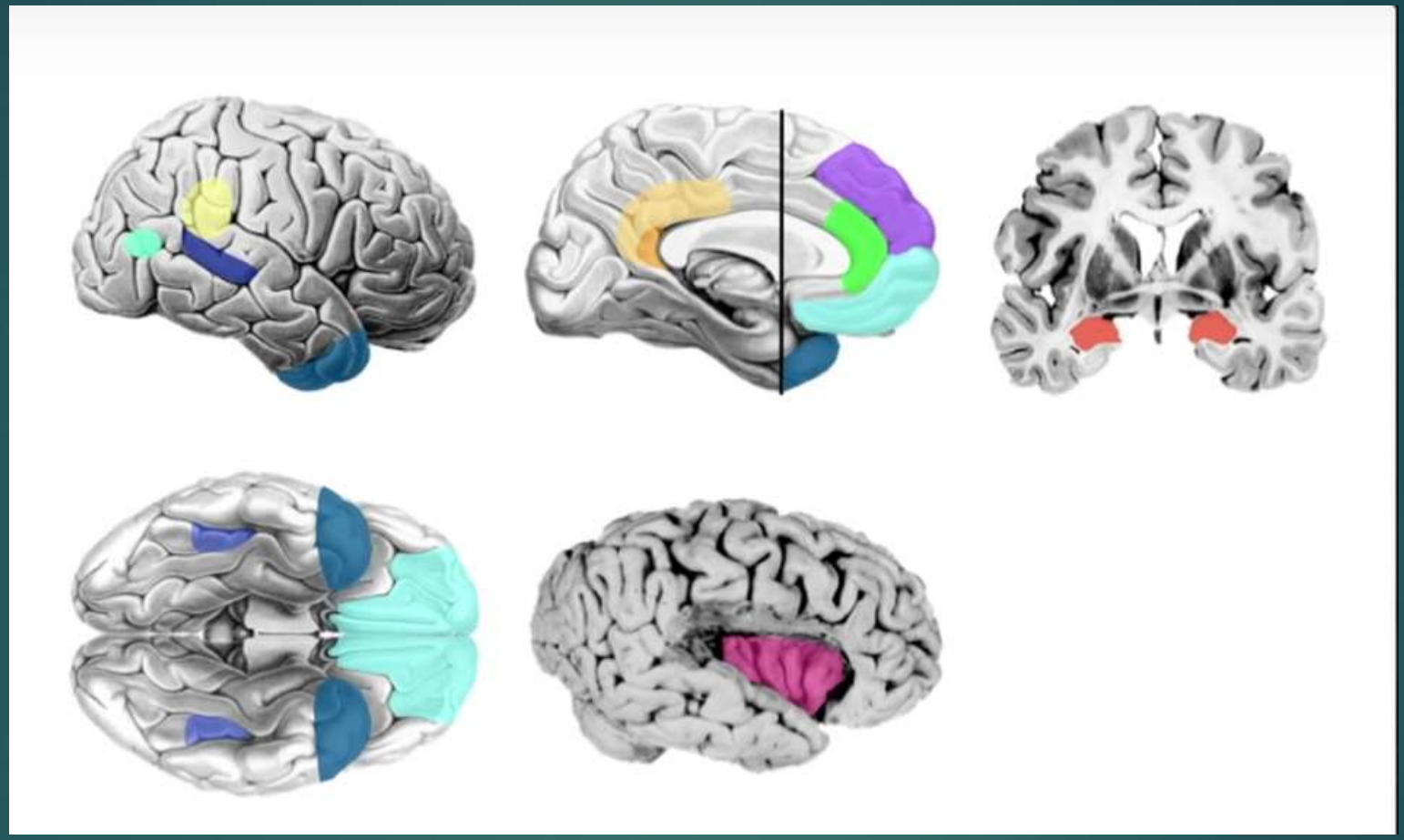
Friends: basal ganglia
Lovers: pCC

When touched:
toucher's motor and somatosensory cortex couples to the other person's STS and somatosensory cortex.

When people communicate: activates mPFC, TPJ, ACC

Ray Lee at Princeton University

Social Brain



Social Perception Social Inference Social Behavior

Assumptions about brain evolution

- There should be continuity of cognitive abilities in primates, based on common ancestry
- Brain evolution happens by means of natural selection
- Memory & associative learning systems arise early and are universal
- Number of neurons in cortex distinguishes humans
- Debate over whether other animals have self awareness or theory of mind

Social Brain

- Evolution has produced the current human brain
- Sociality has been a major influence on the evolutionary structure of our brain.
- What is the current knowledge about the regions of the brain related to social ability and cognition?

What is ‘social brain’?

- Concept of the “social brain” evokes a brain that evolved in the selective pressures of social group living

- Each person shows complex propensities to be in social settings
  - As during childhood relationships
  - Our brain is continually shaped by our social experiences

Social Brain Description

- A growing body of research and theoretical thinking supports this view of the brain as
  - Created by evolutionary processes
  - Developmentally formed
  - Molded by continuing life-long social interactions
  - Embedded in an evolving cultural environment
- This model bears on clinical psychiatry & treatment

Psychiatric conditions as disturbances of social behavior

- Past social interactions structure our brains
  - Both our evolutionary & personal pasts
  - Brain seems elaborately designed to mediate social functioning.
  - It conducts ongoing interpretations of social situation & responds to these interactions
  - Influences the environment & alters the input it receives

Psychiatric Disorders = Social disorders

- Psychiatric Dysfunctions: socially maladaptive cognitive-emotional interpretations & behaviors
- Psychiatric sxs affect social interactions
  - Disruptions of conduct disorder
  - Interpersonal alienation of schizophrenia
  - Interactions of personality disordered people
  - Substance abuser abandons social norms & responsibilities

John Bowlby's Attachment Theory

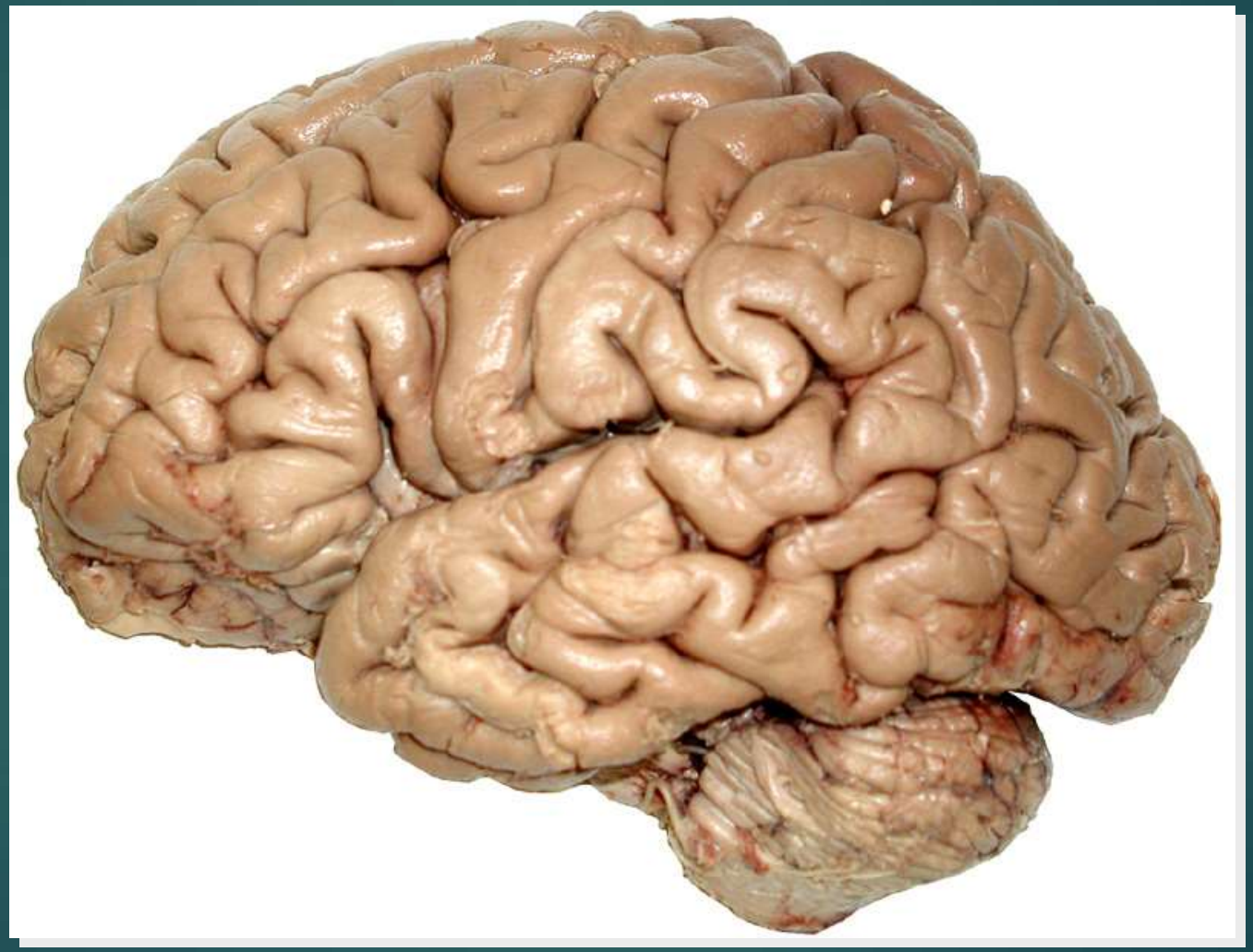
- Bowlby's work ancestral to current social behavior point of view
  - Infants possess innate propensities to seek & maintain proximity to a caregiver
  - Infant behavior elicits specific parental responses in the adult
    - And in turn takes shape from these responses
  - Attachment pattern
    - Shows flexibility & may change with experience
    - Yet it remains stable over the life span
    - It structures one's subsequent social relations
      - from intimate partnerships to the doctor-patient relationship

Development of social ability:

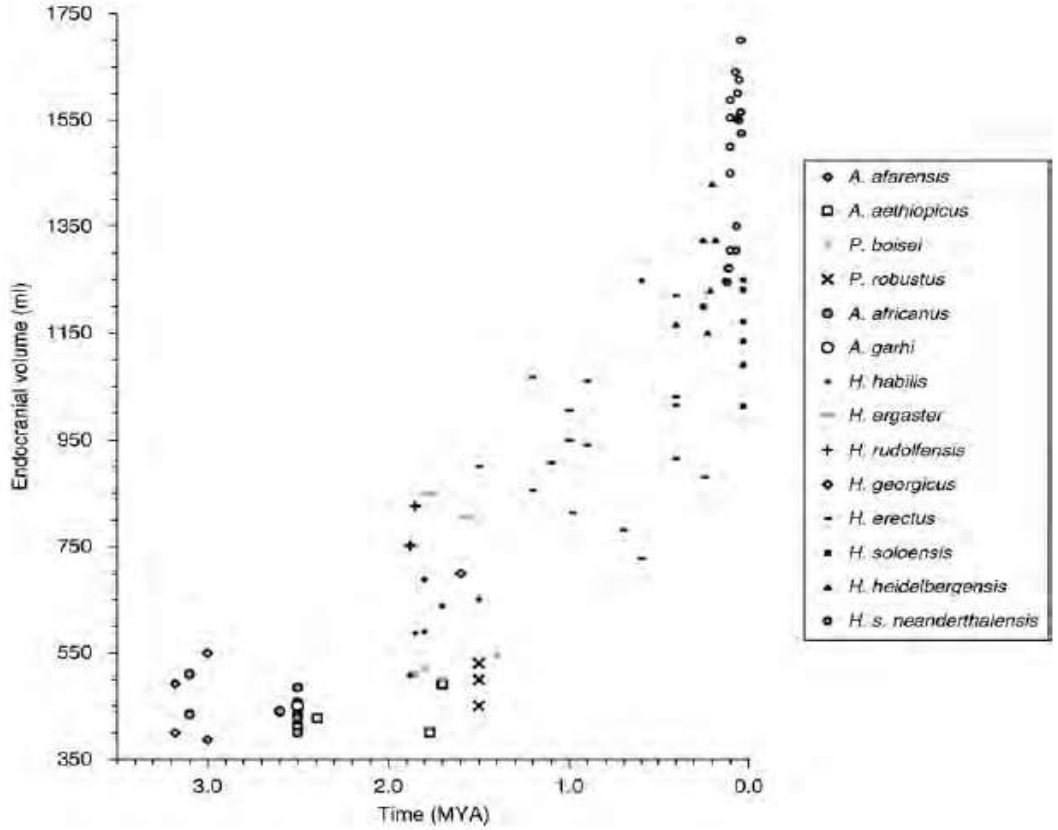
We need a long childhood
with social dependence to program our
hardwired social processors

Takes about 20 years to develop a
functioning adult *Homo sapiens'* brain

Human Brain is large



Increase in brain size during the past 3 million years based on fossil hominid endocasts



Evolution of the Brain in Humans – Paleoneurology. Figure 4 Graph showing increase in brain size during the past 3 million years from the fossil hominid endocasts available. While the graph appears smooth and continuous, it should be remembered that each symbol represents several thousand years, and such a graph cannot accurately portray all of the details of brain size changes with time, particularly given the incompleteness of the fossil record. After Holloway et al. [14].

Classic Evolutionary Brain Theory

- Hominin brain size tripled over 4 million years
- With brain size increase, intelligence increased
- Limbic area conserved
- Significant prefrontal lobe increase
- Probable reorganization of the brain
- Modular paradigm: Cognitive functions isolated to specific brain areas
- Evidence from skull size and endocasts
- Development of use of tools, language, and later art & music ~35kya

Brain size and IQ

- In hominid evolution, brain grew from 400 cc to 1350 cc
- Original belief that there is a positive correlation between increasing brain size and increasing intelligence.
- Wrong! Current Homo sapiens have brains that vary from 1100 to 2000 cc without any noticeable impacts on overall intelligence
- Factors other than intelligence were important for brain development

History of human brain growth

- About 4 MY, first hominids became bipedal with brains about 1/3rd of modern size (400 cc)
- For next million years, brain does not significantly increase in size
- From 3-2.5 MYA, small allometric (related to body size increase) growth (450-500 cc, A. afarensis to A. africanus)
- From 2.5-1.8 MYA, rapid major growth (750 cc, A. africanus to H. habilis); stone tools appear; meat & fish consumption

R. Holloway, 2009

History of human brain 2

- 1.8-.5 MYA, small allometric increase to 800-1000 cc (H. habilis to H. erectus); speculation about language development
- .5-.1 TYA, gradual and modest size increase to archaic H. sapiens, mostly nonallometric, 1200-1700 cc (H. erectus to H. neanderthal)
- .015 to present, small allometric reduction in brain size in modern H. sapiens
- Material culture only in last 100-200,000 years

Newer Perspective & Data on Human Brain Reorganization

- R. Holloway:
  - not just an enlarged ape brain;
  - not just prefrontal size
  - But more mosaic hominid brain reorganization

- K. Semendeferi research using in vivo MRI, post mortem histological analysis, & larger samples

K. Semendeferi, et al., Brain Reorganization in Humans and Apes, 2010

Human Brain Evolution Conclusions 2

- Amygdala has reorganized (increased social cognition)

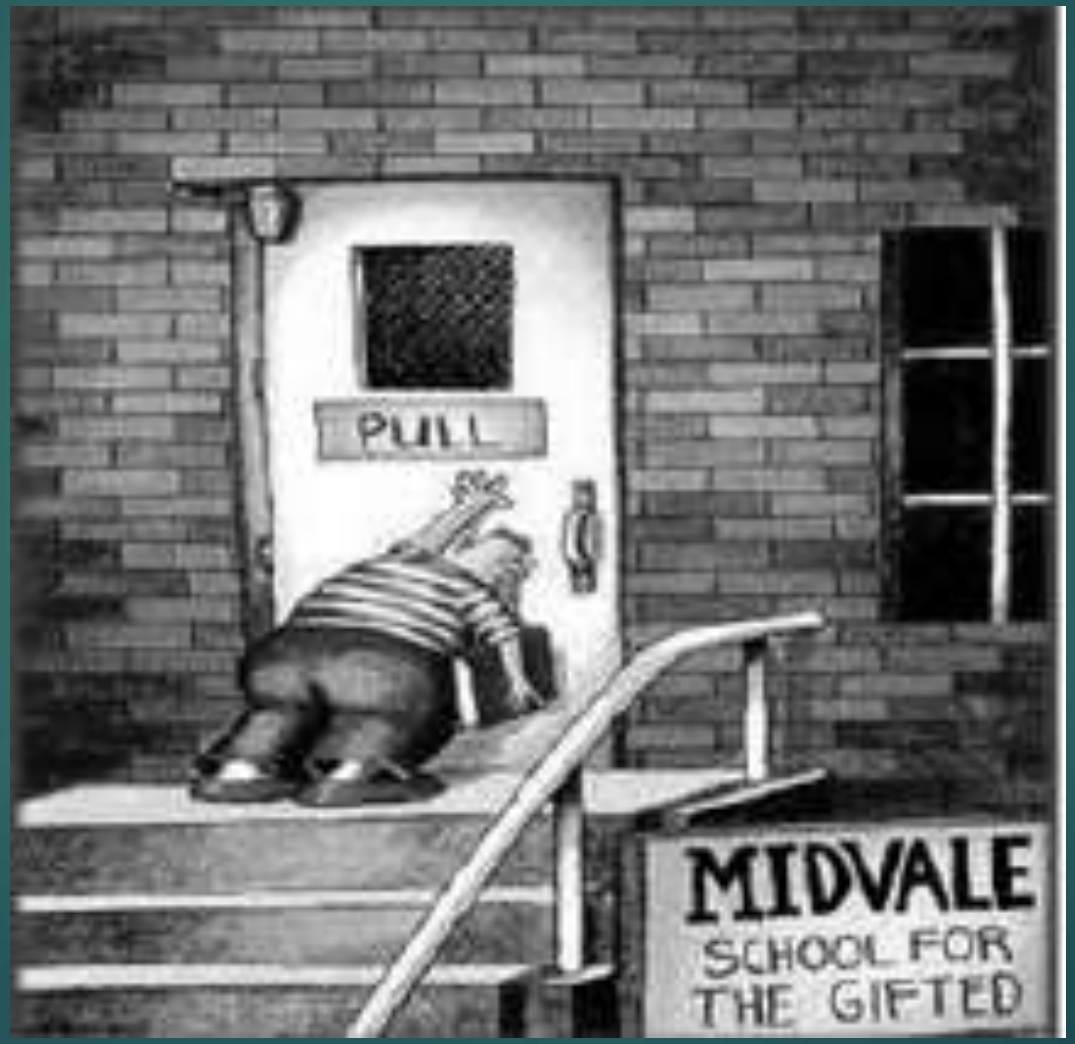
- Richer interconnectivity:
  - Relative volume of white matter is larger in humans
  - Humans exhibit unique patterns of WM distribution
  - Neural connectivity has increased in the humans

- Evolution may be acting on neural systems not just discrete structures

- Social Cognition related neuroanatomy has been enhanced.

Social Intelligence Theory

Sociality: Even if you are smart, it is important to have help



Larson

Cooperation/Compassion at 1.8 MYA

Homo erectus:
Dmanisi D3444, ~1.8 MYA

Neanderthal skull, La Chapelle-aux-Saints

Neanderthal, ~50 kya

Reabsorbed teeth bone: lived without teeth for years;
Must have been taken care of by their social groups

Theorizing about the evolution of social brain

- What types of selection pushed the evolution of the size of the human brain?

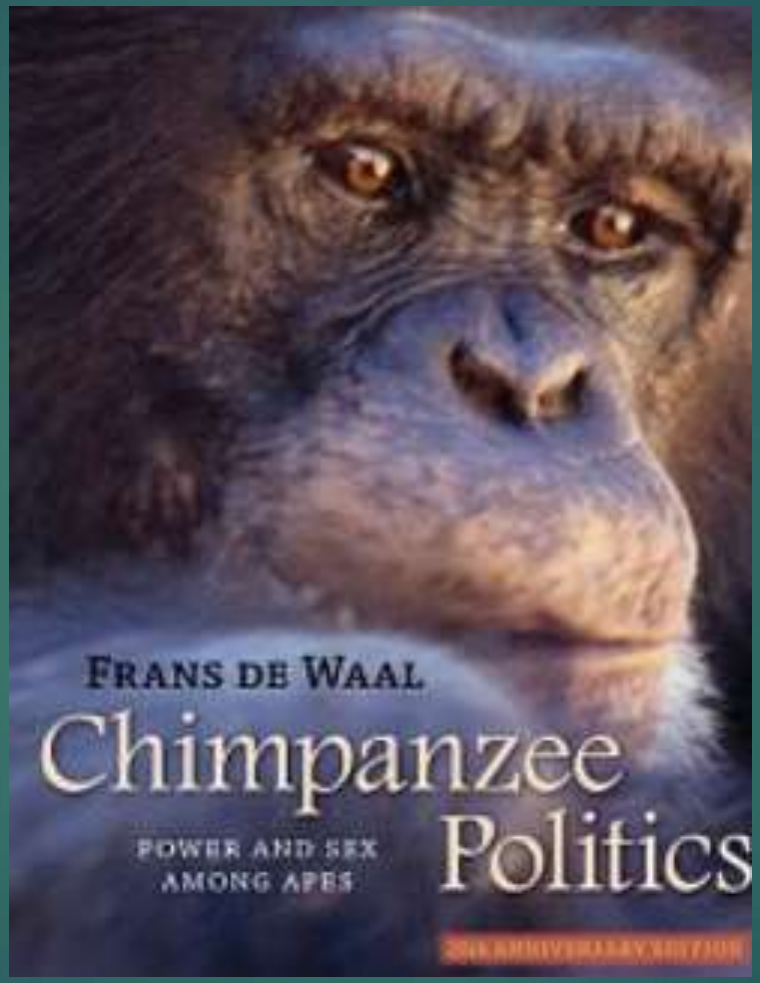
- Charles Darwin, in *The Descent of Man*, proposed that evolution of intelligence is linked to living in social groups.

Theories

- Jolly, 1966 & Humphrey, 1976: complex social life of primates was the source of neocortex increase & improved higher cognitive processes

- Humphrey: human consciousness/self awareness developed as a way to understand social world

Why did Newt Gingrich recommend this book to all new politicians?



Detailed and thoroughly engrossing account of ape rivalries and coalitions.
Machiavellianism**:** political behavior is rooted at a level of development that is below the cognitive and is as much instinctive as it is learned.

de Waal 1982

De Waal, Byrne & Whiten: Machiavellian IQ

- Machiavelli's The Prince: Frans de Waal introduced the term 'Machiavellian Intelligence' to describe the social and political behavior of chimpanzees

- Social behaviors: reconciliation, alliance, and sabotage

- Tactical deception in primates:
  - Vervet monkeys use false predator alarm calls to get extra food
  - Chimpanzees use deception to mate with females belonging to alpha male

2 Theories of brain size development

- Ecological: find food in complex environment; ecological problem-solving
  - Highly fruit eating primates have larger brain to body size ratios

- Social: social group size increases intelligence

Dunbar, 1998

Neocortex size correlates with social group size not ecological variables

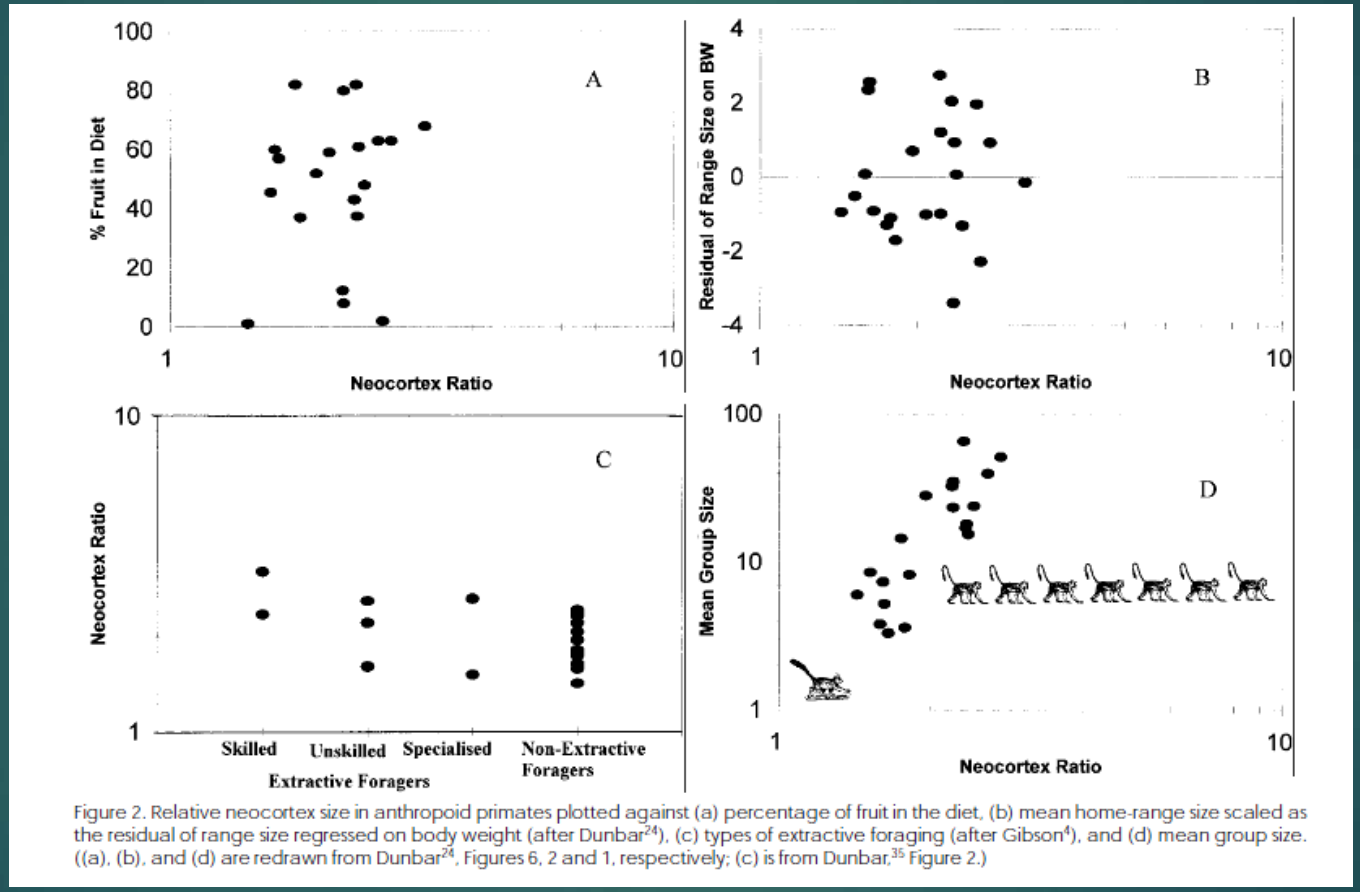


Figure 2. Relative neocortex size in anthropoid primates plotted against (a) percentage of fruit in the diet, (b) mean home-range size scaled as the residual of range size regressed on body weight (after Dunbar[24]), (c) types of extractive foraging (after Gibson[4]), and (d) mean group size. ((a), (b), and (d) are redrawn from Dunbar[24], Figures 6, 2 and 1, respectively; (c) is from Dunbar,[35] Figure 2.)

Fruit in diet, foraging type, foraging range vs. group size

Dunbar, 1998

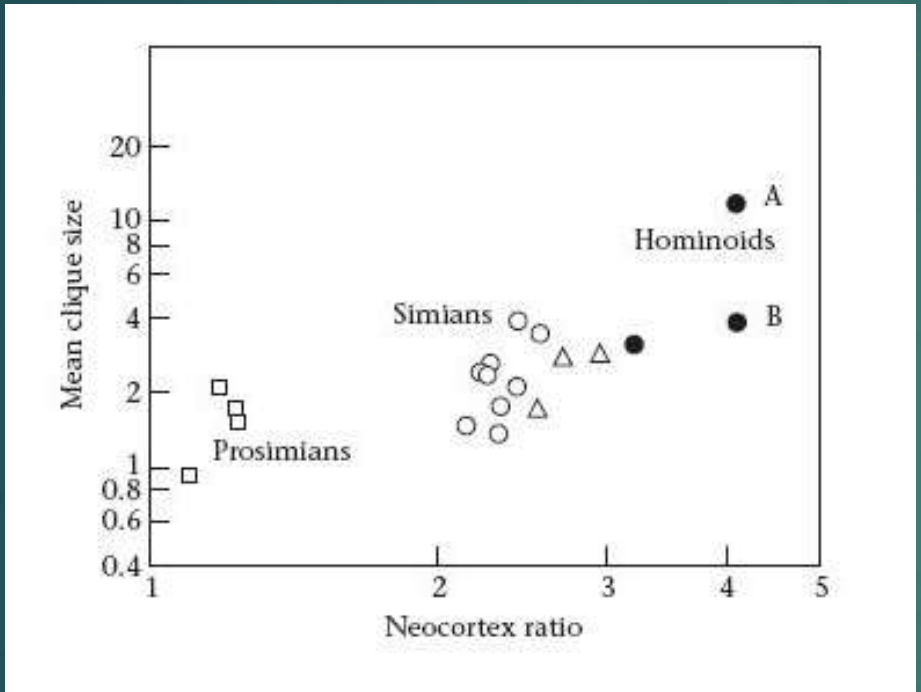
Robin Dunbar: Social Brain Hypothesis

- Primates evolved large brains to manage their unusually complex social systems.

- This hypothesis has found support in a number of comparative studies of group size.

Dunbar, 1998

As group size goes up, so does neocortical brain size



Mean clique size in primates

Average group size

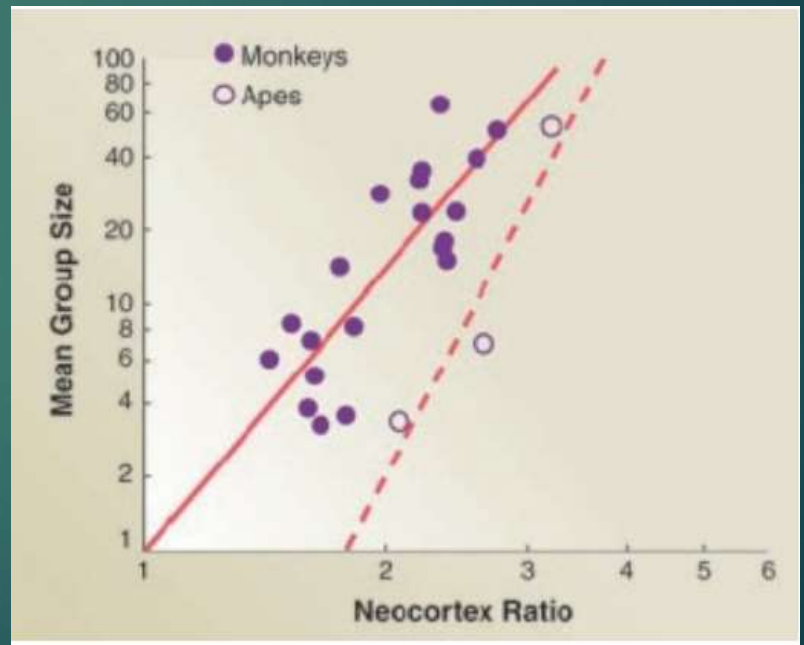
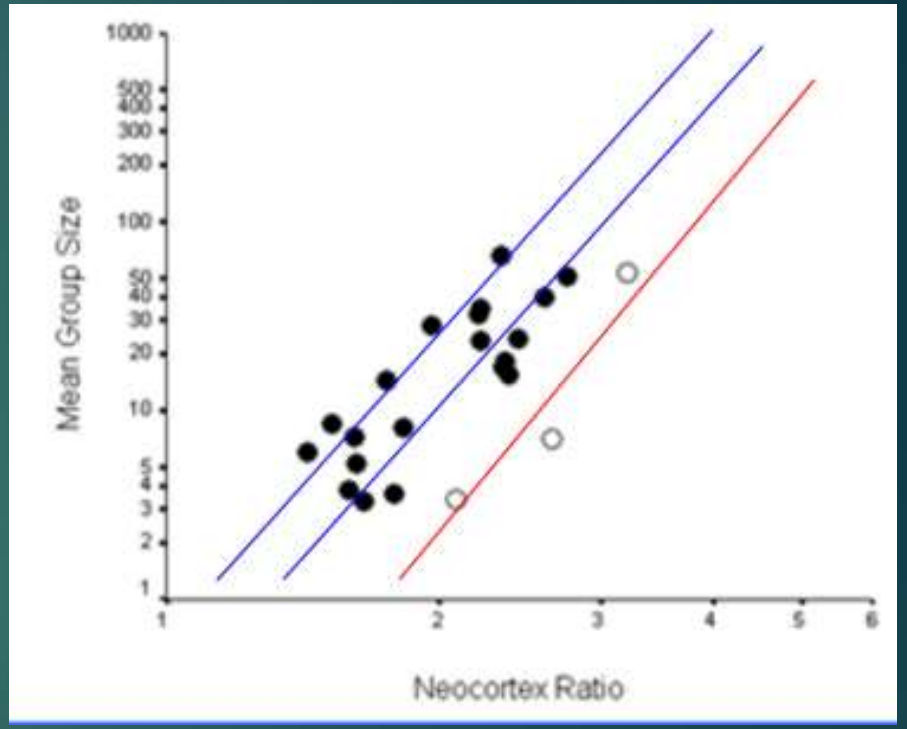


Figure 1. As average group size increases in monkeys and apes, so does neocortex ratio. Reproduced from Dunbar and Shultz (2007).

Social Brain Hypothesis

- An explanation why primates have such big brains compared to all other species
- Primates live in unusually complex societies, and this is computationally very demanding on the brain
- Group size is an index of social complexity
- Neocortex ratio is an index of brain size



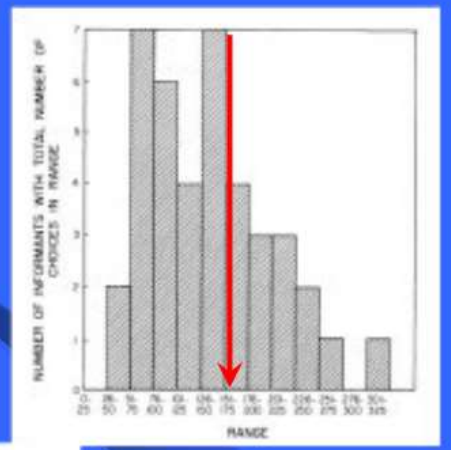
Human Social Groups

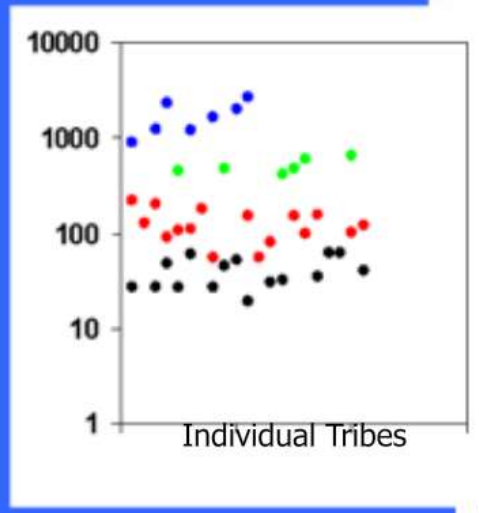
These all have mean sizes of 100-200

Neolithic villages 6500 BC	150-200
Modern armies (company)	180
Hutterite communities	107
'Nebraska' Amish parishes	113
business organisation	<200
ideal church congregations	<200
Doomsday Book villages	150
C18th English villages	160
GoreTex Inc's structure	150
Research sub-disciplines	100-200
Small world experiments	**134**
Hunter-Gatherer communities	**148**
Xmas card networks	**154**

"Reverse" Small World Experiments

Killworth et al (1984)



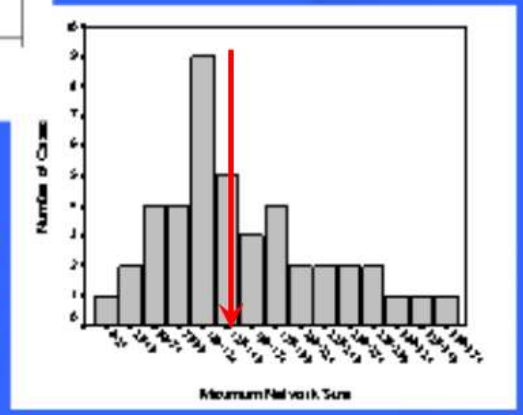


Hunter-Gatherer Societies

Dunbar (1993)

Xmas Card Networks

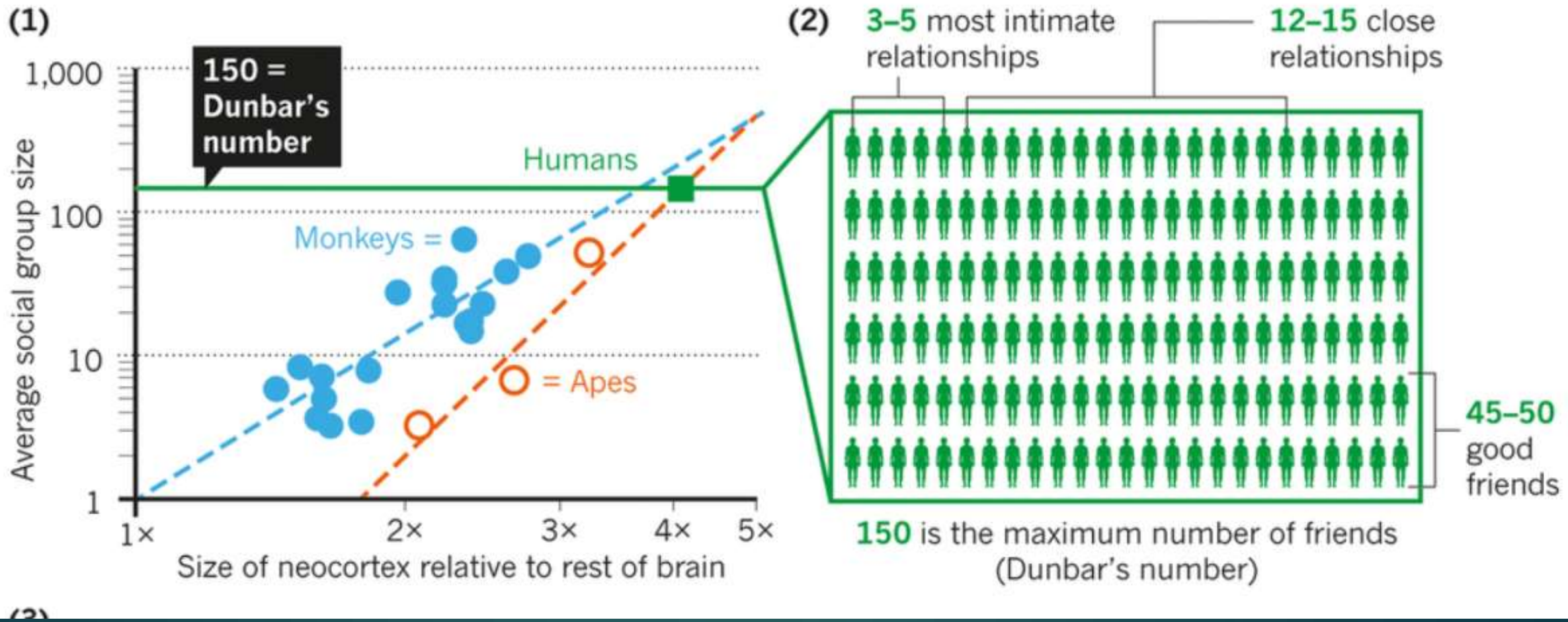
Hill & Dunbar (2003)



6 degrees of separation

SOCIAL ANIMALS

In primates, the size of social circles correlates to the relative size of the neocortex compared with the rest of the brain (1). In humans, Dunbar's number is a suggestion of the amount of relationships a person can maintain. Human social networks seem to be split into hierarchies (2, 3), with group sizes varying by a factor of about three.



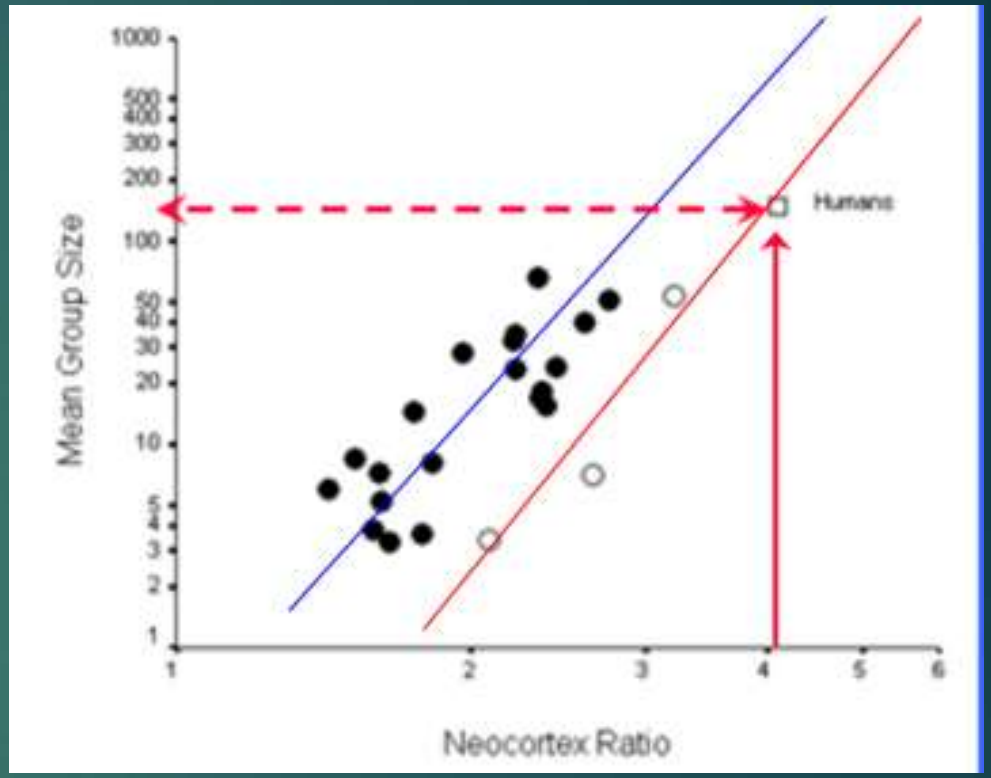
Brain region size correlates of social complexity

- correlation between the size of a person's network and their performance on tests of both memory and 'theory of mind'
- grey-matter volume of parts of the prefrontal cortex vary with social-network size, as well as with performance on theory-of-mind tasks
- volume of the amygdala correlates with the size and complexity of a person's social network.
- grey-matter density in certain parts of the temporal lobe, which is associated with social perception and associative memory, has been found to vary according to the size of volunteers' Facebook networks
- a link between white-matter integrity and the richness of a person's web of social interactions (Isolated individuals have higher levels of inflammation; latter damages WM)

Humans and the Social Brain Hypothesis

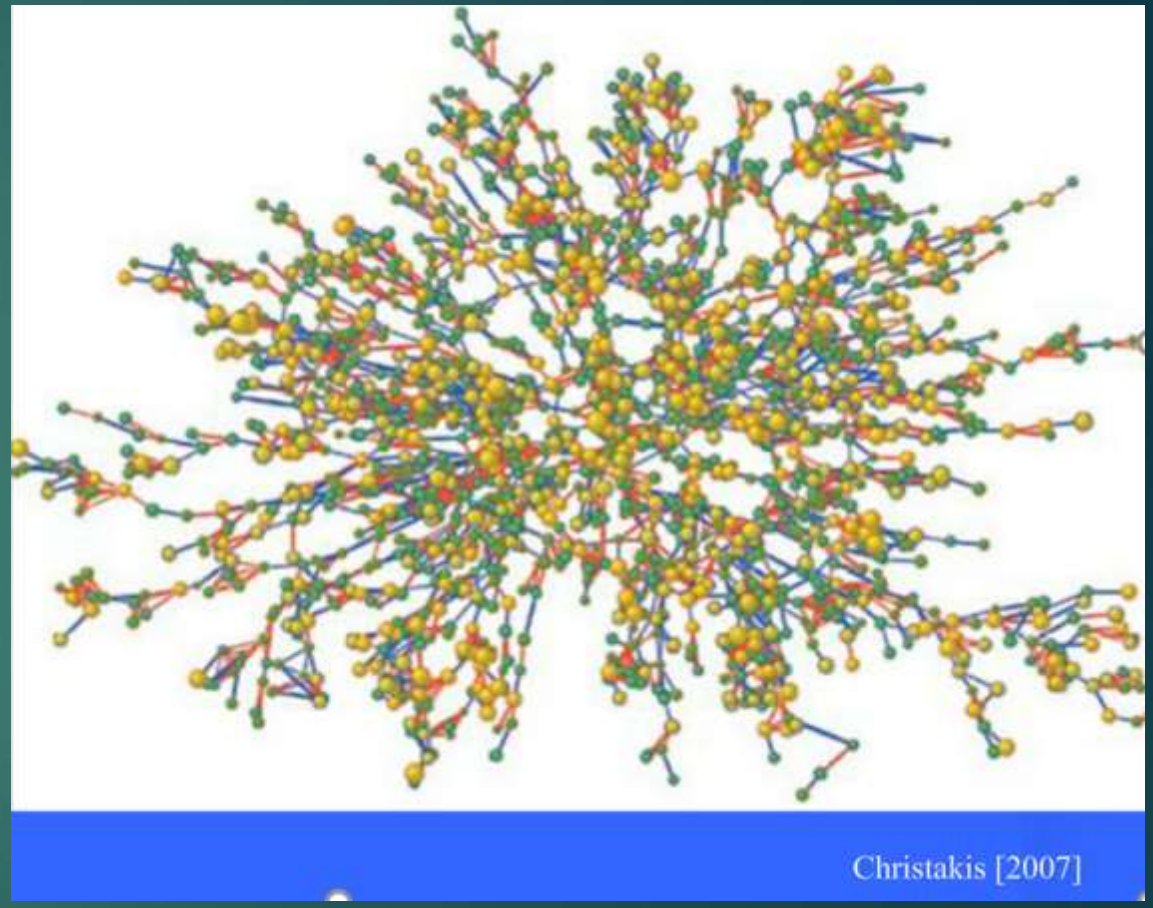
Predicted group size for humans is ~150

Dunbar’s Number



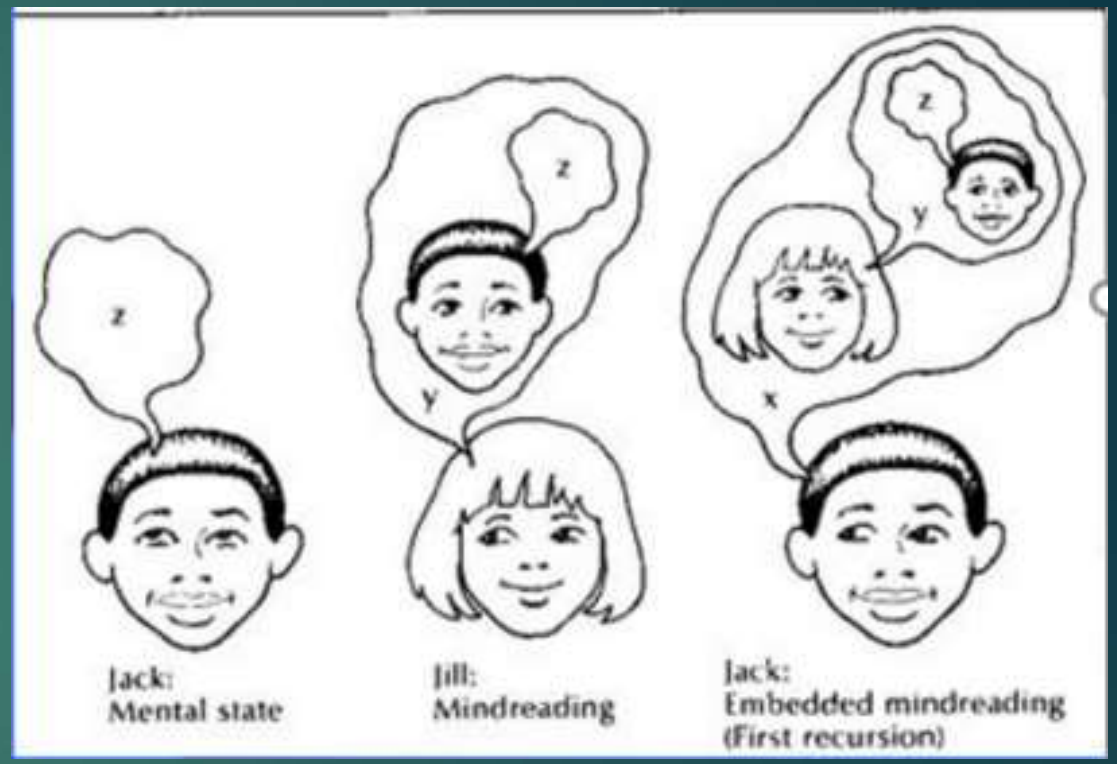
Obesity Clusters in Social Networks

- Framingham Heart Study
- Probability of becoming obese increases by:
  - 57% if a friend becomes obese
  - 40% if a sibling becomes obese
  - 37% if spouse becomes obese
- Independent of genetic relatedness and proximity to a McDonalds



The Role for Social Cognition

- Social cognition as the likely mechanism
- Intentionality as a reflexively hierarchical sequence of belief states
- …that may be very costly in information processing terms for the brain



Complexity of human evolution

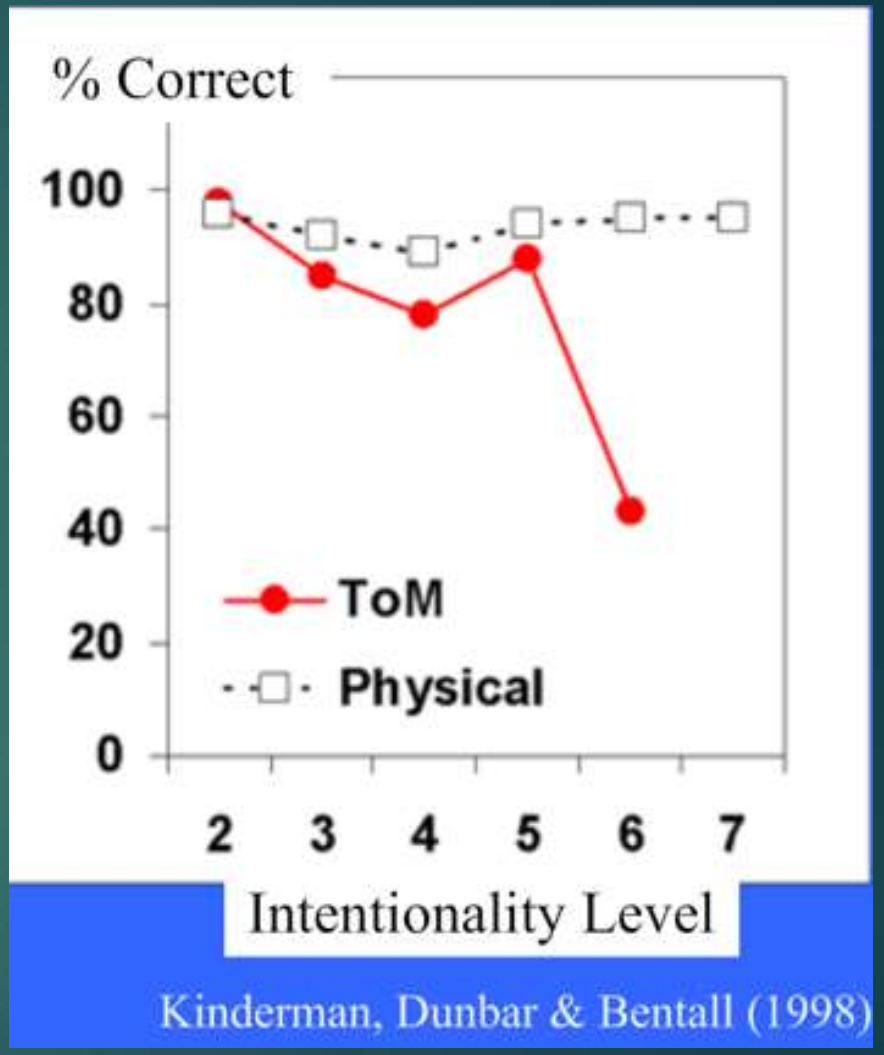
“I know you think you understand
what you thought I said,
but I don’t think you realise that what you heard
was not what I meant.”

~ Daniel Greenspan

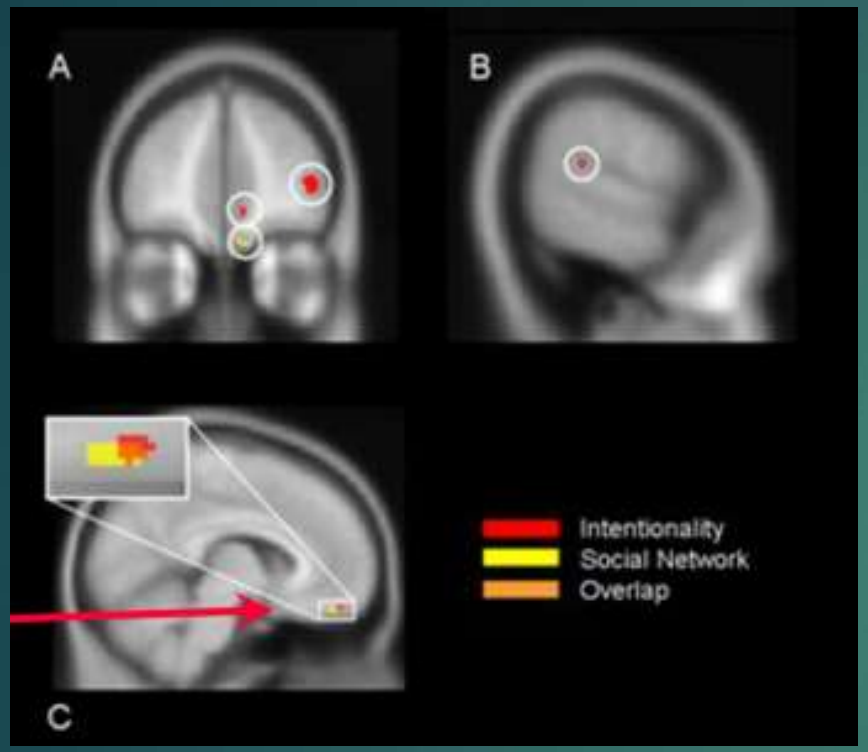
Limits of Intentionality

A natural limit at 5th level of intentionality

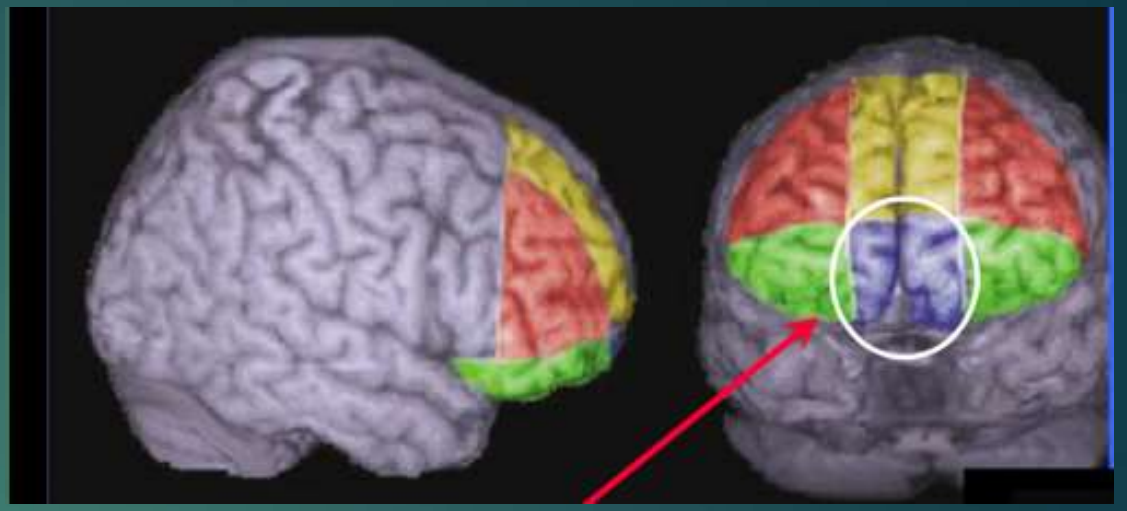
"I intend that you believe that Fred understands that we want him to be willing to do something…"
[level 5]



Insights from Neuroimaging



In a fine-grained VBM (voxel) analysis: overlap of network size and intentional competence in the orbitoventral PFC



- In a stereological analysis of gross volume: best predictor of network size and intentional competence is medial orbitofrontal PFC volume.

Social correlates of neocortical size: emphasis on complexity not quantity

- Social group size
- Average group size of free-ranging primates
- Mean number of females
- Frequency of tactical deception
- Length of the juvenile period (intensive social learning period)
- Grooming clique size
- Proportion of play that is social
- Capacity to exploit subtle mating strategies

R. Dunbar, 1998, 2011

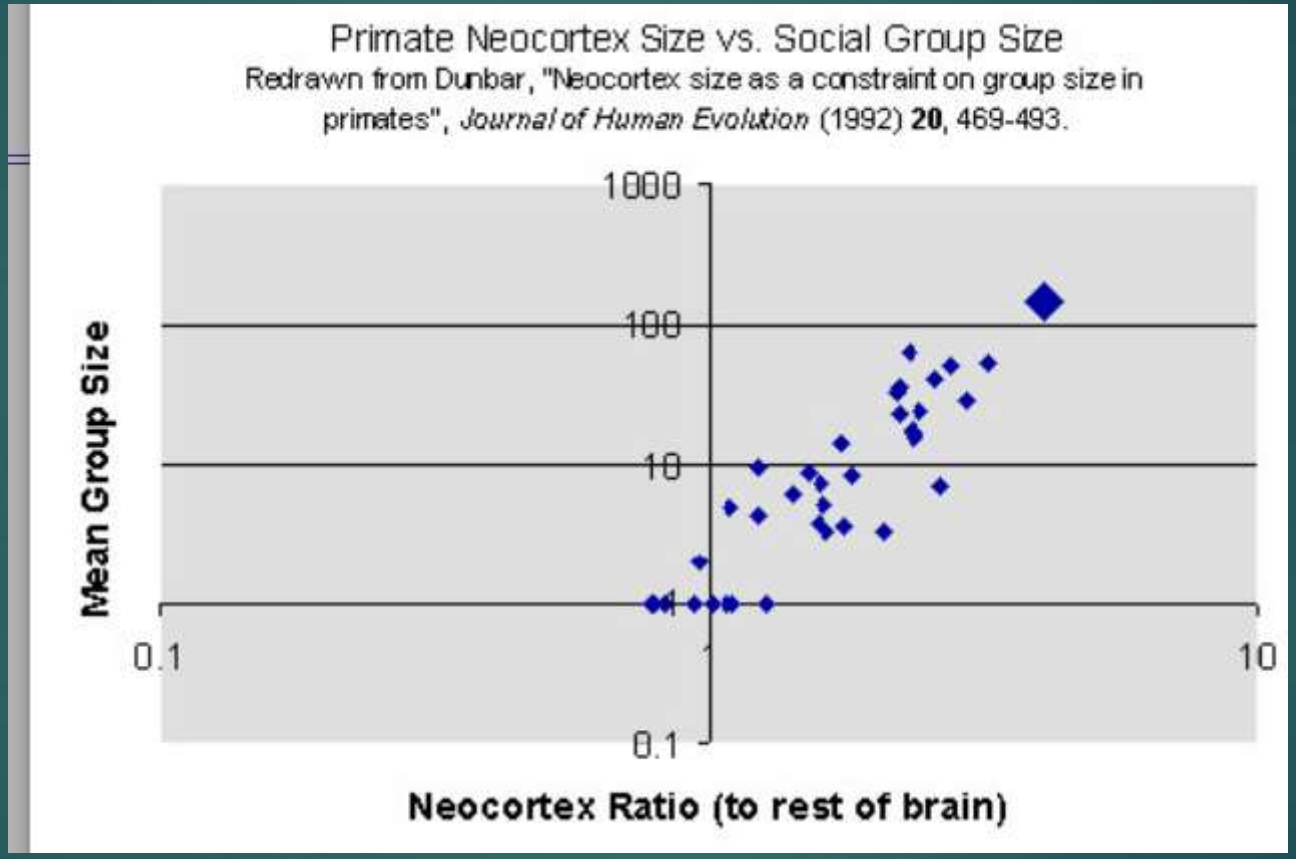
Gossip

- Dunbar: 66% of human talking is dedicated to gossip (affairs, insider trading, food sourcing, trading, who likes who, who is out to get you); impossible to personally monitor the behavior of all group members; way to track reputations

- Prosocial gossip: Share negative gossip to protect others from antisocial behavior

R. Dunbar, 1996;
M. Feinberga et al., 2012

Neocortex size limits group size:
Your brain can just deal with about 150 meaningful relationships.



Dunbar's number (150) represents largest number of people with whom they can maintain a social relationship (who each person is & how each person is related)

Group size vs. brain size: chicken or egg?

- Is it the social network that causes the increase in neocortical size or does brain size allow social networks to expand?
- 2011 experiment by Sallet: housing monkeys in different sized groups
- Randomly assigned 34 rhesus macaques to separate social groups ranging in size from 1 to 7 monkeys
- Brain MRI scans of 23 before they were placed into their various groups and again after more than a year had passed.

J. Sallet, *Science*, 2011

Superior Temporal Sulcus (STS), PFC, Amygdala

Gray matter increased with social network size

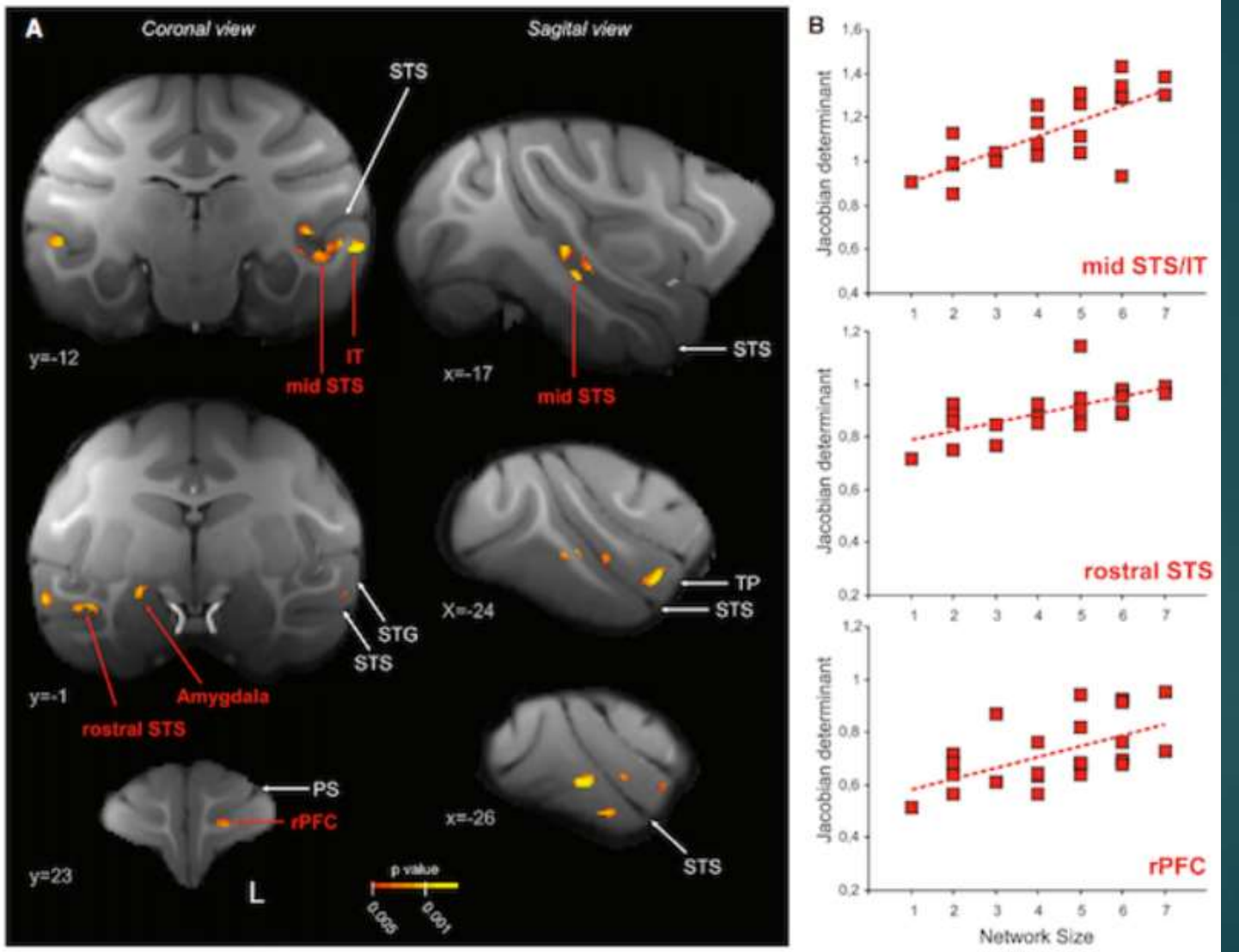


Figure 2. Gray matter increased with social network size; P < 0.005. Reproduced from Sallet et al. (2011).

http://blogs.scientificamerican.com/primate-diaries/2011/11/17/social-networks-matter/

GM increases with social network size

- A linear relationship between the size of a monkey's social network and an increase of neocortical gray matter
  - Specifically in social cognition regions (mid-STS & IT, right PFC, Amg).

- 3-8% increase for each additional member of their social network.

- Average increase of 20% in the most socially complex group compared to monkeys housed individually.

Being boss has benefits

- A linear relationship, at a ratio of 3-to-1, between a monkey's dominance behavior and the growth of key regions in their neocortex.

- Cognitive demands of a larger social network resulted in the growth of brain regions beneficial to social behavior in primates.

Social size matters

- Studies in macaque monkeys have shown that brain areas involved in face processing and in predicting the intentions of others are larger in animals living in large social groups than in ones living in smaller groups.

- Brain areas are enlarged and better connected in people with larger social networks: temporal parietal junction, the anterior cingulate cortex and the rostral prefrontal cortex

- White-matter tracts were better connected in people with bigger social networks.

- Direction of causation still undetermined: born with or social practice?

Prefrontal Functions

- Dorsolateral: Smartness
  - higher cognitive problem solving functions
  - working memory, planning, set shifting
- Medial: Empathy
  - Behavioral activation
  - VentroMedial: emotionally-mediated moral network
- Orbital: Socially appropriate
  - evaluation of social reinforcers
  - behavioral inhibition

Right Hemisphere Language Processes

- Sarcasm
- Humor
- Metaphor appreciation
- Visual image Nouns (tree)
- Emotional content (love)
- Pictorial word form (kanji, logos); pictographic reading
- Distance related material (journey, life)
- Better at semantic (meaning) than lexical (word or not)
- Context processing
- Prosody

- Right Hemisphere: heavily involved in social processes

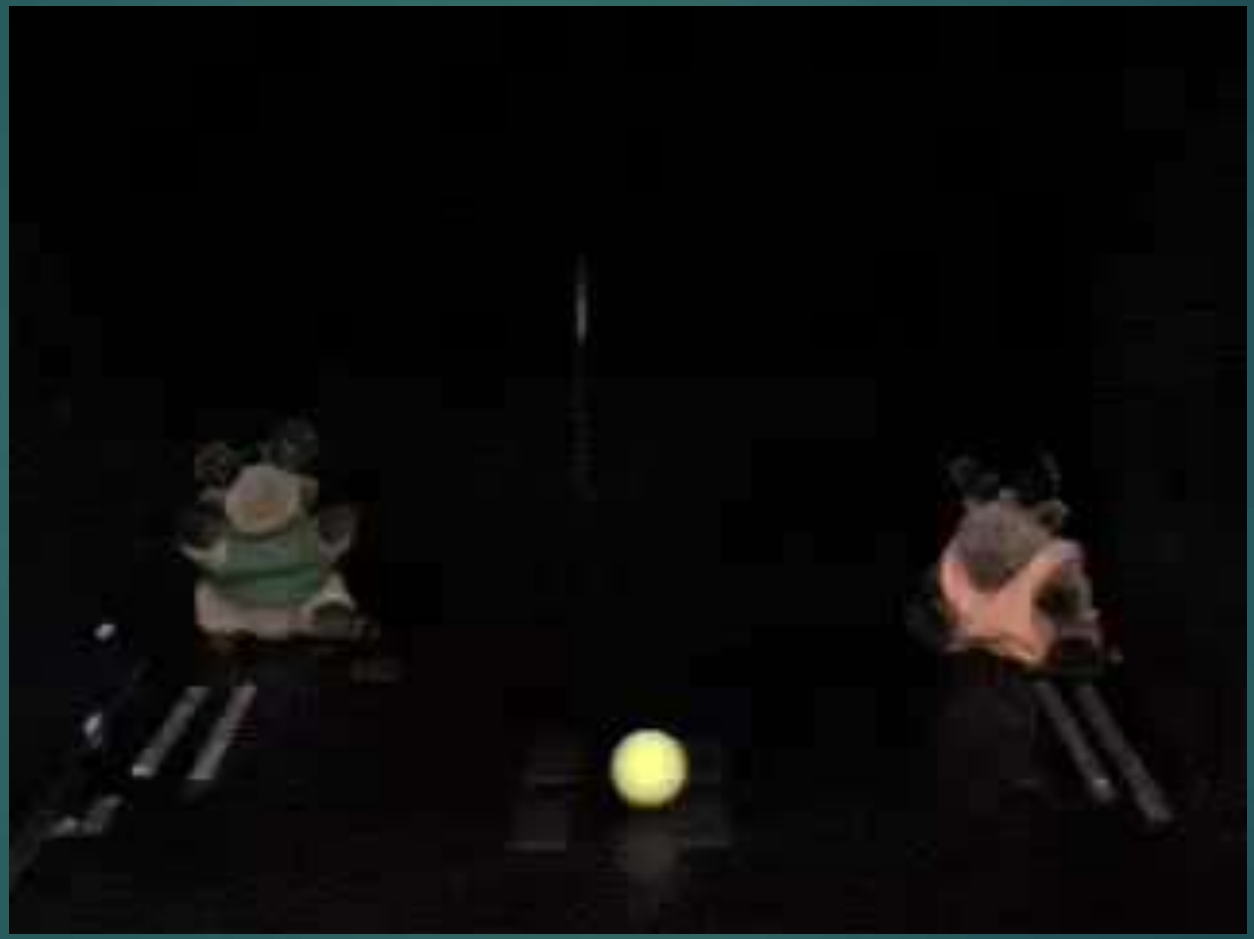
Babies…

- Scientists already know that babies expect some social graces in other people:
  - They expect people in a conversation to look at each other
  - talk to other people, not objects
  - are eager to see good guys rewarded and bad guys punished
  - that they want to interact with nice people
  - before they have any friends themselves, young babies are already making predictions about how people get along: babies are also attuned to other people's relationships, even when those relationships have nothing to do with them.

Just Babies: The Origins of Good and Evil (2013) by Paul Bloom.

- Testing the theory that we have an innate moral sense, Bloom provides experimental evidence that we are born with:
  - a moral sense—some capacity to distinguish between kind and cruel actions;
  - empathy and compassion—suffering at the pain of those around us and the wish to make this pain go away;
  - a rudimentary sense of fairness—a tendency to favor equal divisions of resources;
  - a rudimentary sense of justice—a desire to see good actions rewarded and bad actions punished."

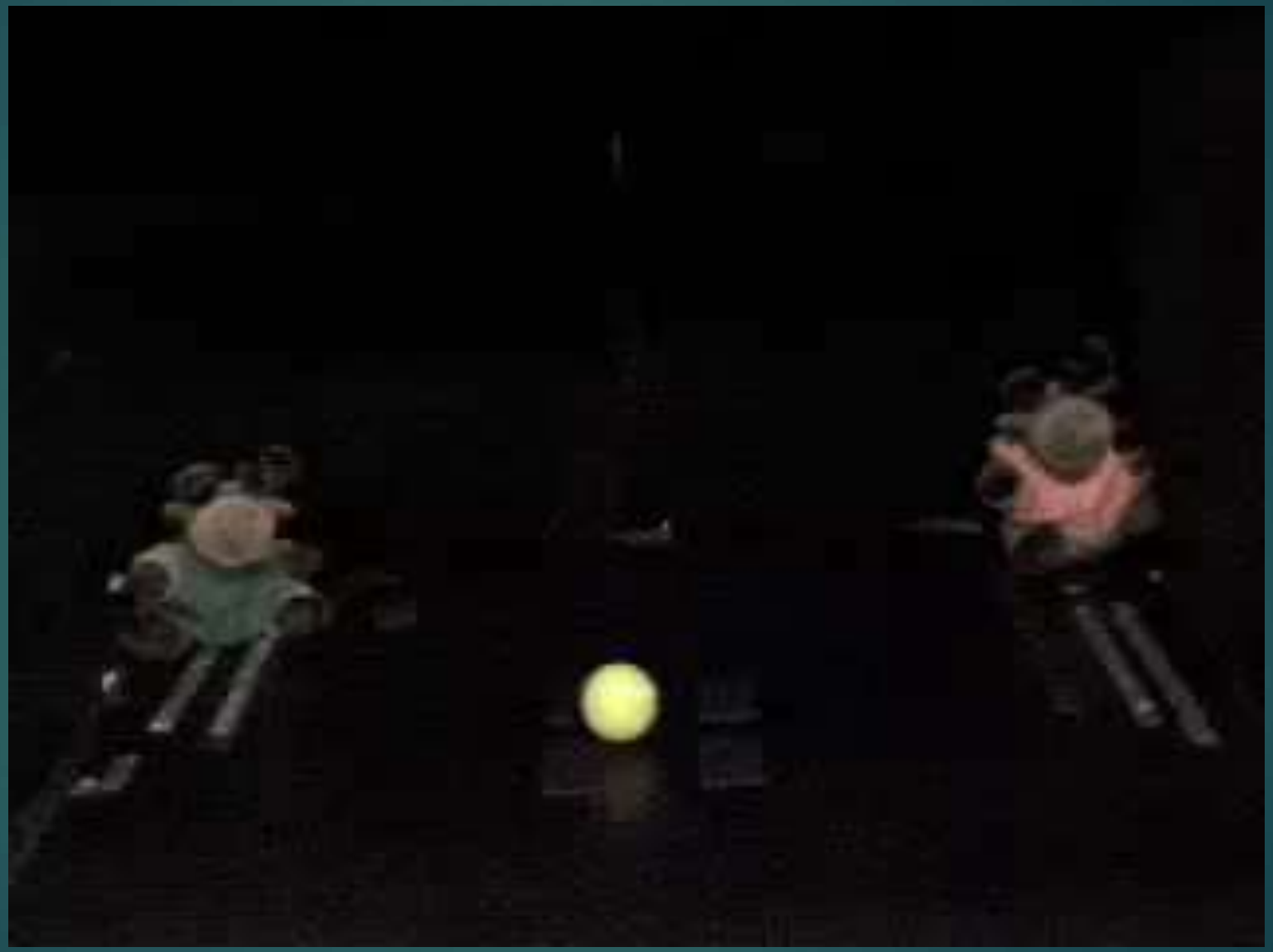
Giving



Notice colors of friendly Moose’s shirts

Hamlin, J.K., & Wynn, K. (2011).

Taking



Bloom

- Time and again, the moral sense of right (preferring helping puppets) and wrong (rejecting hurting puppets) emerges in people between three and 10 months of age, far too early to attribute to learning and culture.
- In Bloom's laboratory, a one-year-old baby watched puppets enact a morality play.
- One puppet rolled a ball to a second puppet, who passed the ball back. The first puppet then rolled the ball to a different puppet, who ran off with the ball. The baby was next given a choice between taking a treat away from the “nice” puppet or the “naughty” one.
- As Bloom predicted, the infant removed the treat from the naughty puppet—which is what most babies do in this experiment.
- But for this little moralist, removing a positive reinforcement (the treat) was not enough. “The boy then leaned over and smacked this puppet on the head,”

5 & 9 month old infants prefer prosocial to antisocial others

8 m old toddlers direct positive behaviors toward prosocial others & negative behaviors toward antisocial others.

Hamlin, J.K., & Wynn, K. (2011).

What is a neuronal commonality in social animals with large brains?

Elephants

Smithsonian.com

Cetaceans: Whales & Dolphins

Primates

Von Economo Neurons (VENs)

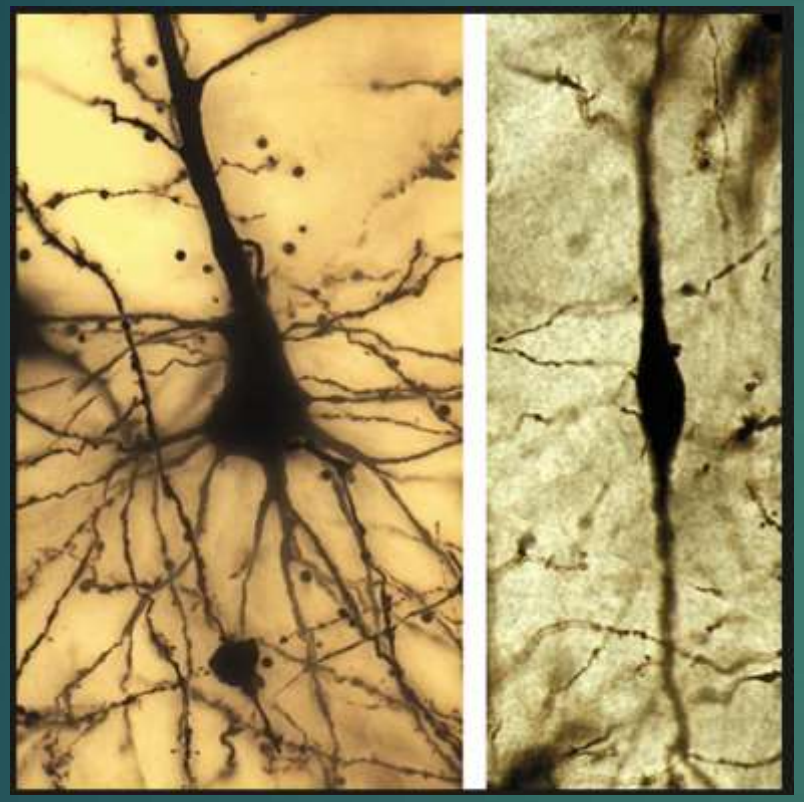
- There are 3 species with the largest brains on the planet.
- They are also the most social species.
- They also have the most VENs.
- P. Hof: "They [VENS] are like the 'express trains' of the nervous system" that bypass unnecessary connections, enabling us to instantly process and act on emotional cues during complex social interactions.
-

Constantin Freiherr von Economo, 1876 -1931

In 1925, his monumental work with Koskinas "Cytoarchitectonics of the Adult Human Cerebral Cortex“ was published.

The name “von Economo neurons” coined by Allman et al. (2005)

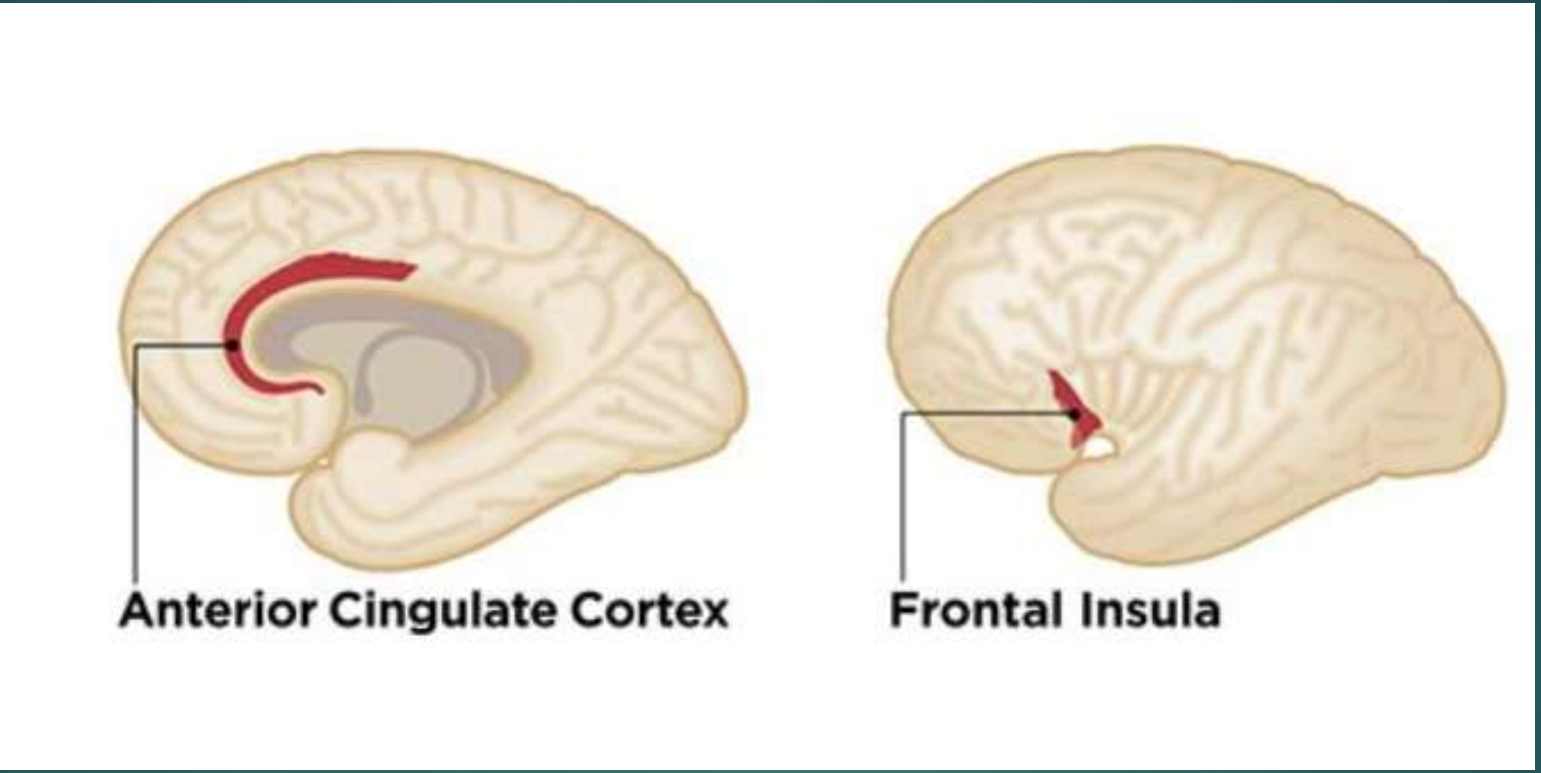
Brain Cells for Socializing?



A focal concentration of VENs in ACC and FI distinguishes large-brained, highly social mammals from other mammalian species.

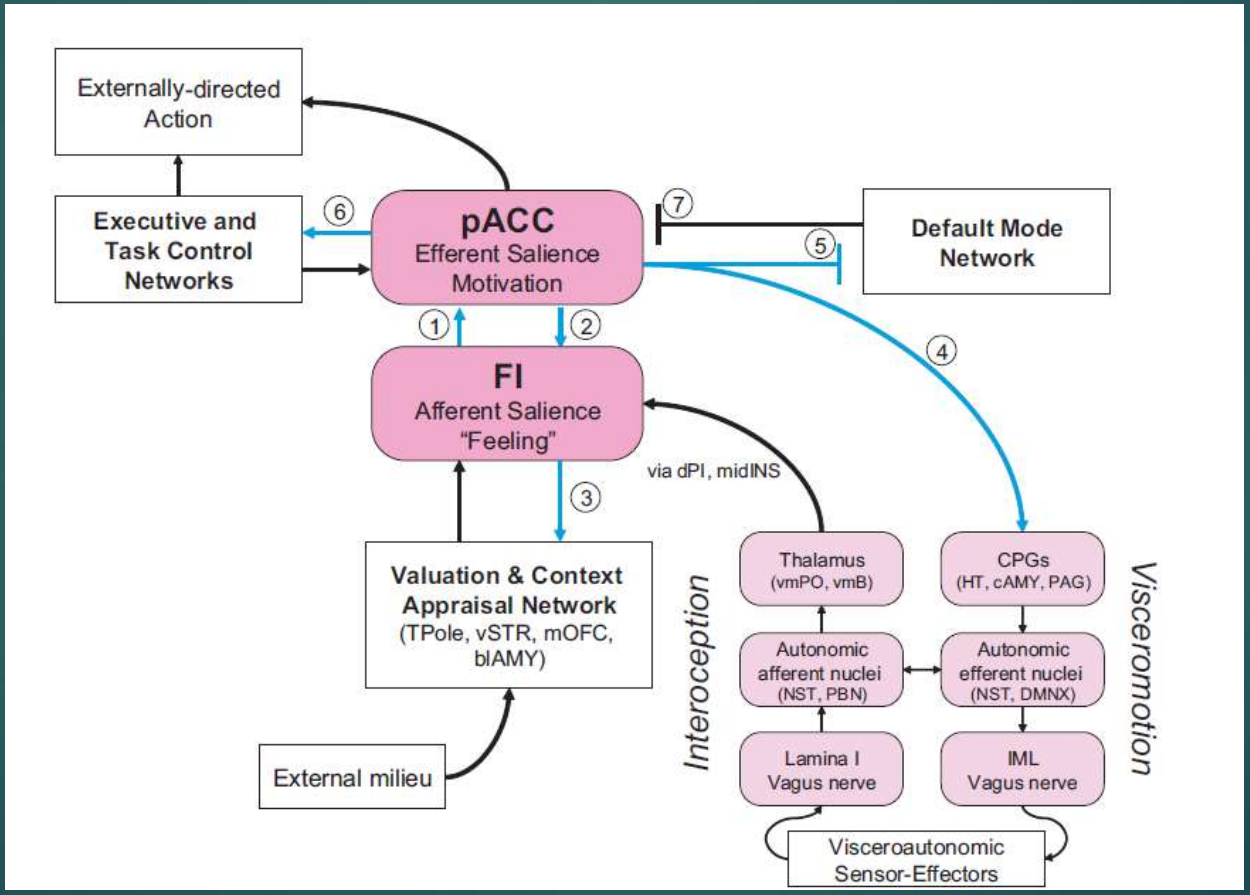
(Allman et al., 2010; Hakeem et al., 2009; Hof and Van der Gucht 2007; Nimchinsky et al., 1999; Rose 1928)

Location of VENS: ACC & FI



The FI features the other layer 5 neuron, the fork cell, which is scarcely seen in ACC.

Social Salience Network Central:
pACC & FI, VENS



W. Seeley, et al., 2011

Von Economo Cells

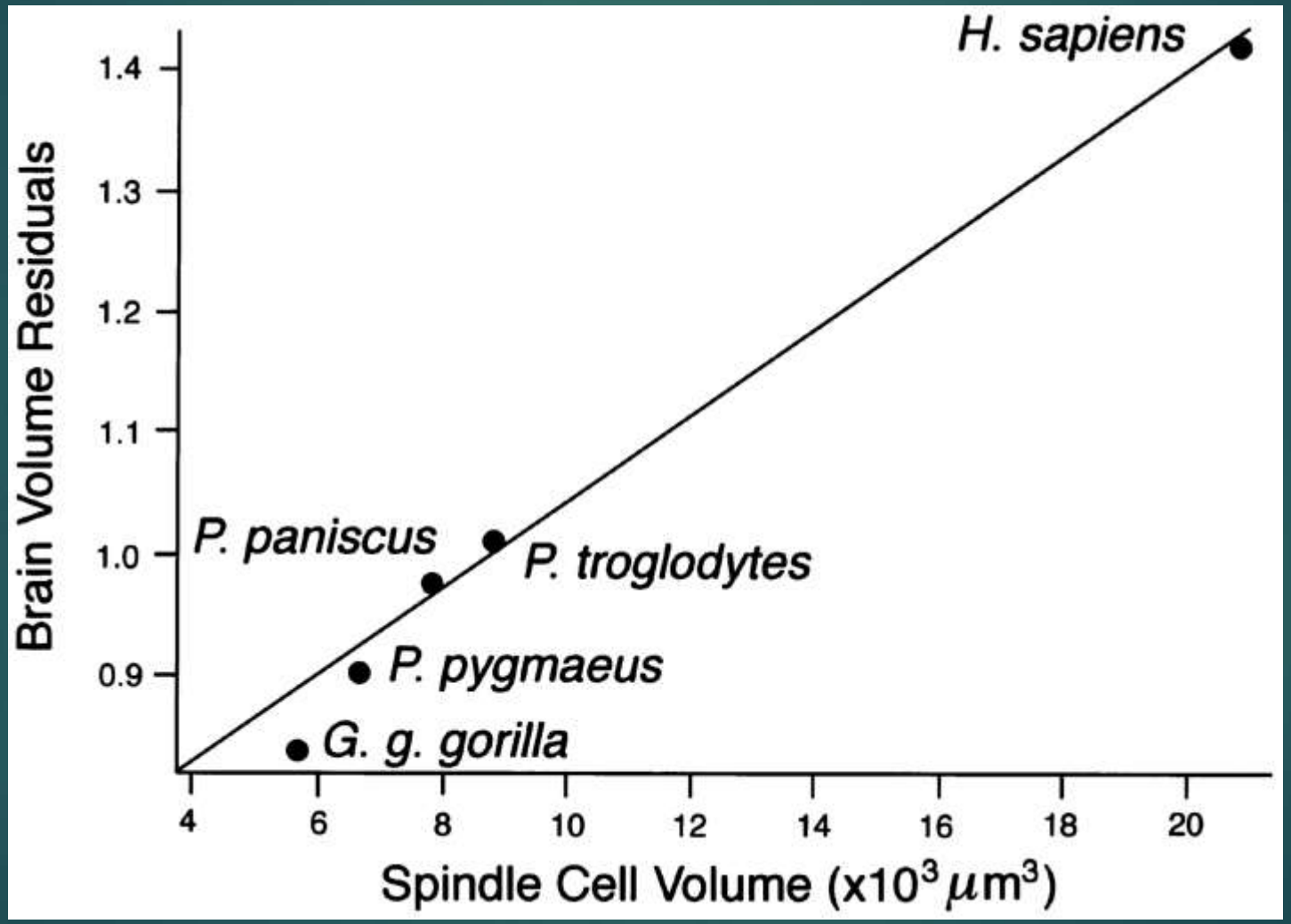
- Fastest and largest neurons located primarily in the anterior cingulate and insula (layer Vb)
- Only 3 groups with significant VENs: primates/humans, certain cetacians, elephants; largest brains and most social species
- Evolved to speed information around a big brain for social analysis

VENS: Von Economo Neurons

- Layer Vb neurons
- FI >>pACC; few in hippocampus & dlPFC
- R/L ~1.3 (30% more abundant in the right hemisphere)
- Emerge late in gestation, 34-38 weeks
- Peak # 8m to 4 y
- Pruned to adult status ~8 y
- Absent in monkeys and lesser apes
- Humans>>>chimps>gorillas>Orangs
- Correlated with increased encephalization (IQ)

Nimchinsky et al., 1995, Allman et al., 2010, W. Seeley lecture, 2011

Comparison of number of VENs and relative brain volume



Nimchinsky E A et al. PNAS 1999;96:5268-5273

Possible functions of VENs

- Regulation of appetite and gastrointestinal function
- Gut feelings: conscious perception of bodily states and in its integration in conscious decisional processing
- Core of social salience network: social ability
- Possible neuronal basis of network switching
- Self awareness via insula

Current idea of distribution of VENs

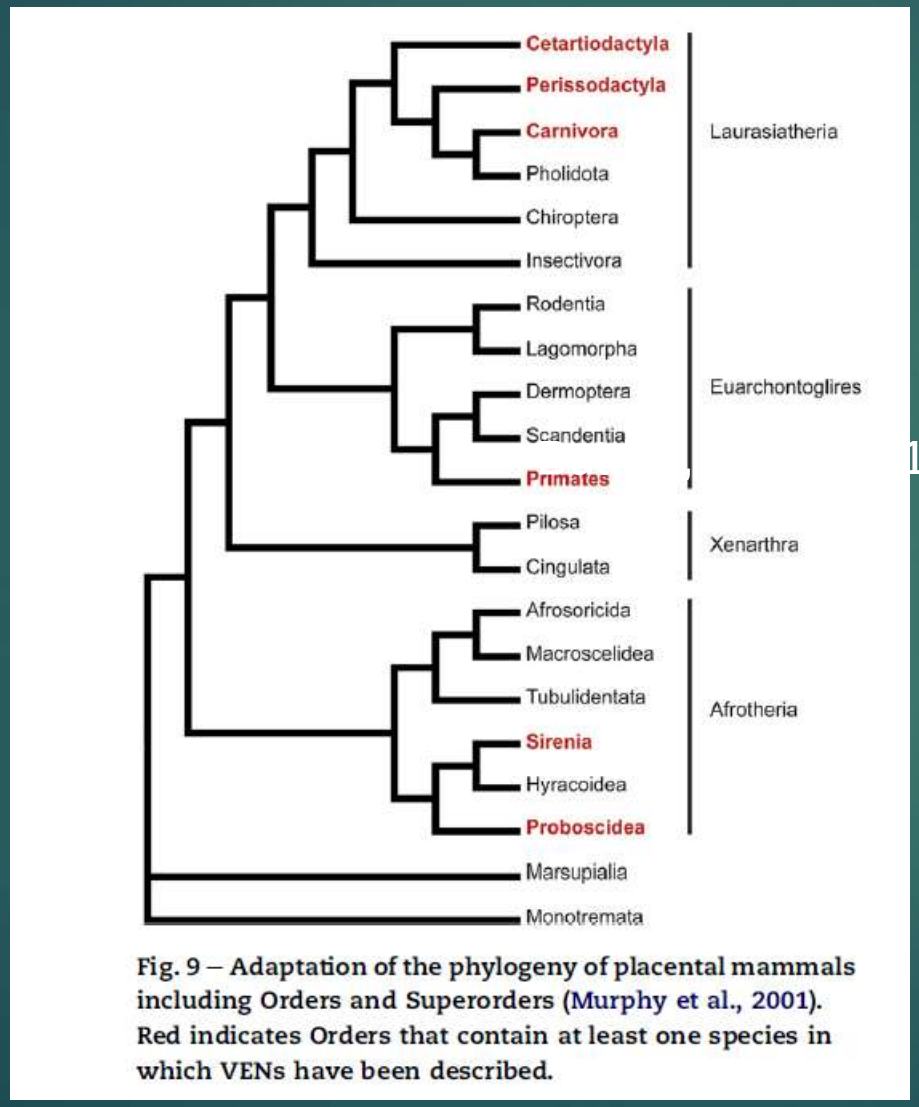


Fig. 9 – Adaptation of the phylogeny of placental mammals including Orders and Superorders (Murphy et al., 2001). Red indicates Orders that contain at least one species in which VENs have been described.

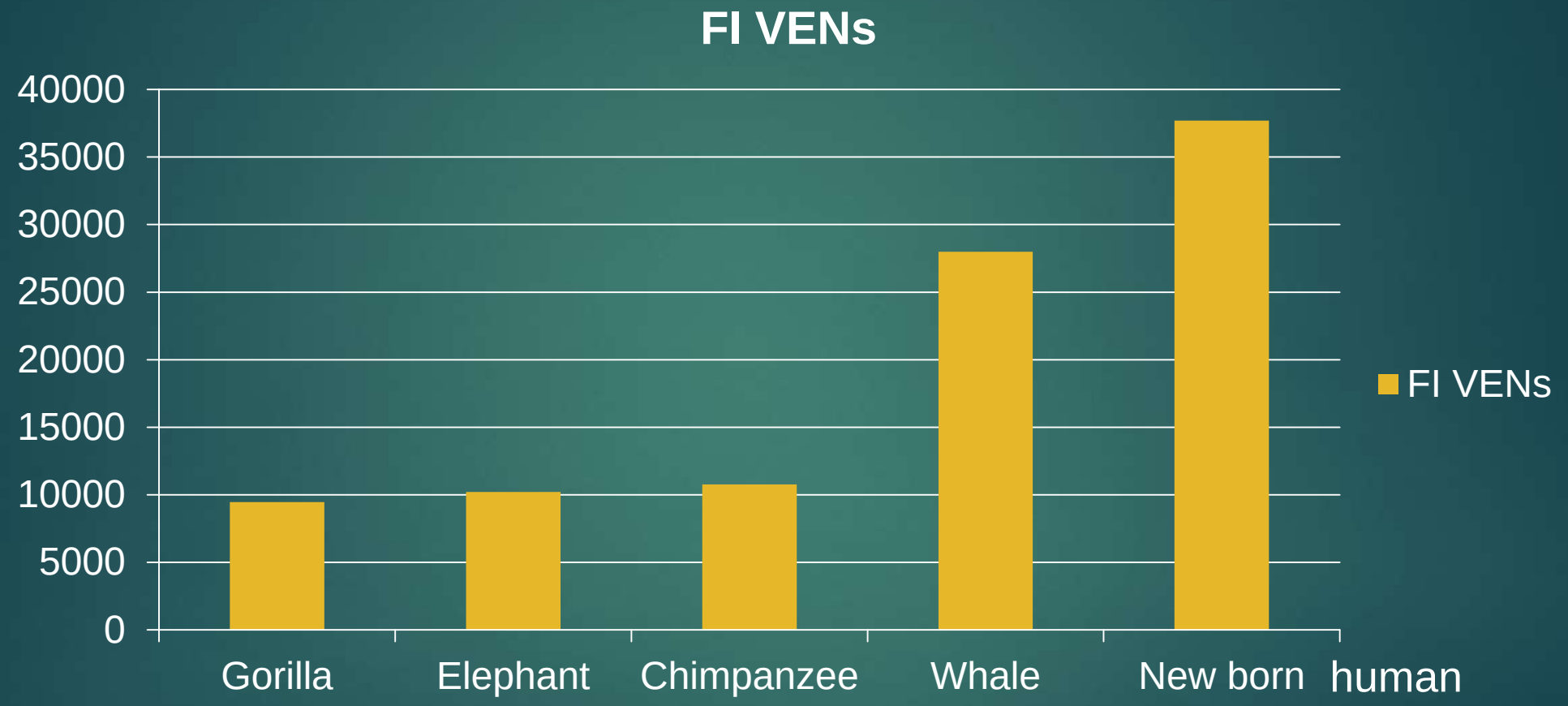
Whales*
Zebras

Primates

Manatee*
Elephants

Butti C, et al.,2011

VENs in right anterior insula



(Allman et al., 2010, 2011; Butti et al., 2009; Hakeem et al., 2009; Hof and Van der Gucht, 2007; Nimchinsky et al., 1999).

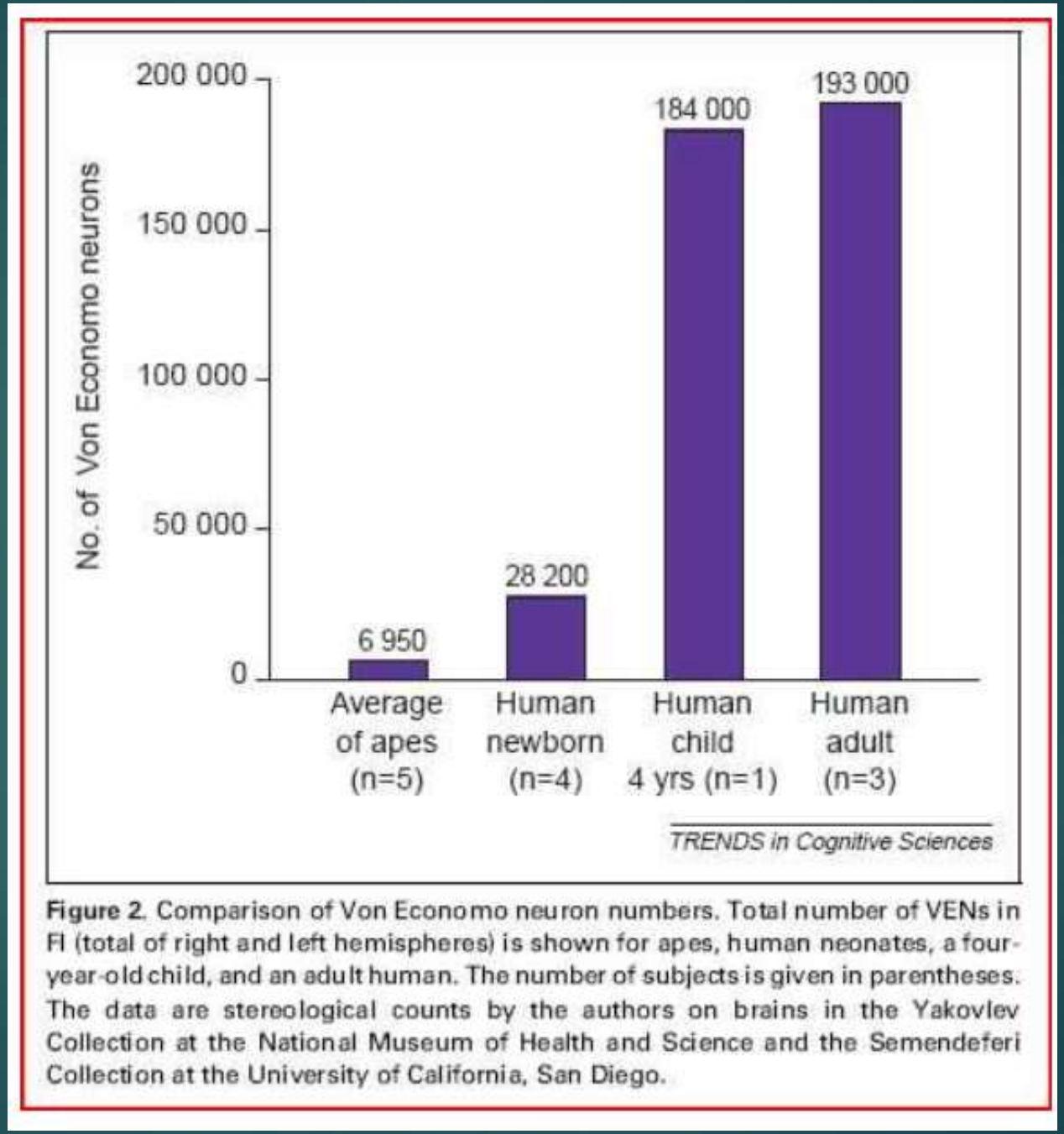


Figure 2. Comparison of Von Economo neuron numbers. Total number of VENs in FI (total of right and left hemispheres) is shown for apes, human neonates, a four-year-old child, and an adult human. The number of subjects is given in parentheses. The data are stereological counts by the authors on brains in the Yakovlev Collection at the National Museum of Health and Science and the Semendeferi Collection at the University of California, San Diego.

Salience Network: FI & pACC

- Salience Network: pACC, R insula (VENs), L inf OFC, R med PFC
- Activate in response to varied forms of social salience:
  - emotional dimensions of pain
  - empathy for pain
  - metabolic stress, hunger, or pleasurable touch
  - enjoyable “chills” to music
  - faces of loved ones or allies
  - social rejection
  - anxiety
- Damage: behave badly socially, no empathy, fart humor

VENs

- Interpretation of their evolutionary significance has changed from “the neurons that make us human” to a broader interpretation.

- VENs are currently conceptualized as part of taxon-specific specialized networks, the functional significance of which depends on their cortical distribution

Nimchinsky et al., 1999); Butti and Hof, 2010; Butti et al., 2011

VENs: Involvement in neuropsychiatric disorders

- If you alter VENS, you produce deficits in social ability
- Frontal Temporal Dementia: destruction of Salience Network
  - 70% reduction VENs in ACC & FI; none in Alzheimer's
  - Correlates with social behavioral severity of bvFTD

Seeley, Allman, and others 2007; Seeley and others 2006; Kim, et al. 2011

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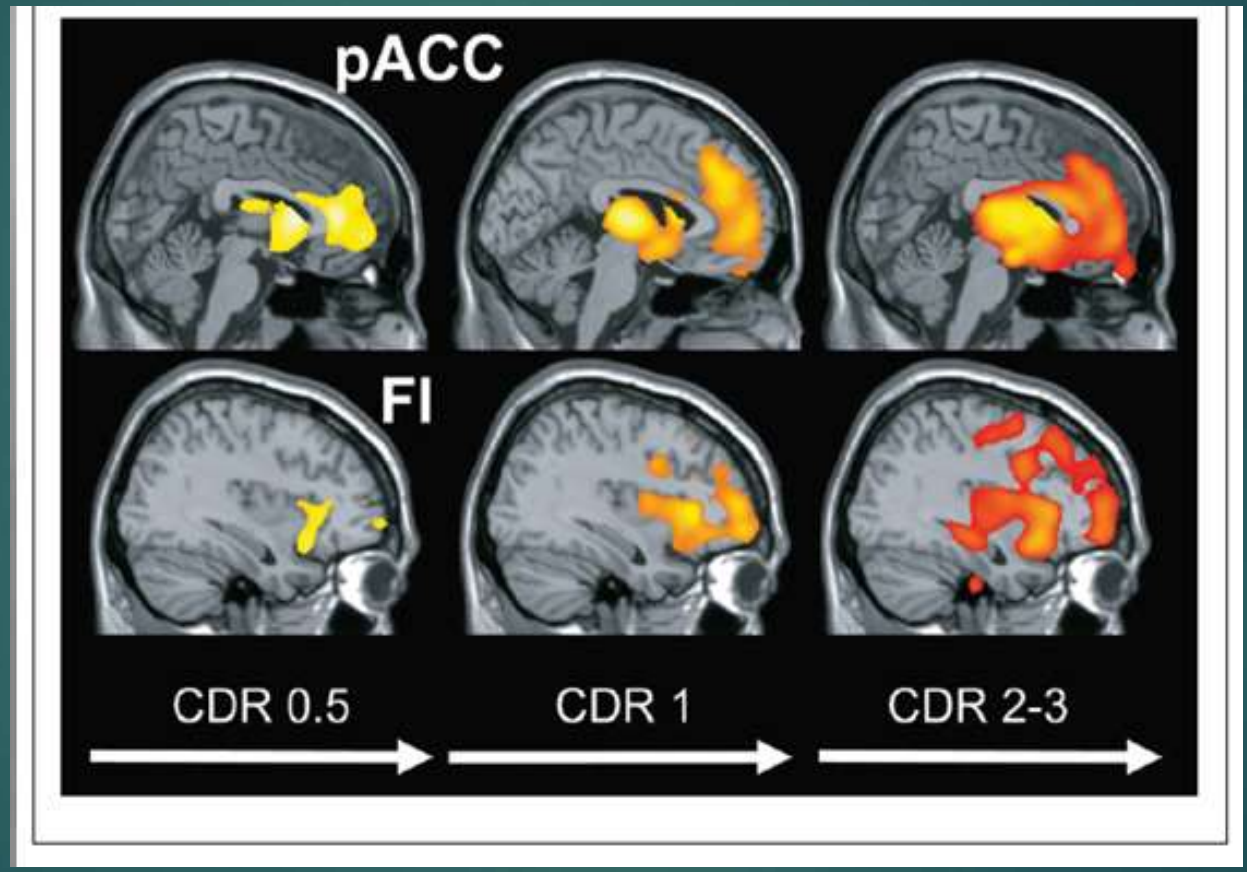
bvFTD degeneration: Salience Network (Right pACC and FI)



W. Seeley, J. Zhou, and E. Kim, 2011

Behavioral variant FTD

- Loss of VEN cells in Insula & ACC
- Total loss of empathy
- Loss of behavioral inhibition
- Normal person who develops bvFTD have new behavior:
  - Peeing in public
  - Sexual peeping Tom
  - Exposing themselves in public
  - Shoplifting

- OK Knowledge of right and wrong

FTD Social-Emotional Deficits

- Emotional empathy (empathic concern)
- Cognitive empathy (perspective taking)
- Interpersonal warmth
- Emotion recognition of faces (negative emotion↓)
- Emotion recognition of music
- Emotional moral judgment
- Prosocial sentiments (guilt, pity, embarrassment ↓)
- Other critical sentiments (anger, disgust ↓)
- Mutual gaze during dyadic interactions

Rankin et al., 2006, Eslinger et al, 2011; Omar et al., 2011, Sturm et al, 2006, 2008, 2011

TABLE 4.
Sociopathic Acts among 16 Patients with Frontotemporal Dementia[145]

Number	*Type*
3	Unsolicited sexual approach or touching
3	Traffic violations including hit-and-run accidents
2	Physical assaults
1	Shoplifting
1	Deliberate non-payment of bills
1	Pedophilia
1	Indecent exposure in public
1	Urination in inappropriate public places
1	Stealing food
1	Eating food in grocery store stalls
1	Breaking and entering into others' homes

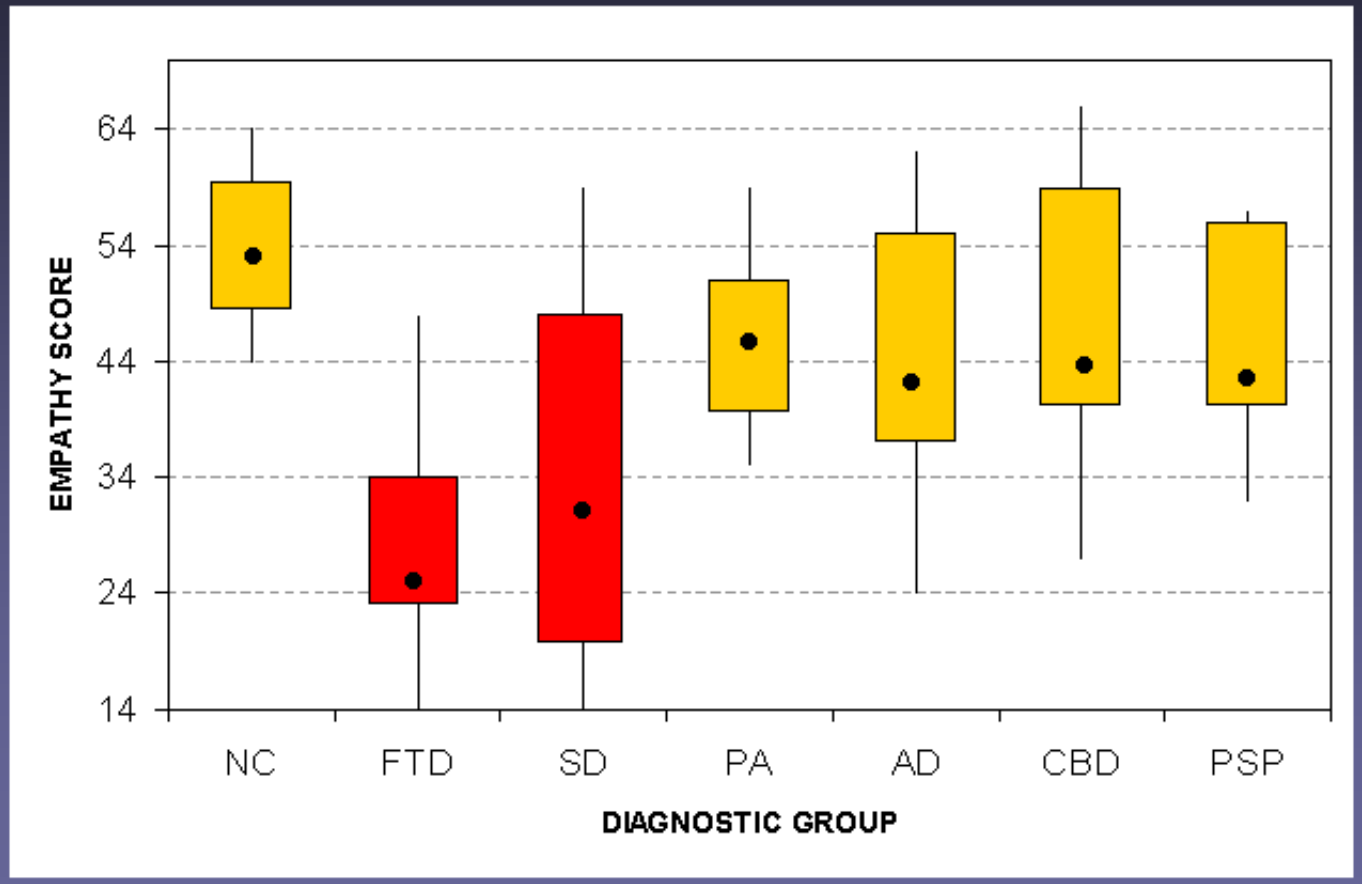
Mendez MF. *CNS Spectr.* Vol 14, No 11. 2009.

Right ACC size predicts self conscious emotional reactivity in FTD

- Self-conscious emotions: embarrassment, pride and guilt; Are felt in the context of others' imagined reactions.
- In a Karaoke experiment of FTD, the degree to which the singers were not embarrassed in hearing themselves sing "My Girl", the smaller the ACC.
- Those with damage in the right ACC were least likely to feel embarrassment.
- Embarrassment may have evolved to motivate us to repair social bonds that become strained when we fall short of expectations.

V. Strumm, et al., 2011

Measuring social cognition: empathy



(Rankin et al., Brain, 2006)

Regions where empathy score positively correlates with tissue density

(Analysis significant after FWE correction at p<0.05)

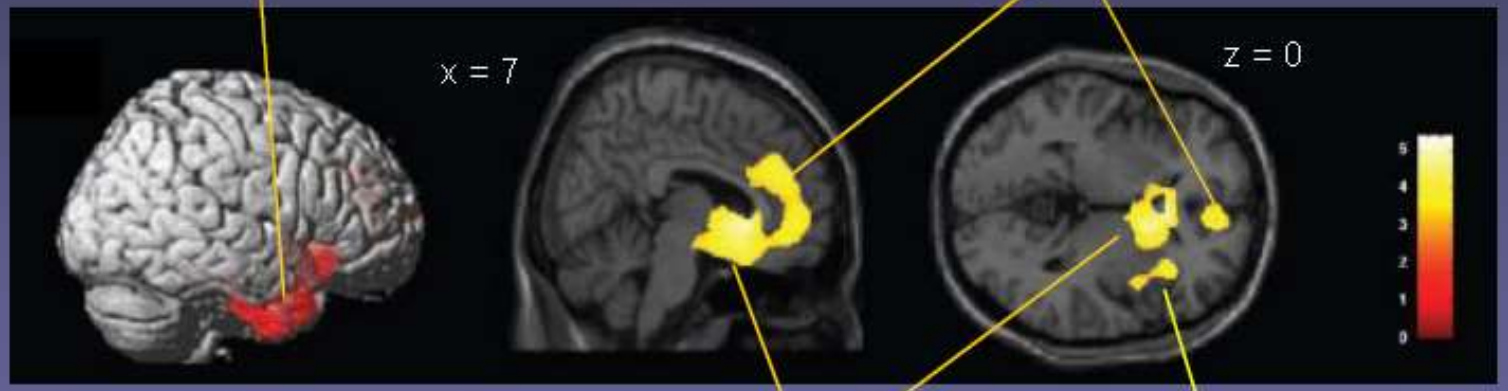
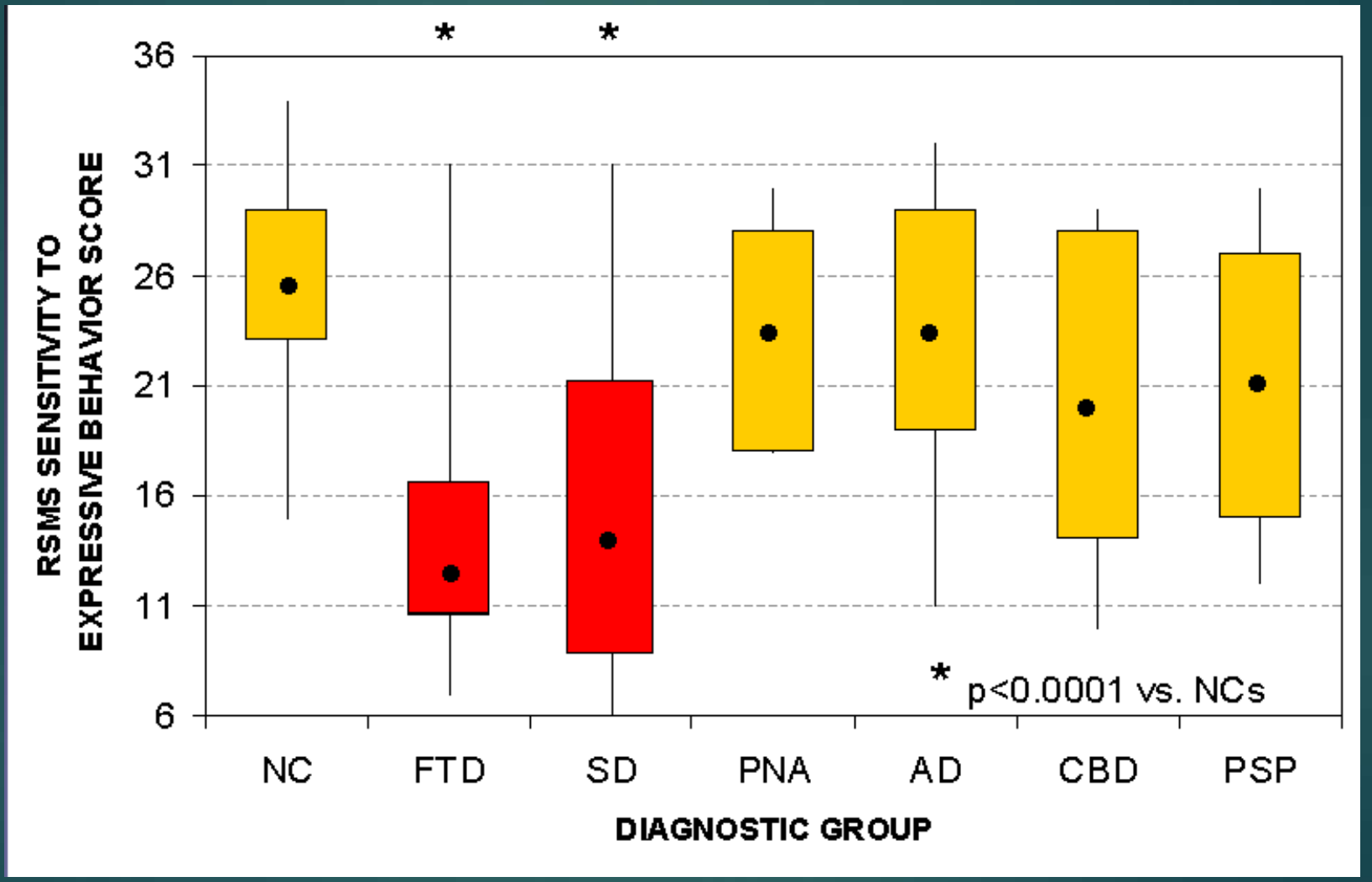


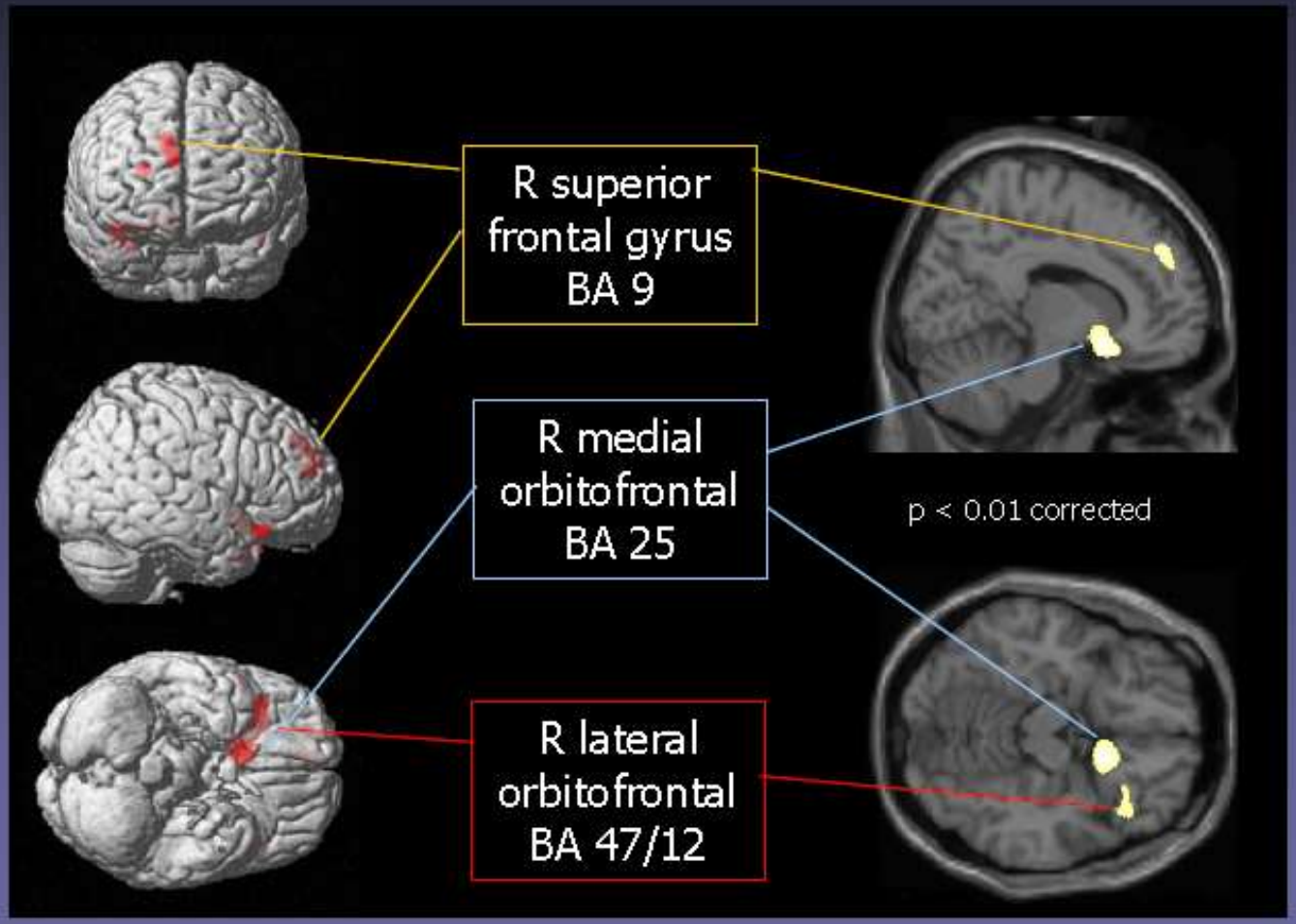
Figure threshold: p<0.001 uncorrected

(Rankin et al., Brain, 2006)

Social Self Monitoring Scale



Regions where social self-monitoring score positively correlates with tissue density



More dense VENs and Successful Suicide

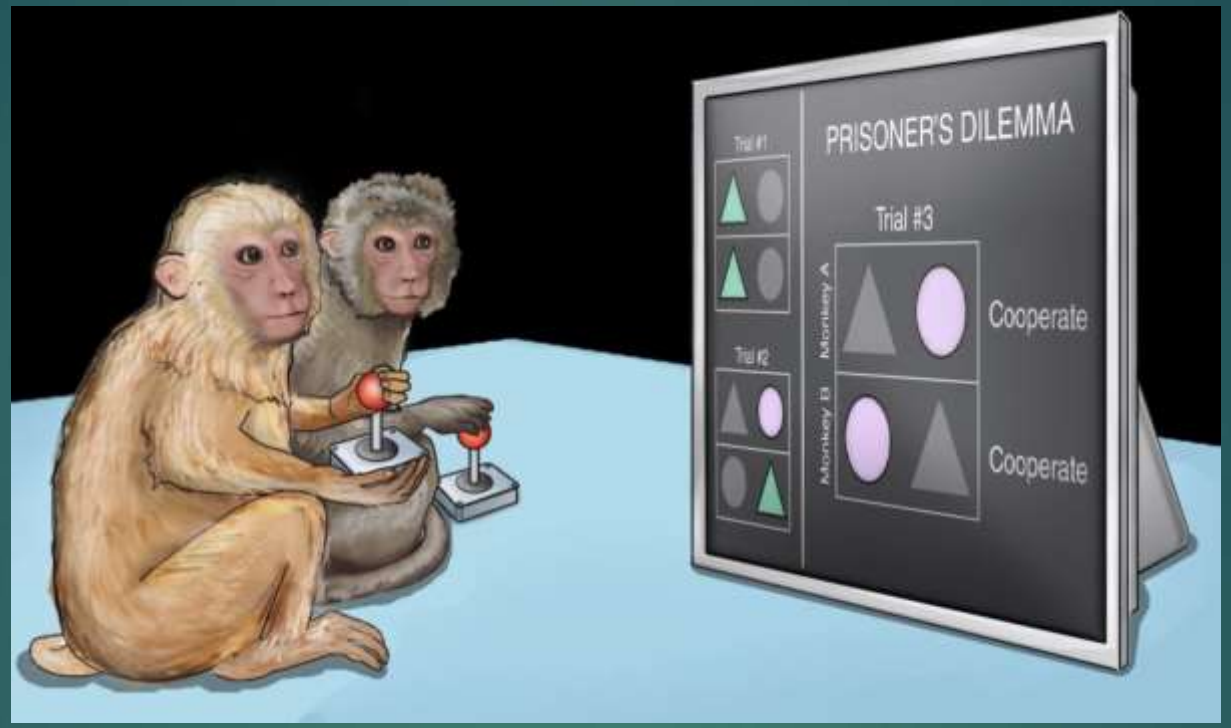
- Study: von Economo neurons in nine patients who died from suicide.
- All subjects had been diagnosed clinically with either schizophrenia or bipolar disorder.
- The researchers found the density of these neurons was significantly greater in those who died of suicide than in those who had not, regardless of what disorder they had.
- Patients with early onset schizophrenia (and longer duration of illness) had a reduced VEN density.
- VENs have a special role in emotion processing and self-evaluation, including negative self-appraisal.

ACC & Intentions of Others

- ACC = the ability to anticipate each other's intentions or actions
- Numerous trials of Rhesus monkeys confronted with the classic prisoners' dilemma game: The key to succeeding in the game relies on one's ability to anticipate the other's concurrent, yet-unknown intentions.
- Activity in the dorsal anterior cingulate cortex accurately predicted the monkey's own choices in 66% of the trials, and the opponent's yet unknown choices in 79% of the trials.
- Disruption of the dorsal neurons at the back of the anterior cingulate cortex made the monkey less cooperative after the opponent had shown cooperation in a trial.
- **These neurons "play a critical role in incorporating recent positive interactions to make mutually beneficial decisions."**

Keren Haroush, et al., 2015

Rhesus Monkeys play Prisoner's Dilemma



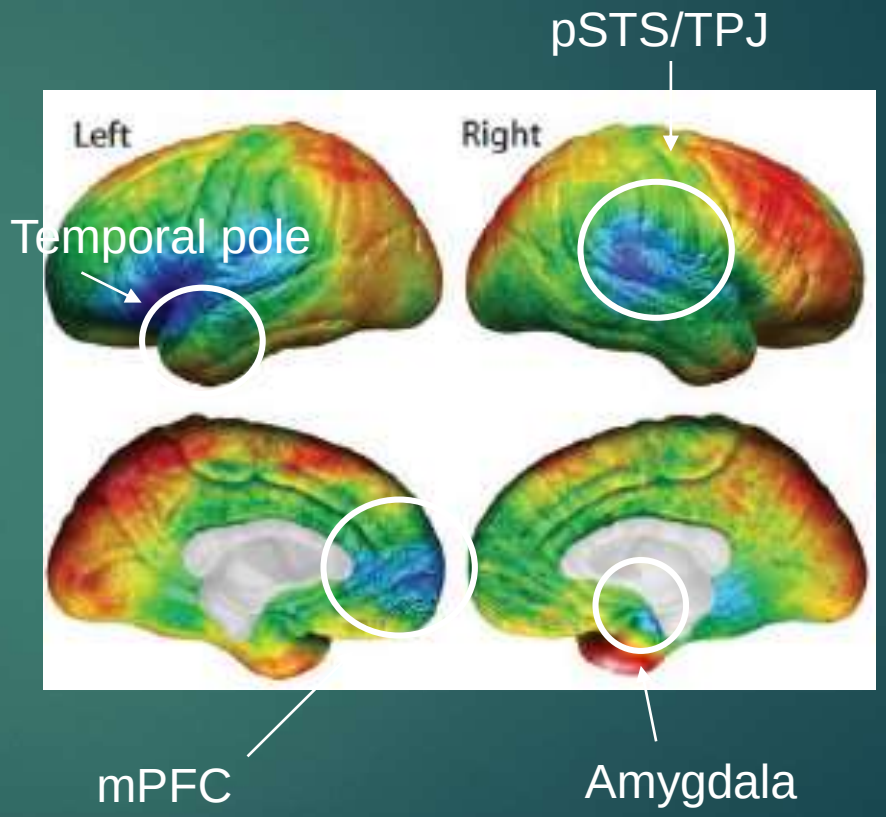
Joint cooperative decisions lead to highest mutual reward; (4 drops of juice each; rejecting cooperative decision lead to highest individual reward (6 drops); if both Refused to cooperate each got 2 drops)
Able to identify self decision neurons (25% of ACC neurons) vs other predictive neurons (unknown other's decisions/covert intentions/state of mind (33%) (majority of task specific neurons in ACC)

The social brain

- The ‘social brain’ comprises key brain regions for social cognition
- *Social cognition: understanding and interacting with other people*
- Social emotions: emotions which require mental state representation

Brothers et al. 1990; Frith & Frith, 2003, 2007; Frith 2007

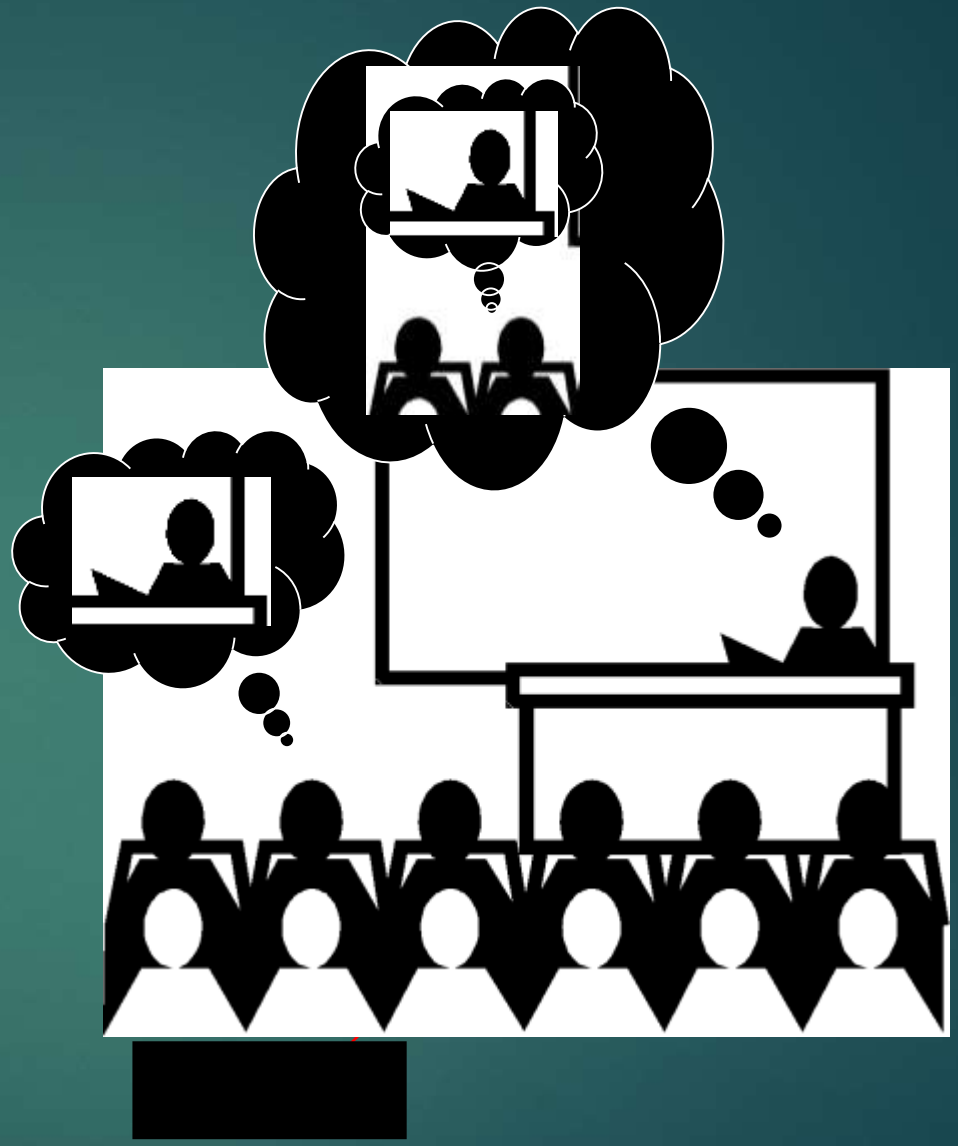
The social brain: Anatomy



Giedd et al., 1999; Sowell et al., 1999

The social brain: Anatomy

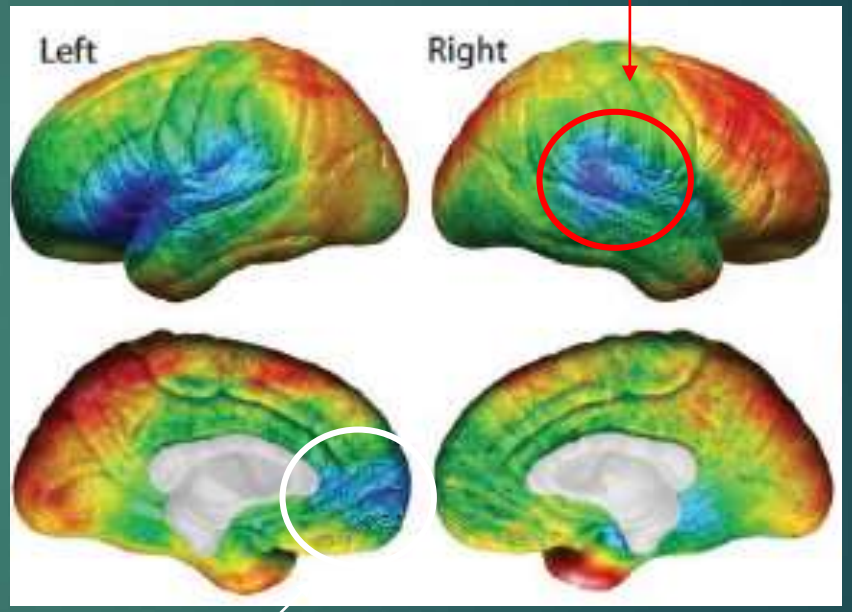
- i. Medial prefrontal cortex
  - 'Mentalising'
    - Implicit ability to infer mental states such as beliefs, feelings and desires in others
    - Representing people's mental states



Fletcher et al., 1995; Gallagher et al., 2000; Gilbert et al., 2006 (meta-analysis)

The social brain: Anatomy

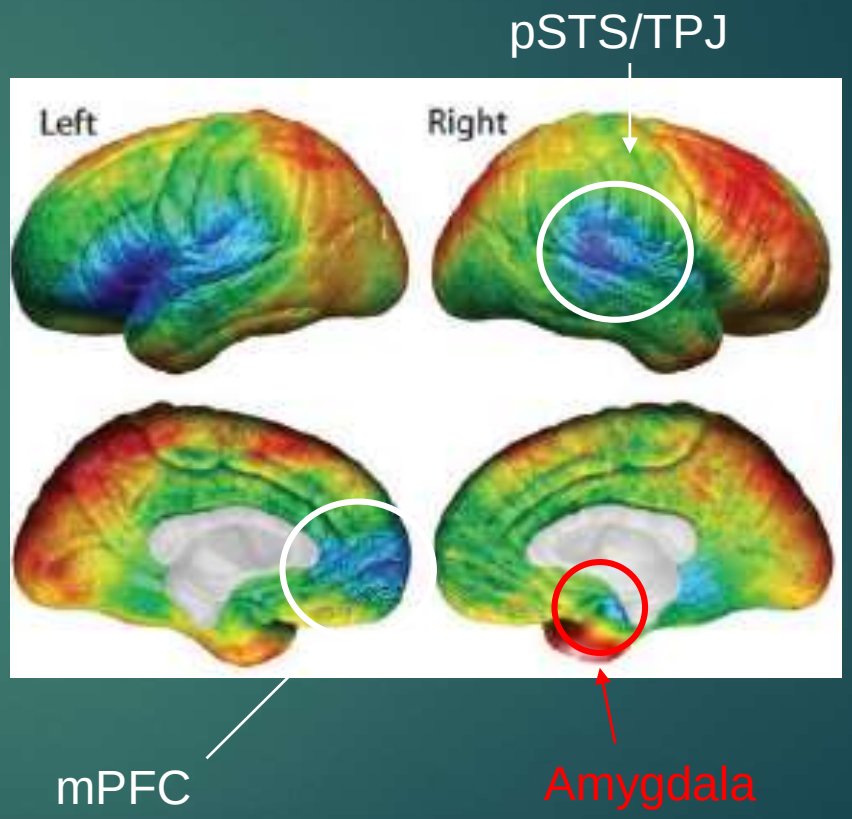
- ii. pSTS/TPJ
  - Social prediction and perspective-taking
    - E.g. Eye gaze – what can they see? What do they want?



Pelphrey et al., 2004a,b; Kawawaki et al., 2006 (review); Mitchell 2007

The social brain: Anatomy

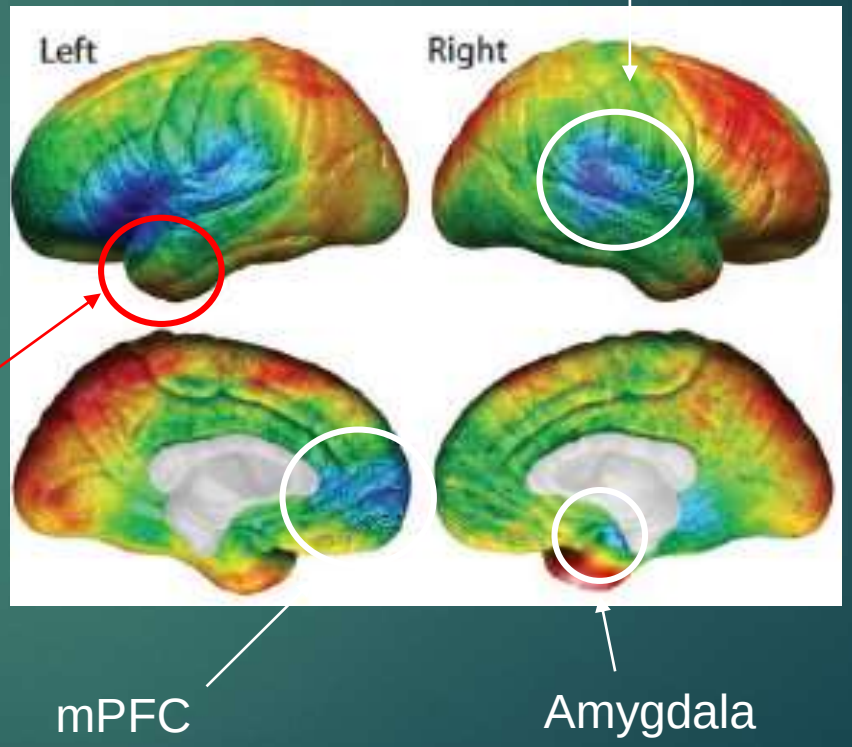
- iii. Amygdala
  - Attaching reward values to social and non-social stimuli
    - ‘Approach’ vs. ‘avoid’
    - E.g. Facial expressions



Dolan 2002; LeDoux 2000; Winston et al., 2002; Phelps et al., 2000, 2003

The social brain: Anatomy

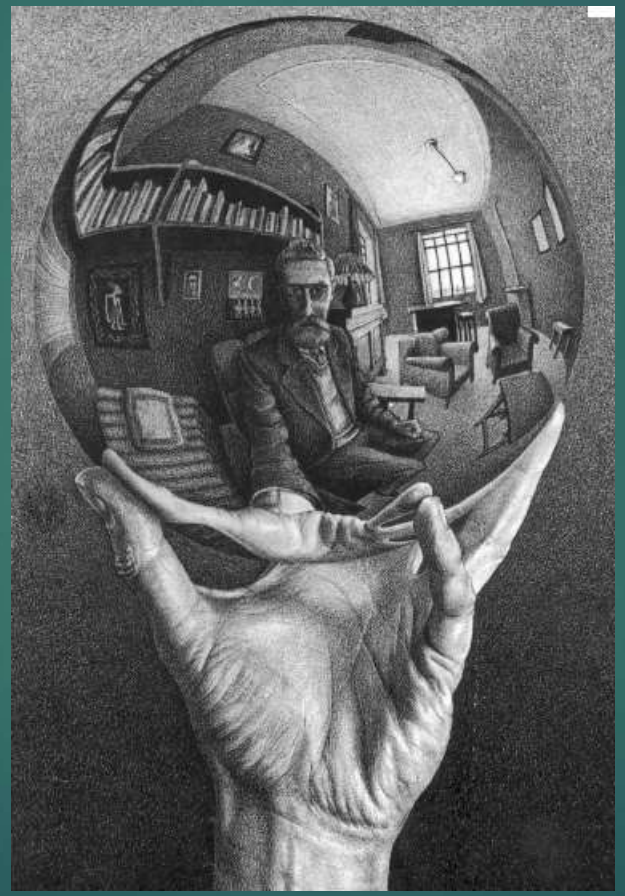
- iv. Temporal poles
  - Semantic social knowledge: abstract knowledge of complex events



Funnell, 2001; Damasio et al., 2004; Moll et al., 2001, 2002; Zahn et al., 2007

Monkey See, Monkey Do

Mirror Neurons

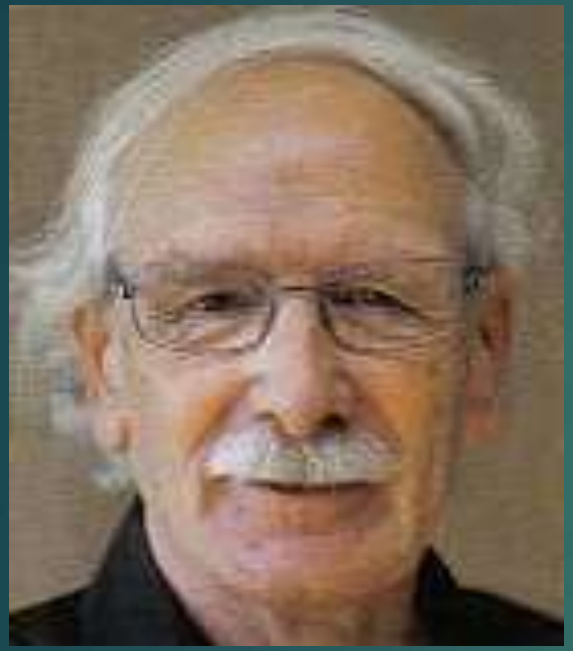


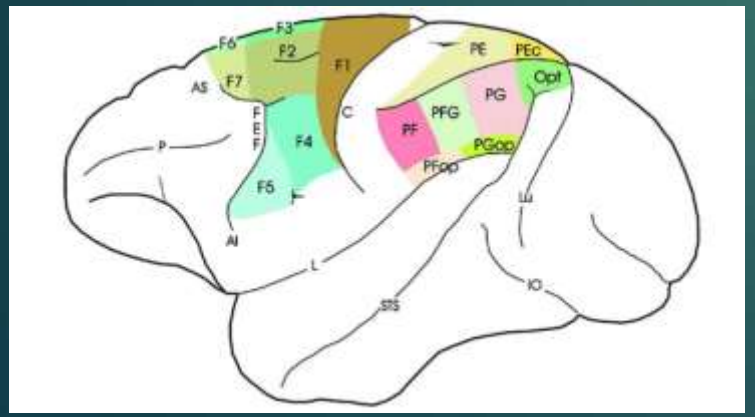
Mirror Neurons:

Understanding of an actor by an observer
without any cognitive mediation;
direct stimulation of same neurons in both

Dr. Rizzolatti:
"Mirror neurons allow us to grasp the minds of others not through conceptual reasoning but through direct simulation.
By feeling, not by thinking."

Giacomo Rizzolatti 1937-

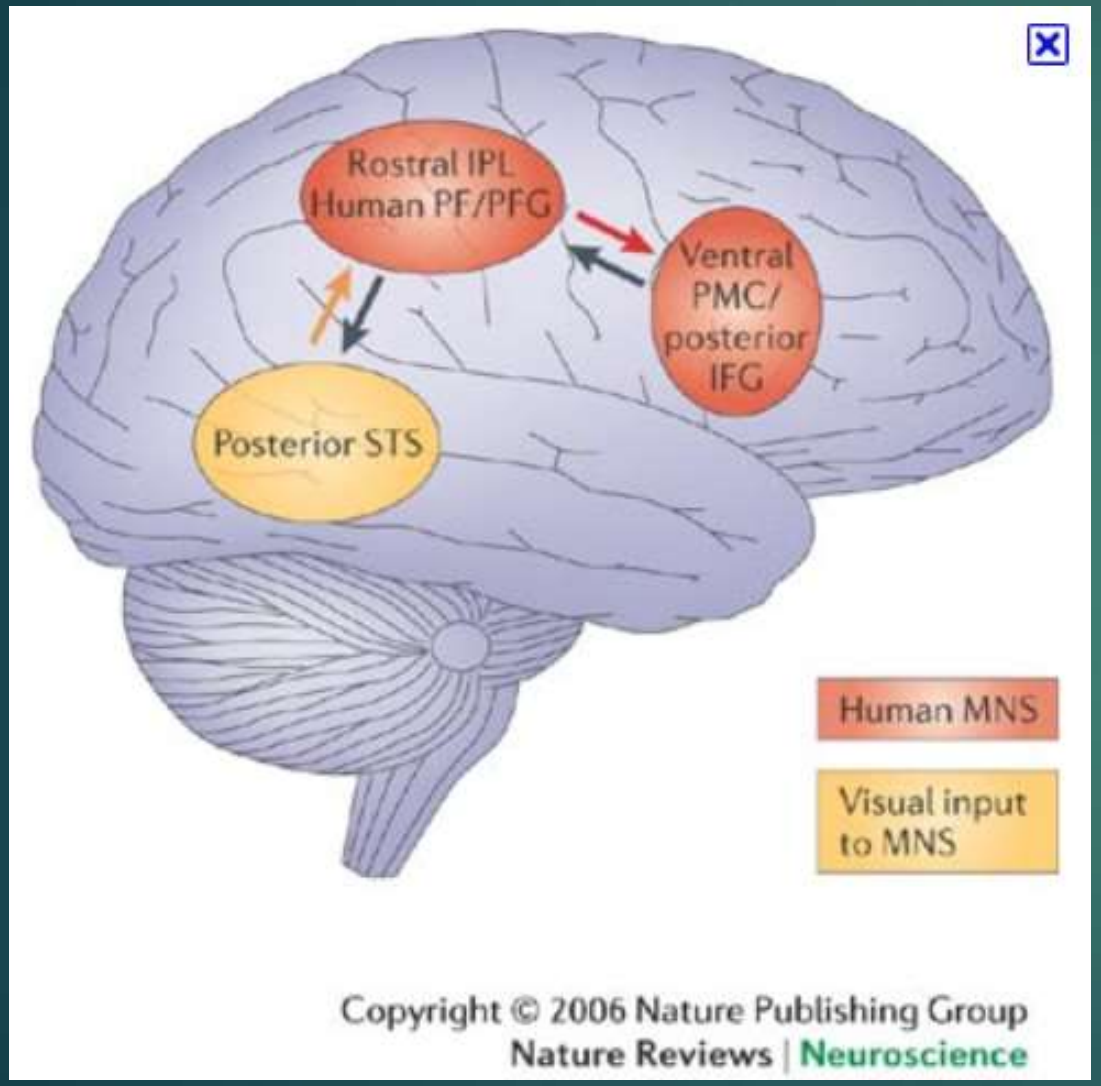




- 1992: describes mirror neurons in area F5 of monkey premotor cortex
- Premotor area neurons that discharge both when the monkey does a particular action and when it observes another individual (monkey or human) doing a similar action
- The discovery was initially sent to *Nature* but was rejected for its "lack of general interest"

(Di Pellegrino et al. 1992, Gallese et al. 1996, Rizzolattiet al. 1996a).

Mirror Neuron System



1 Posterior inferior frontal gyrus (pIFG)

2 Anterior inferior parietal lobule (aIPL)

3 STS: superior temporal sulcus

Gandhi neurons:
dissolve the barrier between you and me

Consequence of MNS

- If 1 person discovers something new, 2nd person can imitate
- New knowledge through imitation
- Could be evolutionary basis for proliferation of tool use, fire, shelter building, language
- ToM: Theory of Mind

Evidence for MNS

- In monkeys: recordings of single neurons
- In humans: EEG, MEG, fMRI, TMS
- In 2010, recordings from single neurons with mirror properties in the human brains of 21 epileptics

G. Rizzolatti and L. Craighero, 2004; Mukamel et al (Current Biology, 2010)

Evidence for expanded MNS Functions

- Action understanding
- Emotional response
- Imitation
- Gestural speech and language
- Intuition (complex social analysis)
- ToM
- Empathy
- Social Communication
- Social Cognition
- Can mirror: movement, intentions, emotions, touch, pain

V. Rajmohan and E. Mohandas, 2007

Marco Iacoboni on MNS

- "When you see me perform an action - such as picking up a baseball - you automatically simulate the action in your own brain.

- You understand my action because you have in your brain a template for that action based on your own movements.

- When you see me pull my arm back, as if to throw the ball, you also have in your brain a copy of what I am doing and it helps you understand my goal.

MNS

- Because of mirror neurons, you can read my intentions. You know what I am going to do next.
- You know how I feel because you literally feel what I am feeling.
- Mirror neurons seem to analyze scenes and to read minds. If you see someone reach toward a bookshelf and his hand is out of sight, you have little doubt that he is going to pick up a book because your mirror neurons tell you so. “

Grasping a teacup in context: Read Intention

MNs discriminate between reaching for a teacup to drink (on a clean table) or to remove it (on a messy table)

Iacoboni, 2005

MNS: Your actions are my actions

- MNs match an observed movement onto its internal motor representation in your brain
- We use ourselves as template/simulation of the other.
- Basis for our capacity to learn by watching.

Not just action but intentions

- Many studies link mirror neurons to understanding goals and intentions.
- They fire in response to chains of actions linked to intentions.
- But you understand my action because you have in your brain a template for that action based on your own movements.

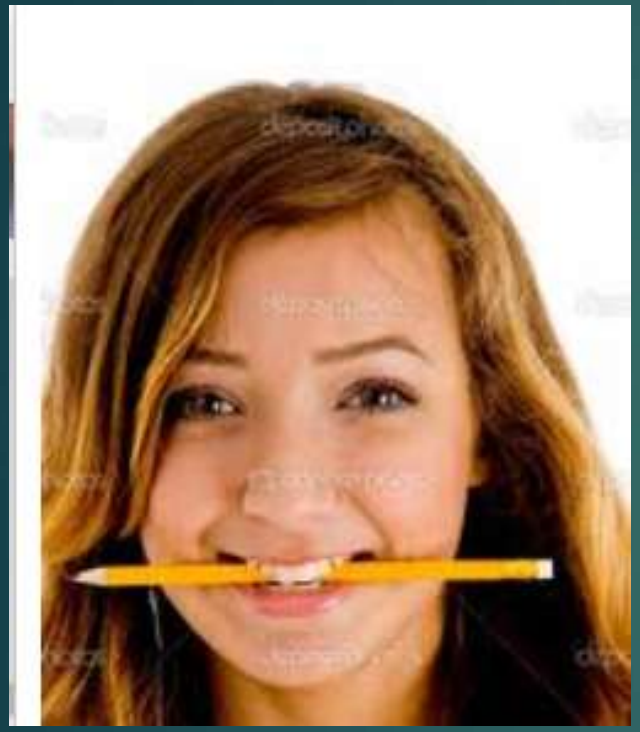
MNS created by Hebbian classical conditioning

- Learned associations: Neurons that fire together wire together
- You can only mirror what you can do from prior experience
- More experience you have, better ability to predict same activity in another

Mirror neurons fire when:

- Seeing intentional action
- Watching R2D2 moving
- Seeing piano being played if you play piano (or tennis, etc.): own expertise increases MN action
- In female ballerinas doing gender specific ballet move
- In people born without arms: MN activate to the use of the substitute performance method (i.e. mouth or foot)
- To the sound of actions, i.e. tearing up paper

Congruent facial muscle response: Seeing the emotions of others



- When we view facial emotion in another, our facial muscles mimic theirs in 100ms.
- Holding a pencil horizontally in your mouth immobilizes facial muscles & decreases your ability to identify a happy emotion on the other's face. (Same with increasing Botox)
- 70% of "neurotypicals" have congruent facial muscle response; Autistics only 35%

MNS Conclusion

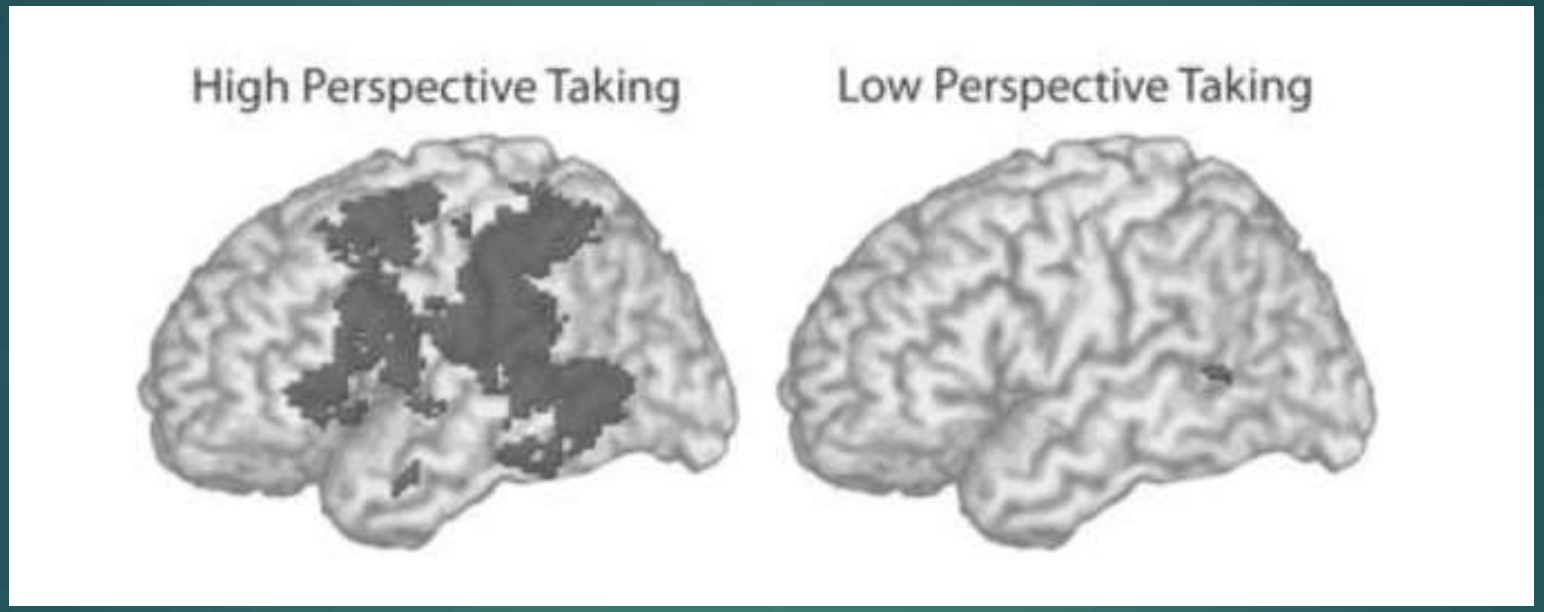
- When empathizing with others' affective states, we activate representations reflecting the same bodily states in ourselves.
- These shared affective representations allow us to know how it feels like for someone else to be, for example, in pain, even in the absence of any stimulation to our own body

Empathy: I feel what you feel

- Mirror neuron system is involved in reading emotions and empathy
- FI, ACC (VENs), & inf PFC are active:
  - Both when people experience an emotion (disgust, happiness, pain, etc.)
  - And when they see another person experiencing an emotion.
  - Our “gut feelings”

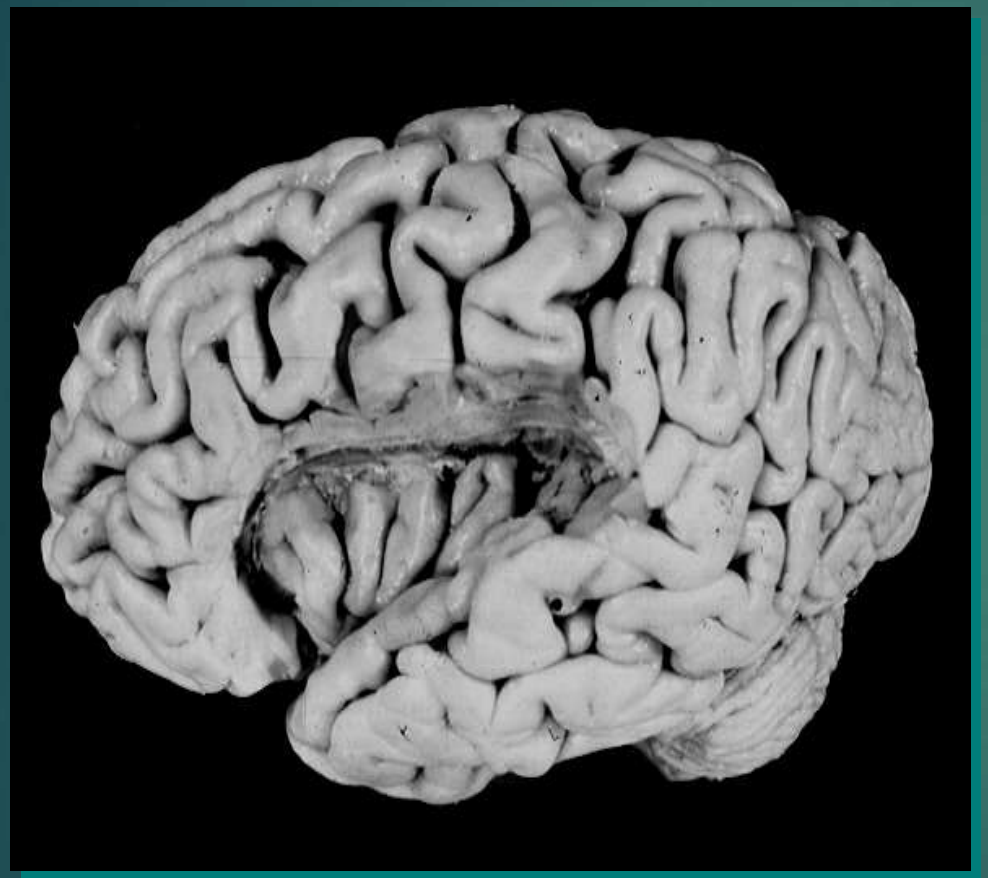
Christian Keysers, 2011

Empathic people mirror more



Low perspective taking individuals showed no activation of MNS

Insula



- Gut reactions
- Cravings
- Body states or sensations:
  are recast as
  social emotions, empathy
- von Economo neuron site

Evidence for MN system for emotions: Disgust

- Disgust = evolutionary safety feeling
- Insula triggered both for
  - experiencing disgust feelings
  - recognition of disgust in others

- Insula activates
  - if smell rotten odors
  - watch a movie of rotten food (visceral sense of nausea)
  - watch a film of facial disgust in others

Sensation

- Being touched or seeing person being touched activate primary somatosensory cortex (SI) & secondary (SII)

Capacity for social pain

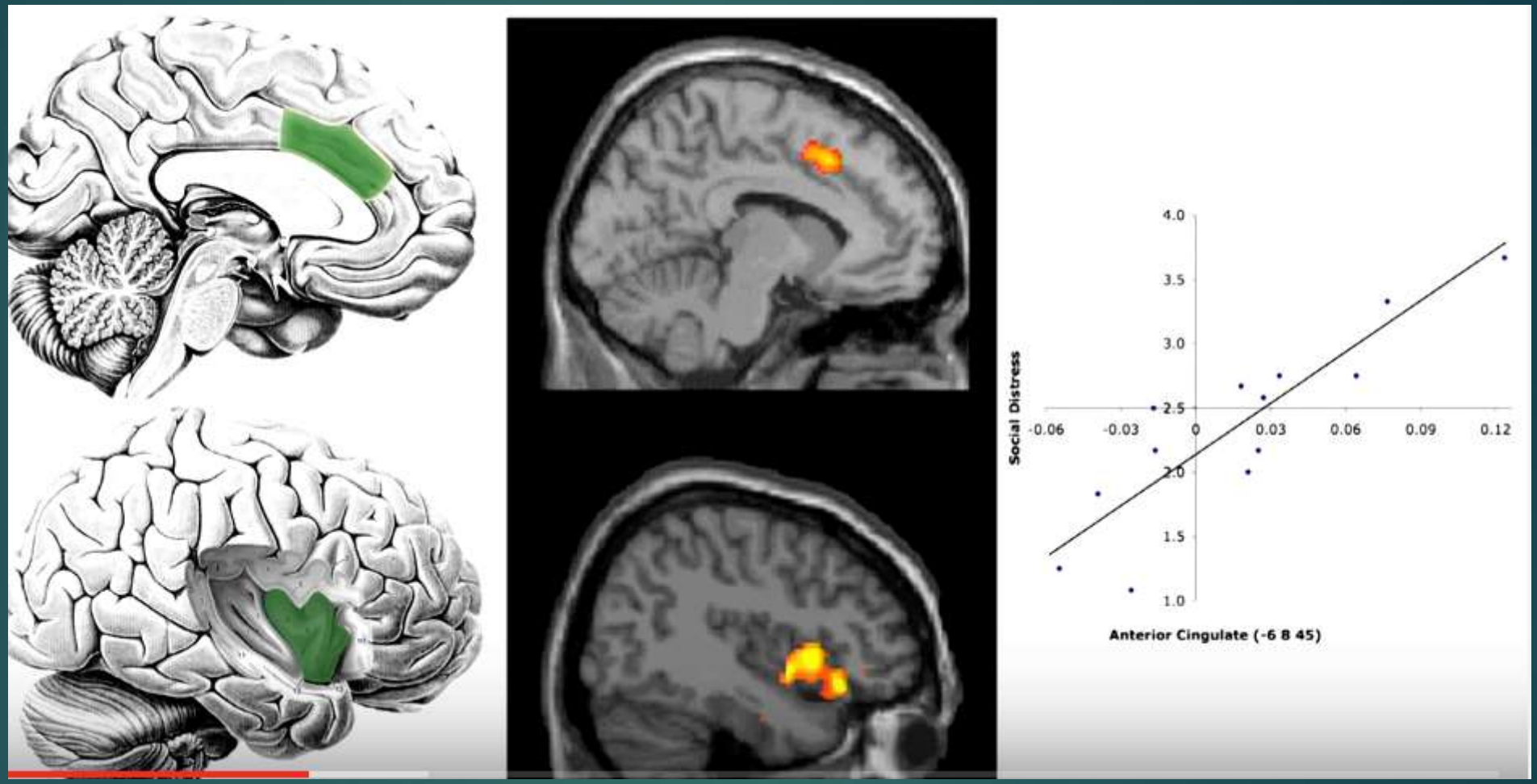
- Mammals are social by evolutionary need
- Long infancy that requires bonding and care
- Being social is a fundamental brain mechanism
- Social pain is not our kryptonite but our super power

Most painful memory

- When asked what their most painful memory is, most people report the death of a loved one, not a broken leg
- Social pain: based on loss or rejection

Social Game under fMRI:
Start with alternatively ball being thrown to you or other person
Then ball is never thrown to you again = MRI registers social rejection as physical pain response

Social pain is real pain = same activation of physical pain sites



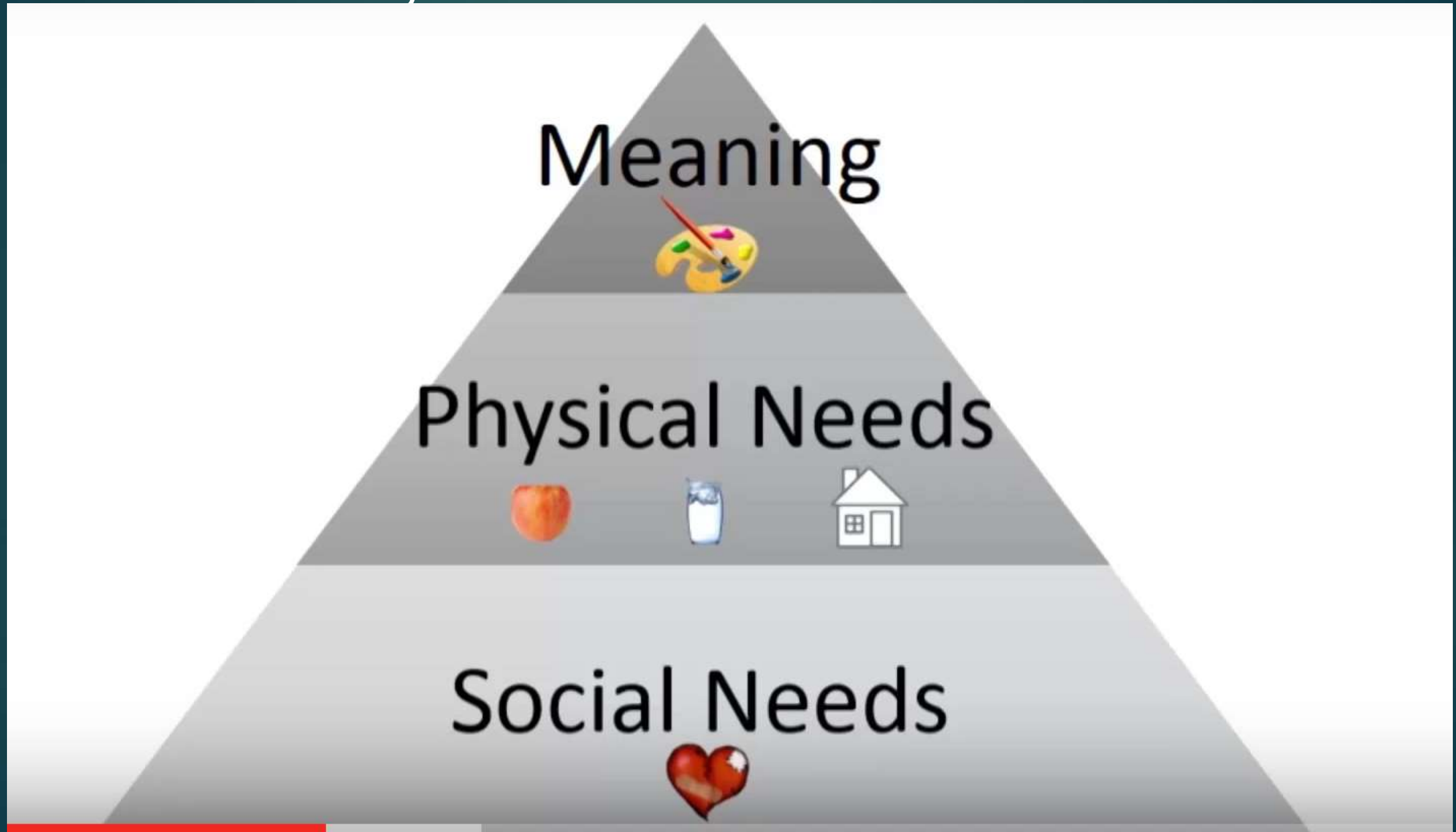
Physical pain sites

Social pain sites

More hurt by rejection, stronger ACC activation

Tylenol/pain med makes both kinds of pain go away

Maslow's Hierarchy of Needs



Your pain is my pain

- Anterior Cingulate & Insula (VENs) = site of pain empathy
- Pain's affective component the "I care" portion of pain as opposed to the discriminative, or "where, when, what type of pain?" component).
- Most empathic activate own pain perception most strongly
- Sex difference:
  - men are more empathic for fair people (in trust games)

And language

- MNs in the inferior frontal cortex (area 44), Broca's area.

- Iacoboni: MNS for imitation overlaps with Broca’s language area: evolutionary continuity between action recognition, imitation, and language

- Rizzolatti &Arbib (1998): MNS as mechanism from which language evolved; speech evolved mostly from gestural communication

- R. Holloway: *Homo habilis* skulls show Broca’s area enlargement: mimicry of oral & manual gestures

MNS in Psychopaths

- Observation of the painful stimulus is associated with a significant reduction in MNS in psychopaths
- Correlated with higher scores on the coldheartedness subscale of the PPI
- Other research: can empathize, but don't do so spontaneously

.

Fectau, et al., 2011

Oxytocin & Mirror Neurons

- Oxytocin: the love and trust hormone
- Variations in the oxytocin receptor are linked with a higher risk of autism.
- 24 men given oxytocin exhibited an increase in mirror neuron activity

Richard Ebstein, 2010

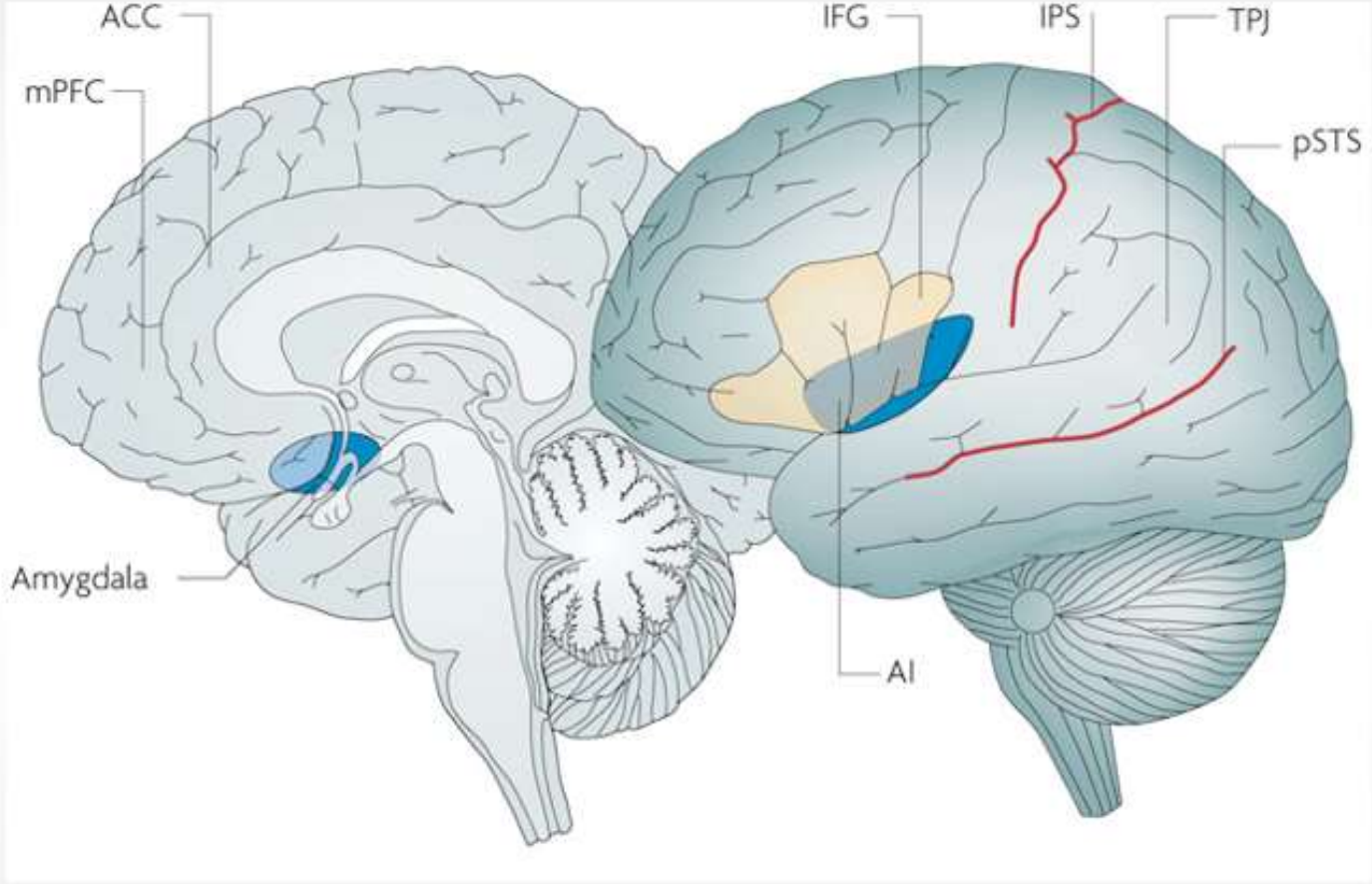
Mirror Neurons and Bias

- Mirror neurons distinguish between “us and them”
- Mirror neurons distinguishes between people who are physically and culturally similar to us and those who are not.

What parts of the brain are involved in Mentalization?

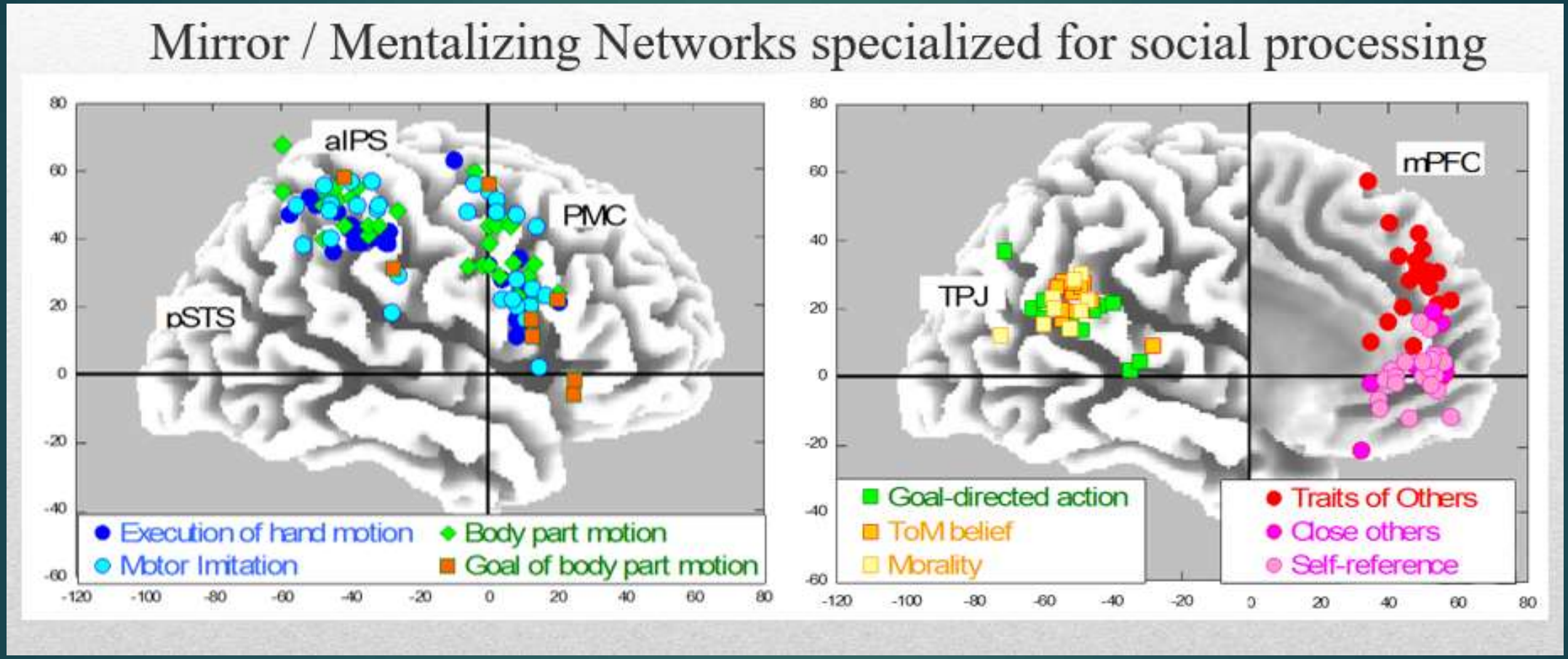
- Medial prefrontal cortex (MPFC)
- Temporo-parietal junction
- Precuneus/posterior cingulate
- Amygdala
- Superior temporal sulcus
- Temporal poles

The Social Brain



From Blakemore, S. J. (2008). The social brain in adolescence. *Nature Reviews Neuroscience, 9,* 267-277.

Social Processing in the brain



Do social and nonsocial cognition draw on distinct or overlapping processes?

- Fletcher et al. (1995)
  - The MPFC activated when reading stories involving social cognition
- Mitchell, Macrae, and Banaji (2004)
  - Social situations encode better because we use distinct mental processes for social cognition
    - MPFC again

BUT, WAIT!

- Saxe and colleagues (e.g., Saxe and Kanwisher, 2003)
  - Stories involving someone’s erroneous beliefs (social) and stories involving erroneous physical representations (nonsocial) both activate the right temporo-parietal junction

Self-referencing model

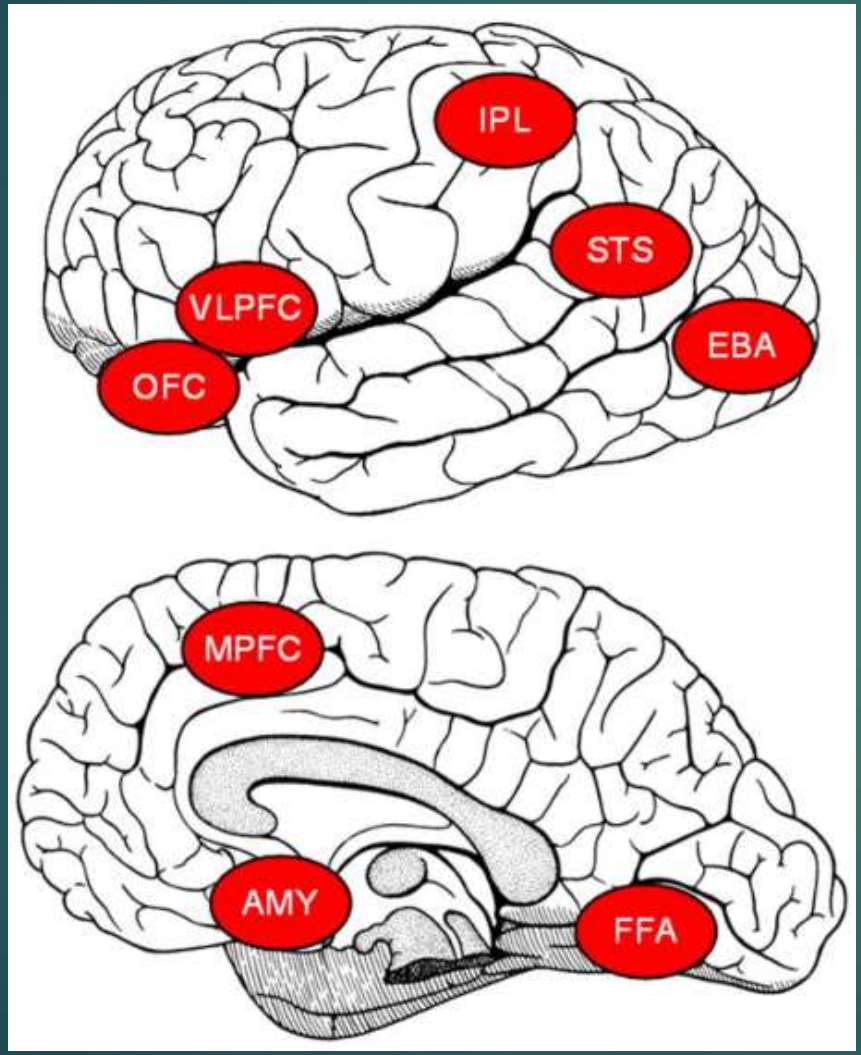
- Singer et al. (2004)
  - The anterior cingulate cortex activates for the person experiencing pain and the person watching

Self-referencing model

- Singer et al. (2004)
  - The anterior cingulate cortex activates for the person experiencing pain and the person watching

- Wicker et al. (2003)
  - The subregions of the anterior insula are activated in the person smelling the foul odor and the person watching the person smelling the foul odor

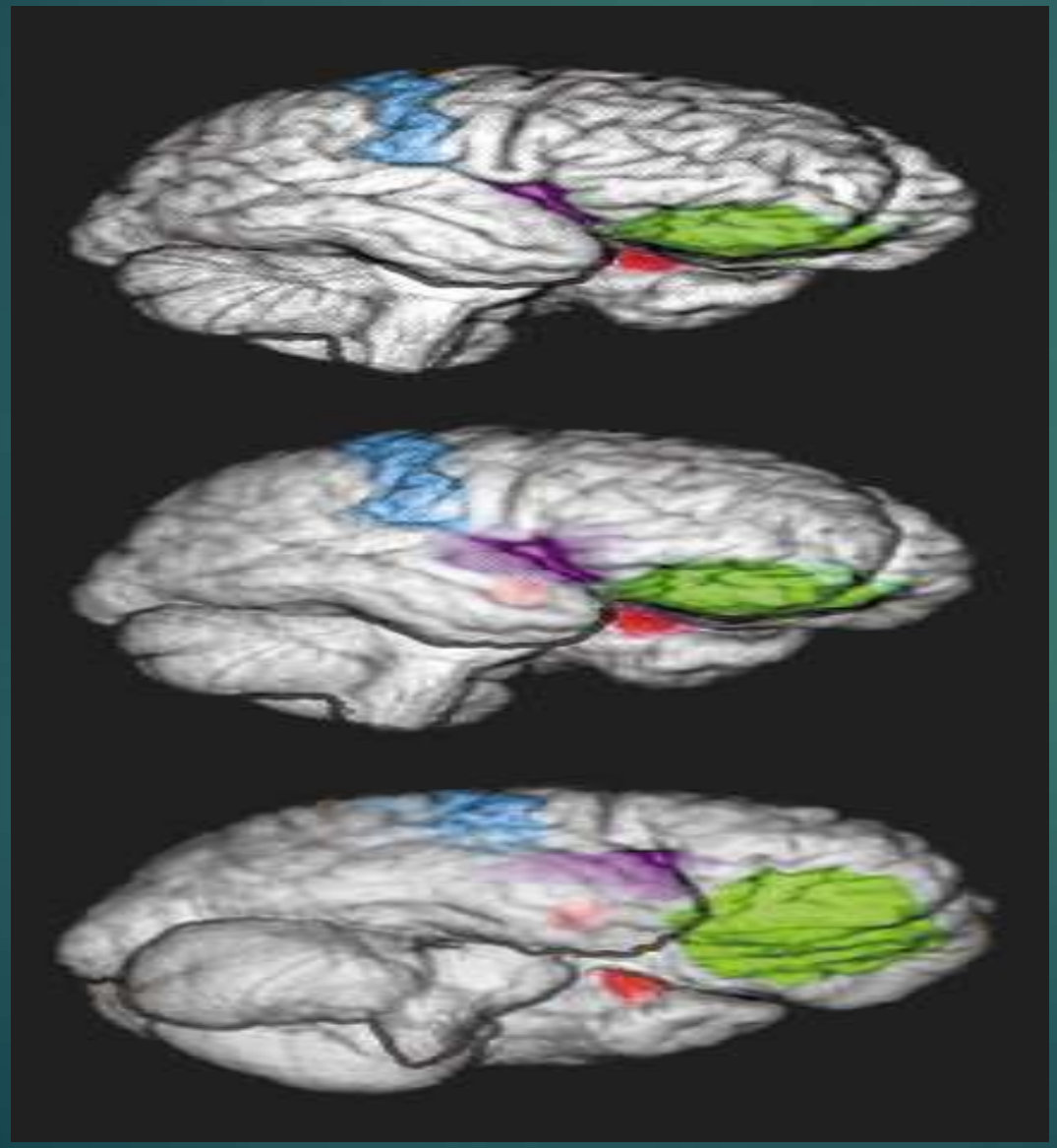
Social Cognition:
Brain nodes in social brain



Some of the brain regions involved in various aspects of social cognition and social perception.
VLPFC = ventral lateral prefrontal cortex,
IPL = inferior parietal lobule,
STS = superior temporal sulcus,
OFC = orbital frontal cortex,
MPFC = medial prefrontal cortex,
EBA = extrastriate body area,
AMY = amygdala,
FFA = fusiform face area.

K. Pelphrey & E. Carter, 2008

Social Cognition Areas



Green: ventromedial prefrontal cortex

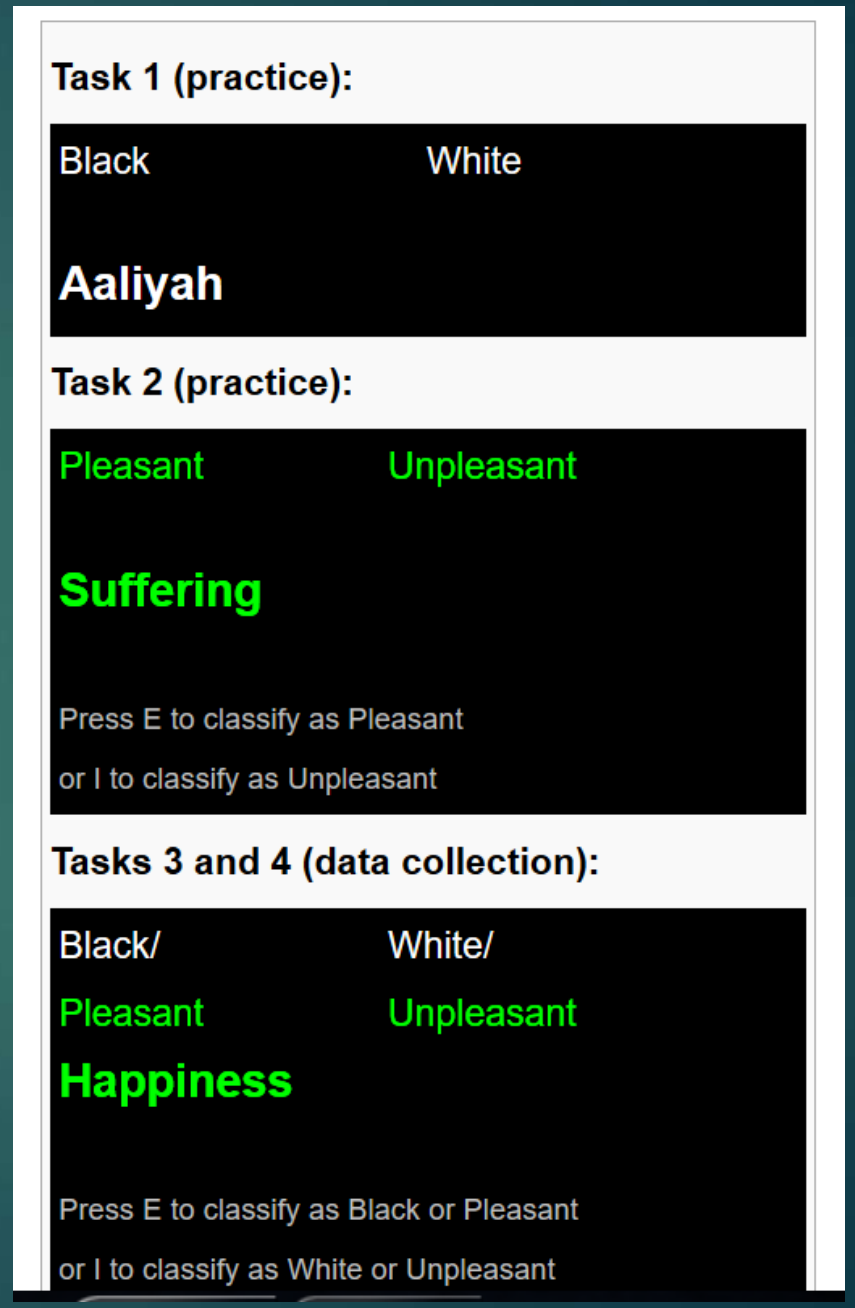
Red: amygdala

Blue: right somatosensory cortex

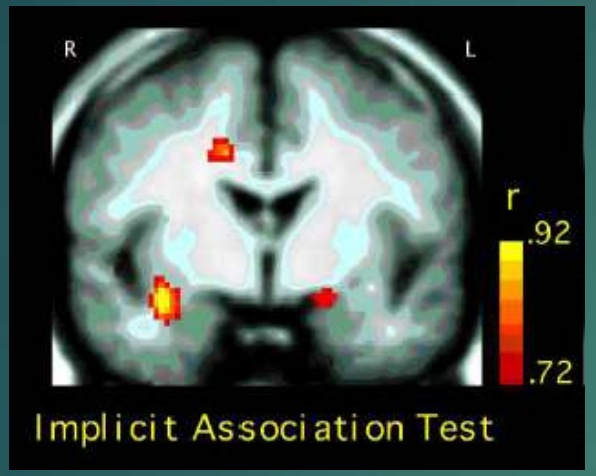
Purple: insula

Implicit Association Test

- A positive association with one's own group, an "in-group", happens unconsciously faster than with an "outgroup".
- These different reaction times become visible in the Implicit Association Test (IAT) with which psychologists examine unconscious processes and prejudices.
- A computer-based measure, the IAT requires that users rapidly categorize two target concepts with an attribute (e.g. the concepts "male" and "female" with the attribute "logical"), such that easier pairings (faster responses) are interpreted as more strongly associated in memory than more difficult pairings (slower responses).
- The IAT is thought to measure implicit attitudes about sex, race, stereotypes, etc.

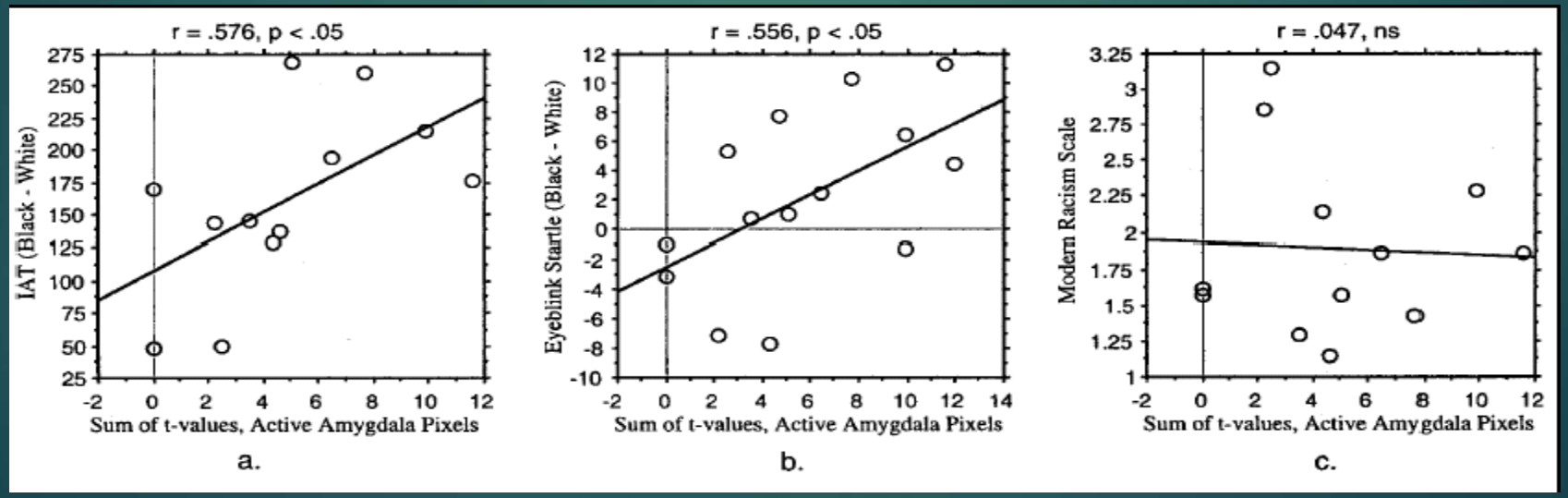


Unconscious racial biases



In White subjects, amygdala activation in response to Black faces correlates with unconscious measures of bias (IAT response latencies)

….but not with score on Modern Racism Scale, measuring how "racist" they perceive themselves. (Phelps et al J Cogn Neurosci 2000)



Neural correlates of morality

Areas shown are those activated by moral (physical assaults, poor children abandoned in the streets, war scene) versus non-moral unpleasant visual stimuli. Differential activation was also seen in moral vs. neutral conditions.

How would we interpret someone's scan that does not show this pattern of activation. Are they immoral? Amoral?

(Moll et al J Neurosci 2002)

Wired for Bias: Innate Prejudice

- Hominid on African Savannah, 2 Mya: fast identification of stranger/the other fosters survival and is an evolutionary advantage

- Despite this overwhelming evidence that our brains are evolutionarily wired for bias, our society continues to think about prejudice as premeditated behavior.

- Our current laws against discrimination, as well as the majority of diversity training programs, assume that prejudice is overt and intentional.

Prejudice

- Rarely do we teach people about how automatic prejudices might taint their behavior towards others.

- The fact that prejudice often occurs automatically doesn't mean we can't find ways of overcoming its negative effects. We have prefrontal lobes to control our amygdala (if our brains are normal)

- Monkeys show ingroup and outgroup prejudice.

Are we born racist?

- Evolution favored individuals who banded together = source of prejudice in brain activation
- Racial prejudice is rooted in brain areas that emerged early in primate evolution.
- But also that the more recently evolved neocortex functions to regulate our automatic impulses

Susan Fiske, 2010

Evidence of prejudice

- NBA referees more likely to call fouls on players of a different race
- Baseball umpires more likely to call a strike when pitcher is of same race
- White men who see unfamiliar black male have amygdala triggered.
- Better able to remember same race faces
- Twice as likely to have death penalty conviction if face judged as “stereotypically black”
- In video game, faster to shoot an armed black man
- Biased police driving arrests: “DWB = driving while black”

OFC & Stereotyping

- Evolution favored fast identification of us vs. them, of categories vs individuals.
- OFC: rapid evaluation of complex social information based on learned associations
- Stereotypes = cognitive “shorthand” for instantaneously decoding social situation for rapid behavioral response
- Faster reaction time to stereotypes

Amygdala and Prejudice: In vs. Out group

- Stereotyping and primitive emotional prejudice responses: amygdala has major role in implicit prejudice.
- Greater amygdala activation to black faces in white subjects despite denial of prejudice; but do not activate to famous black faces
- People who exhibit more prejudice, show more amygdala response
- Not inevitable: malleable by social goals and PFC activation.

Amygdala & Insula: Us vs. Them

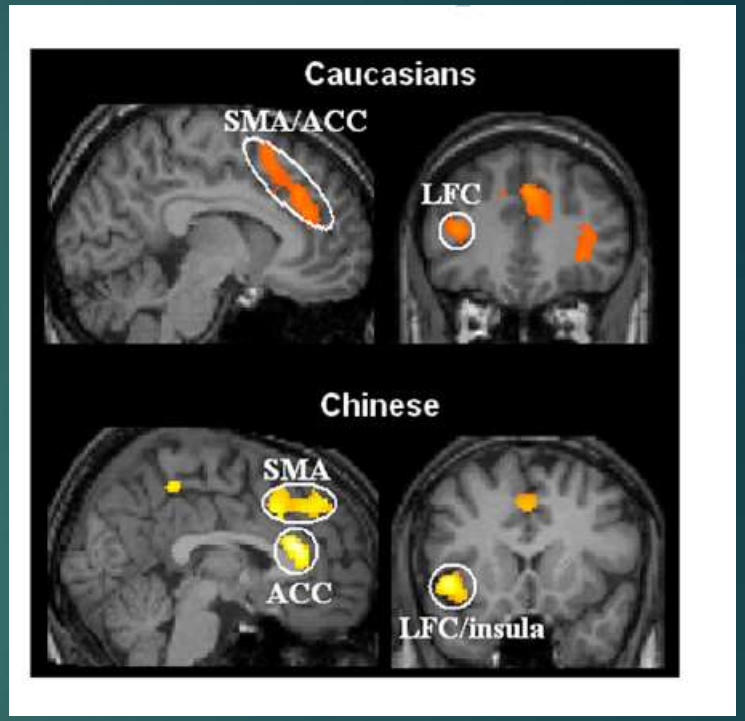
- Amygdala & insula are strongly activated (in milliseconds):
  - Apparent race
  - Gender
  - Age: older
  - Disabled
  - Homeless
  - Drug addicts
  - Rich businessmen

Arabs vs. Israelis

- Hoping to see a correlation between empathy levels and amount of activity in those brain regions, the researchers then recruited Israelis and Arabs for a study in which subjects read stories about the suffering of members of their own groups or that of conflict-group members. The study participants also read stories about a distant, neutral group -- South Americans.
- As expected, Israelis and Arabs reported feeling much more compassion in response to the suffering of their own group members than that of members of the conflict group. However, the brain scans revealed something surprising: Brain activity in the areas that respond to emotional pain was identical when reading about suffering by one's own group or the conflict group.
- Also, those activity levels were lower when Arabs or Israelis read about the suffering of South Americans, even though Arabs and Israelis expressed more compassion for South Americans' suffering than for that of the conflict group.
- Those findings, published Jan. 23 in Philosophical Transactions of the Royal Society: Biological Sciences, suggest that those brain regions are sensitive to the importance of the opposing group, not whether or not you like them.
- He hypothesizes that when someone reads about the suffering of an in-group member, the brain regions identified in this study send information to areas that process unpleasant emotions, while stories about suffering of a conflict-group member activate an area called the ventral striatum, which has been implicated in schadenfreude -- taking pleasure in the suffering of others.

Loyalty & Empathy & Prejudice in the In Group: **Do You Feel My Pain?**

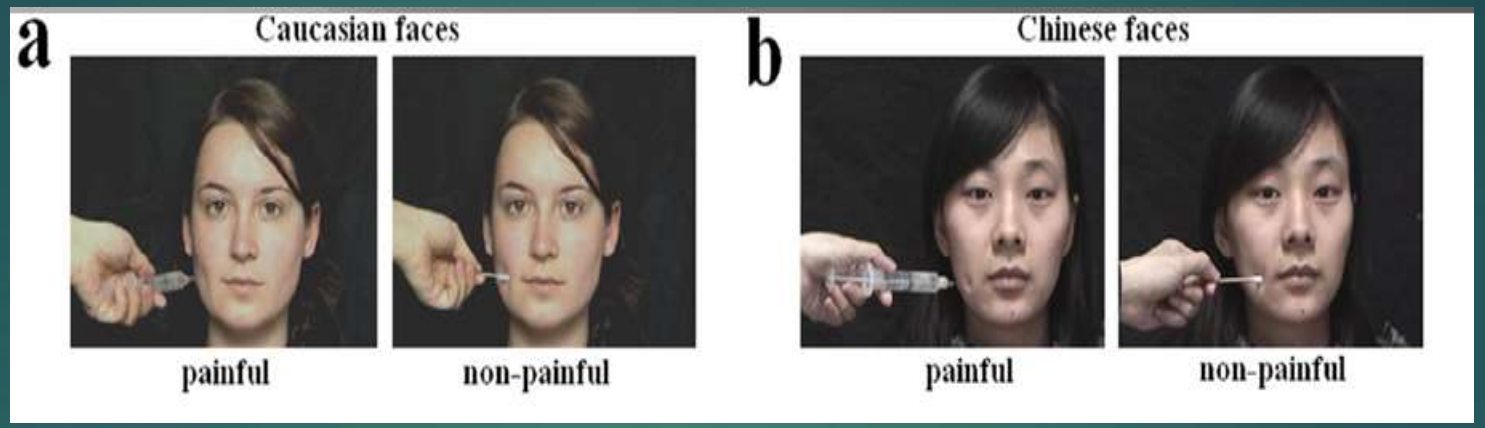
- People show more empathy to own group.
- ACC mainly contributes to the affective component of empathy
- ACC & FI activate when witnessing someone in pain



Do You Feel My Pain?

Own-race bias in ACC activity in empathy for pain

ACC ↑ if white viewer



ACC↓ if white viewer

Pain applied to racial in-group faces induced increased activations in the ACC & inf FI in both Caucasians and Chinese when viewing own group.

Empathic neural response in the ACC decreased significantly when subjects viewed faces of other race.

Most empathic to in-group showed stronger empathy to out-group members

Xiaojing Xu et al., 2009

But we have Frontal lobes & evolved for cooperation

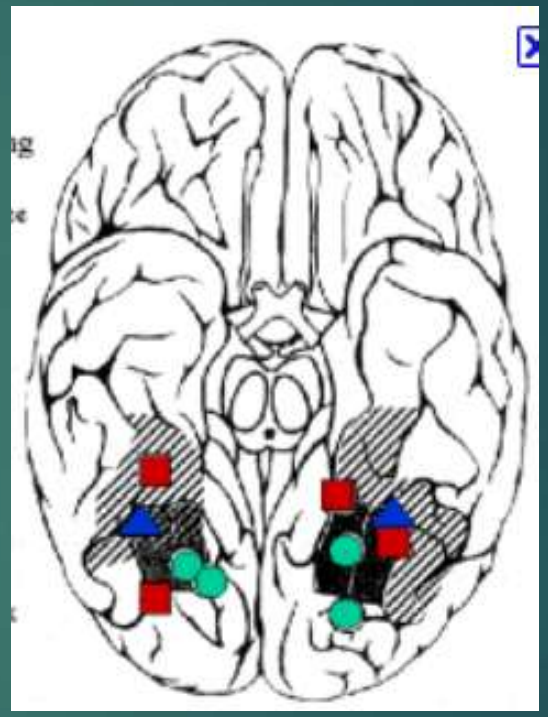
- We can rein in our unwanted prejudices:
  - Among whites, longer exposure to black faces reduces Amygdala response (30 ms vs 525 ms)
  - People with positive attitudes toward African Americans show greater left PFC activity in situations were stereotyping was possible
  - Less prejudiced people have ACC (conflict resolution circuit, empathy) activation in same situation
  - Smiling reduces racial categorizaiton

Conclusion

- Our brain's evolution to avoid threat leads to unconscious prejudice.
- Our basic snap judgments and gut reactions are evolutionarily based subcortical responses for protecting ourselves from threating situations.
- We cannot stop spotting differences and sorting people into categories.
- But hominids also developed the frontal lobes to suppress inappropriate social reactions and maintain appropriate goals.

Fusiform Face Area in Temporal lobe: facial identity

- Fusiform face area (FFA):
  - Holistic processing of highly familiar multipart visual input
  - 57 Chevy fins
  - Chess board perception
  - Perception of unchanging (identity) aspects of human face



Blue & Red

Fusiform Face Area (FFA): Face Recognition

Brain regions for face vs. object recognition

Genetic: Face perceptual abilities are inherited

No correlation between IQ & face recognition

Confirmed in epileptic pt with 2 electrodes on FFA

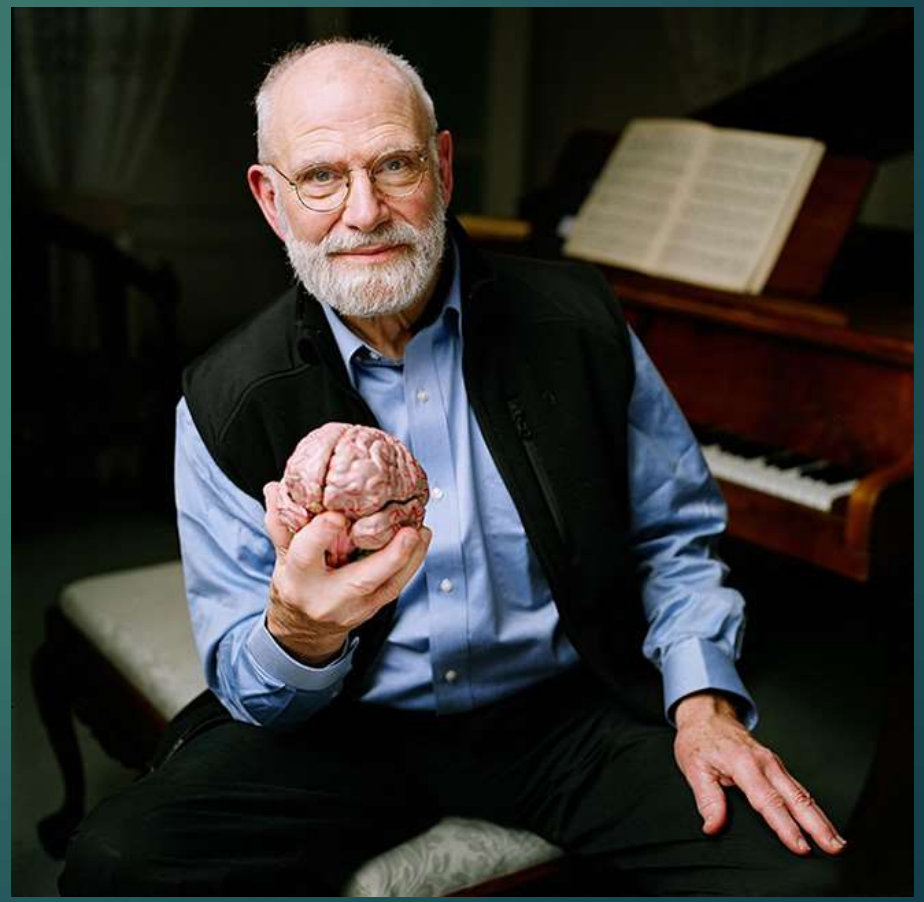
Nancy Kanwisher at MIT

Prosopagnosia or Face Blindness

- Patients are unable to recognize faces consciously
- Bilateral damage to the FFA
- Patient isn't blind (can still read a book); can no longer recognize faces by looking at people.

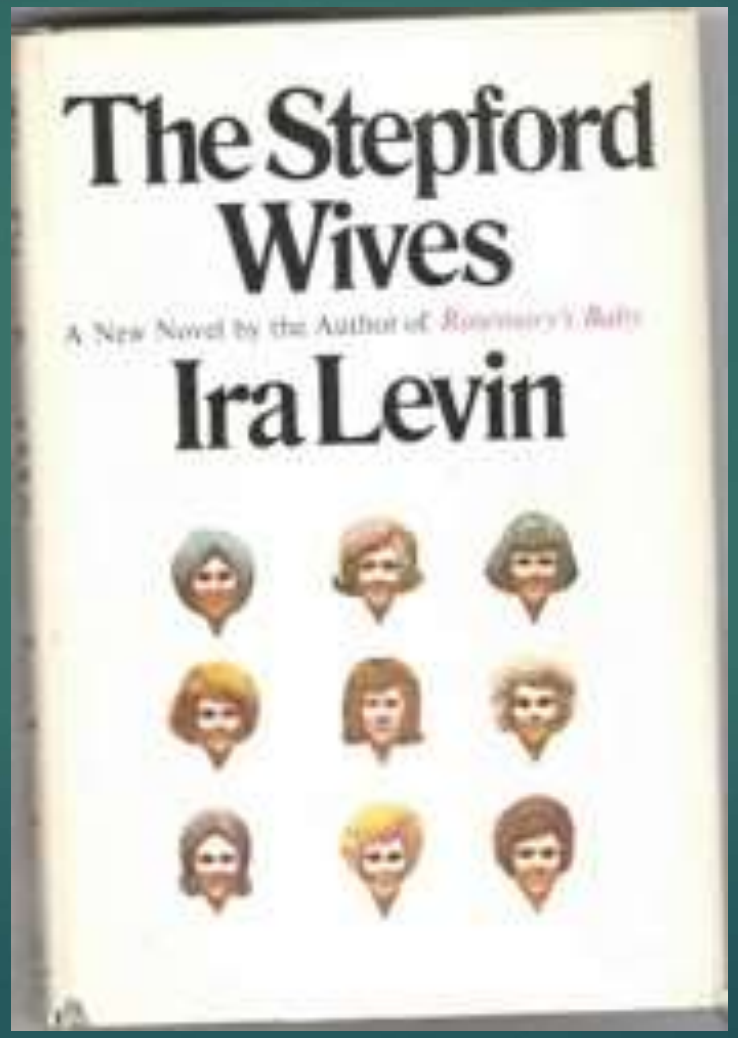
Oliver Sacks, MD

- *The Man who Mistook his Wife for A Hat*
- Face Blind (prosopagnosia)
- As is Jane Goodall



http://www.faceblind.org/facetests/index.php

Capgras Syndrome:
A loved one has been stolen by a doppelganger



Capgras Syndrome:
The trouble with disconnections
I know your face, but you are not familiar

- FFA Visual Recognition ok; amygdala/Hippocampus Familiarity circuits ok; but 2 are disconnected
- V. S. Ramachandran: a disconnection between the FFA (visual face recognition↑↑) and the limbic system (amygdala and hippocampus) (emotional familiarity↓↓)
- When wife calls on the phone and he hears her voice, he instantly recognizes her. Yet if she walks in the room after that call, he is again convinced that she is an impostor.

Eye Gaze:
One key to social interactions

Human & Dog Eye Gaze

- Preverbal infants: Must first talk to them, then turn your head and they will follow your gaze
- Dogs too: Vocally address them “Hi dog”, then look them in eye; then they will follow your gaze
- Dogs: left gaze bias only for human faces; right side of the human face is better at expressing emotional state.
- Dog's gaze at its owner increases owner's urinary oxytocin during social interaction

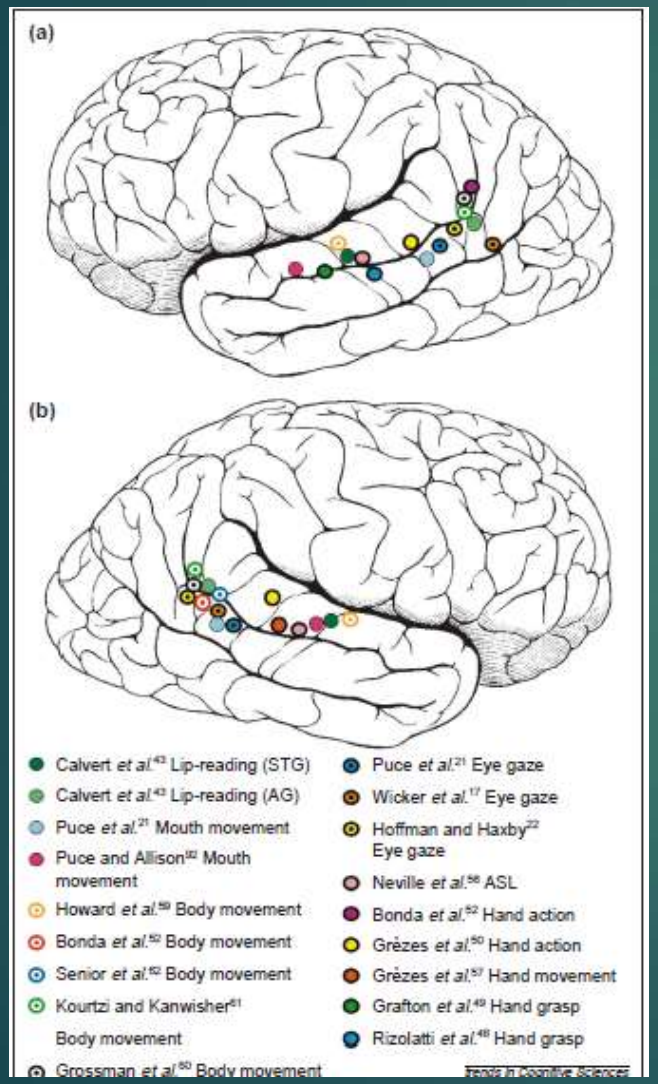
E. Téglás, et al., 2012; Nagasawa, et al., 2008

Social interaction for language acquisition in infants

- Learning language in infants depends on social skills
- 8-10 months is language critical period for sound discrimination
- Study: Exposure to second language Mandarin instruction for 12 sessions
- Only successful if done in person, not via TV
- Infant gaze following and pointing predict vocabulary development.

Patricia Kuhl

STS: Superior Temporal Sulcus



Activated:

- Lip reading
- Mouth movement
- Body movement
- Eye gaze
- ASL
- Hand movement
- Hand grasp

T. Allison, et al., 2000

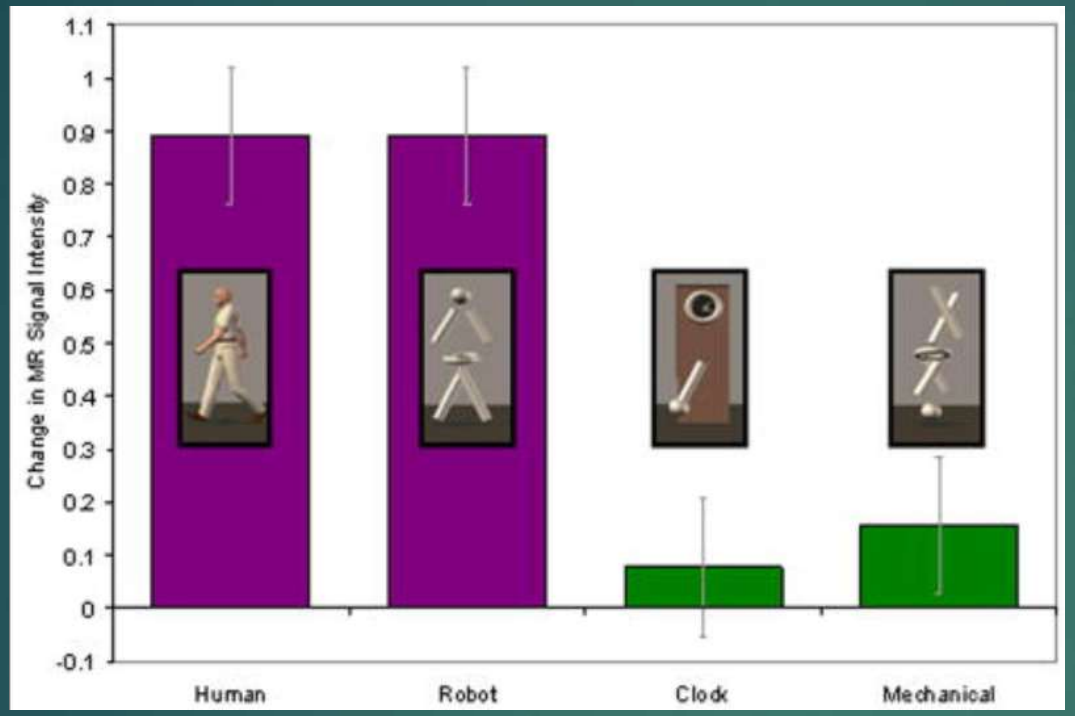
STS: Grasping the Intentions of Others

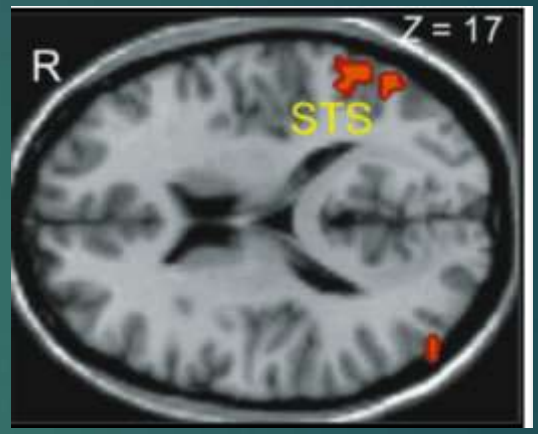
- STS region is activated by movements of the eyes, mouth, hands and body:

- The posterior STS region:
  - biological motion & intentionality of an action
  - goals of others via gaze shifting or reaching-to-grasp

- In autism, dysfunction in the right STS is strongly and specifically correlated with the level of social impairment exhibited.

STS activation in biological motion



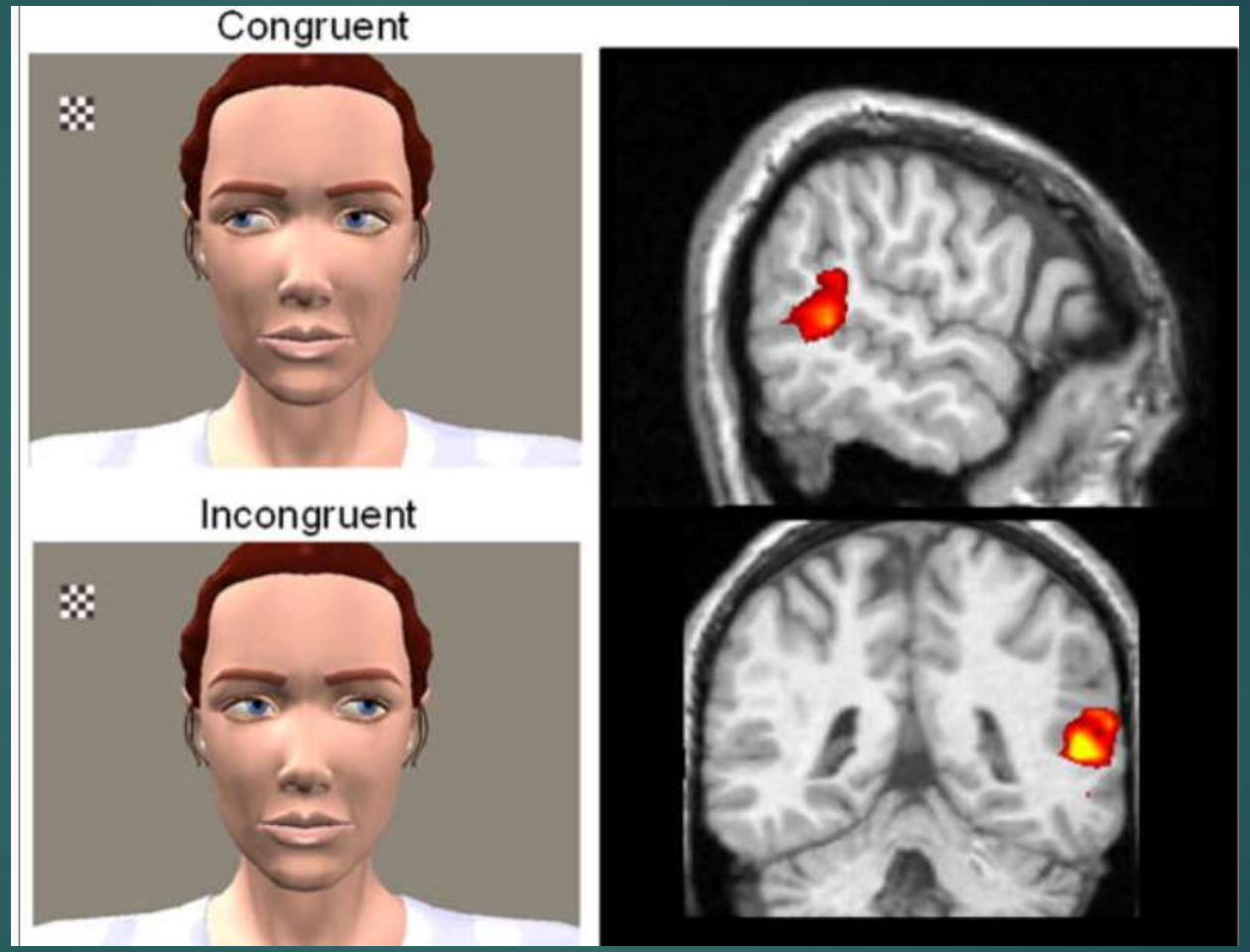


Biological motion selectively activates the STS: social perception of human action.

Autistics did not have different STS activity for biological and non-biological motion.

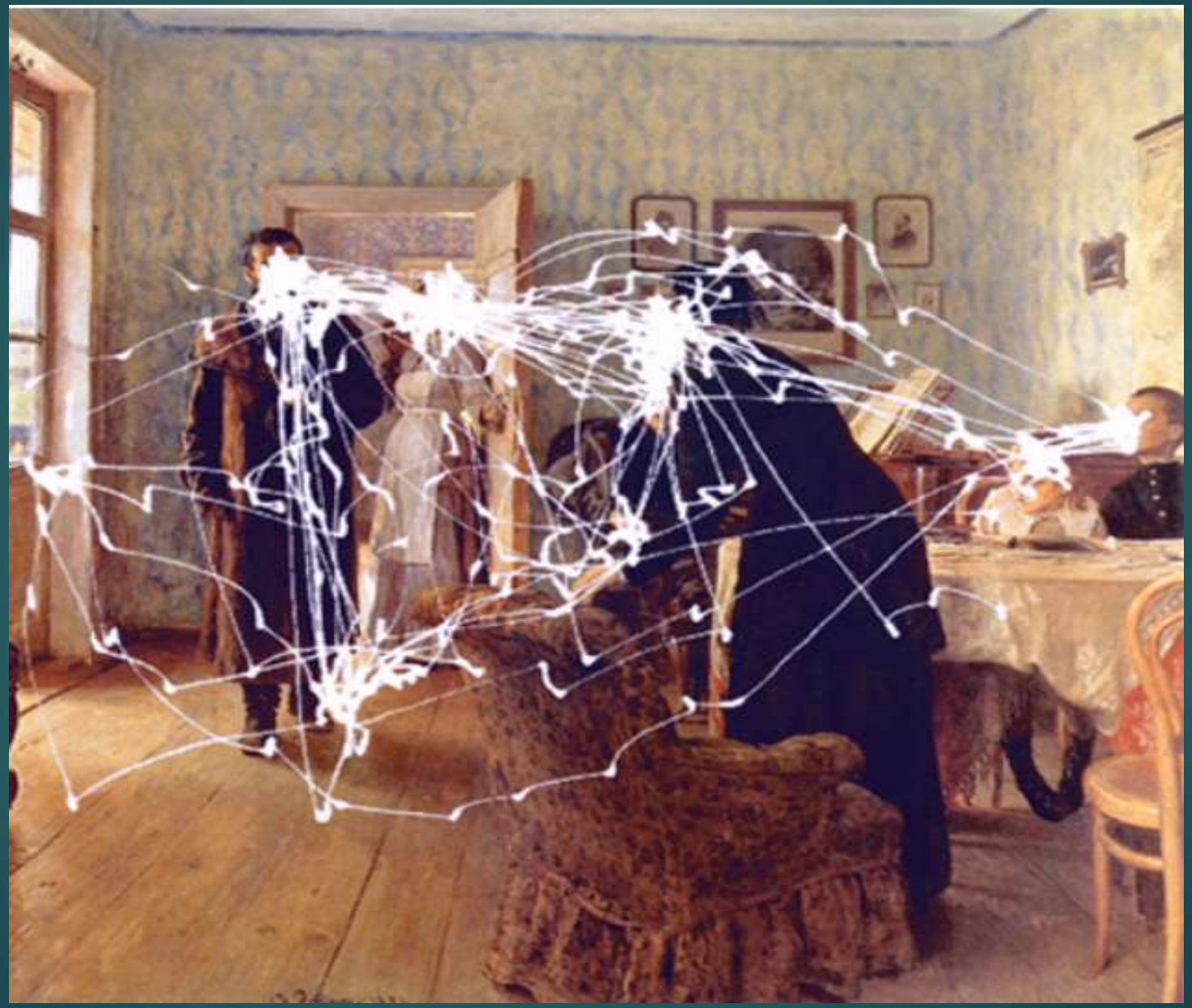
K. Pelphrey & E. Carter, 2008

STS: Monitoring expectations about the goals of others via eye-gaze

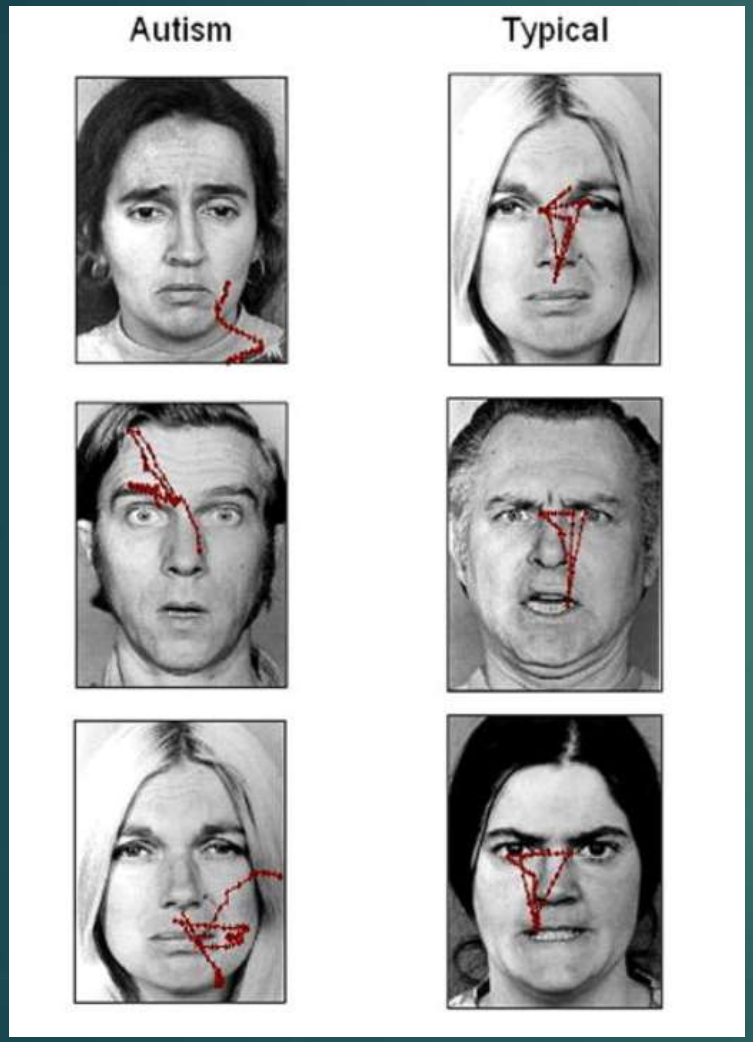


Incongruent trials evoked greater right hemisphere STS activity than did congruent trials, demonstrating the sensitivity of the STS region to the intentions conveyed by eye-gaze shifts. STS was *more* active during the "incorrect" trials.

Social eye tracking



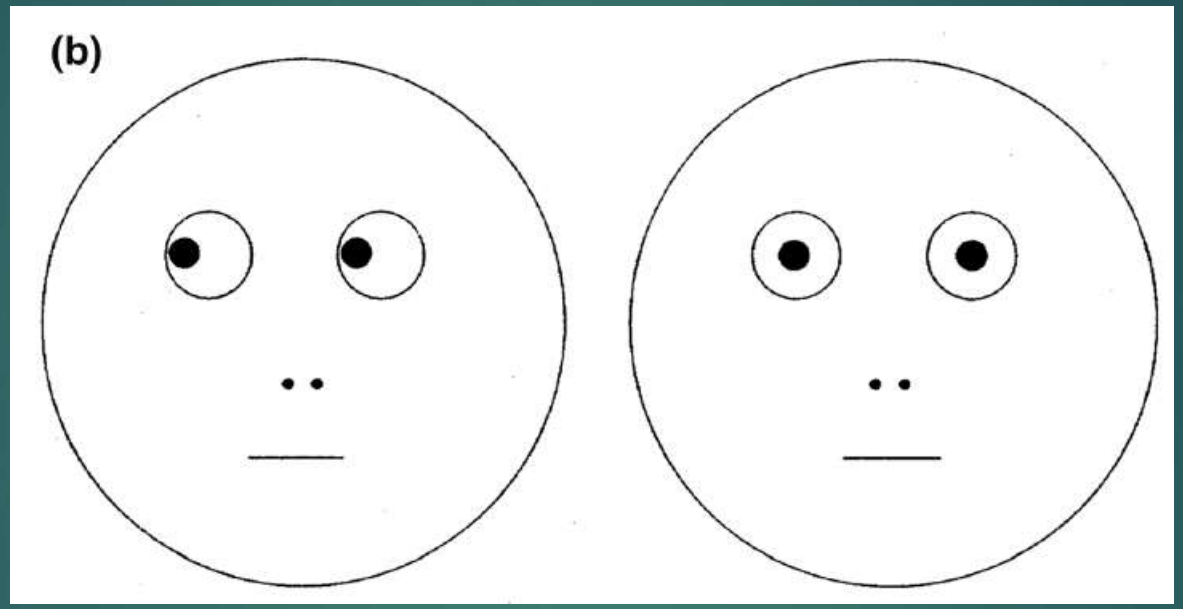
Autism: Deficit in social eye tracking



- Neurologically normal focus on the eyes, nose and mouth).
- Individuals with autism do not look at the eyes
- Using gaze information to infer mental states and intentions is consistently impaired even in high-functioning adults with autism

Pelphrey et al. (2002).

Autism:
Able to perceive the direction of gaze



- When asked ‘which one is looking at you?’, autistic children score as well as normal children.

Autism: Can do gaze following, but not it's meaning

When asked which candy 'Charlie' prefers, most normal children point to the Polo Mints, but autistic children are less likely to do so.

Orbital Frontal Cortex (OFC): how rewarding a reward is

- Primary functions:
  - analysis of rewards and punishments;
  - rapid evaluation of cost/benefits of behavioral responses to environment, esp. social
- Damage in non-human primates: abnormal social behavior, especially social isolation and avoidance

- Damage in human: severe social deficits

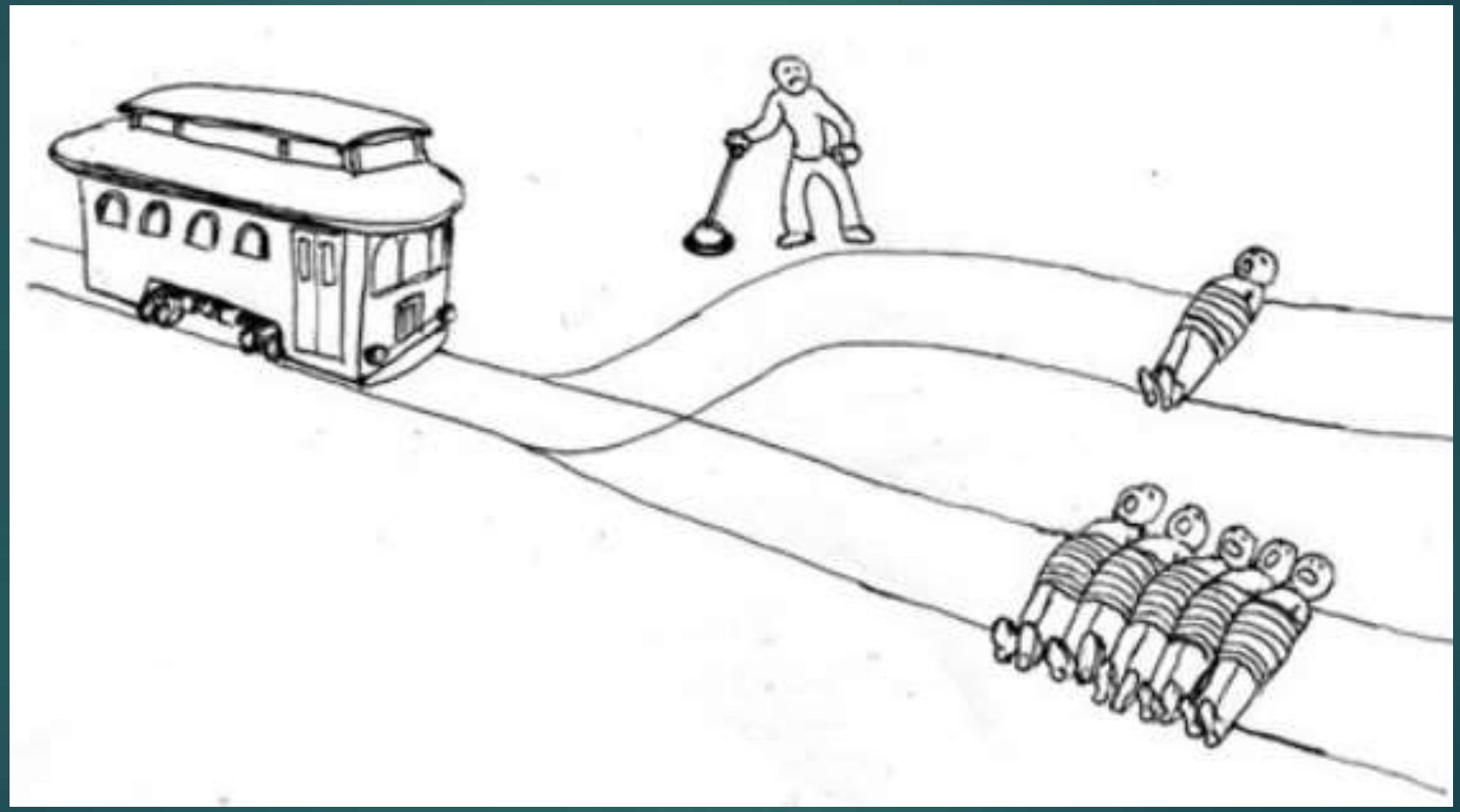
Lateral Orbital Frontal: Social conformity

- LOFC linked with our response to consensus.
- Subjects who had more volume in the lateral orbitofrontal cortex are more likely than their peers to change their ratings to more closely align with the critics' ratings.
- The findings suggest that the lateral orbitofrontal cortex is particularly sensitive to signs of social conflict or disagreement, which may influence changes of opinion.

Damage to OFC:
Alters interpersonal behavior

- Abnormal social behavior and violations of social norms
- Cannot see how behavior might be viewed negatively by others & be socially punished
- Bilateral damage: impaired identification of self conscious emotions (embarrassment, shame)
- Unilateral right damage: impaired recognition of anger & disgust

Trolley Problem 1: DL PFC active



9 of 10 people confronted with this scenario say it's O.K. to hit the switch.

Trolley Problem 2: vmPFC active

9 of 10 people say it's not O.K. to kill one person to save five;
Individuals with vmPFC damage 3x more likely to push the person off.

vmPFC Damage

- VMPFC damage: strongest predictor of empathic deficits
- 3 x more likely to advocate throwing a person to certain death in front of a runaway train to keep it from killing five other people.
- 5 x more likely to advocate smothering one's baby to save others

Damasio, 2007; Amitai Shenhav and Joshua D. Greene, 2010

ToM: Theory of Mind

Theory of Mind

- Nicholas Humphrey (1977): notion that the capacity to theorize about other minds is an evolved specialism, dependent on a new kind of cognitive architecture

ToM: Theory of Mind

- The term 'theory of mind' (ToM) was coined in by Premack and Woodruff in 1978 in relation to chimpanzees' capacity for deception

- ToM: Other individuals possesses a mind just like one's own.

- ToM is the ability to attribute mental states to others and thus forms the very basis of social interaction and communication.

Premack & Woodruff 1978).

4 Neural circuits of ToM

- Medial prefrontal cortex (mPFC),
- Posterior superior temporal sulcus (pSTS),
- Precuneus and amygdala/temporopolar cortex
- RTPJ

Simon Baron-Cohen ToM theory

- 4 independent skills:

- Ability to detect Intentionality (purposeful action)
- Ability to detect eyes & gaze direction
- Ability to share attention: gaze shifting & pointing are ways to direct attention In humans by age 1; also by dogs
- Higher order ToM: rules of social cognition: others have mental states; can deceive & be deceived; others can have false beliefs

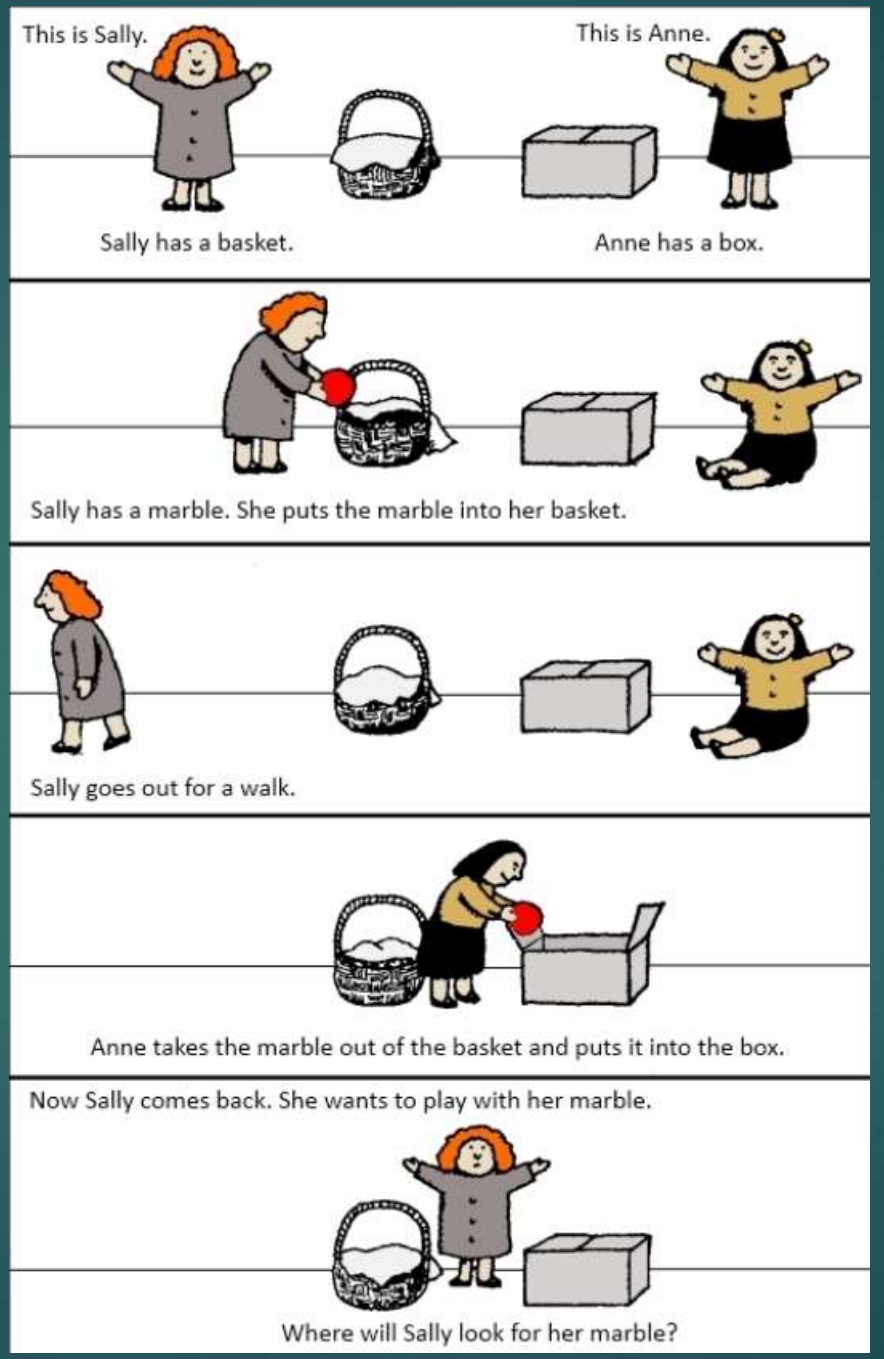
False Beliefs

- Highest level of ToM includes ability to attribute *false belief*.
- Ability to recognize that others can have beliefs about the world that are wrong and we can predict their behavior based on this fact

Box of Cookies?

Jerome, with a physics PhD & autism is shown a cookie box filled with pencils. Box then closed. Joe walks into room.
Jerome is asked “What would Joe guess is in this closed cookie box?“
He consistently answered “pencils”

Sally Ann Task



False Belief: Sally-Anne task

- The child passes the task if she answers that Sally will look in the basket;
- Understand that another's mental representation of the situation is different from their own, and ability to predict behavior based on that understanding.
- By age 4: Most normally-developing children (incl. Down's syndrome) are able to pass the task
- 80% of children diagnosed with autism are *unable* to do so
- Failure in false belief tasks in 2 chimpanzee and 1 dolphin studies criticized

Chimpanzees have partial ToM

- Solid evidence that chimpanzees understand the goals and intentions of others
- No evidence that chimpanzees understand false beliefs.
- Current conclusion: chimpanzees have a perception–goal psychology (other acts in a certain way because she perceives the world in a certain way, i.e. change behavior if know competitor can see a food source)
- But do not have a full-fledged, human-like belief–desire psychology (in which they appreciate that others have mental representations of the world that drive their actions even when those do not correspond to reality; false beliefs)

Call and Tomasello, 2011

Mind blindness: rTPJ in autism

- “Mindblindness”= deficits in representing mental states
- RTPJ was the only mentalizing region that responded atypically in autistics
- Less activity of rTPJ correlated with most socially impaired.

M. V. Lombardo et al., 2011; (Happé, 1995).

Autism

- Characterized by language delay, deficit in social interactions, lack of ToM; 70% retarded

- Deficit in interpretation of meaning of eye gaze

- Deficits in imitation skills

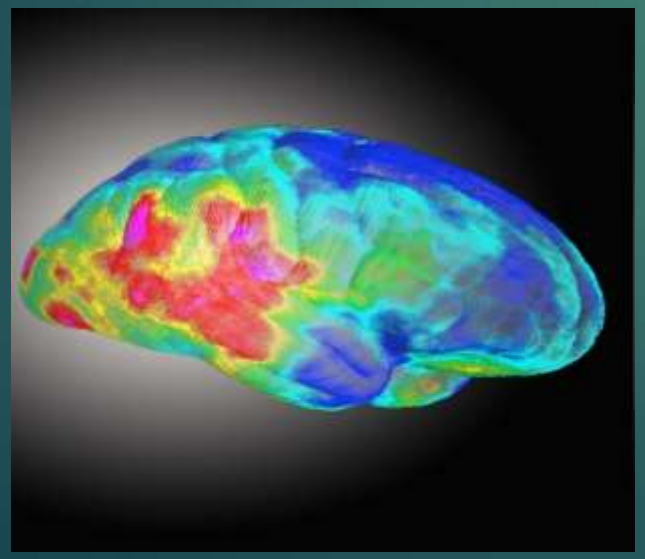
Social Deficits in Autism

- Right STS & rTPJ deficits correlate with behavioral severity
- Lack social meaning of eye gaze tracking
- Developmental difficulties with VENs
- Structural deficits in ACC & FI (Social Salience network)
- MNS delayed
- Lack of ToM

MNS in Autism: Delayed not broken

- MNS: Often can, but don’t; development delay
- MNS was functional, but less sensitive; more when watched videos of family members, but not of strangers.
- MNS areas: thinner and the degree of thinning was correlated with autism symptom severity
- Those with best MNS, have best social skills; imitation problem decreases with age

William's Syndrome: Social ++



- Neurodevelopmental disorder
- Mental retardation coupled with:
- Unusually cheerful demeanor and ease with strangers
- Severe VS deficits

Williams Syndrome: No Social Fear

- Gregarious, Increased empathy, no social fear
- Positive interpersonal facial perceptual bias
- Inability to detect social danger
- Reduced Amygdala activation to social danger cues (faces)
- Increased activation in the MNS (Inf PFC, bilateral IPL, and right STS)

(Hoeft et al, 2007);

Amygdala: Affect Central

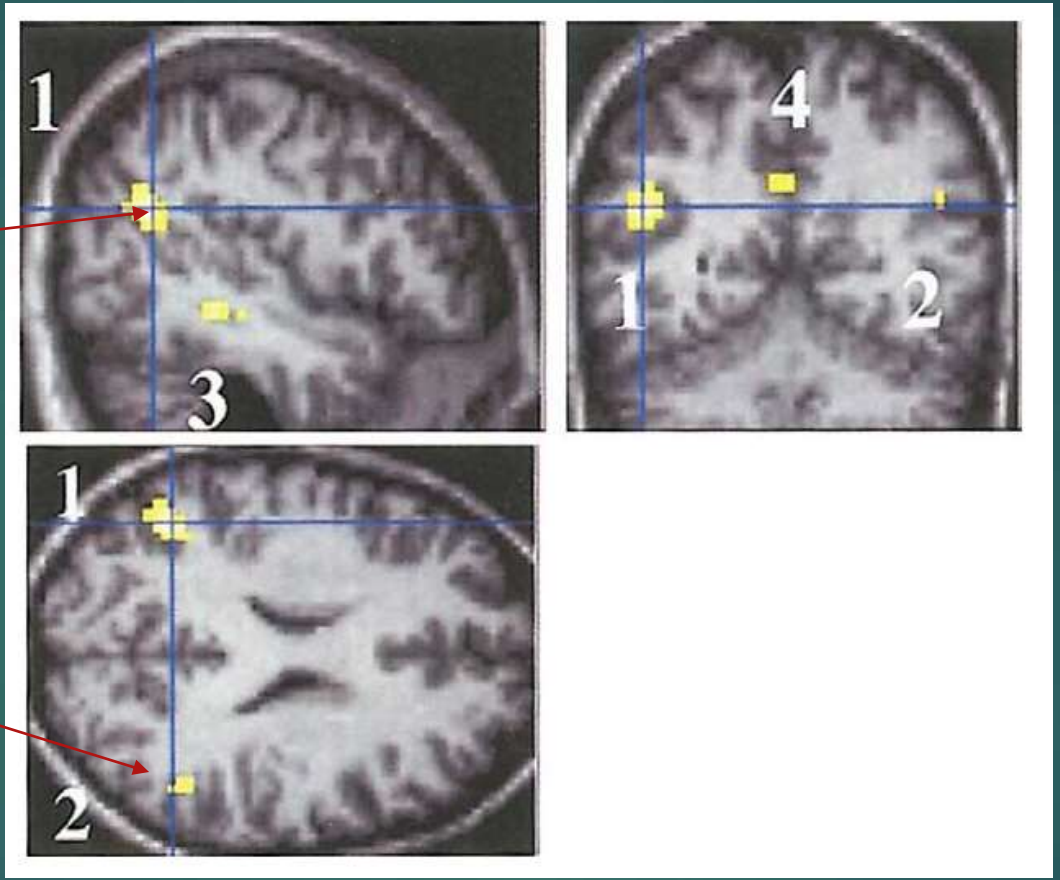
- Function:
  - Positive or negative affective significance to sensory input
  - Fear response, threat/danger response
  - Recognition of emotions from facial expressions,
  - Responsive to complex body movements & direction of eye gaze in a face
  - Cheating detection

Murray EA, Trends Cogn Sci. 2007

rTPJ: Source of Reading Thoughts, Theory of Mind, Intention

left TPJ
verbal

rTPJ
pictures



Reading stories that describe or imply a character's goals and beliefs

Theory of mind vs. mechanical inference stories. Crosshair marks the most significant voxel in the left TPJ (1). Also visible are activations in right TPJ (2), left aSTS (3), and precuneus (4). TPJ, temporo-parietal junction; aSTS, anterior superior temporal sulcus.

Saxe & Kanwisher, 2003

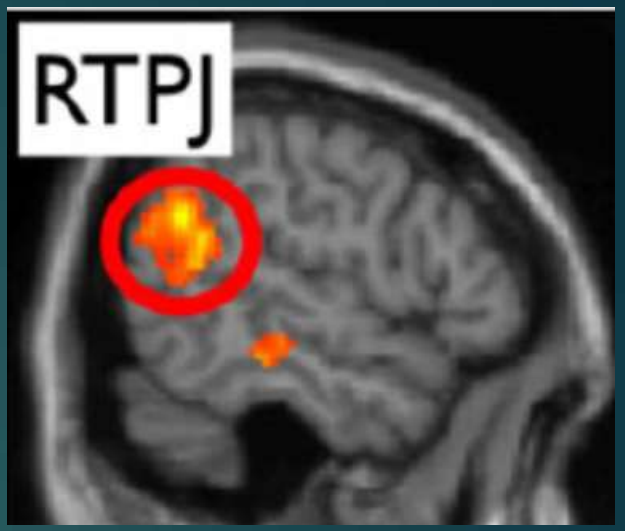
TPJ: Mind reading of intention

- Right Superior temporal sulcus (STS): ability to follow people's gaze and determine where another's attention is directed; movement intention from visual context

- TPJ active when people try to understand the minds of other people, as well as when people redirect their attention.

- If TPJ Lesion: poor ability to interpret other people's actions and emotions, and ability to judge intention of another

RTPJ:
It's the thought/intent that counts



- Evil twin tries to poison twin brother but fails
- In judging people, usually bad intention more important than the outcome: people call foul if act is intentional

- **Premeditation.** When rTPJ was turned off, rely less on the actor's intentions and, judge attempted harms as less morally forbidden and more morally permissible; Moral judgments shift toward a “if no harm, no foul”

, L. Young, et al., 2009

Right Temporal Parietal Junction (vPC):
Moral Judgment: Judging intentions

- 1 – Joan asks Susan to get coffee with sugar. Susan sees bowl labeled poison and puts it in coffee. But powder is actually sugar. Joan drinks coffee and is fine. (Bad intention; should be blamed, based on outcome)
- 2 – Or Joan asks Susan to get coffee with sugar. Susan sees bowl labeled sugar and puts it in coffee. Powder is toxic poison. Joan drinks coffee and dies. (Accident: Caused harm but Good intention; can forgive)
- Question: In which condition is Susan to blame?
- People say Susan deserves blame in scenario 1. We interpret Susan morally by her intention. Adult capacity to do this by age 12 (kids with older sybs do better)
- Disrupt rTMJ: make decision on basis of outcome (#1), not intention

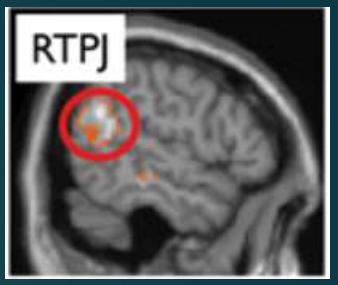
Rebecca Saxe

Temporal Parietal Junction: Intention detector

- Used TMs to disrupt RTPJ function:
  - Lower RTPJ activation: harsh, outcome-based judgments of accidents; (e.g., she *poisoned* her friend; deliberate intention)
  - Higher RTPJ activation: more lenient belief-based judgments; (e.g., she *thought* it was sugar; accident)

- ASD: lower rTPJ; only outcome-based moral judgments, blame even for accidental outcome
- Psychopaths: more likely to "forgive" accidental harms; blunted response to harmful outcome

rTPJ: Judge and jury



- rTPJ is critical for representing mental state information, irrespective of whether it is about oneself or others.
  - As RTPJ activates, so does the influence of more lenient belief information on moral judgment

- Higher the activation: take intention into account; less blame/more forgiveness if believe harm was accidental (see from their perspective)

- Lower the activation: less able to take intent into account; reduces the influence of belief information on moral judgments

L.Young and R. Saxe, 2007, L. Young, et al., 2009

Tell jury a gruesome murder

- Amygdala: our emotional urge to punish.

- Emotionally graphic descriptions of harmful acts amplify punishment severity, boost amygdala activity and strengthen amygdala connectivity with lateral prefrontal regions involved in punishment decision-making.

- However, this was:
  - only observed when the actor's harm was intentional;
  - when harm was unintended, a temporoparietal-medial-prefrontal circuit suppressed amygdala activity and the effect of graphic descriptions on punishment was abolished.

Treadway MT, et al., 2014

How we blame

- Emotion guides the decision-making process over logic
- Across all cultures:
- 1 Intentional harm is most blameworthy (murder)
- 2 Bad intentions with no harm is next (attempted murder)
- 3 No bad intention with harm is next (civil negligence)
- 4 No bad intention with no harm is not blameworthy

RTPJ: integrating intent with harm.

- rTPJ: codes for intention
  - In normals, rTPJ assess intentionality and amygdala assesses harm
  - calculation of blame based on these two,
  - using intent as main driver and harm only as tiebreaker.

- Normals – intent based: we blame intentional killing most, attempted killing next, accidental killing least

- rTPJ impaired – harm based: using intention to break the ties: blame intentional killing most, accidental killing next, attempted killing least

rTPJ

- rTPJ is necessary to integrate intent and harm, but not necessary for evaluation of either; impaired can still assess harm accurately & blame based on harm. Can assess intent accurately.

- Brain has 3 circuits: assess intention (rTPJ), assess harm (Amygdala), and 1 (PFC) to integrate these 2 into level of blame

- Young children blame based primarily on harm, with intention as tiebreaker.

Blaming tree in brain: We blame first on intention, & use harm as tiebreaker

- Was harm significant?

If yes, then was harm intentional?

If not, then DO NOT Blame

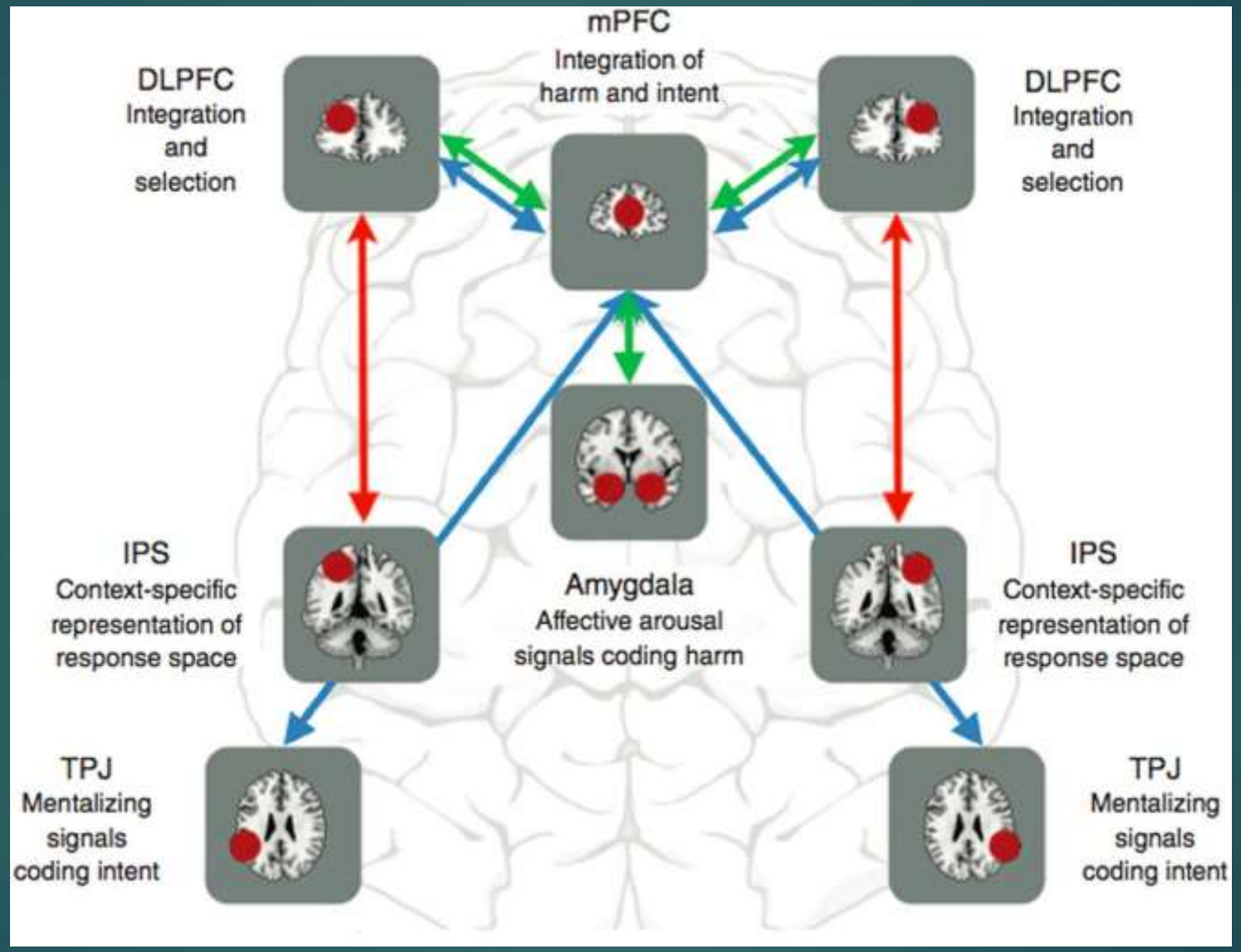
If not, then NO OR LOW BLAME, graded to harm

If yes, then HIGH Blame, graded to harm

A neurocognitive hypothesis for third-party punishment behavior.

Harm

Intent



Owen D. Jones et al. J. Neurosci. 2013;33:17624-17630

Larger & Smaller Amygdala in Autism

- Amygdala size was associated with both autistic symptoms and attention to other people's eyes in young autistics.
- Among 50 children diagnosed with autism before age 2, left and right amygdala volumes were 15% and 19% larger, respectively, up to age 4
- Larger amygdala volumes were associated with increased "joint attention. Such activity is typically diminished in autistic children, who tend to avoid people's gazes.
- But it was only a minority of autistic children -- some 21% -- who initiated or responded to a joint attention activity. In other words, the autistic children who scored well on joint attention were clustered at the high end of the amygdala volume spectrum.
- Previous researchers had found that, in autistic adolescents and adults, smaller amygdala volumes were associated with reduced eye contact.
- Repeated exposure to a highly stimulating event leads to a compensatory response (allostasis) within the amygdala, including increased dendritic arborization and consequent overgrowth. But this overstimulation produces chronically and, eventually, lethally high levels of glucocorticoids.
- Initial amygdala hypertrophy in autism is thus followed by reduced amygdala volume later in development.

The adolescent social brain

- Social emotion
  - Social emotions defined as emotions which require the representation of others' mental states
    - Guilt, embarrassment
      = social
    - Disgust, fear
      = non-social (basic)
  - Social emotion activates parts of the social brain network

Moll et al., 2002, 2005

The adolescent social brain

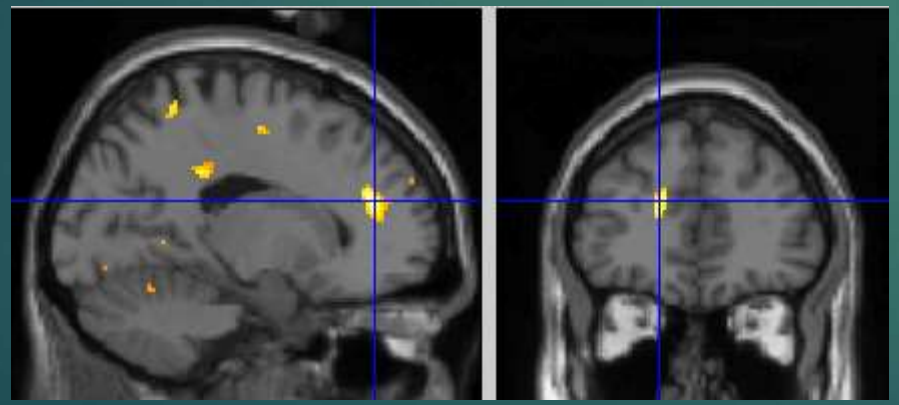
Study of adolescents vs adults:

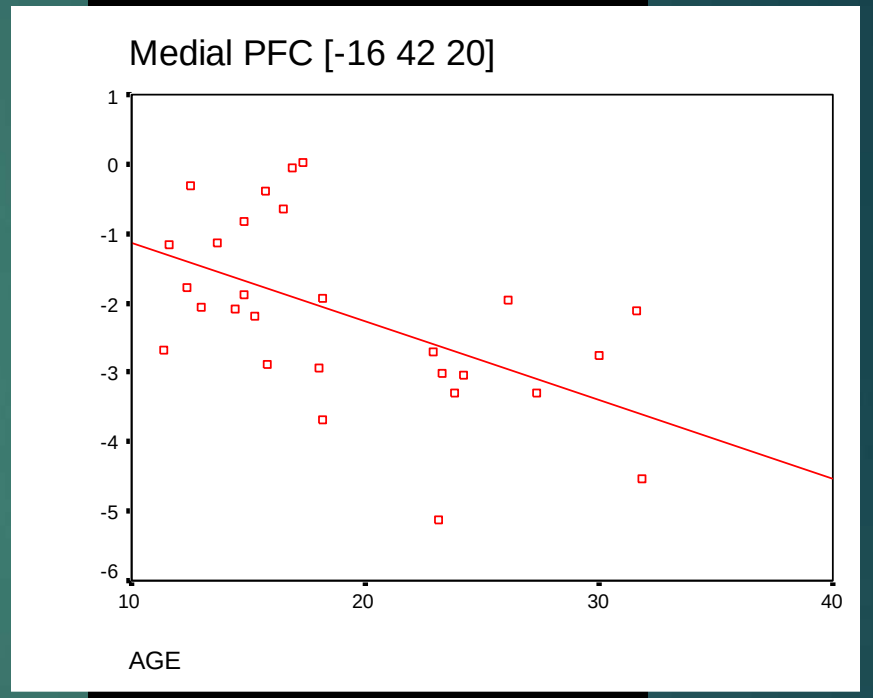
“Imagine…

Social	Guilt:	‘You laughed when your friend told you she was feeling upset’
	Embarr-assment:	‘You were quietly picking your nose but someone saw you’
Basic	Disgust:	‘You were with your friend and you put your hand in slimy cat poo’
	Fear:	‘Your friend said there was a huge hairy spider climbing up your neck’

The adolescent social brain

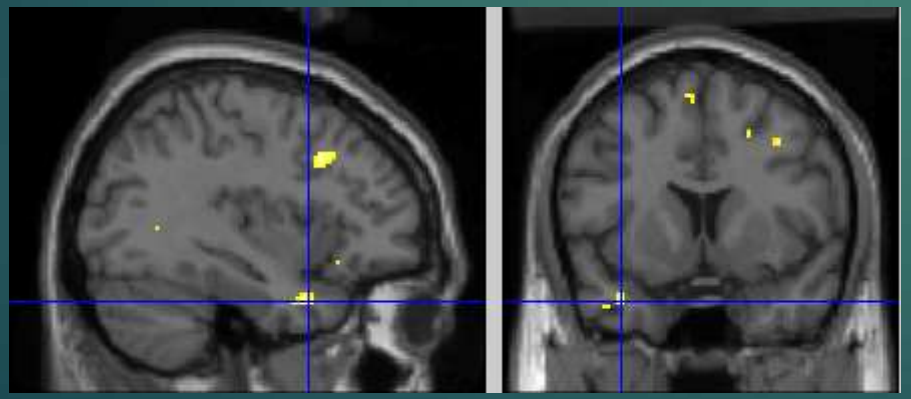
- Results:
- Age-group differences in social vs. basic emotion
  - Adolescents activated MPFC more than adults did for social vs. basic

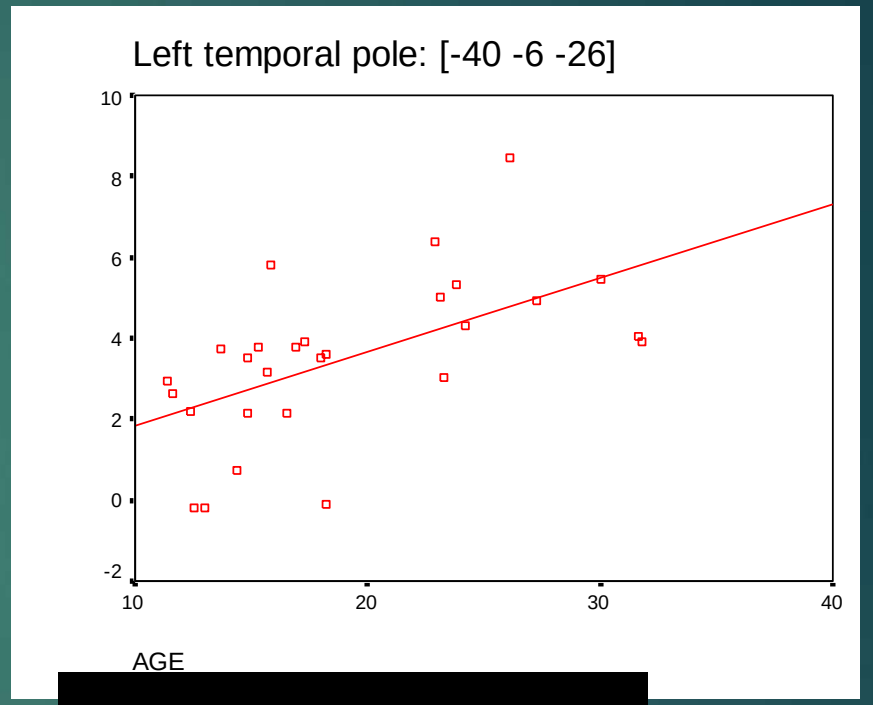




The adolescent social brain

- Results:
- Age-group differences in social vs. basic emotion
  - Adults activated left temporal pole more than adolescents did for





The adolescent social brain

- The neural strategy for thinking about social emotion situations develops between adolescence and adulthood
  - Adolescents activate MPFC more
  - Adults activate temporal poles more

The adolescent social brain

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The social brain in adolescence

Sarah-Jayne Blakemore

- Understanding intentions
- Understanding subtle linguistic meaning

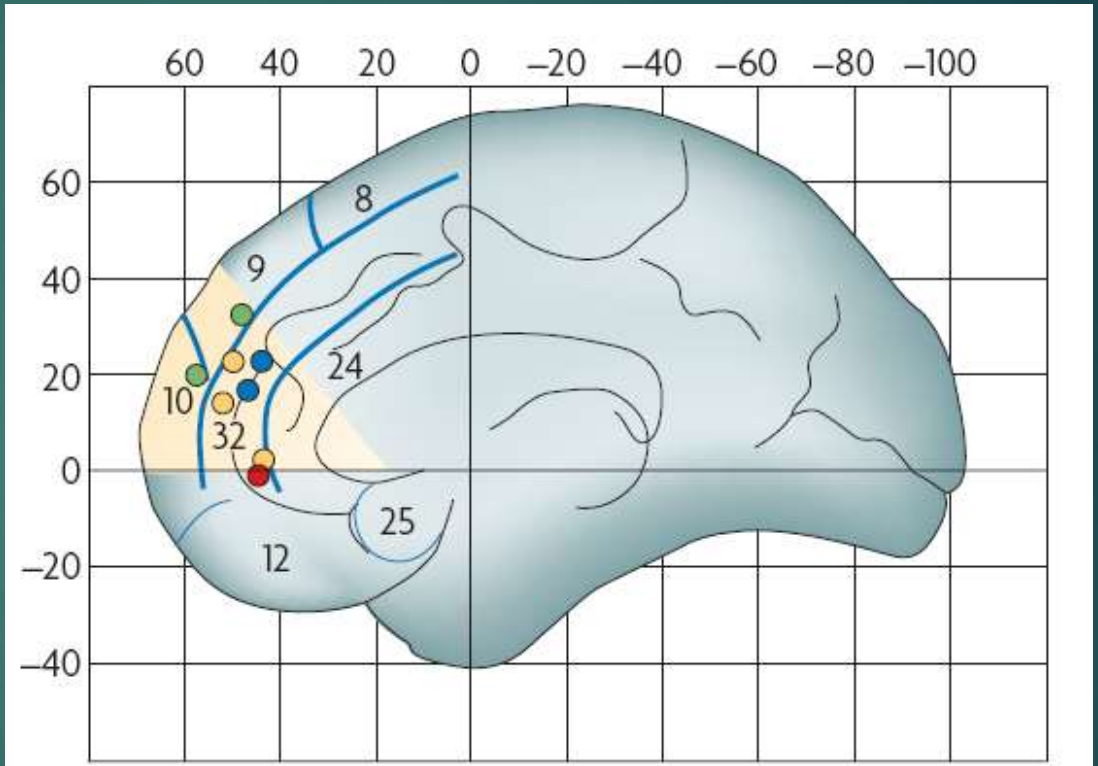

Figure 2 | **Activation of the medial prefrontal cortex (mPFC) during mentalizing tasks decreases during adolescence.** [redacted]

Conclusions and implications

- The neural strategies for social cognition are developing during adolescence
- At the same time:
  - Neuroanatomical development is taking place
  - Social abilities develop
  - An adolescent experiences new social environments and ideas

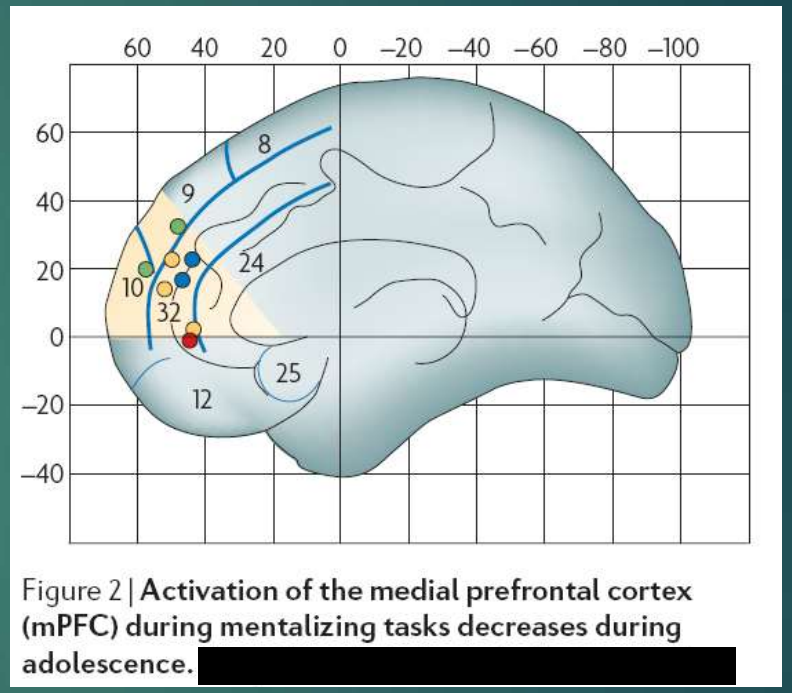

Figure 2 | **Activation of the medial prefrontal cortex (mPFC) during mentalizing tasks decreases during adolescence.** [redacted]

Social comfort

Conclusion

Modern *Homo sapiens sapiens* has evolved multiple brain regions related to living in complex social groups.

Social living has reorganized the human brain; we are wired to be social.

With the benefit of many social brain regions, we have the cost of more neurological social disorders.

Further Reading

Mirroring People – Marco Iacoboni
Empathic Brain – Christian Keysers
The Adolescent Brain – Reyna, Chapman, Dougherty, Confrey
Evolutionary Cognitive Neuroscience – S. Platek, J. Keenan, T. Shackelford
Cognitive Neuroscience of Social Behaviour – ed. A. Easton & N. Emery
The Lives of the Brain – John S. Allen
Social Intelligence – N. Emery, N. Clayton, C. Frith
The Human Brain Evolving: Paleoneurological Studies in Honor of Ralph L. Holloway by D. Broadfield, K. Schick, N. Toth & M. Yuan

Dunbar, R. I. M. (1998), The social brain hypothesis. *Evolutionary Anthropology: Issues, News, and Reviews,* 6: 178–190.
Butti C, et al., Von Economo neurons: Clinical and evolutionary perspectives, *Cortex* (2011), 30: 1-15

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