CNS 102a
January 22, 2018

Introduction to social cognition

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Overview of social cognition, evolution, and key features

1. what is social cognition?
2. what do we see across animal species?
3. what's special about humans?
4. two neural mechanisms: empathy and mentalizing
5. study example

STAGES of social information processing

TYPE of processing

STAGES of social information processing

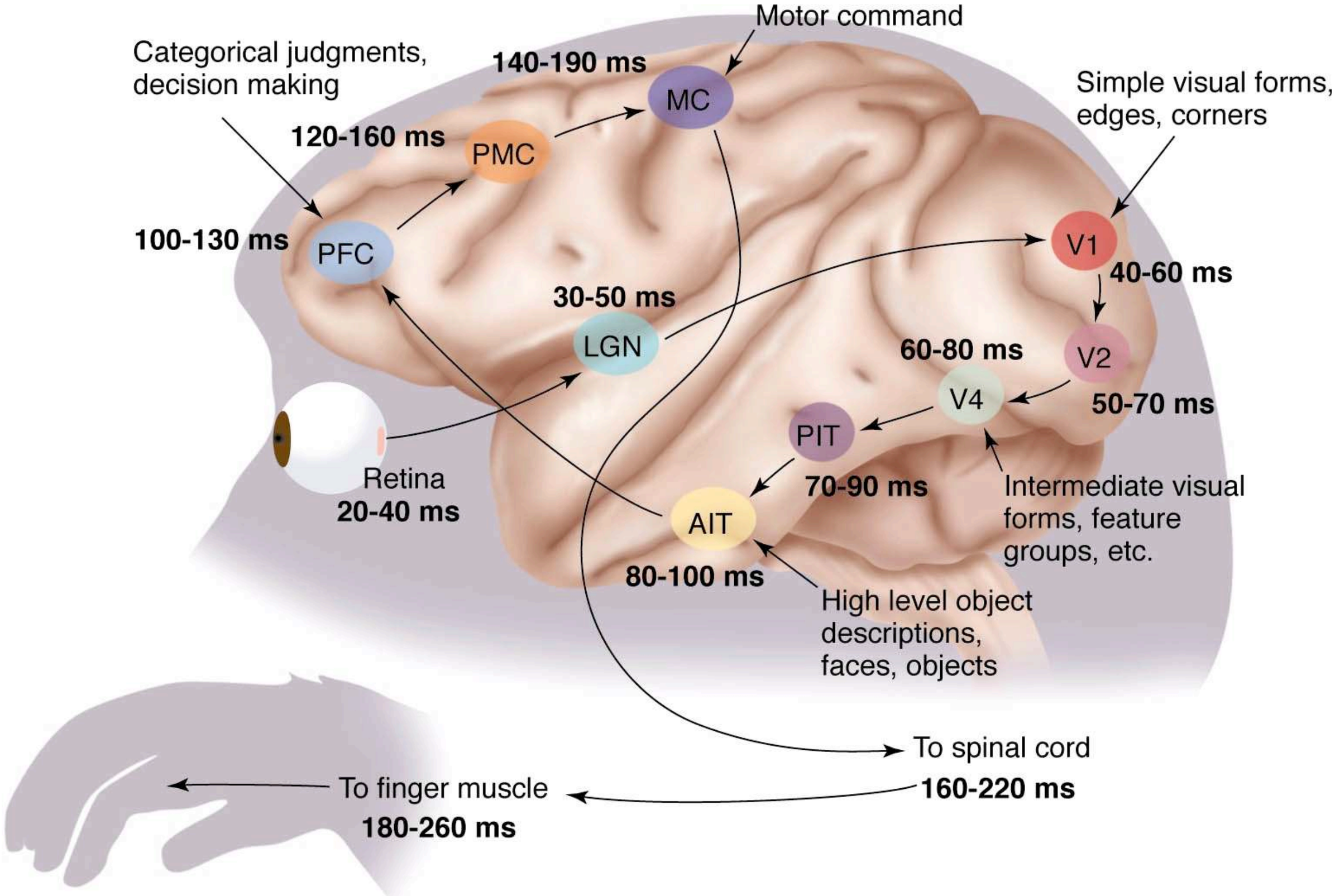
- transduction
- perception
- inference

- "cognition" (attention, memory, learning, reasoning)

- decision-making
- behavior

TYPE of processing

- domain-specificity


Motor command
Categorical judgments, decision making
140-190 ms
MC
120-160 ms
PMC
Simple visual forms, edges, corners
100-130 ms
PFC
V1
40-60 ms
30-50 ms
LGN
60-80 ms
V2
V4
50-70 ms
PIT
Retina
20-40 ms
70-90 ms
Intermediate visual forms, feature groups, etc.
AIT
80-100 ms
High level object descriptions, faces, objects
To spinal cord
160-220 ms
To finger muscle
180-260 ms

Sensory modality specializations

<u>peripheral</u>

- olfaction/vomeronasal: pheromones
- touch: social touch

<u>central</u>

- vision: face processing
- audition: language

Another way of carving things up

1. Knowledge of the nonsocial environment

    -- sensory physiology, perception, object recognition

2. Knowledge of our own minds

    --sensory feedback and efference copies

3. Knowledge of other minds

    --Theory of mind, empathy, simulation

What is Social Cognition?

"Thinking about other people"

"The collection of processes that allow us to understand and make sense of other people"

Social perception--> attributions --> social behavior

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Types of human social behavior	Animal models
- sexual, pairbonding	- yes, many (e.g., voles)
- maternal	- yes, many (e.g., sheep)
- small group cooperation	- yes, many mammals
- outgroup aggression	- yes, many mammals
- helping	- unclear
- peacemaking	- great apes
- cultural transmission	- great apes
- observational learning	- yes, many (e.g., octopus)
- pedagogy	- probably none
- language	- definitely none

Power and limitations of invertebrate models of cognition and behavior

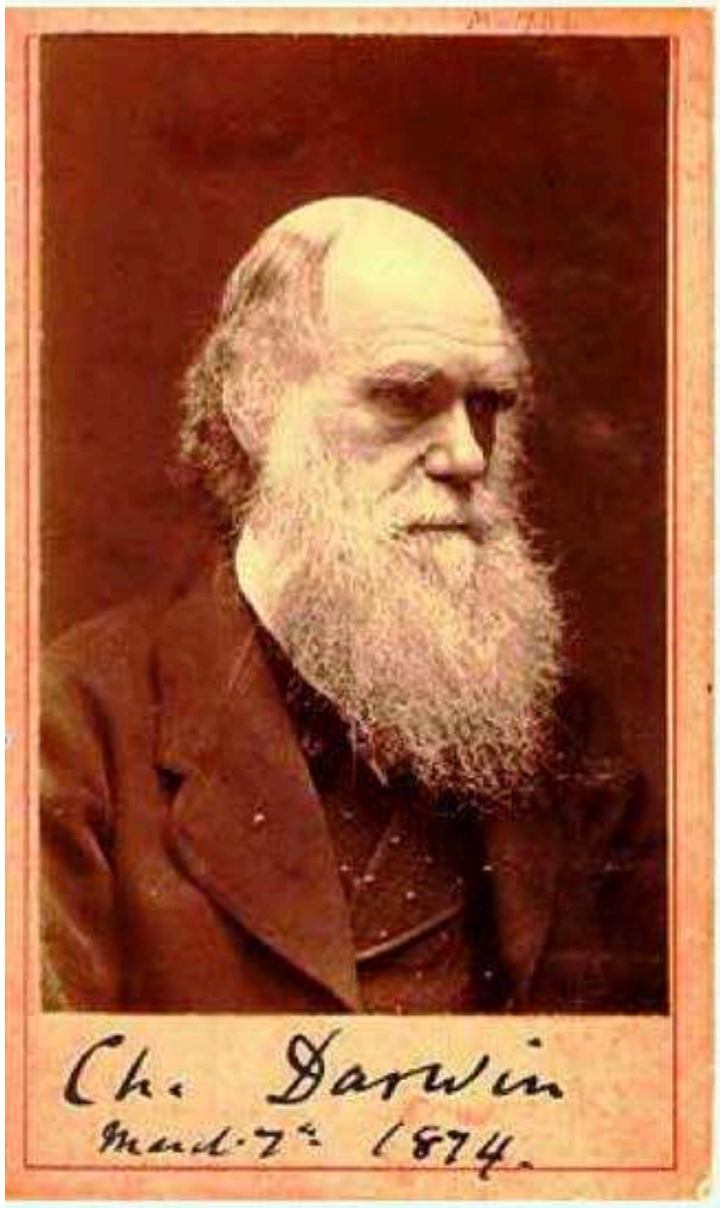
Common name	Species	Neuroanatomy	Biochemistry	Molecular biology	Electrophysiology	Optophysiology	Modelling of cellular pathways	Non-associative learning	Associative learning	Operant learning	Natural learning	Modelling at the systems level
Nematoda												
Eelworm	*Caenorhabditis elegans*	High	Low	High	Low	Low	High	High	None	None	None	None
Mollusca												
Sea hare	*Aplysia californica*	Low	High	High	High	None	High	High	Low	Low	None	Low
Opalescent sea slug	*Hermissenda crassicornis*	Low	Low	Low	High	None	Low	Low	None	None	None	None
Freshwater snail	*Lymnea stagnalis*	High	High	Low	High	None	Low	High	High	Low	None	Low
Land slug	*Limax maximus*	Low	Low	Low	High	Low	Low	Low	High	Low	None	None
Octopus	*Octopus vulgaris*	Low	Low	None	Low	None	Low	None	Low	High	High	Low
Arthropoda												
Cockroach	*Periplaneta americana*	Low	Low	None	Low	None	Low	Low	High	Low	None	Low
Locust	*Locusta migratoria*	High	None	None	High	None	High	None	Low	None	None	None
Cricket	*Gryllus bimaculatus*	Low	None	None	High	None	None	Low	High	High	None	None
Hawkmoth	*Manduca sexta*	High	Low	None	High	None	Low	None	Low	Low	None	None
Fruitfly	*Drosophila melanogaster*	High	High	High	Low	High	High	Low	High	High	Low	Low
Honeybee	*Apis mellifera*	High	High	Low	High	High	None	Low	High	High	High	Low

Eusociality

- bees, ants, termites
- arose at least 8 times in insect evolution
- honey bee (Apis mellifera) one of the most advanced eusocial animals

- reproductive division of labor
- cooperative brood care
- overlap of generations

Darwin's enigma



"This difficulty (of sterile workers), though appearing insuperable, is lessened, or, as I believe, disappears, when it is remembered that selection may be applied to the family, as well as to the individual, and may thus gain the desired end"

Bees

Invertebrate arthropods
Insects
Hymenoptera
Family Apidae

- ca 25,000 species
- high biodiversity in tropics

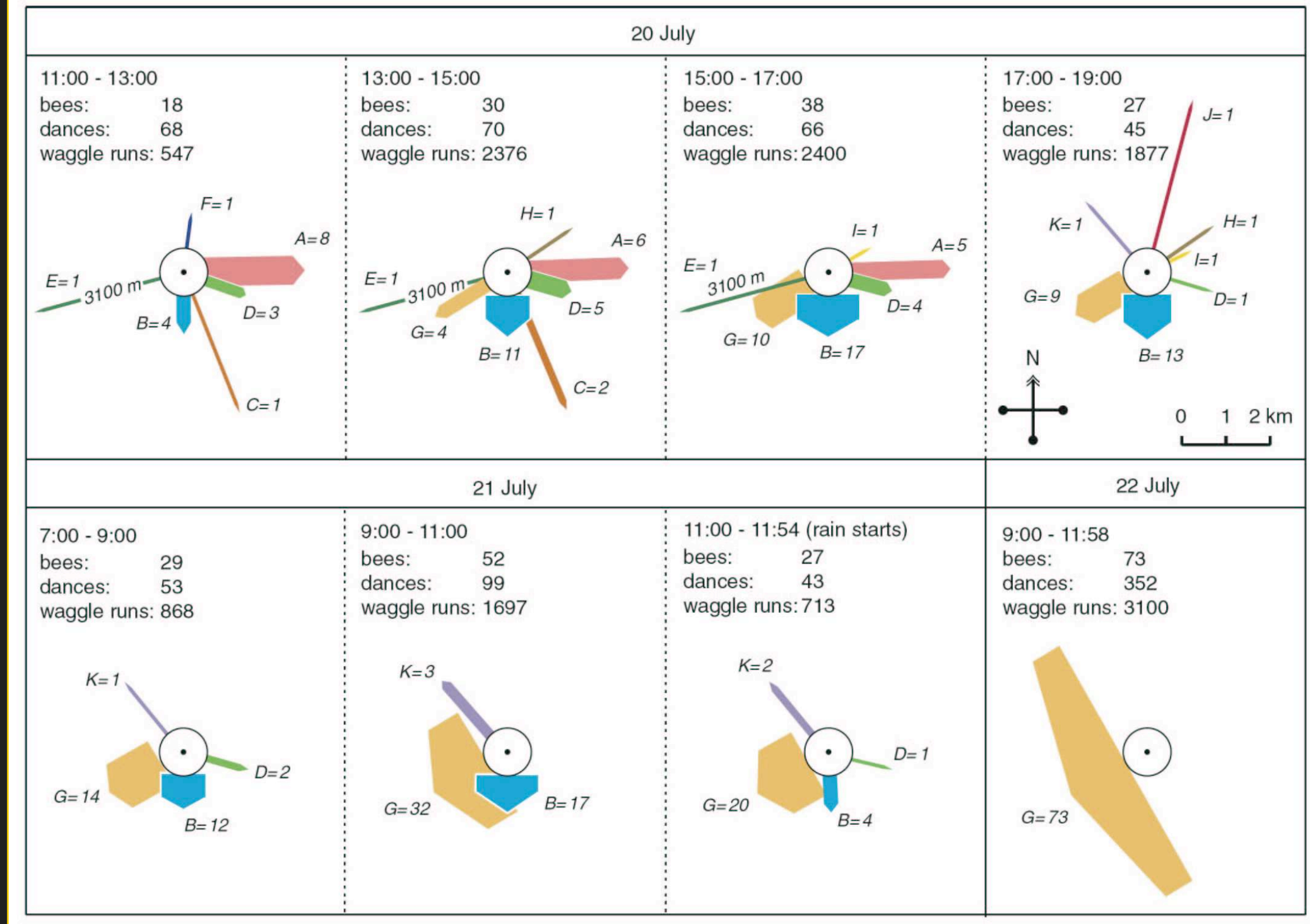
- several eusocial species
- honeybee (Apis mellifera) highly eusocial
- queen, drones, workers

The real estate preferences of bees (1975)

(“>” means “is preferred to”)

- Entrance height: 5 > 1 m
- Entrance area: 15 > 75 sq cm
- Entrance direction: south > north
- Entrance position: bottom > top
- Cavity volume: 40 > 10 liters
- Combs: with > without

One 16-hour "debate": 11 sites, 149 scouts



Seeley& Buhrman (1999) Behav. Ecol. Sociobiol. 45:19-31.

The question of social choice:

How can a group use the knowledge and opinions possessed by its members to produce an optimal choice of action for the group as a whole?

Group decision making

Individual Inputs

↓

Aggregation Process

↓

Group Action


Roger T. Peterson

Conditioned defeat


0:00:00:0

Species Differences in Social Organization

Prairie Vole Montane Vole

Highly Social
"Monogamous"
Biparental

Solitary
Promiscuous
Uniparental

Vasopressin and Oxytocin

The molecules of bonding

Vasopressin

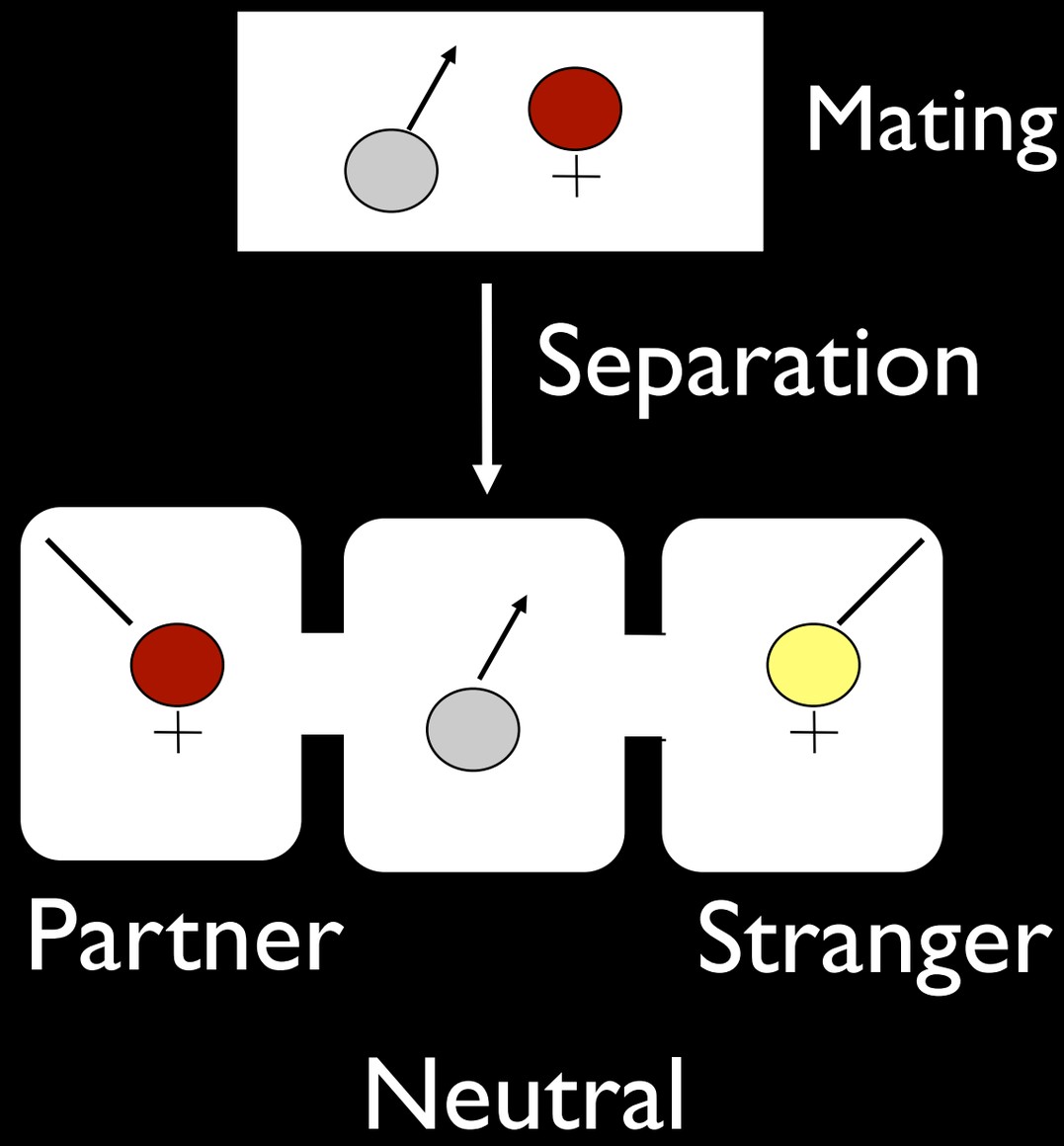
Cys-Tyr-Ile-Gln-Asn-Cys-Pro-Leu-Gly-NH_2

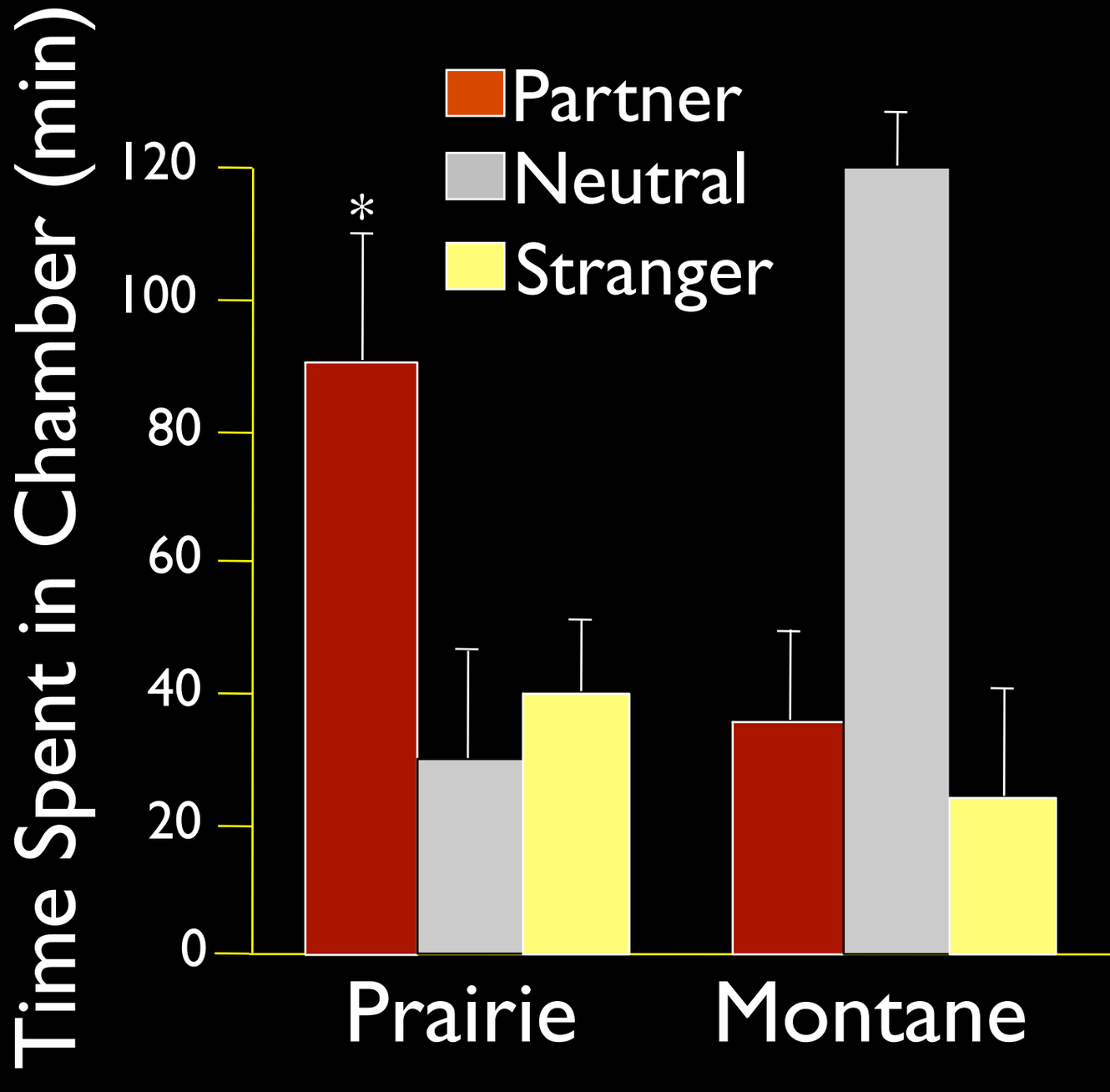
Oxytocin

Cys-Tyr-Phe-Gln-Asn-Cys-Pro-Arg-Gly-NH_2

Partner Preference Test

A laboratory assessment of pair bonding





Dogs

- Canis lupus. Domesticated ca. 15,000 years ago (but maybe as far as 40,000)
- Common ancestor with gray wolf
- First domesticated species, most abundant carnivore
- Huge behavioral and morphological variation
- Complex social co-evolution with humans

- Hunting, other specific tasks
- Companionship, "pets"
- Both require tameness
- But breeding tameness brings several correlated traits with it

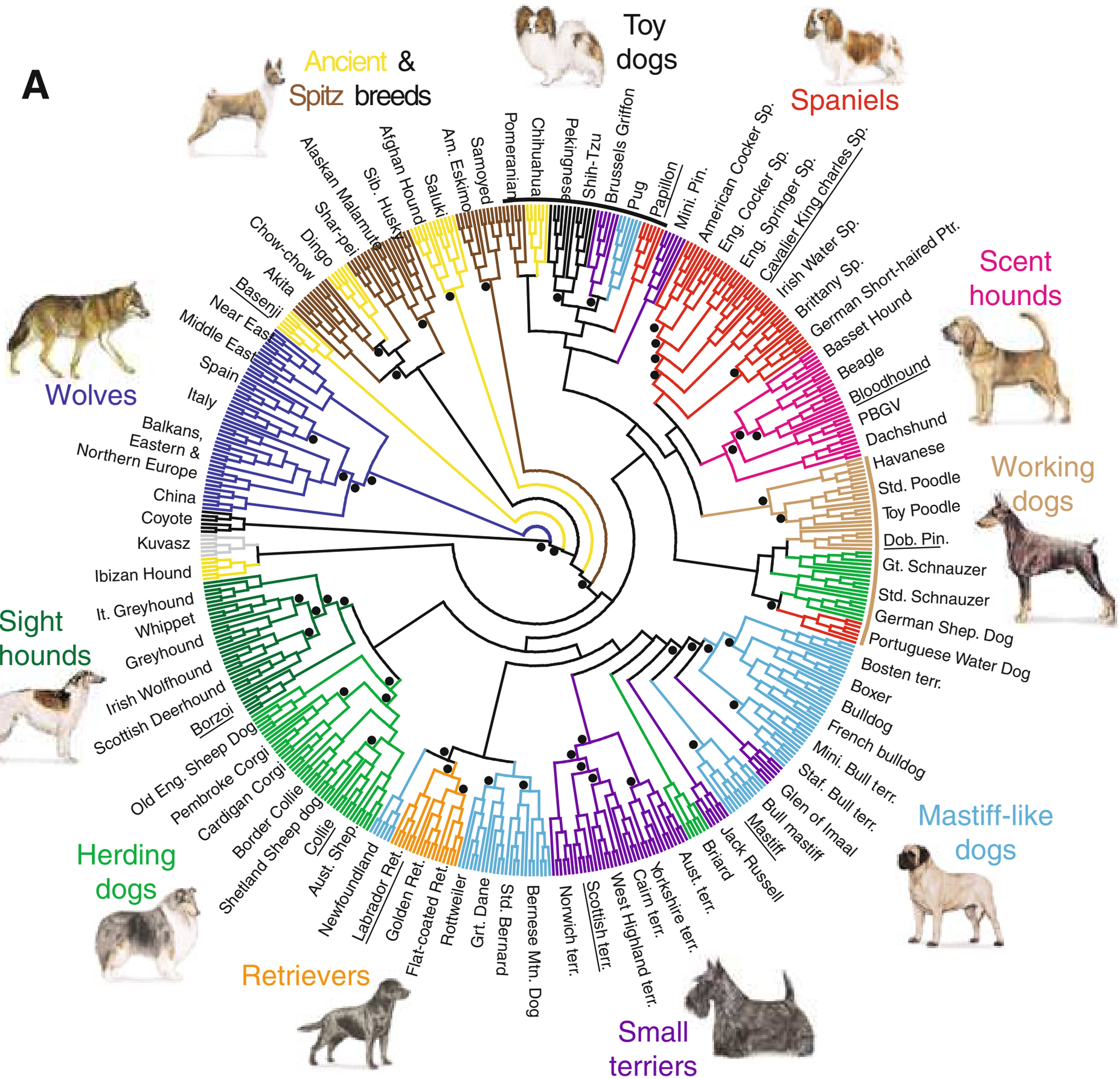

A
Ancient & Spitz breeds
Toy dogs
Spaniels
Scent hounds
Working dogs
Mastiff-like dogs
Small terriers
Retrievers
Herding dogs
Sight hounds
Wolves
Alaskan Malamute
Shar-pei
Dingo
Chow-chow
Akita
Basenji
Near East
Middle East
Spain
Italy
Balkans, Eastern & Northern Europe
China
Coyote
Kuvasz
Ibizan Hound
It. Greyhound
Whippet
Greyhound
Irish Wolfhound
Scottish Deerhound
Borzoi
Afghan Hound
Sib. Husky
Saluki
Am. Eskimo
Samoyed
Pomeranian
Chihuahua
Pekingnese
Shih-Tzu
Brussels Griffon
Pug
Papillon
Mini. Pin.
American Cocker Sp.
Eng. Cocker Sp.
Eng. Springer Sp.
Cavalier King charles Sp.
Irish Water Sp.
Brittany Sp.
German Short-haired Ptr.
Basset Hound
Beagle
Bloodhound
PBGV
Dachshund
Havanese
Std. Poodle
Toy Poodle
Dob. Pin.
Gt. Schnauzer
Std. Schnauzer
German Shep. Dog
Portuguese Water Dog
Bosten terr.
Boxer
Bulldog
French bulldog
Mini. Bull terr.
Staf. Bull terr.
Glen of Imaal
Bull mastiff
Mastiff
Jack Russell
Briard
Aust. terr.
Yorkshire terr.
Cairn terr.
West Highland terr.
Scottish terr.
Norwich terr.
Bernese Mtn. Dog
Std. Bernard
Grt. Dane
Rottweiler
Flat-coated Ret.
Golden Ret.
Labrador Ret.
Newfoundland
Aust. Shep.
Collie
Shetland Sheep dog
Border Collie
Cardigan Corgi
Pembroke Corgi
Old Eng. Sheep Dog

Table 2 The genetic basis of breed-defining traits in domestic dogs based on genome-wide studies. Bold indicates the likely candidate gene(s) in an associated region

Phenotype category	Phenotype variant	Gene(s)	Variant mutation	CFA	References
	White spotting	MITF	Promoter mutations	20	Karlsson et al. (2007)
Behavior	Boldness	DRD1	Not fined-mapped	4	Chase et al. (2009)
	Boldness	**IGF1**	Not fined-mapped	15	Chase et al. (2009)
	Boldness	**PCDH9**	Not fined-mapped	22	Chase et al. (2009)
	Compulsive disorder	CDH2	SNP allele association	7	Dodman et al. (2010)
	Herding	**MC2R**	Not fined-mapped	1	Chase et al. (2009)
	Pointing	CNIH	Not fined-mapped	8	Chase et al. (2009)
	Domesticated	ZNF407, **CNDP1, CNDP2**	Not fined-mapped	1	vonHoldt et al. (2010)
	Domesticated	NEDD4L	Not fined-mapped	1	vonHoldt et al. (2010)
	Domesticated	MEIS3, GPR77, C5AR1	Not fined-mapped	1	vonHoldt et al. (2010)
	Domesticated	SNP cluster association	Not fined-mapped	2	vonHoldt et al. (2010)
	Domesticated	OPRM1, hNT	Not fined-mapped	5	vonHoldt et al. (2010)
	Domesticated	**WBSCR17**	Not fined-mapped	6	vonHoldt et al. (2010)
	Domesticated	**SLC24A4**	Not fined-mapped	8	vonHoldt et al. (2010)
	Domesticated	SNP cluster association	Not fined-mapped	12	vonHoldt et al. (2010)
	Domesticated	**ADCY8**	Not fined-mapped	13	vonHoldt et al. (2010)

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- domestication from gray wolves (Canis lupus) 15,000 years ago
- breeding: most variable mammalian species
- variability in genetics, morphology, and behavior
- genome sequenced 2005, great for behavioral genetics

Distinctive (or not) abilities:

- gaze and pointing following
- joint attention
- distinguishing owner's attention focus from their own
- social learning
- emotional contagion
- "showing behavior"
- auditory discrimination
- training, behavioral control
- attachment

Models for aspects of human social abilities

Models for human pathologies (OCD, separation anxiety)

Tame

Socialized Wolves

Socialization

Pet Domestic Dogs

Genetically Wild

Genetic Domestication

Genetically Domesticated

Free-Living Wolves

Feral

Free-Living Domestic Dogs

What skills distinguish/enable dog-human social interactions?

- in some respects, dogs exhibit social behavioral tendencies similar to human infants

- attachment
- attention (ostension-based learning)
- ability to use referential signals from humans

- big question: these are high-level behavioral dimensions; how do they come about? Can many different "building blocks" make them happen?

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B

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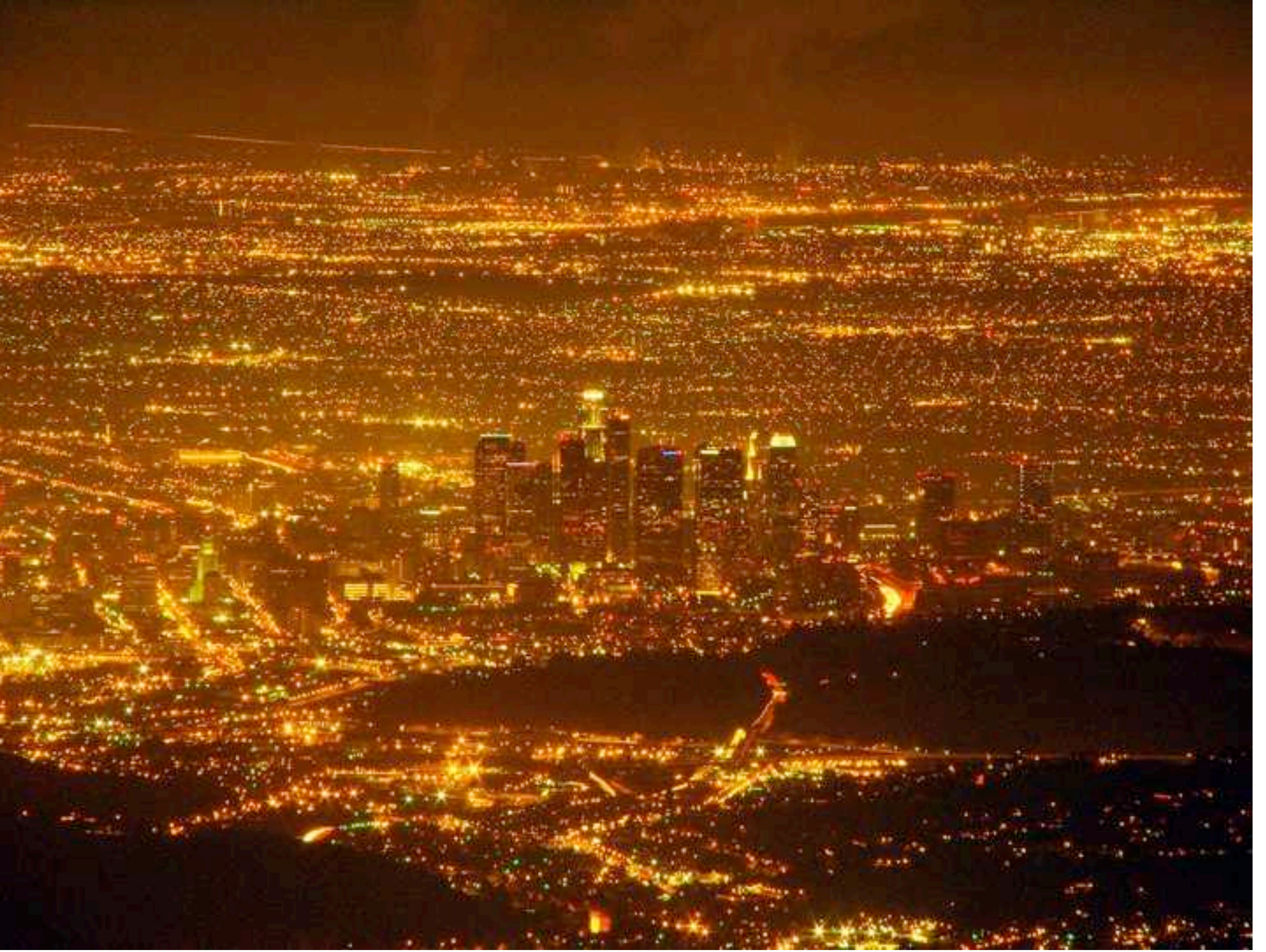
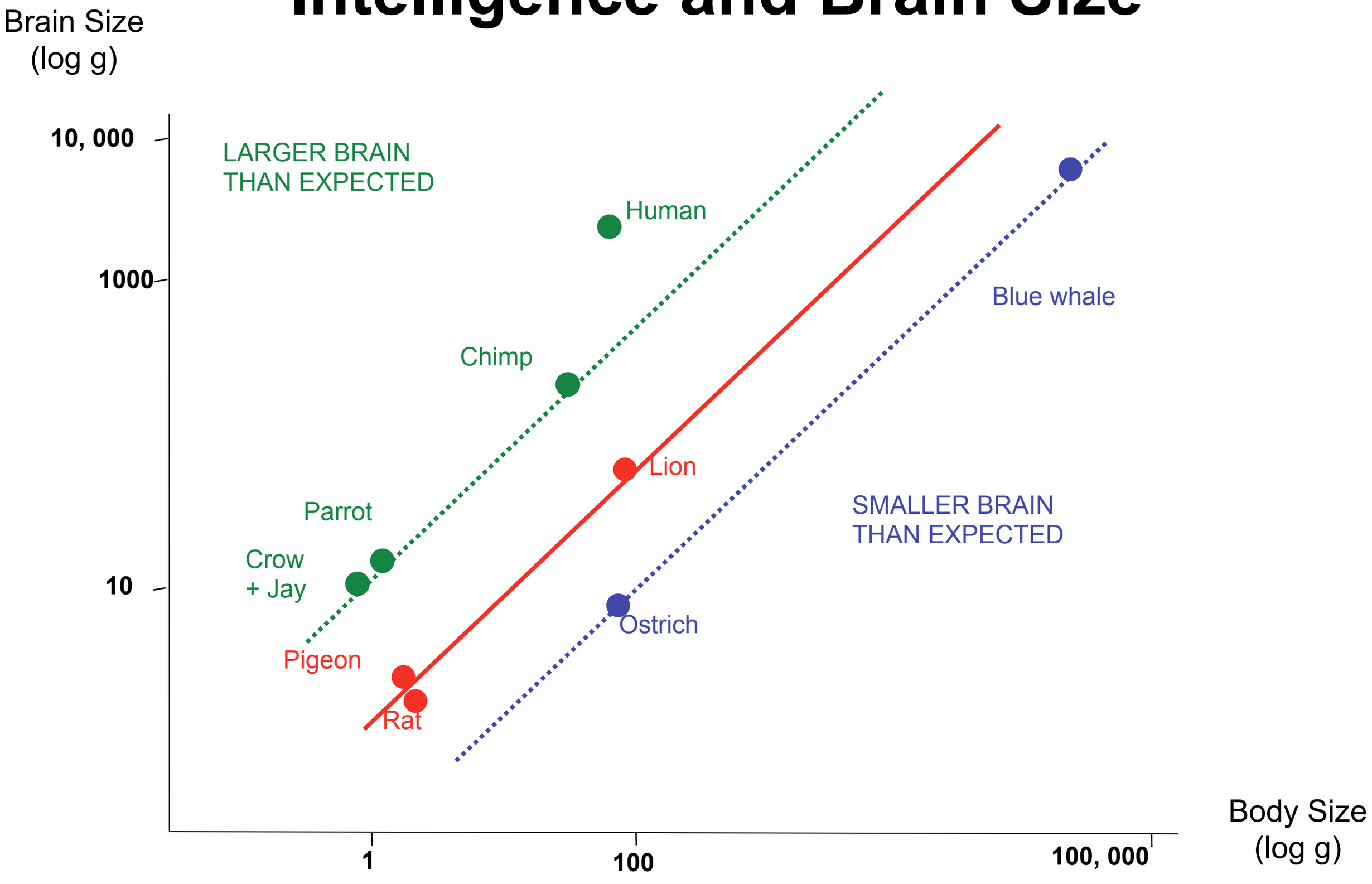


"Our species is unique because, in only 35,000 years or so, we revolutionized the face of the earth." (R. Passingham, 1982)

"The ability to travel mentally in time constitutes a discontinuity between humans and other animals." (Suddendorf and Corballis, 1997)

"The basic fact is thus that human beings are able to pool their cognitive resources in ways that other species are not…made possible by a single very special form of social cognition, namely, the ability of individual organisms to understand conspecifics as beings *like themselves* who have intentional and mental lives like their own." (Tomasello, 1999)

Intelligence and Brain Size

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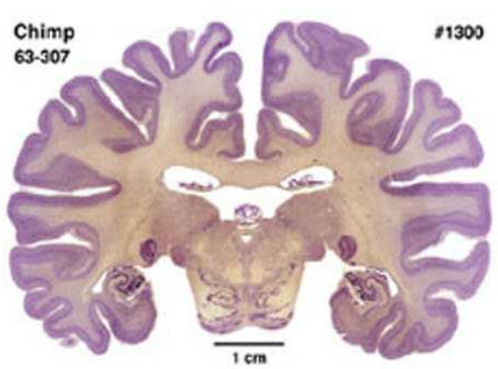
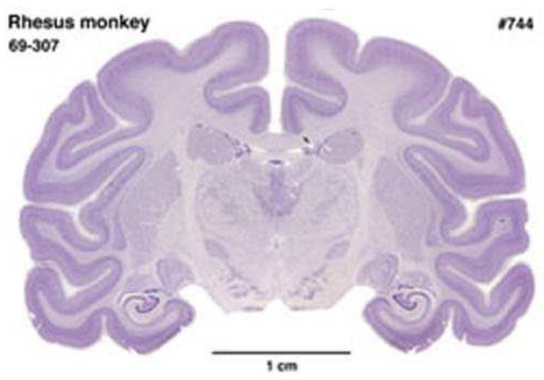
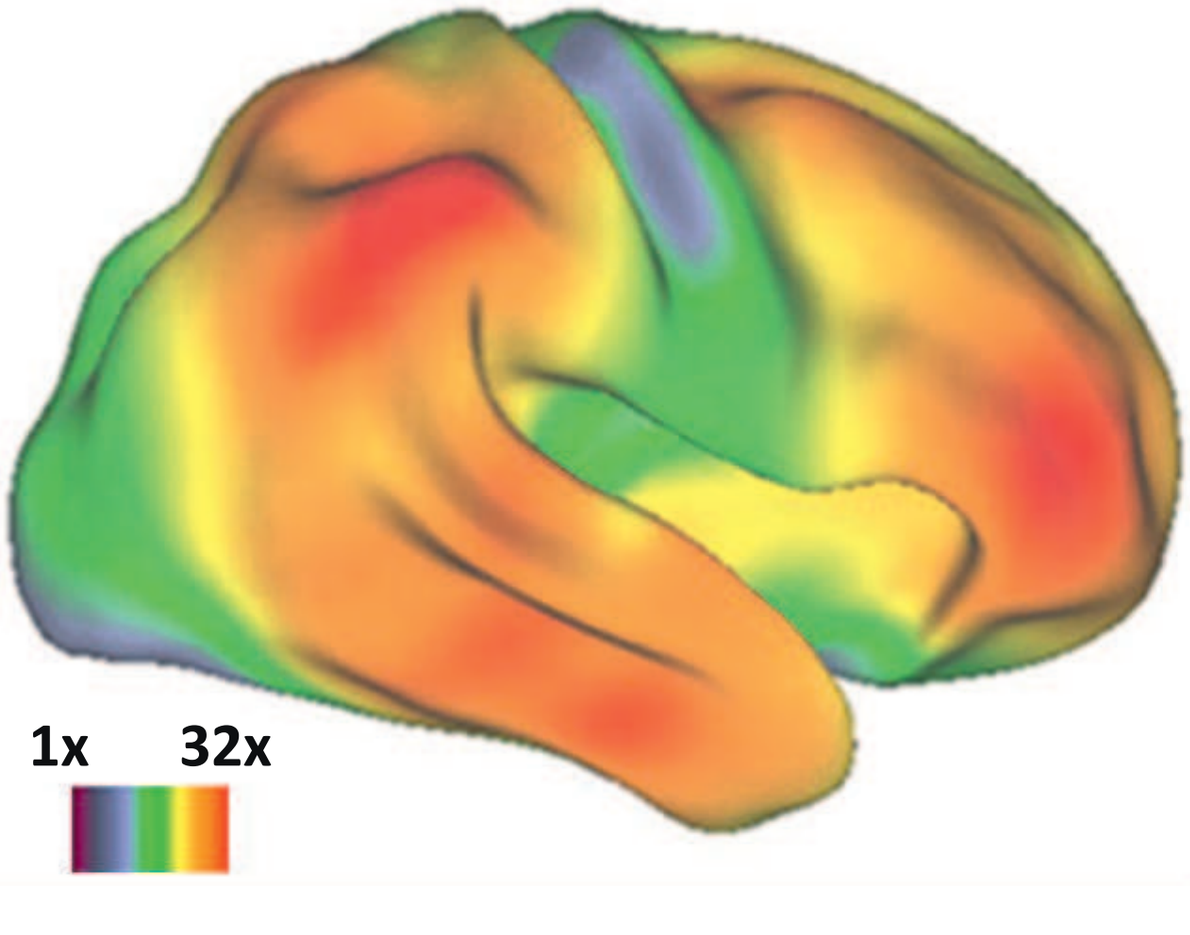

Chimp
63-307
#1300
1 cm


Rhesus monkey
69-307
#744
1 cm

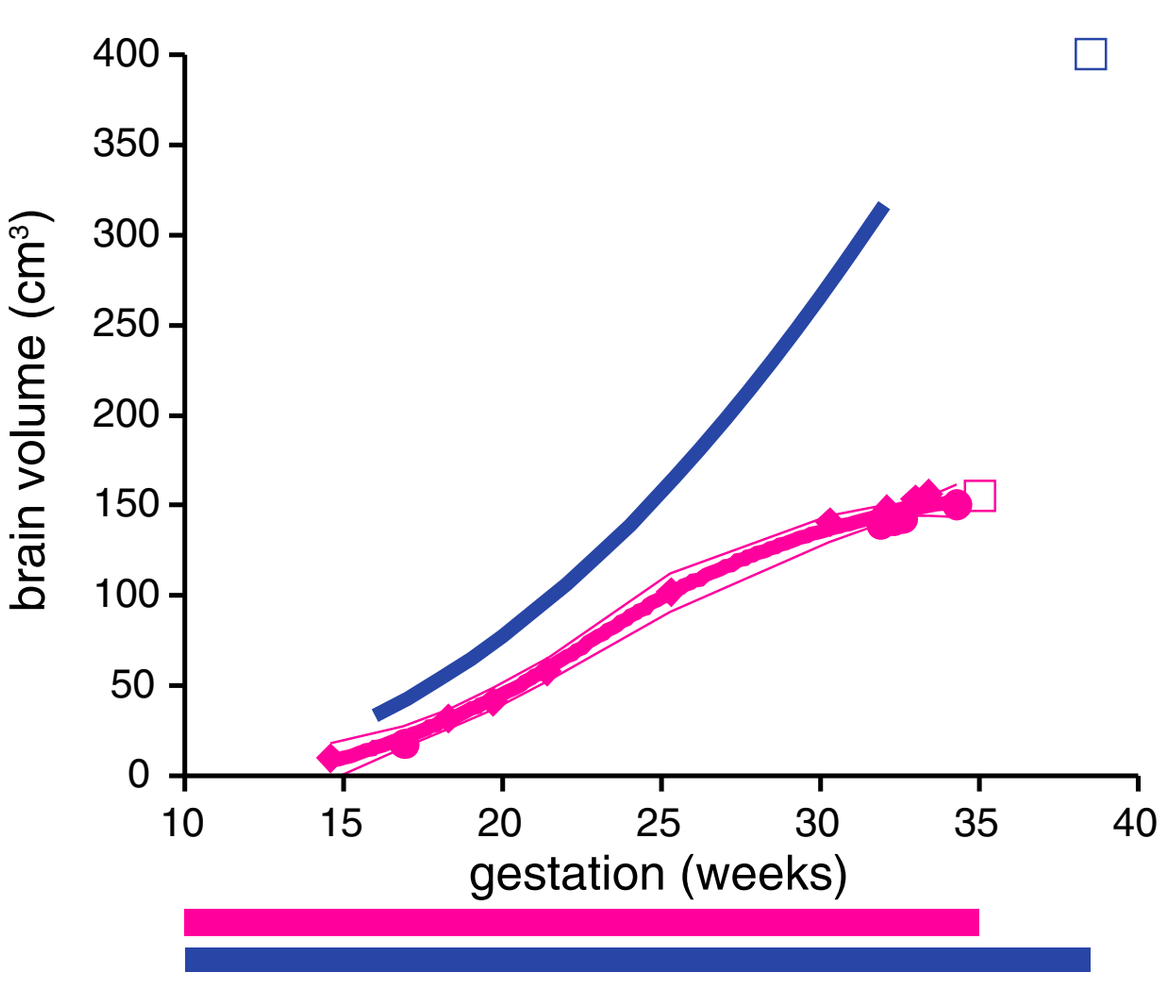


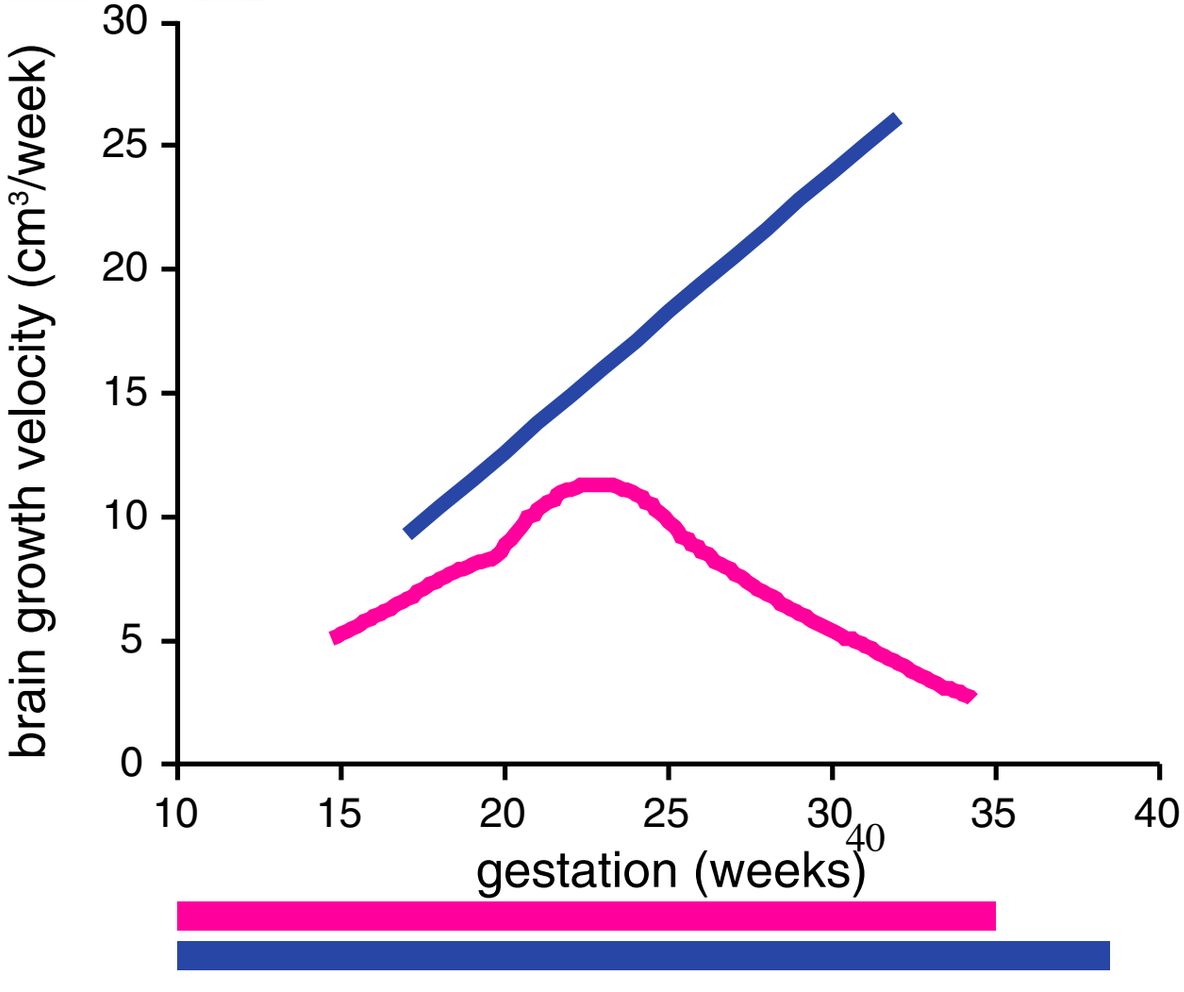
Amount of Macaque brain expansion needed to fit a monkey brain to a human brain

Rilling (2014). Trends in Cognitive Sciences 18: 46-55

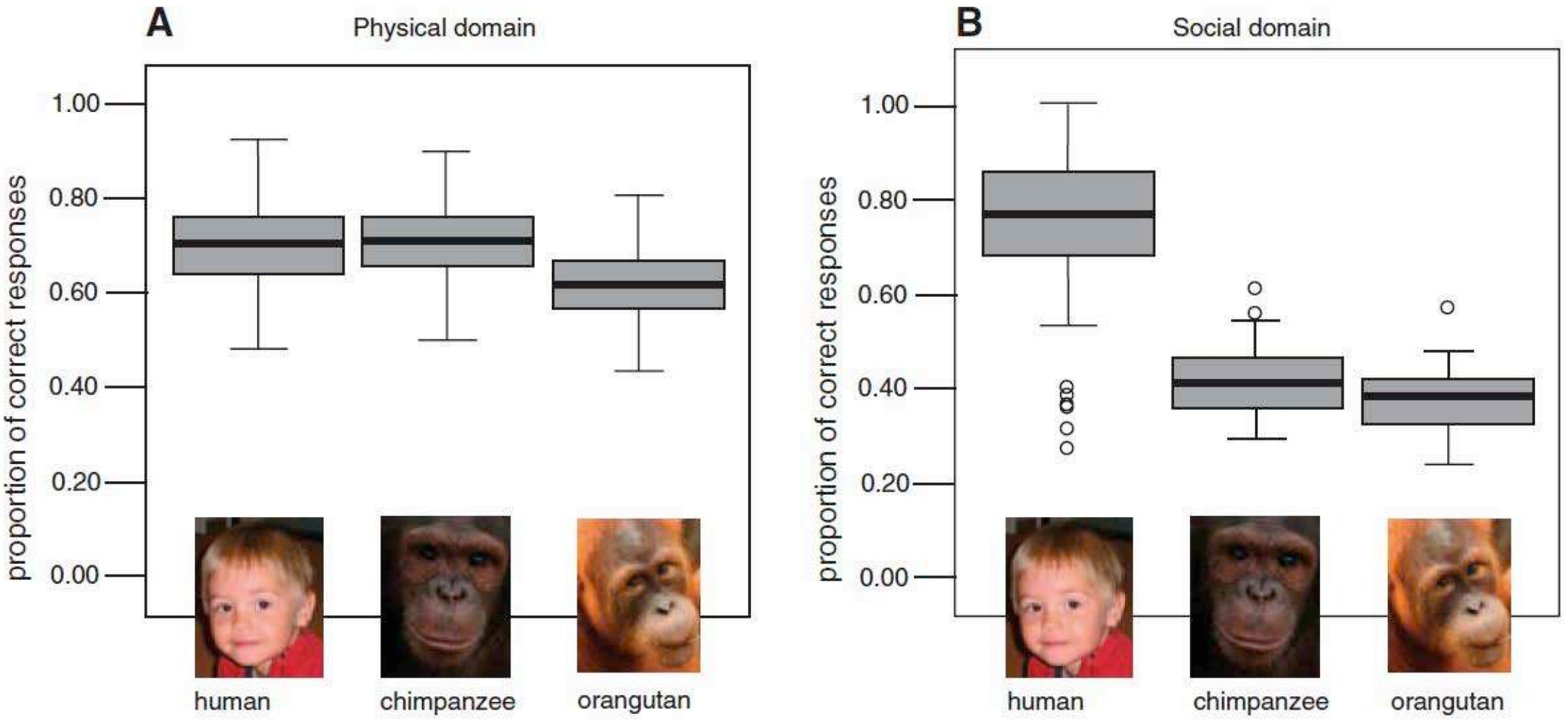
work of Tetsuro Matsuzawa

Sakai et al.,Current Biology 2012



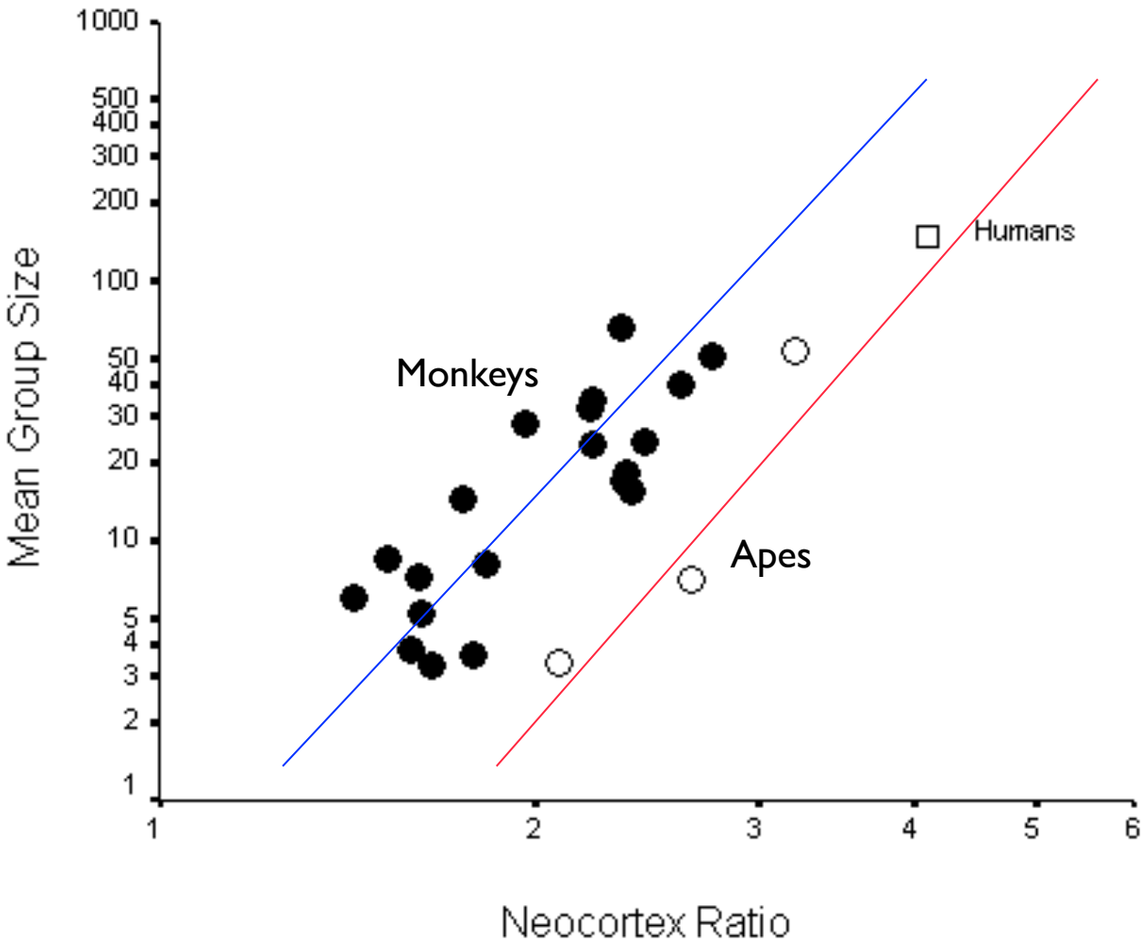


Domain	Scale	Task	Description
Physical	Space	Spatial memory (1 item, 3 trials)	Locating a reward.
		Object permanence (3 items, 9 trials)	Tracking of a reward after invisible displacement.
		Rotation (3 items, 9 trials)	Tracking of a reward after a rotation manipulation.
		Transposition (3 items, 9 trials)	Tracking of a reward after location changes.
	Quantities	Relative numbers (1 item, 13 trials)	Discriminating quantity.
		Addition numbers (1 item, 7 trials)	Discriminating quantity with added quantities.
	Causality	Noise (2 items, 6 trials)	Causal understanding of produced noise by hidden rewards.
		Shape (2 items, 6 trials)	Causal understanding of appearance change by hidden rewards.
		Tool use (1 item, 1 trial)	Using a stick in order to retrieve a reward which is out of reach.
		Tool properties (5 items, 15 trials)	Understanding of functional and nonfunctional tool properties.
Social	Social learning	Social learning (3 items, 3 trials)	Solving a simple but not obvious problem by observing a demonstrated solution.
	Communication	Comprehension (3 items, 9 trials)	Understanding communicative cues indicating a reward's hidden location.
		Pointing cups (1 item, 4 trials)	Producing communicative gestures in order to retrieve a hidden reward.
		Attentional state (4 items, 4 trials)	Choosing communicative gestures considering the attentional state of the recipient.
	Theory of mind	Gaze following (3 items, 9 trials)	Following an actor's gaze direction to a target.
		Intentions (2 items, 6 trials)	Understanding what an actor intended to do (unsuccessfully).



Herrmann et al. (2007) Science 317:1360.

- The human brain is exceptionally large
- We are exceptionally smart
- WHY?
    - Evolved in a complex social environment
        - Have to compete with other smart people
        - Idea of a “mental arms race”



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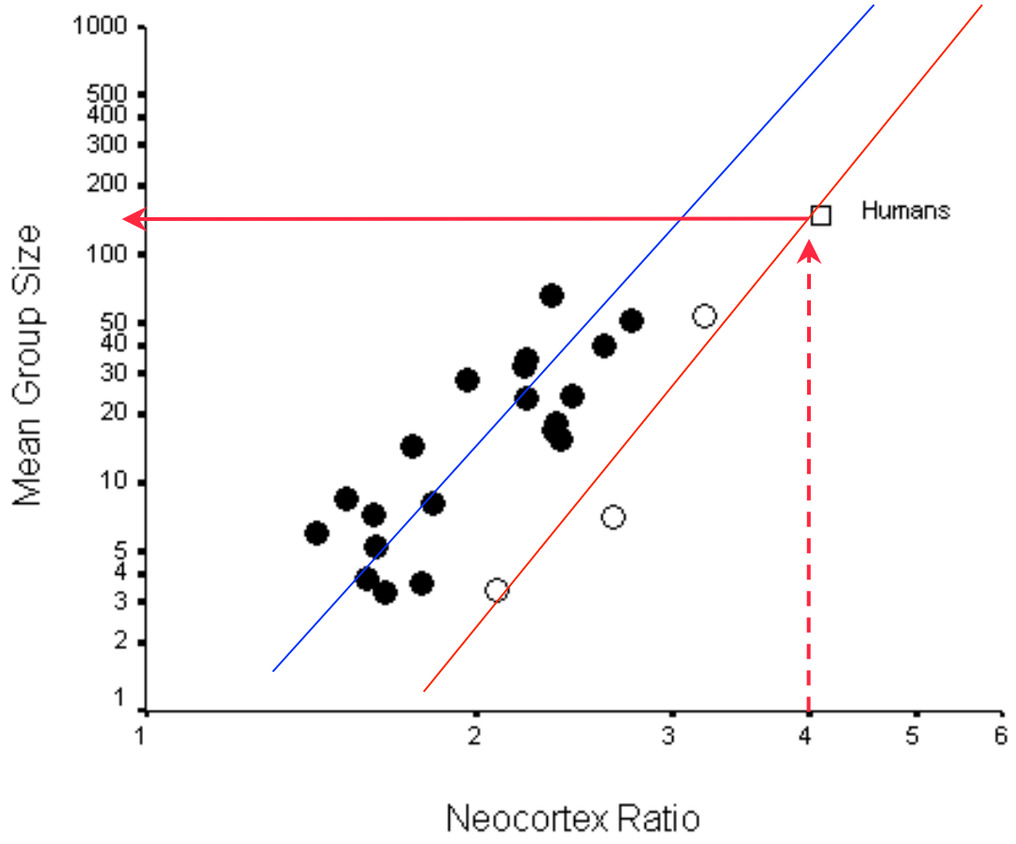

But it is more complicated than this!

Robin Dunbar (1992, 1993, 1998)

1993 BBS 16:681-735

Takehome points:
- essentially all animals show social behavior
- this shows many parallel modules to aspects of human behavior
- certain species may be good model systems to study
- humans may be especially smart in the social domain

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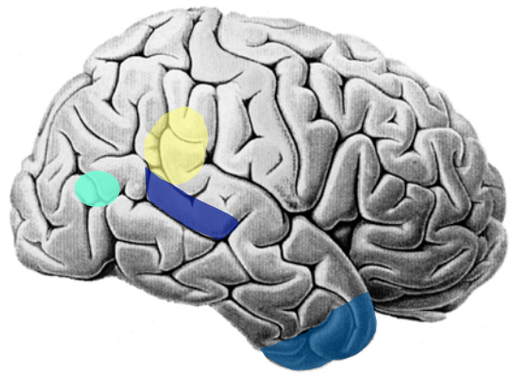
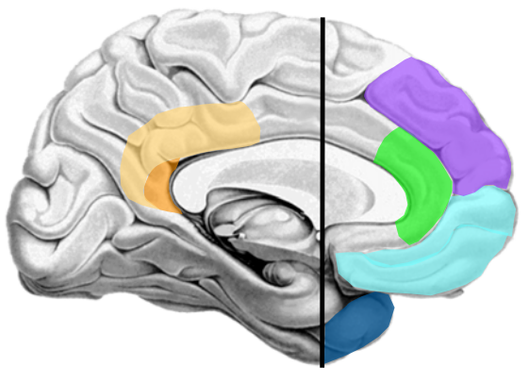
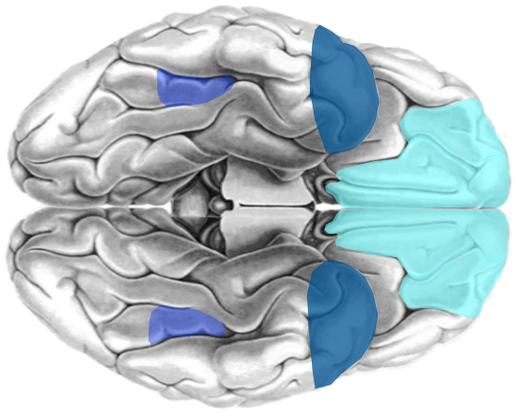
“The Social Brain”

- Amygdala
- Insula
- TPJ
- dMPFC
- Anterior Cingulate
- STS/STG
- Posterior Cingulate
- Retrosplenial Cortex
- FFA
- Temporal Pole
- vMPFC/OFC
- Extrastriate Body Area







Key:

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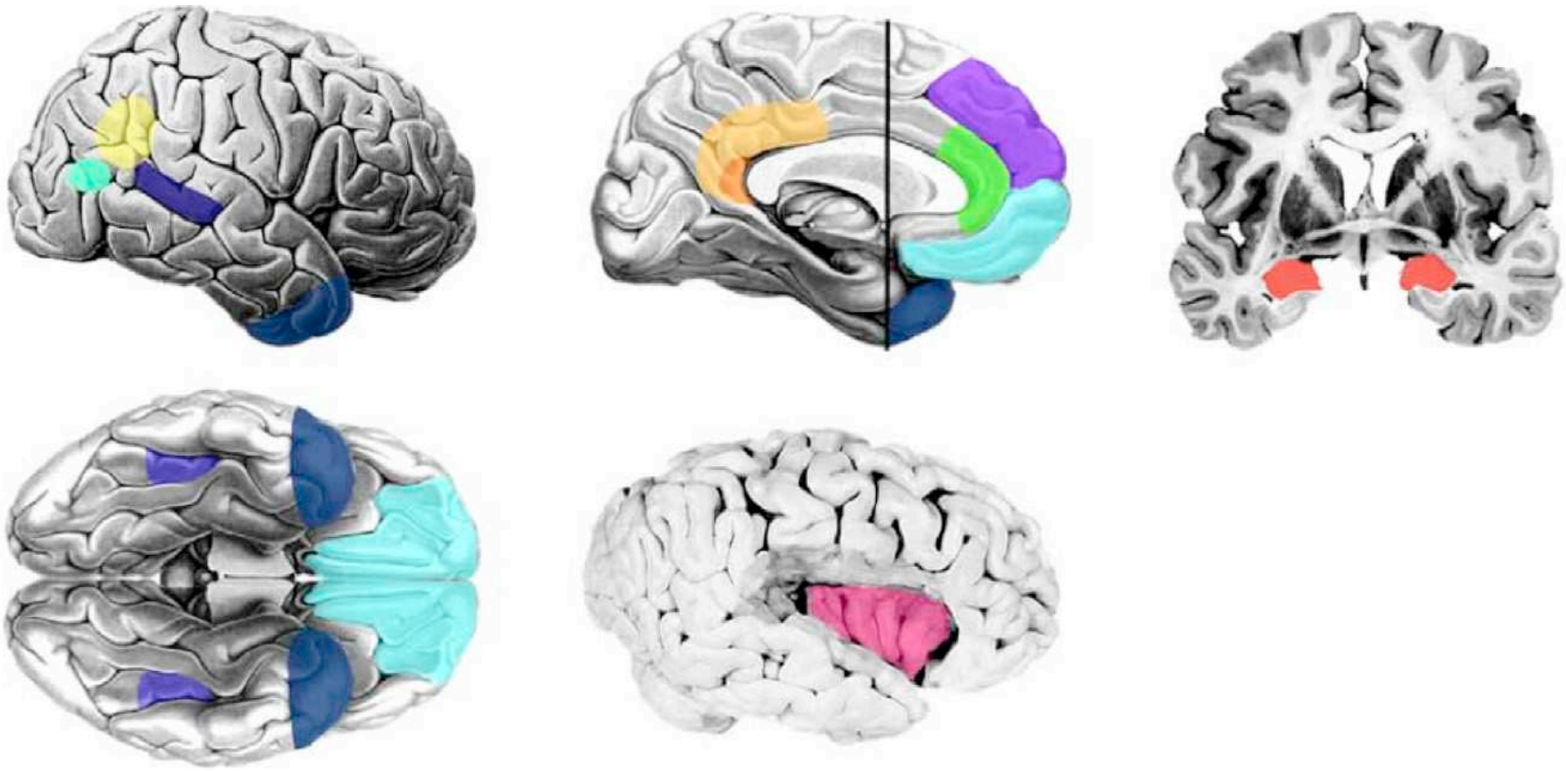
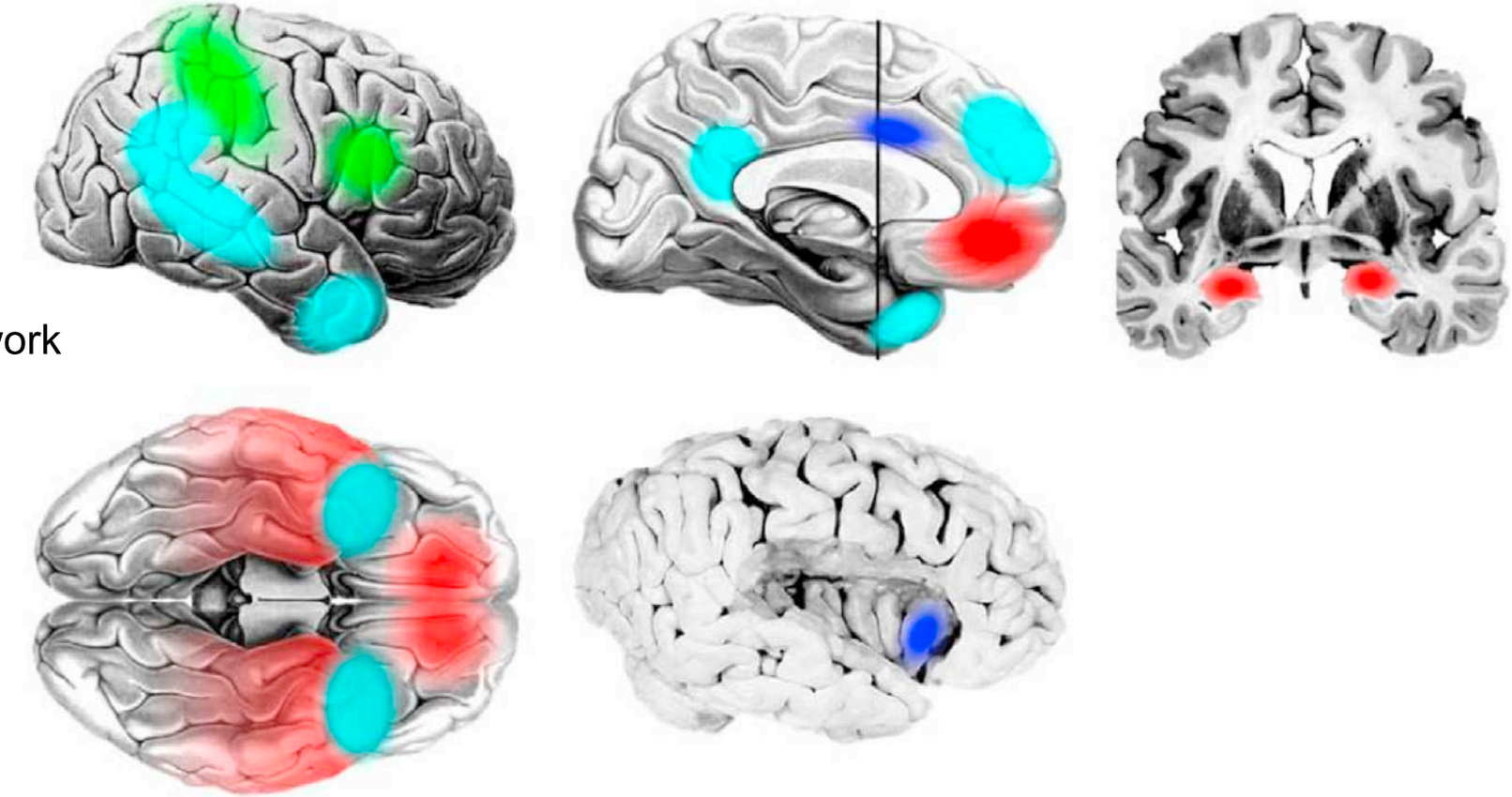


Key:

- Amygdala Network
- Mentalizing Network
- Empathy Network
- Mirror/Simulation/ Action-Perception Network



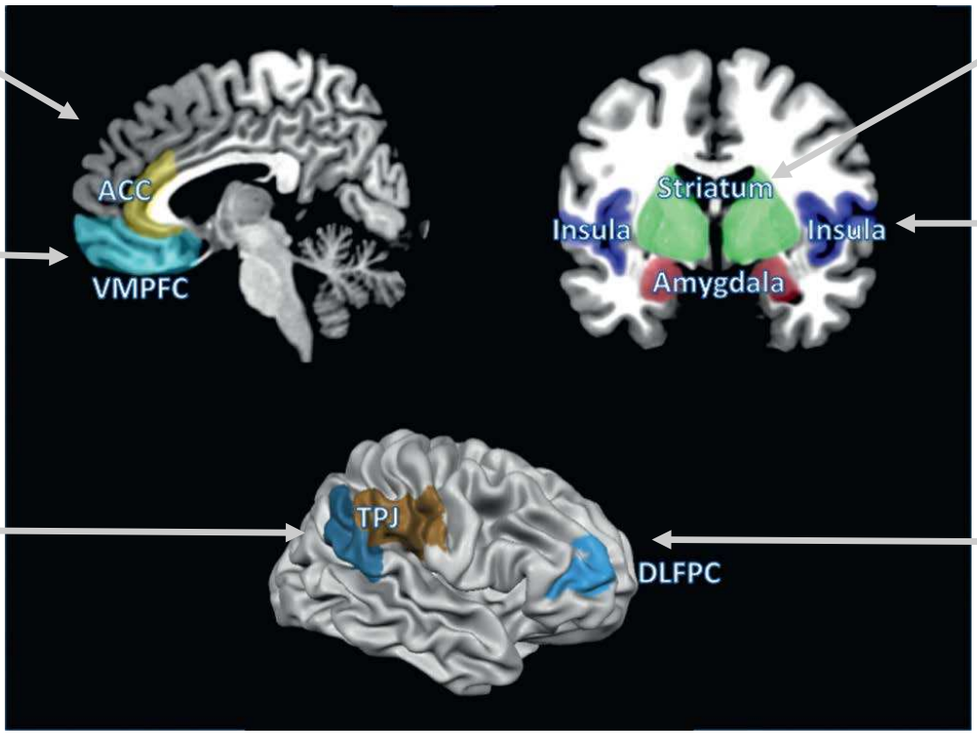
D. Kennedy, R. Adolphs (2012). Trends in Cognitive Sciences 16: 559-572.

Conflict monitoring

Value

Attention

Mentalizing



Reward, Learning

Uncertainty, Arousal

Empathy

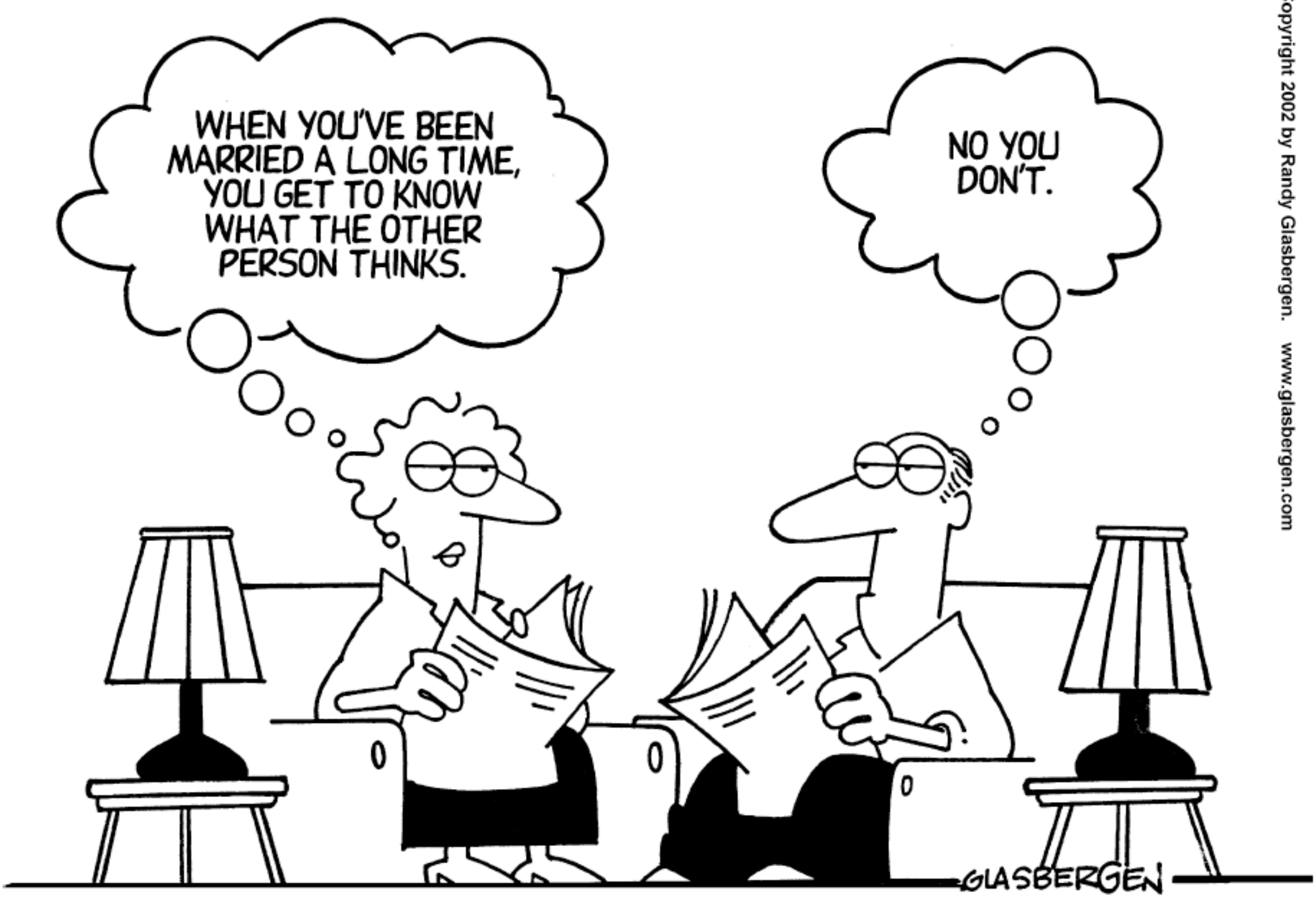
Cognitive control

Perceptual processes, memory, motor preparation…

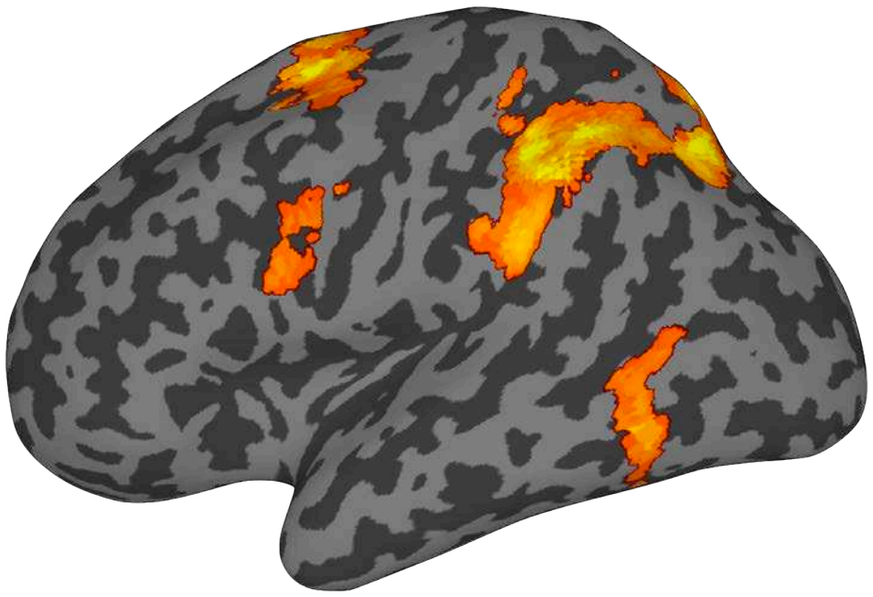
Fehr & Kraibich (2014) Neuroeconomics

Figuring out other people's internal states:

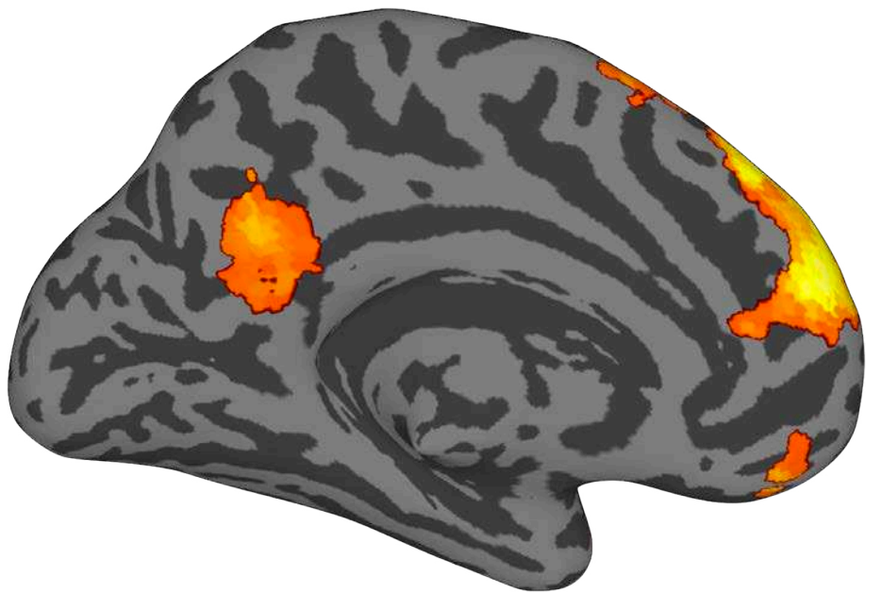
Simulation/empathy versus
Theory of Mind



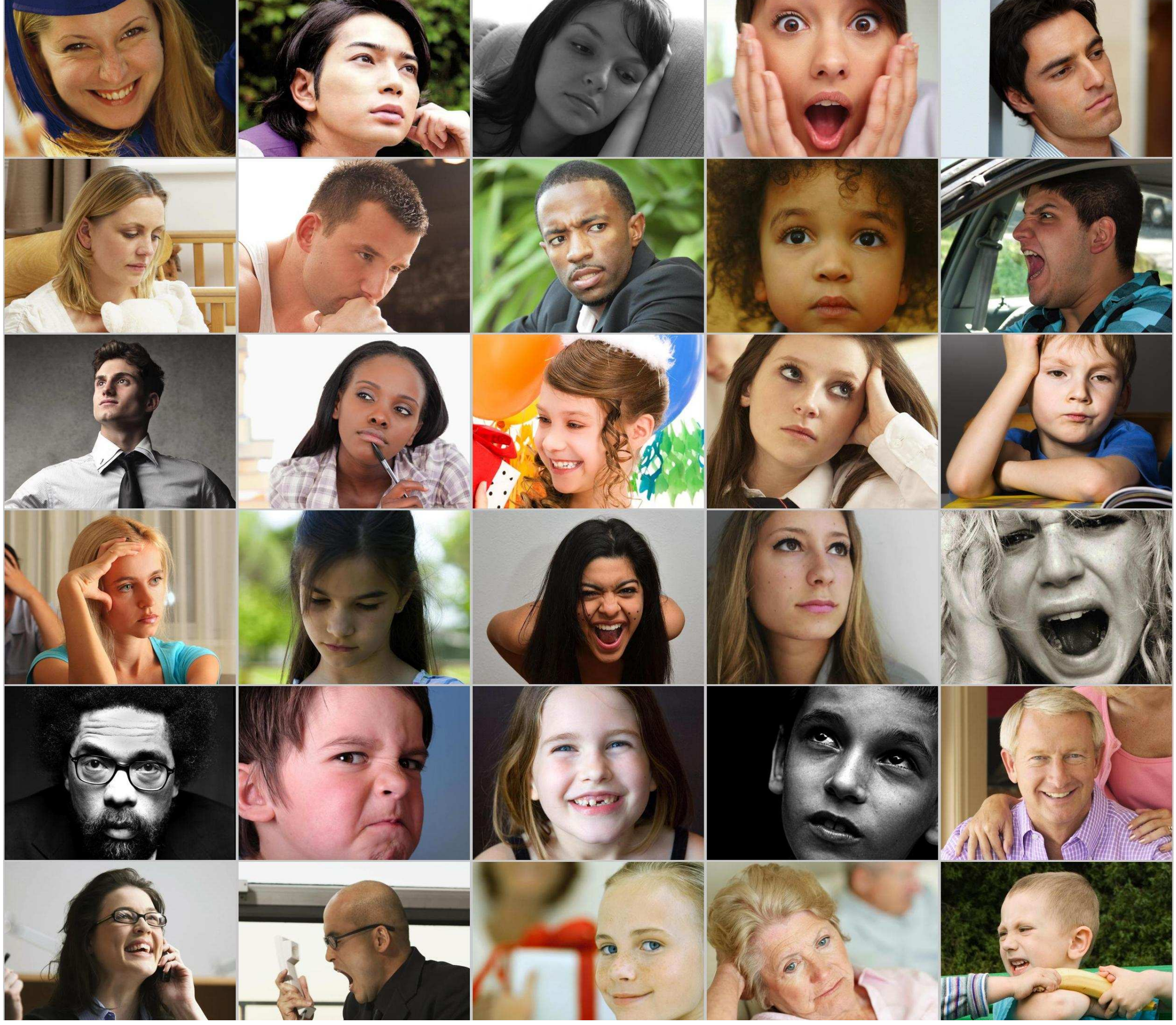
Mirror Network

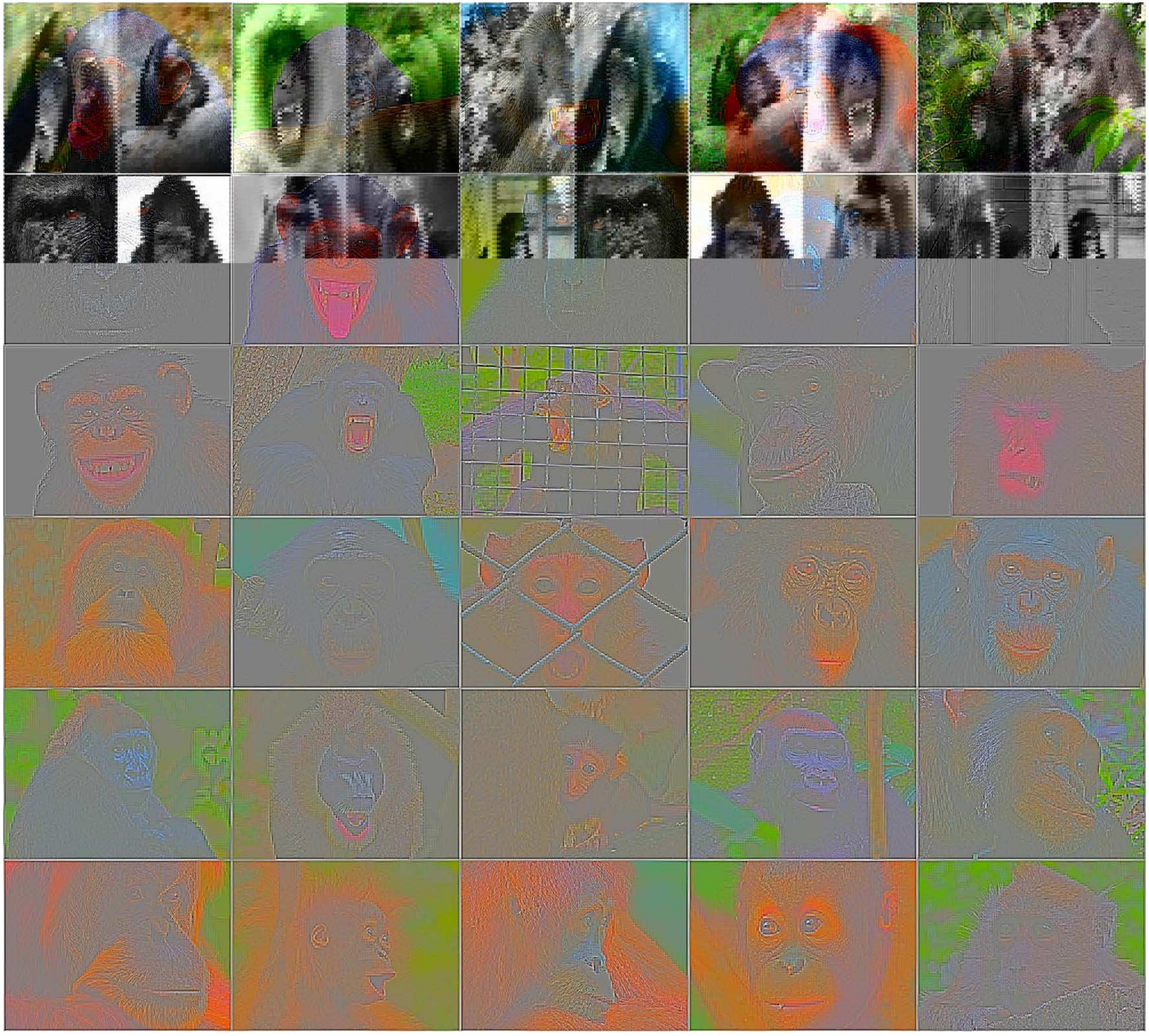


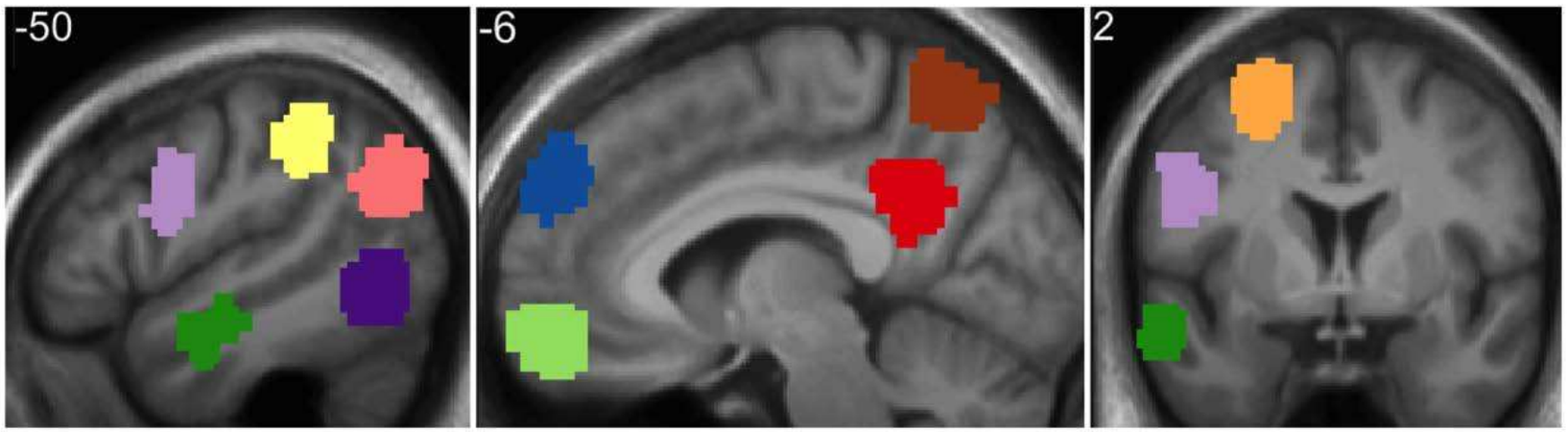
Mentalizing Network



Van Overwalle & Baetens, Neuroimage 2009







Dorsomedial PFC

Ventromedial PFC

Anterior STS

TPJ

PCC

Dorsal PMC

Ventral PMC

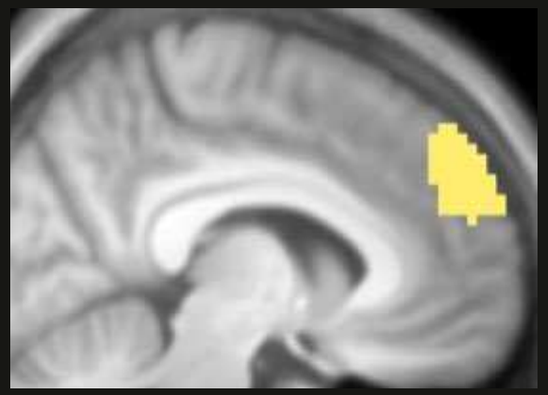
Posterior MTG

Rostral IPL

Dorsal Precuneus

Social vs. Non-Social attribution

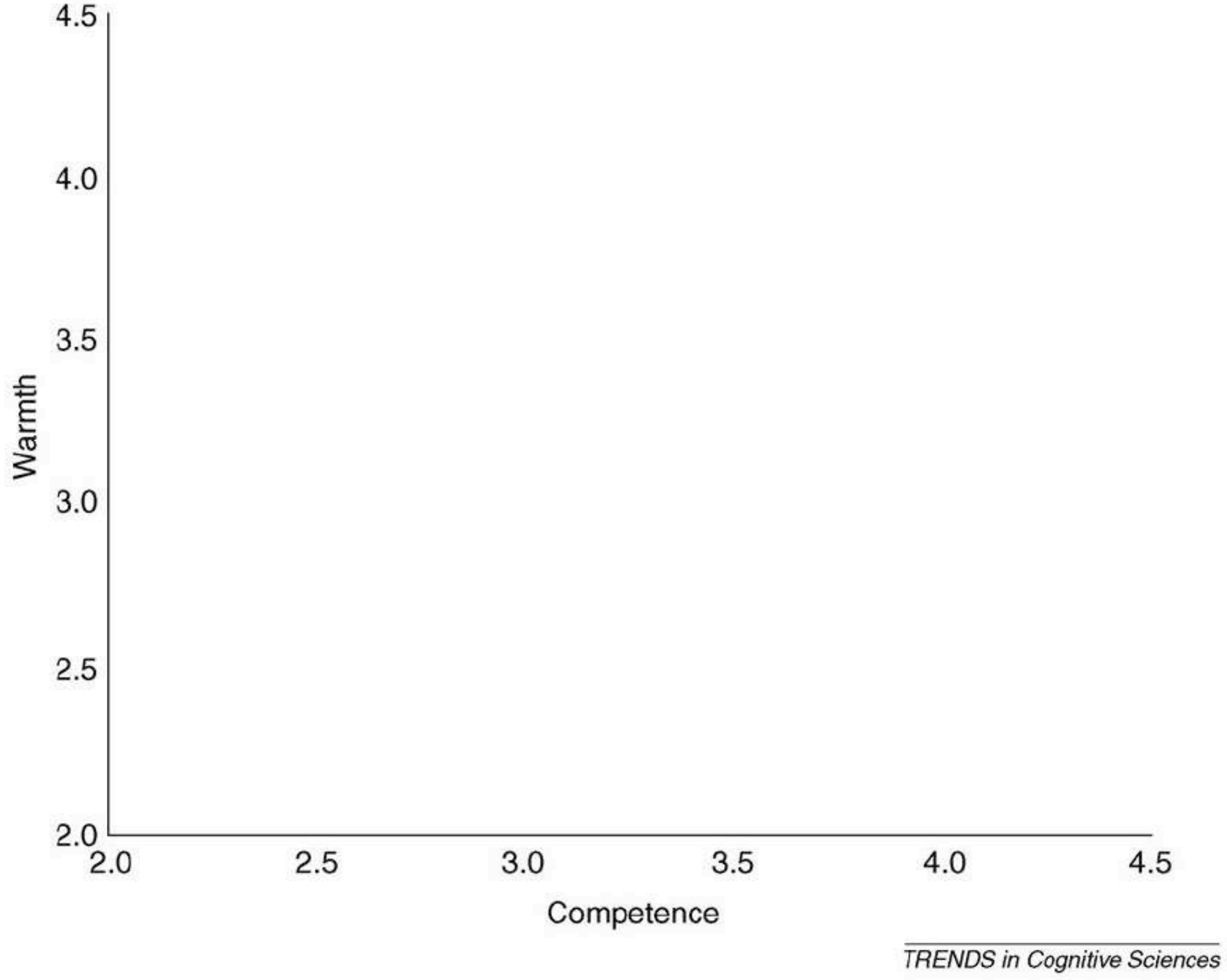
	Social		Nonsocial
			
Why	Is the person showing affection?	Is the person sharing knowledge?	Is it the result of a rainstorm?
How	Is the person smiling?	Is the person lifting something?	Is the photo showing moving water?



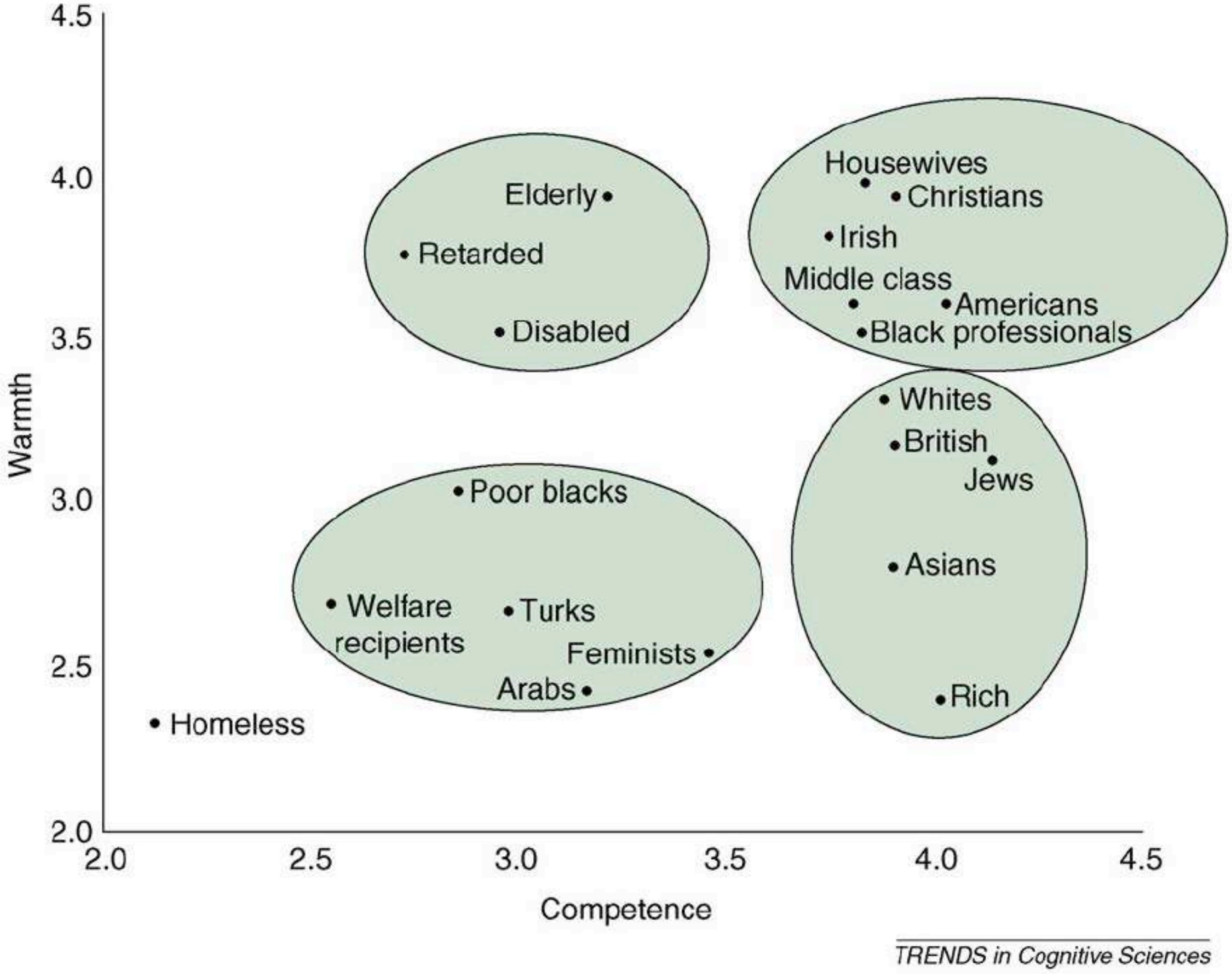
Spunt & Adolphs (2014). Psychological Science 26: 724-736

Overview of social cognition, evolution, and key features

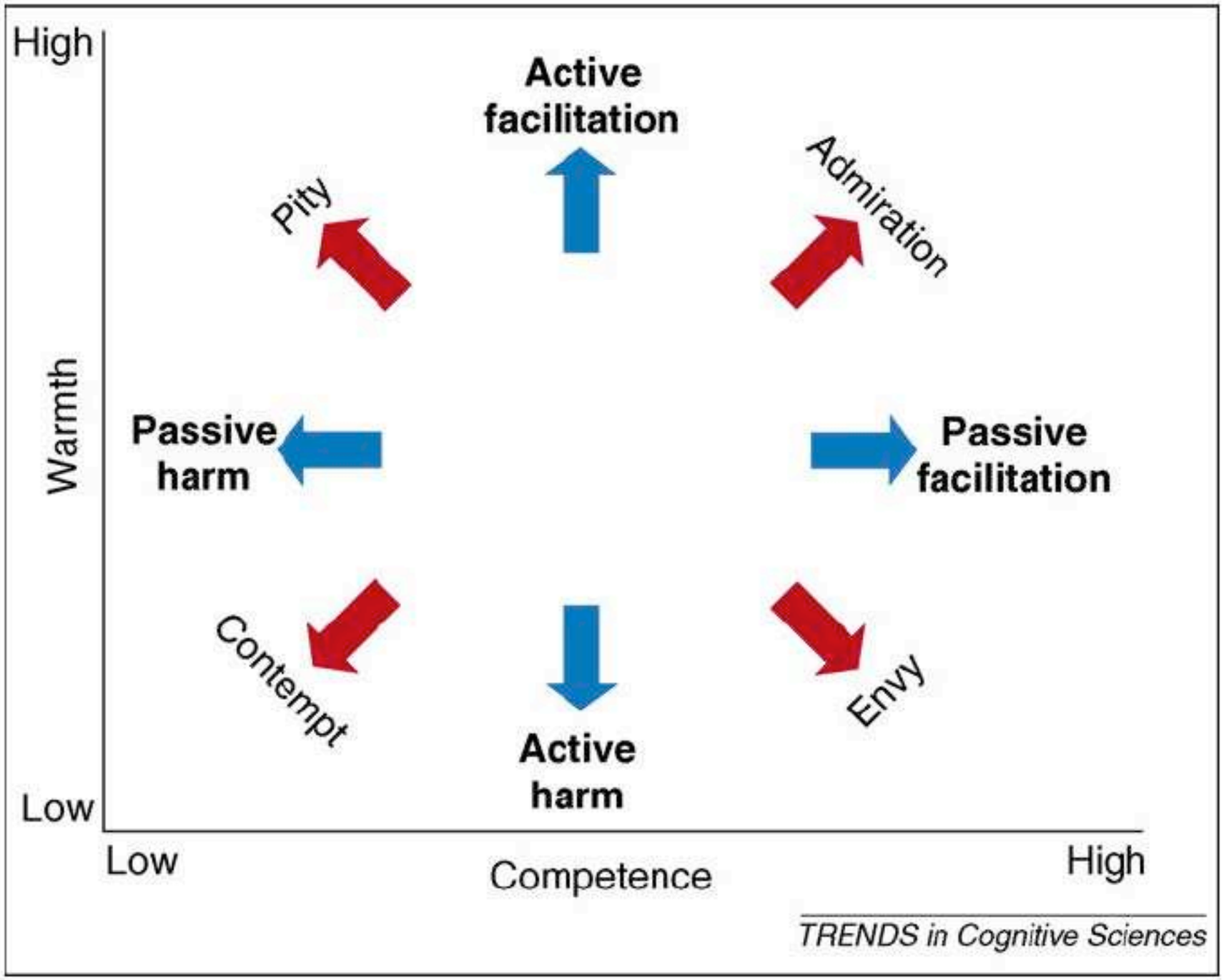
1. what is social cognition?
2. what do we see across animal species?
3. what's special about humans?
4. two neural mechanisms: empathy and mentalizing
5. **study example**

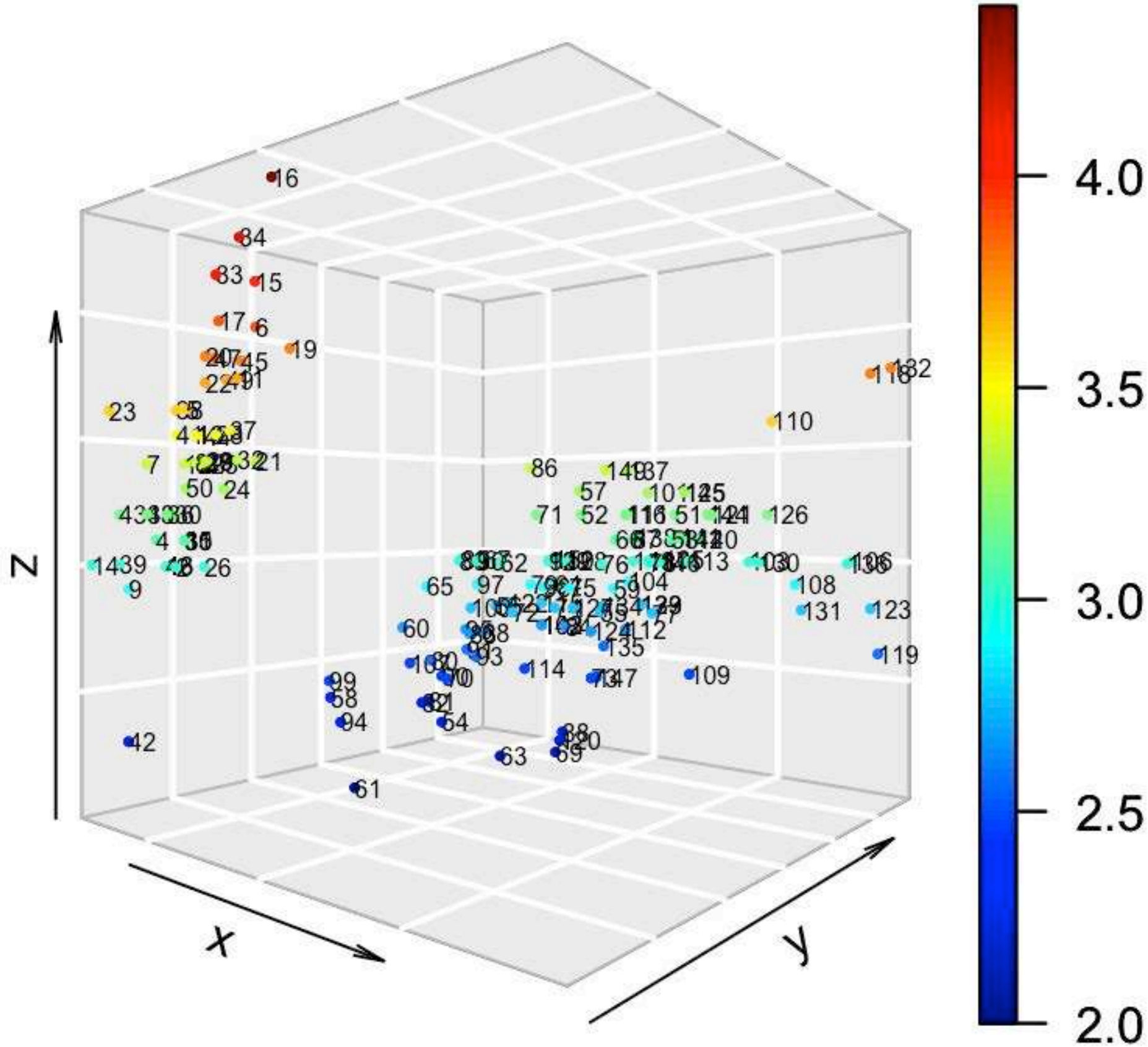


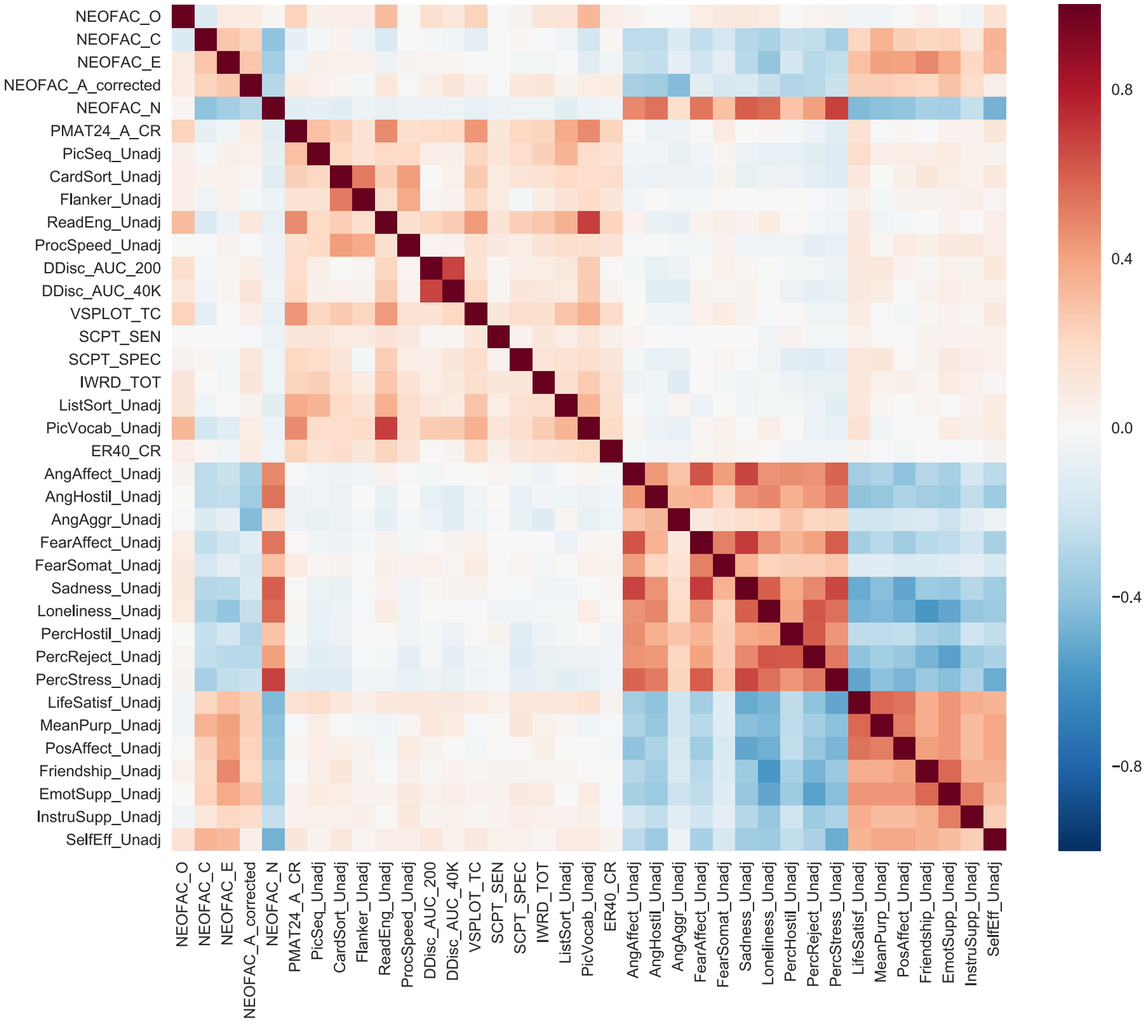
Susan Fiske et al., TICS (2006) 11:77-83



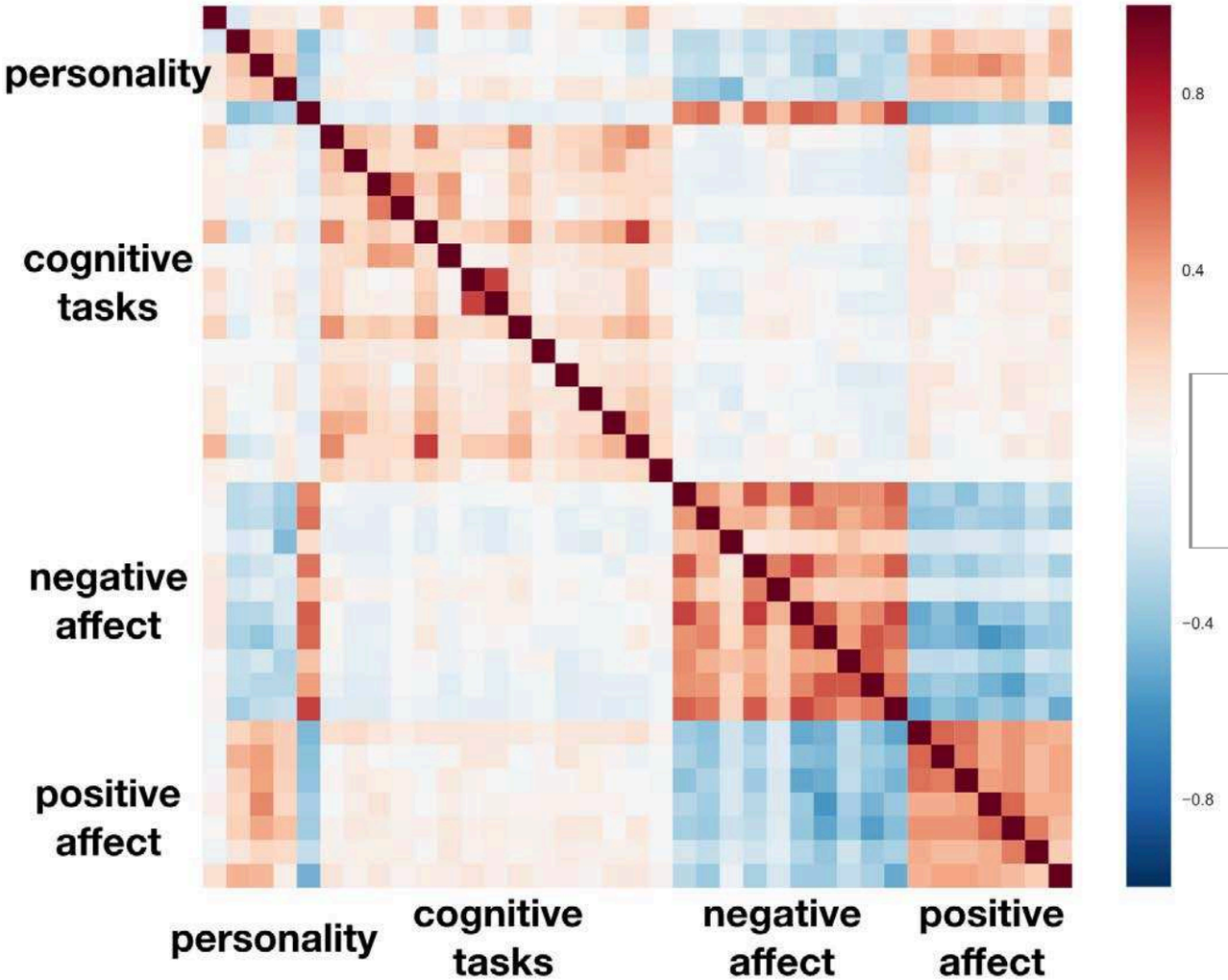
Susan Fiske et al., TICS (2006) 11:77-83

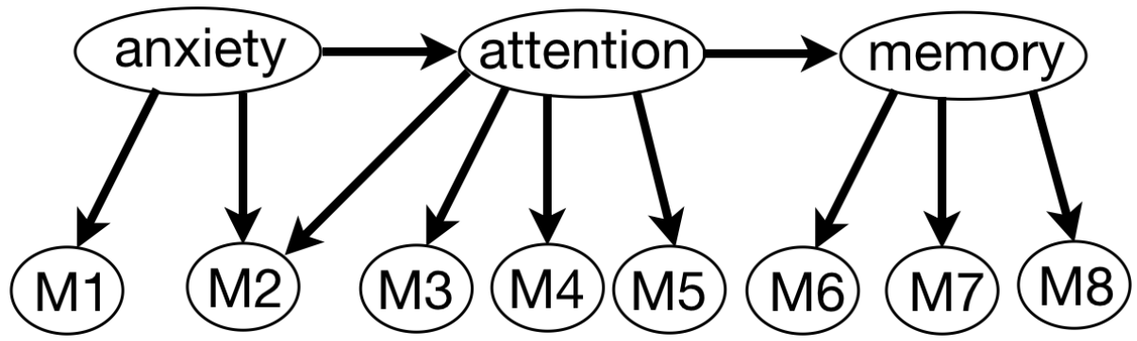

High
Warmth
Low
Active facilitation
Pity
Admiration
Passive harm
Passive facilitation
Contempt
Active harm
Envy
Low
Competence
High
TRENDS in Cognitive Sciences


Z
X
Y
4.0
3.5
3.0
2.5
2.0


NEOFAC_O
NEOFAC_C
NEOFAC_E
NEOFAC_A_corrected
NEOFAC_N
PMAT24_A_CR
PicSeq_Unadj
CardSort_Unadj
Flanker_Unadj
ReadEng_Unadj
ProcSpeed_Unadj
DDisc_AUC_200
DDisc_AUC_40K
VSPLOT_TC
SCPT_SEN
SCPT_SPEC
IWRD_TOT
ListSort_Unadj
PicVocab_Unadj
ER40_CR
AngAffect_Unadj
AngHostil_Unadj
AngAggr_Unadj
FearAffect_Unadj
FearSomat_Unadj
Sadness_Unadj
Loneliness_Unadj
PercHostil_Unadj
PercReject_Unadj
PercStress_Unadj
LifeSatisf_Unadj
MeanPurp_Unadj
PosAffect_Unadj
Friendship_Unadj
EmotSupp_Unadj
InstruSupp_Unadj
SelfEff_Unadj
0.8
0.4
0.0
−0.4
−0.8

64


personality
cognitive tasks
negative affect
positive affect
0.8
0.4
−0.4
−0.8
personality
cognitive tasks
negative affect
positive affect


anxiety
attention
memory
M1
M2
M3
M4
M5
M6
M7
M8

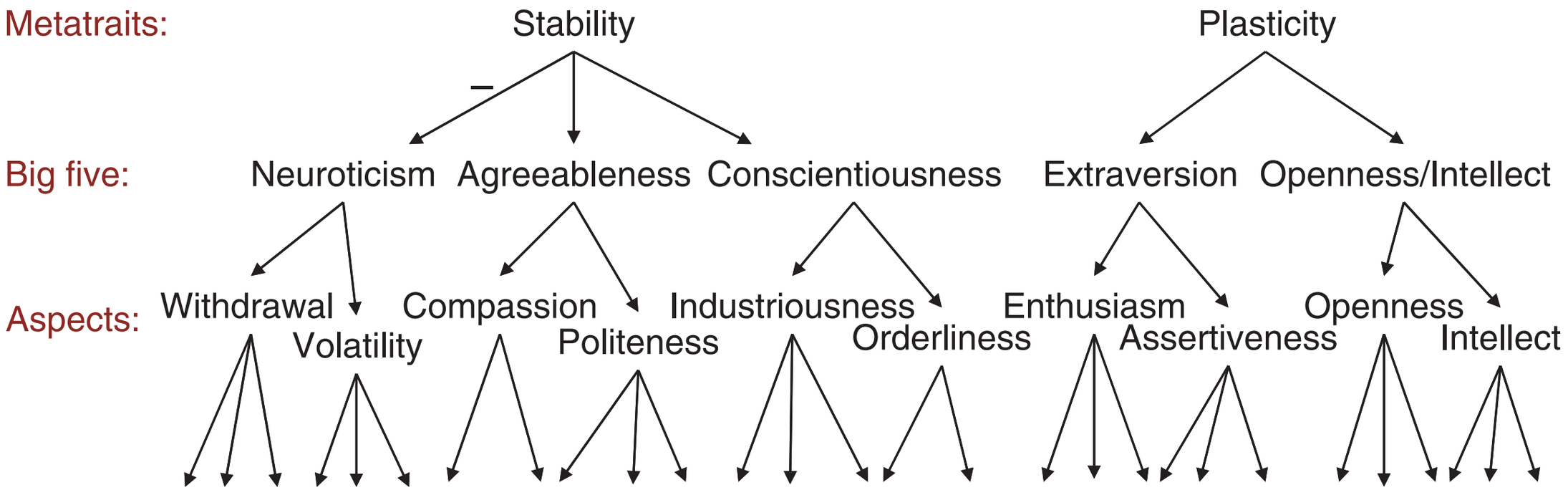
Predicting personality traits from resting-state fMRI

Julien Dubois[1,4,*], Paola Galdi[5,*], Yanting Han[2], Lynn K. Paul[1], Ralph Adolphs[1,2,3]

Case study: predicting personality traits from resting-state fMRI

- 2 sets of data: fMRI, personality
- source: Human Connectome Project (N=1000)
- are the measures valid?
- are the measures reliable?
- are the measures sensitive?
- are the measures specific?

- clean up the data: exclude outliers, bad sessions
- decide how to process the data
- set aside some data for replication
- use cross-validation to test your model
- use permutation statistics for significance tests


Metatraits:
Stability
–
Plasticity
Big five:
Neuroticism
Agreeableness
Conscientiousness
Extraversion
Openness/Intellect
Aspects:
Withdrawal
Volatility
Compassion
Politeness
Industriousness
Orderliness
Enthusiasm
Assertiveness
Openness
Intellect
Facets:
(number and identity of facets is uncertain; any list would be partially arbitrary)

Openness to new experience: Feelings, Ideas, Values, Actions, Fantasy, Aesthetics

Conscientiousness: Competence, Achievement striving, Self-discipline, Orderliness, Dutifulness, Deliberation

Extraversion: Gregariousness, Activity level, Assertiveness, Excitement seeking, Positive emotions, Warmth

Agreeableness: Trust, Altruism, Straightforwardness, Compliance, Modesty, Tender-mindedness

Neuroticism: Anxiety, Self-consciousness, Depression, Vulnerability, Impulsiveness, Angry hostility

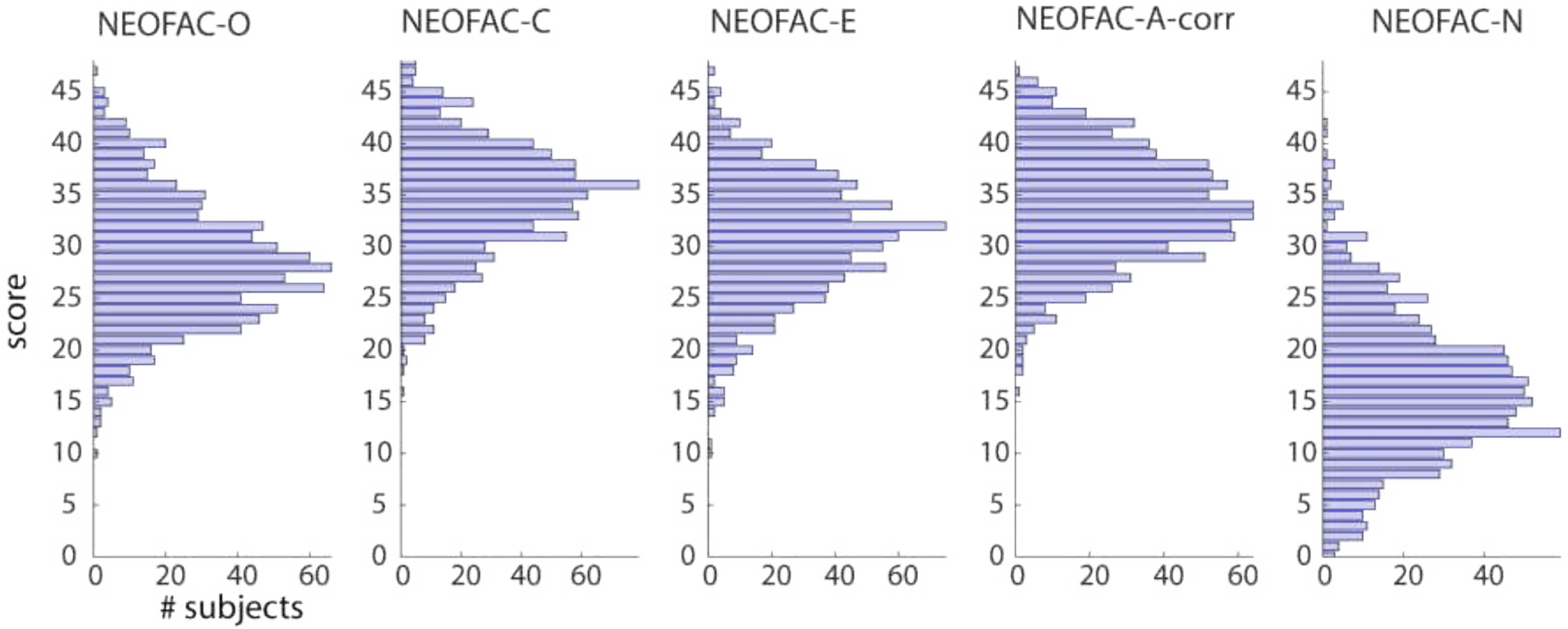
Personality dimension	Monozygotic (MZ; identical) twins	Dizygotic (DZ; fraternal) twins	Heritability estimate $h^2 = 2\,(r_{mz} - r_{dz})$
Extraversion	0.56	0.28	56%
Neuroticism	0.53	0.13	80%
Agreeableness	0.42	0.19	46%
Conscientiousness	0.54	0.18	72%
Openness	0.54	0.35	38%

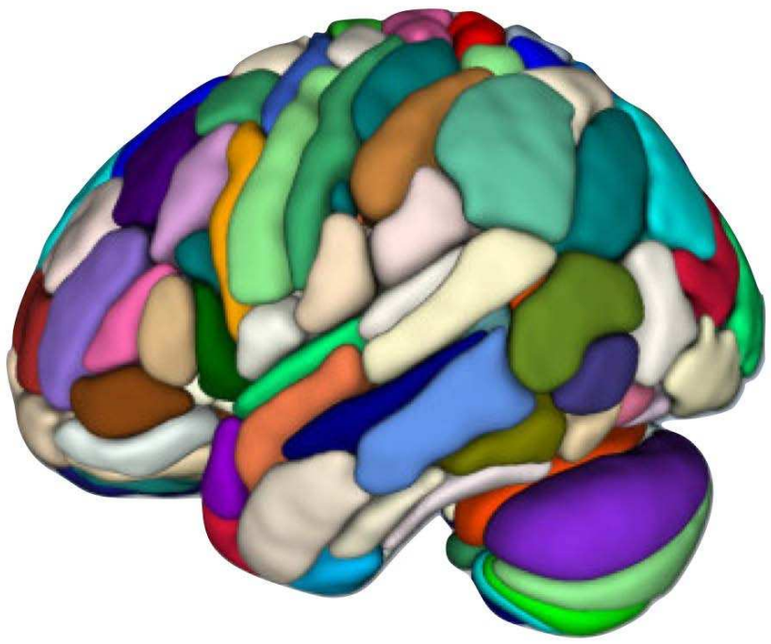
NEO

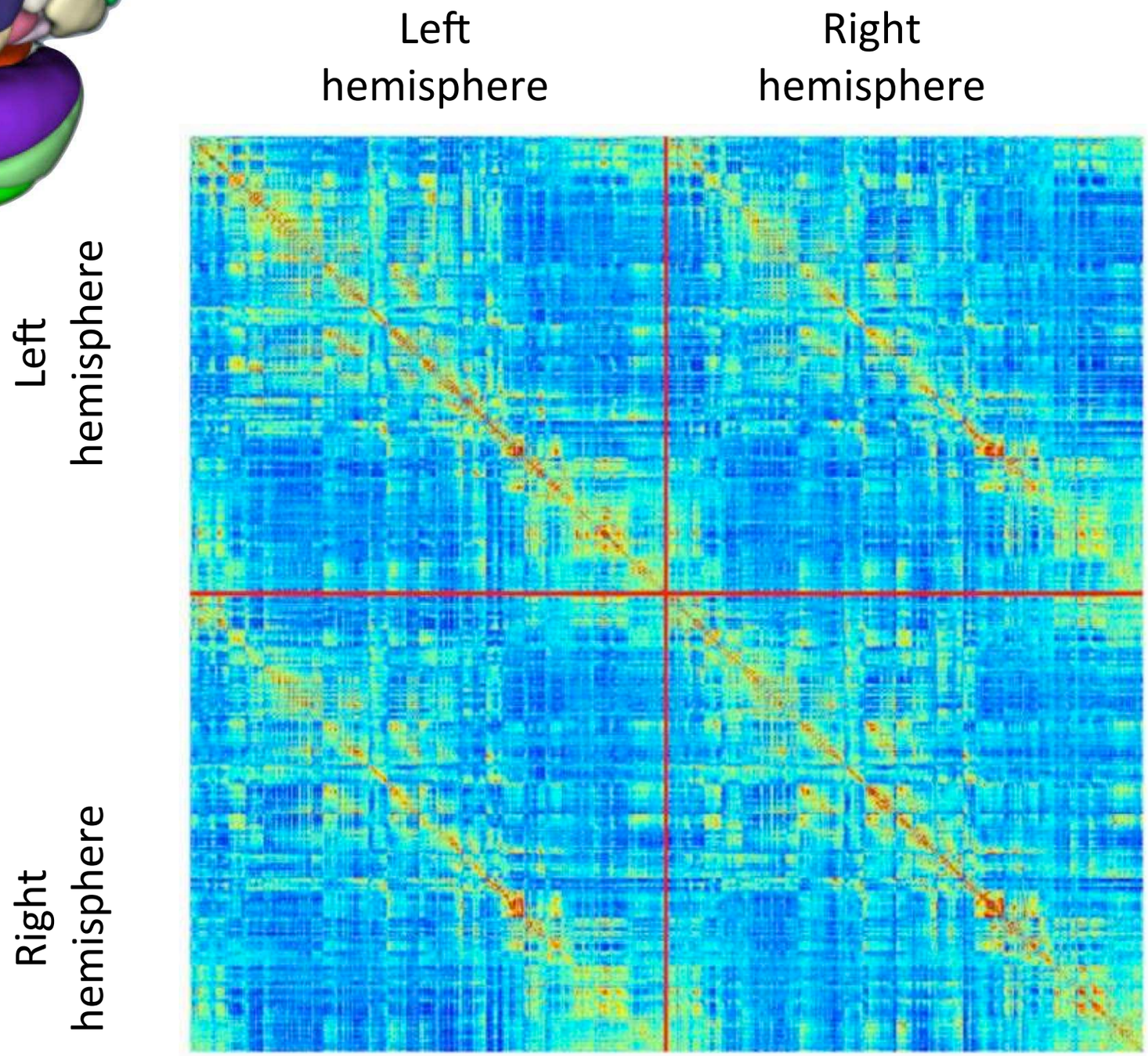
- NEO-PI: 180 items

- NEO-FFI: selected 12 items for each of the 5 factors (60 items)

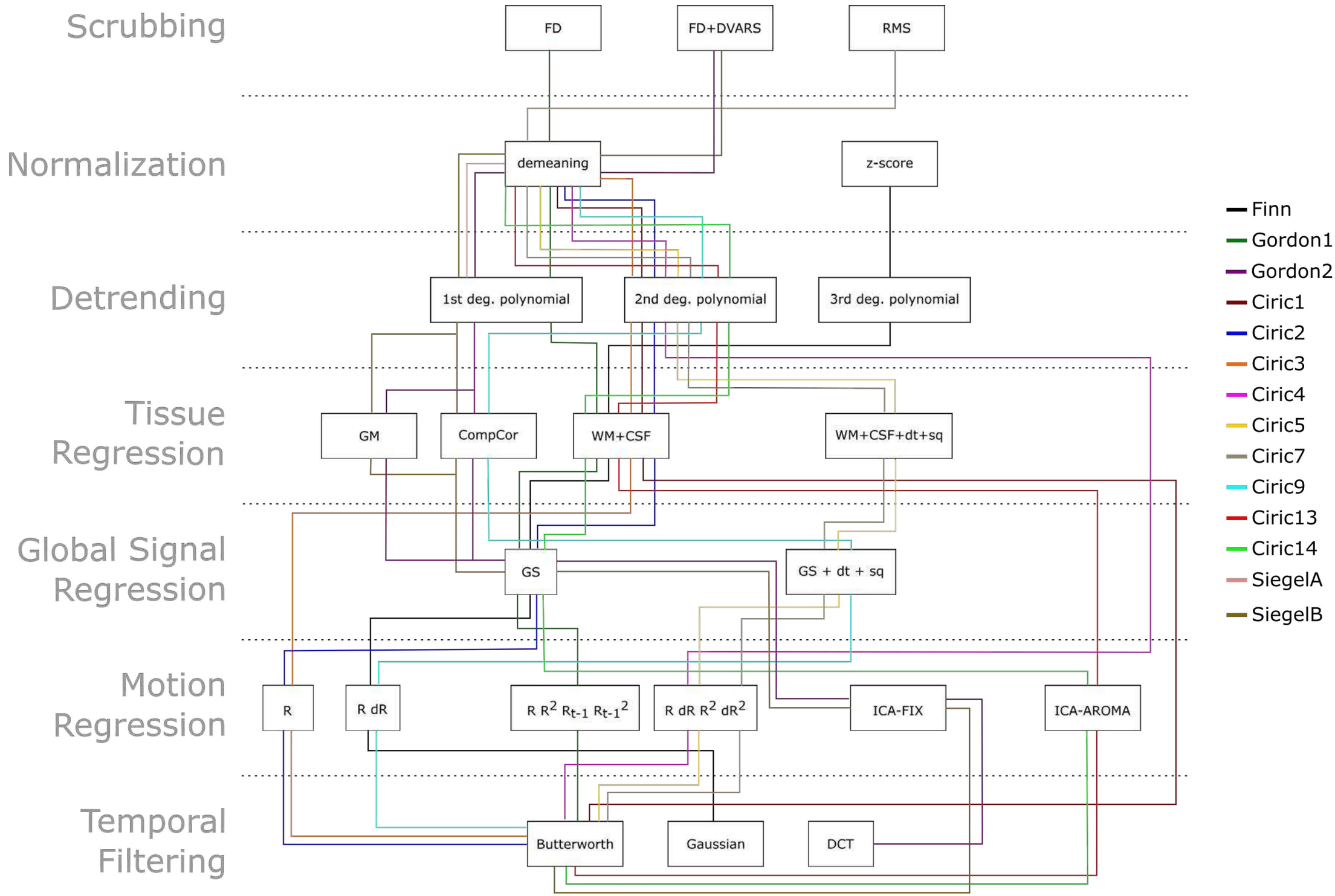
- test-retest reliability = 0.9
- internal consistency = 0.7-0.8

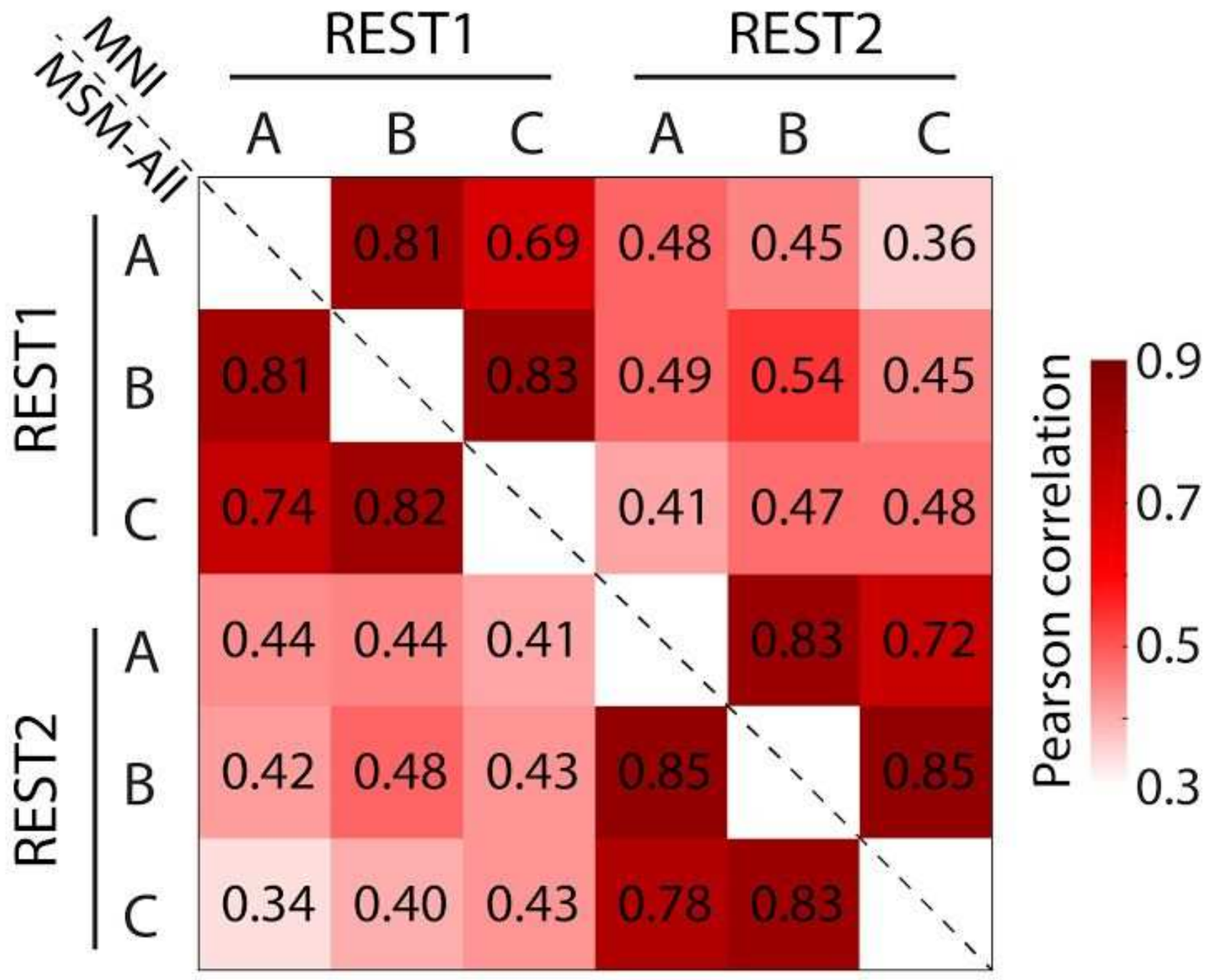

NEOFAC-O
NEOFAC-C
NEOFAC-E
NEOFAC-A-corr
NEOFAC-N
score
subjects

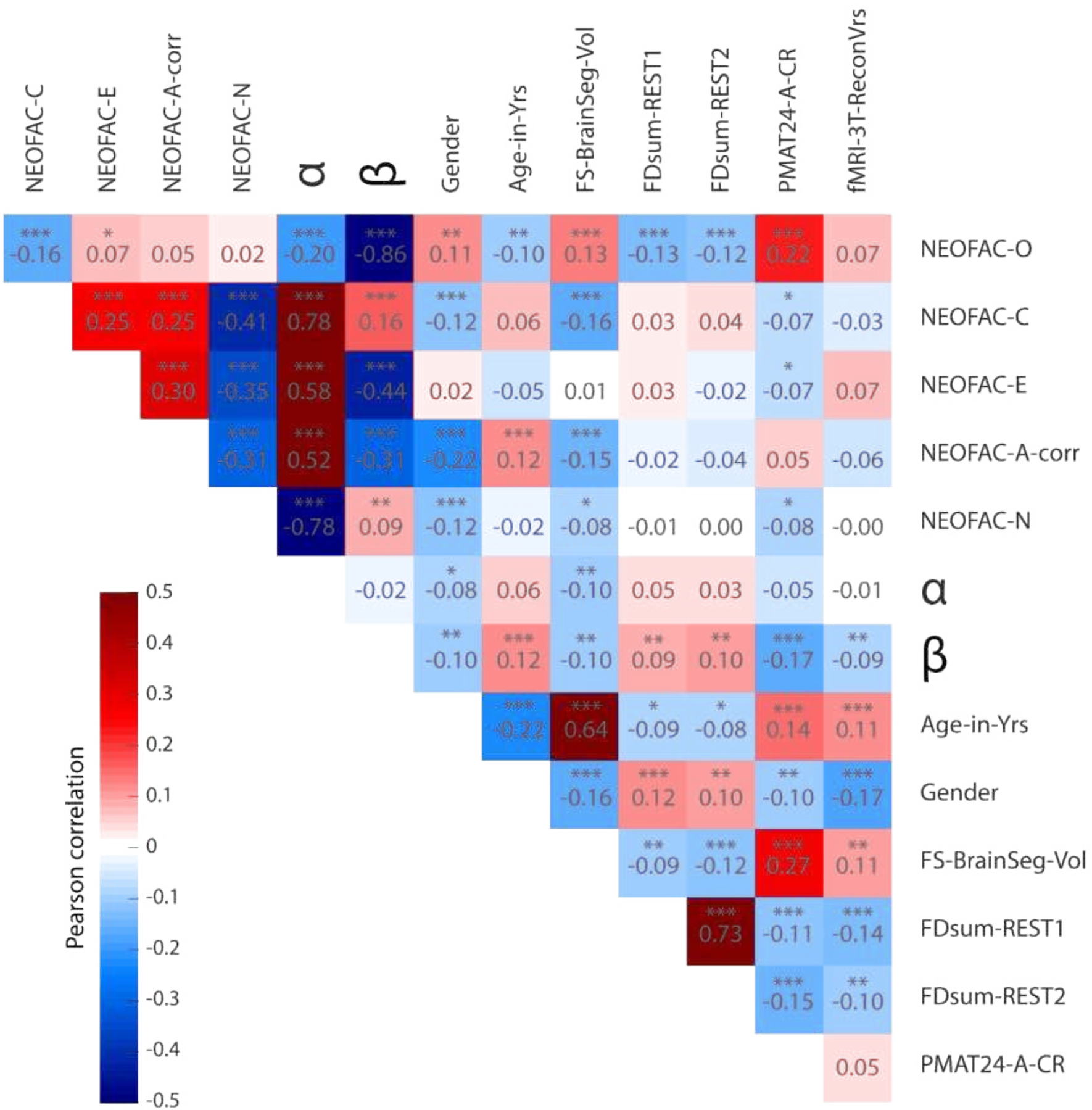


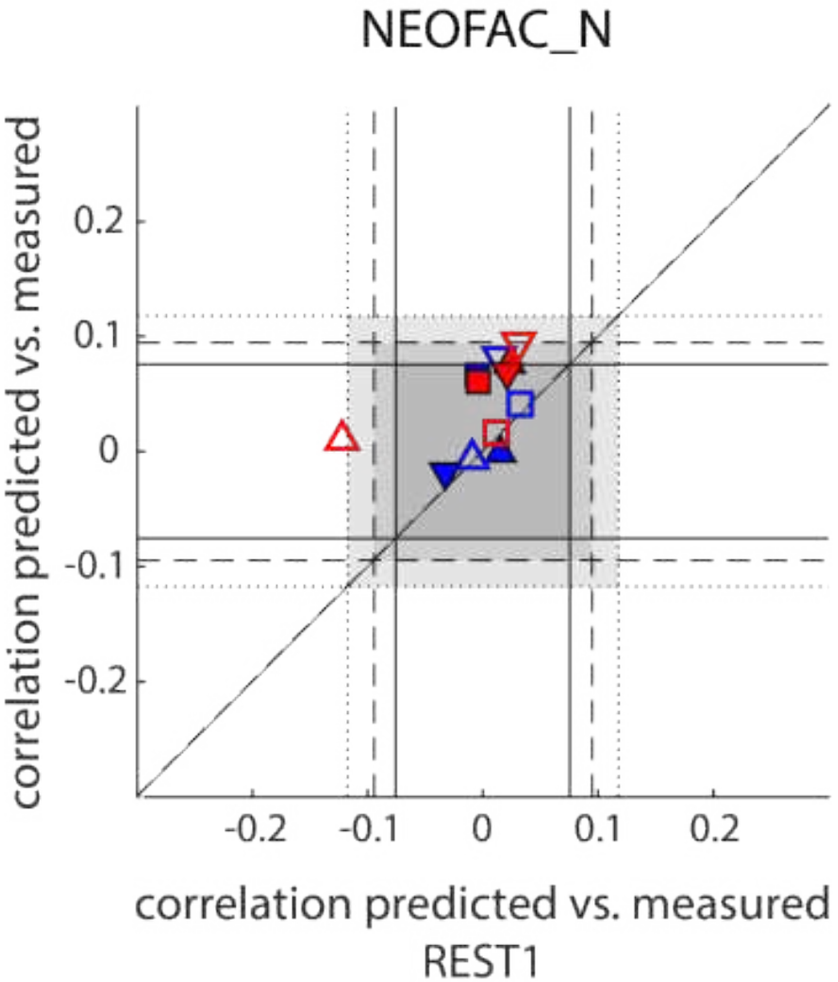

Left hemisphere
Right hemisphere
Left hemisphere
Right hemisphere
0.6
0.3
0
-0.3

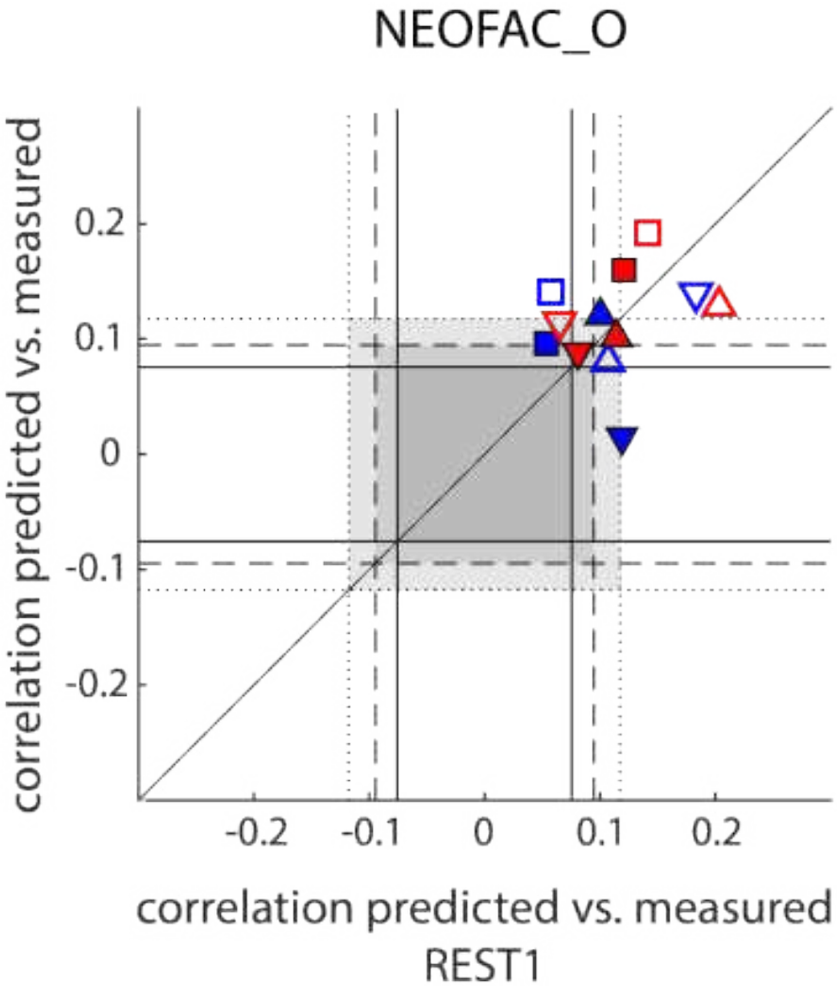
rsFC


Scrubbing
Normalization
Detrending
Tissue Regression
Global Signal Regression
Motion Regression
Temporal Filtering
FD
FD+DVARS
RMS
demeaning
z-score
1st deg. polynomial
2nd deg. polynomial
3rd deg. polynomial
GM
CompCor
WM+CSF
WM+CSF+dt+sq
GS
GS + dt + sq
R
R dR
R R2 Rt-1 Rt-12
R dR R2 dR2
ICA-FIX
ICA-AROMA
Butterworth
Gaussian
DCT
Finn
Gordon1
Gordon2
Ciric1
Ciric2
Ciric3
Ciric4
Ciric5
Ciric7
Ciric9
Ciric13
Ciric14
SiegelA
SiegelB


MNI
MSM-All
REST1
REST2
A
B
C
A
B
C
REST1
A
B
C
REST2
A
B
C
0.81 0.69 0.48 0.45 0.36
0.81 0.83 0.49 0.54 0.45
0.74 0.82 0.41 0.47 0.48
0.44 0.44 0.41 0.83 0.72
0.42 0.48 0.43 0.85 0.85
0.34 0.40 0.43 0.78 0.83
Pearson correlation
0.9
0.7
0.5
0.3


NEOFAC-C
NEOFAC-E
NEOFAC-A-corr
NEOFAC-N
α
β
Gender
Age-in-Yrs
FS-BrainSeg-Vol
FDsum-REST1
FDsum-REST2
PMAT24-A-CR
fMRI-3T-ReconVrs
NEOFAC-O
NEOFAC-C
NEOFAC-E
NEOFAC-A-corr
NEOFAC-N
α
β
Age-in-Yrs
Gender
FS-BrainSeg-Vol
FDsum-REST1
FDsum-REST2
PMAT24-A-CR
Pearson correlation
0.5
0.4
0.3
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5


NEOFAC_N
REST2
correlation predicted vs. measured
0.2
0.1
0
-0.1
-0.2
-0.2
-0.1
0
0.1
0.2
correlation predicted vs. measured
REST1


NEOFAC_O
REST2
correlation predicted vs. measured
0.2
0.1
0
-0.1
-0.2
-0.2
-0.1
0
0.1
0.2
correlation predicted vs. measured
REST1

Analysis of resting-state fMRI correlation structure

Discovery

Causal graph, anatomical features: further predictions

Hypotheses

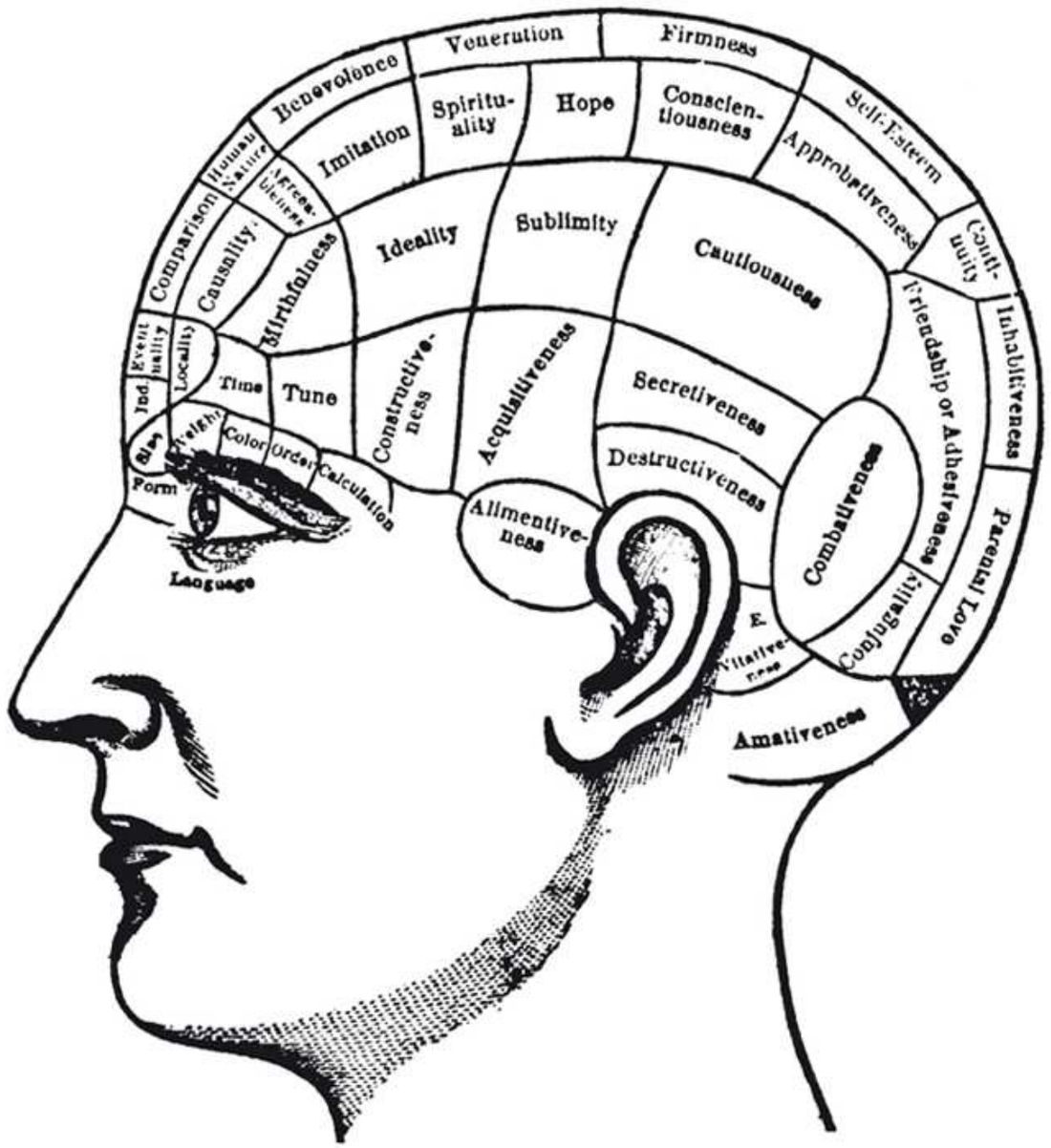
Testing in independent dataset

Reliability

Lesion Studies

Causality

Takehome points:
- the social brain encompasses perception, cognition, action
- essentially all animals show social behavior
- this shows many parallel modules to aspects of human behavior
- certain species may be good model systems to study
- humans may be especially smart in the social domain
- empathy and mentalizing provide inferences about minds
- we evaluate others along a few basic dimensions
- but we don’t know if those dimensions will be scientific


Benevolence
Veneration
Firmness
Imitation
Spirituality
Hope
Conscientiousness
Self-Esteem
Approbativeness
Comparison
Causality
Ideality
Sublimity
Cautiousness
Time
Tune
Constructiveness
Acquisitiveness
Secretiveness
Destructiveness
Alimentiveness
Combativeness
Friendship or Adhesiveness
Conjugality
Parental Love
Amativeness
Language

Main open questions:

1. Is social cognition "domain-specific"?
2. Is there a "social brain"?
3. How is human social cognition unique?