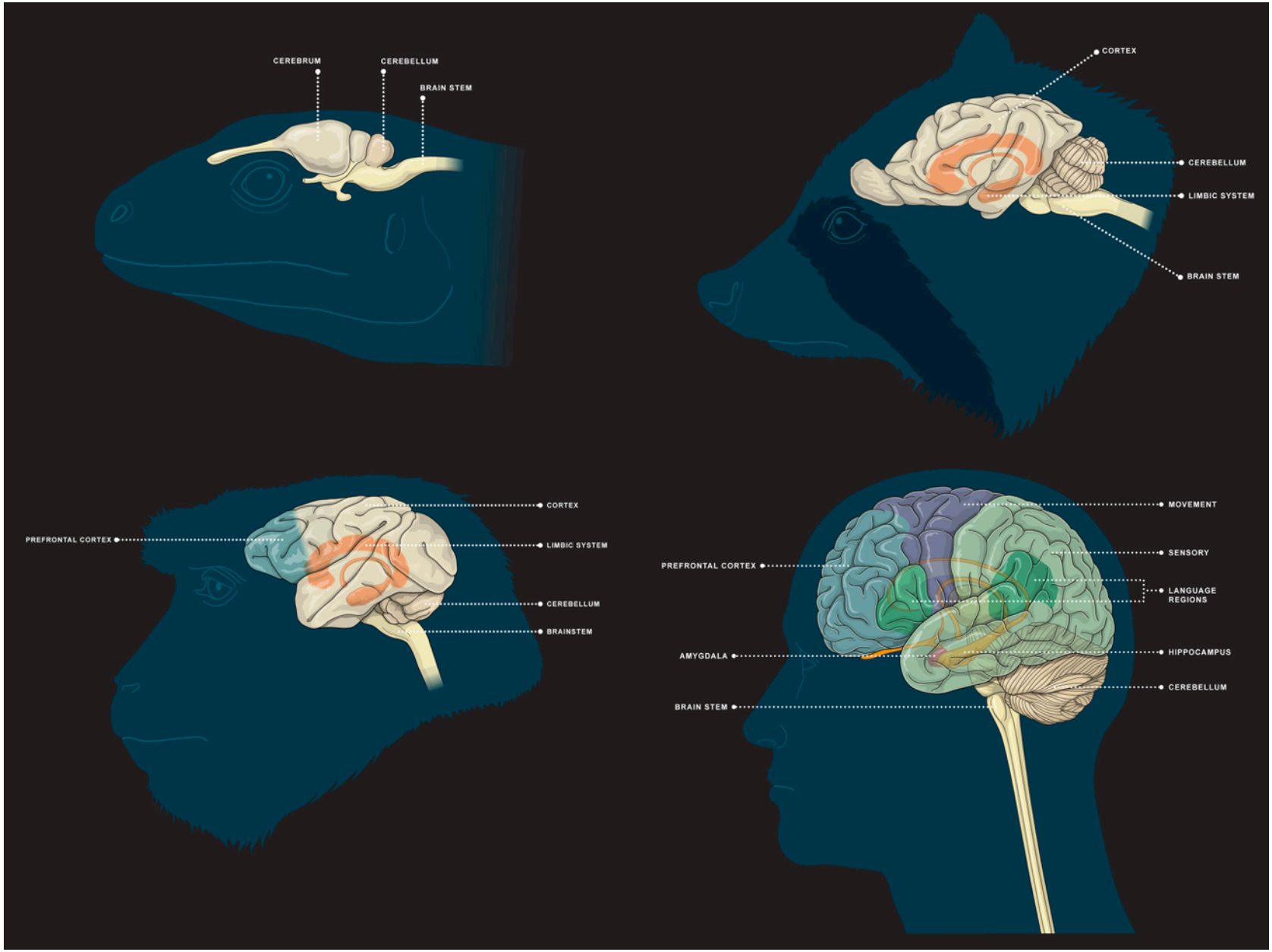
The Emotional Brain

11/2/2013

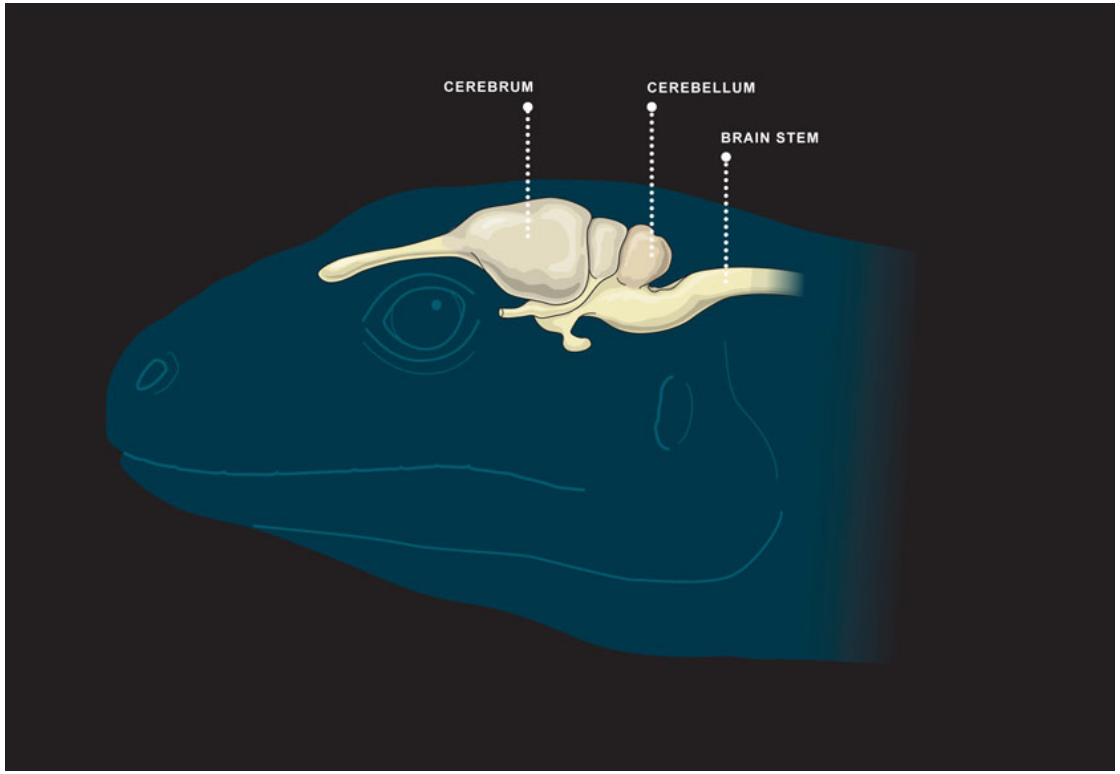
Why have emotions?

Evolution of the emotional brain



The Reptile Brain

- The R complex: brain stem, cerebellum, and the oldest basal ganglia
- Fight or flight response
- Not much plasticity



Ancestral mammals

- The paleopallium- really old cortex, but the olfactory cortex and the parahippocampal gyrus appear (along with the older hippocampus)

Why have emotion?

Plato: pain is the destruction of organic harmony, pleasure is its restoration, neutral is harmony

Aristotle: First classified emotions, divided them into antagonistic pairs (love/fear, anger/gentleness) AND said emotions are due to the Pneuma (fear is due to cold blood, etc)

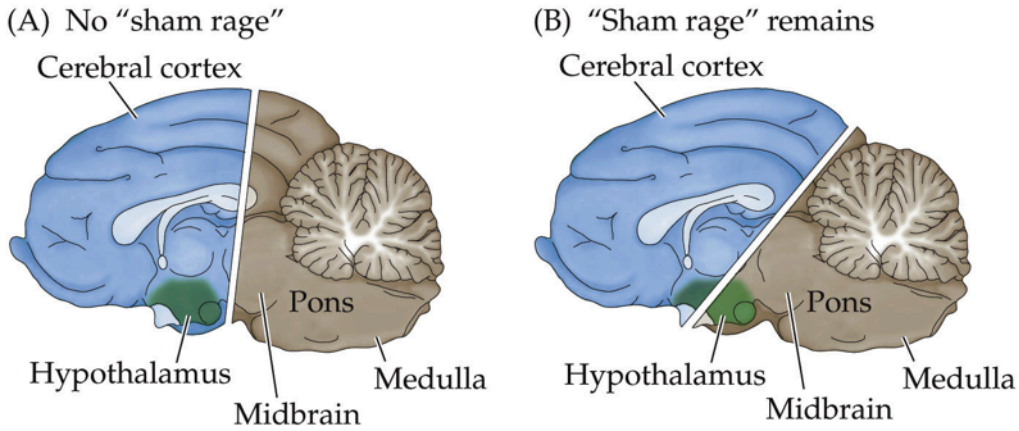
Why have emotion?

Early theories of emotions:

- **The James-Lange Theory (1893)**: an external stimulus leads to a physiological change which is then registered as emotion

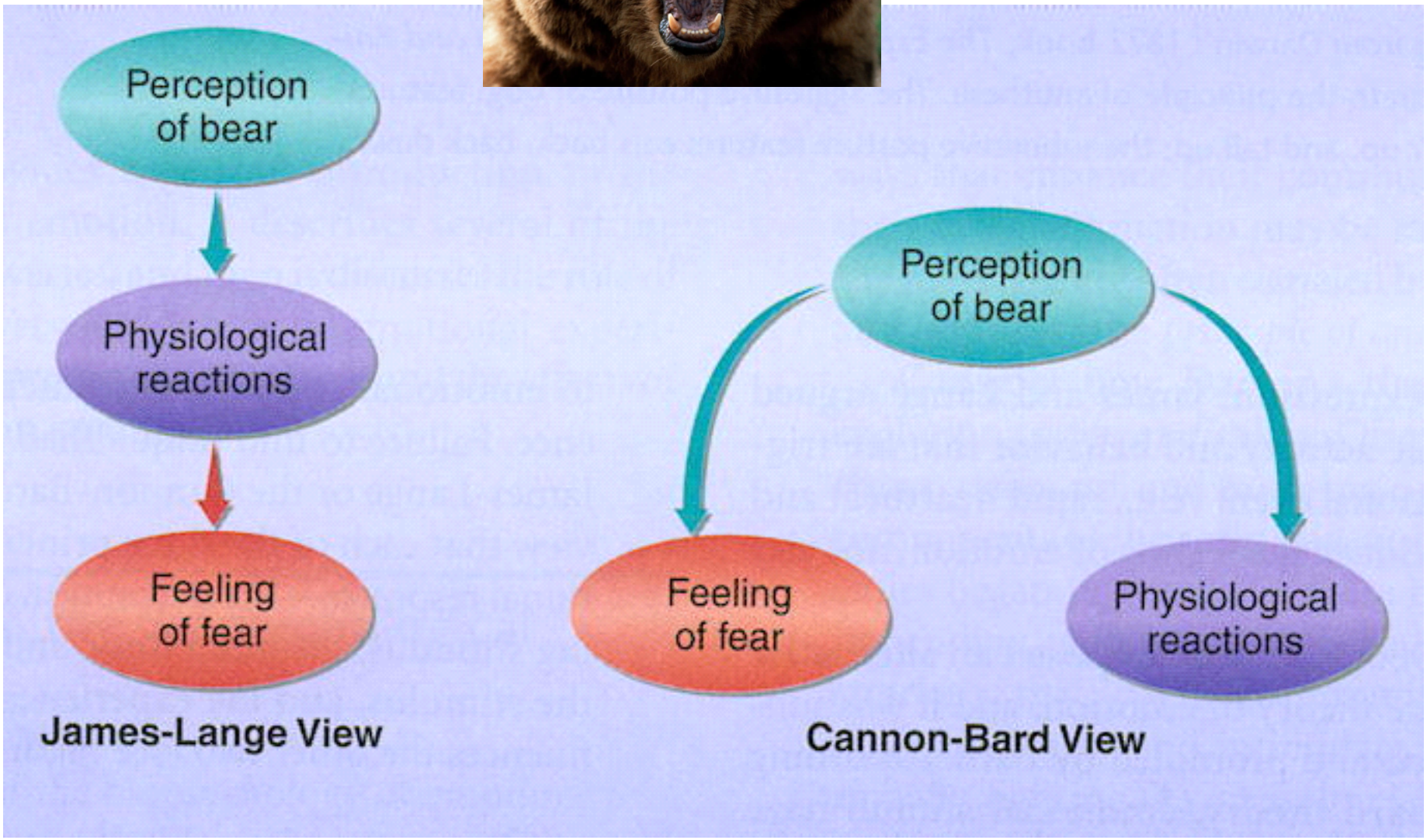
The Cannon-Bard Theory (1928): emotion occurs even without the bodily reaction- or more frequently, the bodily reaction and the emotional reaction occur at the same time, independently

They proposed that the thalamus and hypothalamus are critical for the emotional response



Poor angry cats!

***NEUROSCIENCE, Fourth Edition,* Figure 29.1**


Perception of bear
Physiological reactions
Feeling of fear
James-Lange View
Perception of bear
Feeling of fear
Physiological reactions
Cannon-Bard View

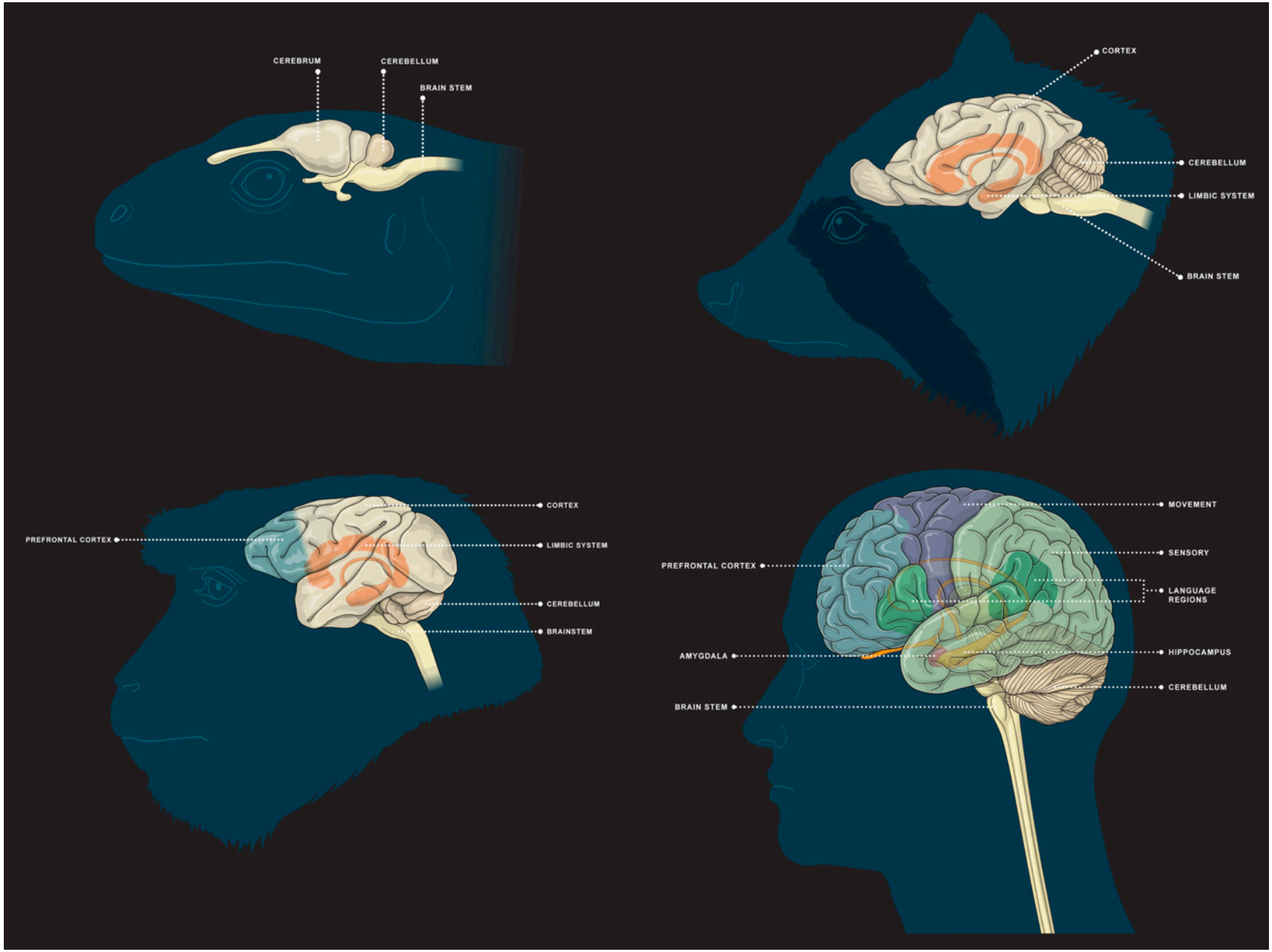
Modern refinements

Schachter- The cortex translates information from the periphery into specific feelings

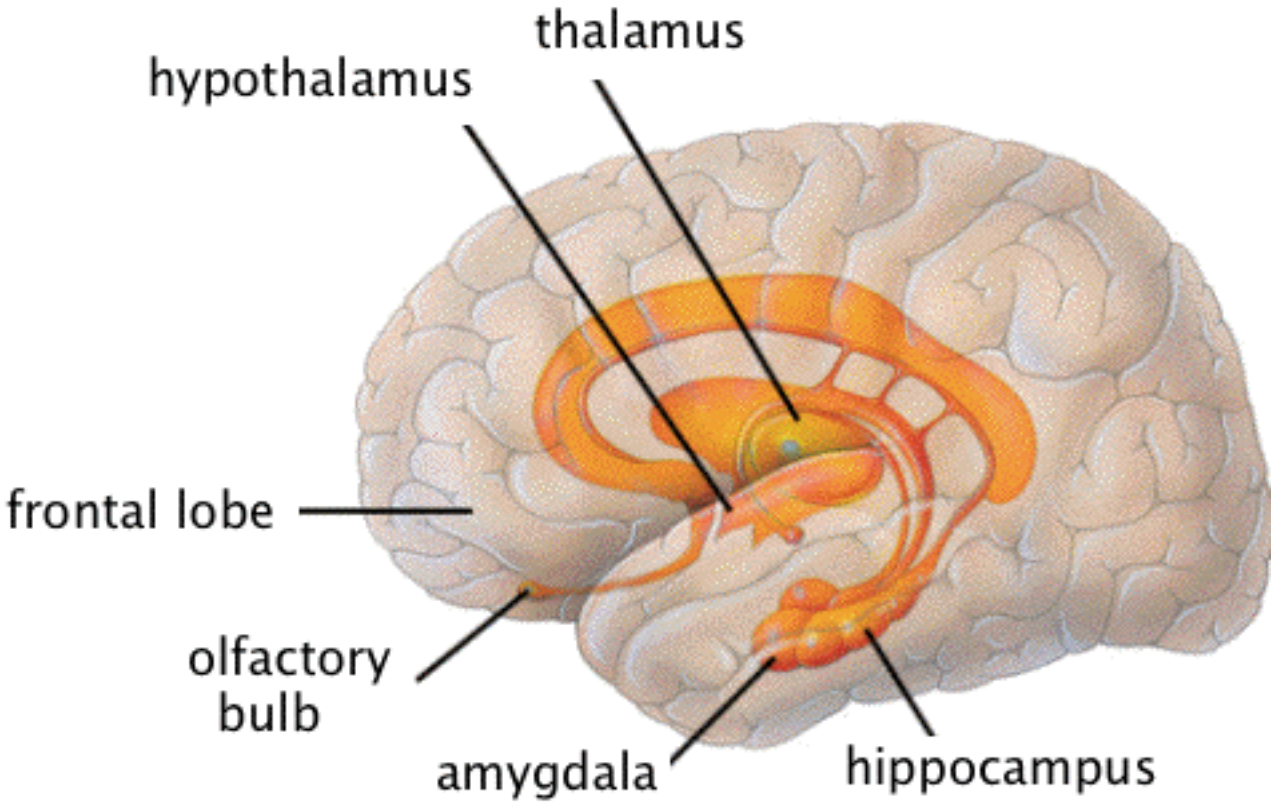
Experiment: Inject volunteers with epinephrine, only tell some of them, expose them to either annoying or amusing stimuli:

Damasio- The emotional experience is a story constructed by the cortex to explain bodily reactions

Evolution of the emotional brain



The mammalian limbic system



The limbic system

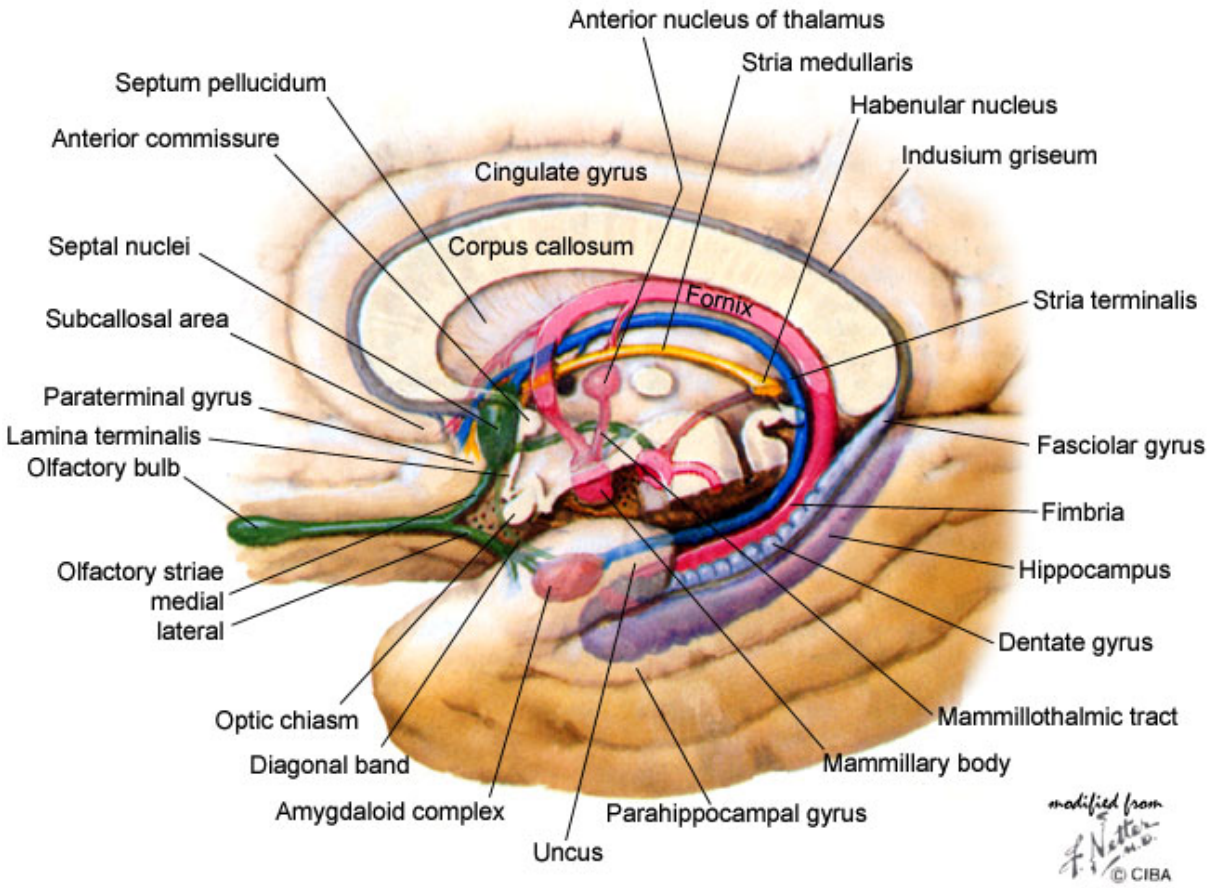
-**Hypothalamus:** Controls the autonomic nervous system

-Hippocampus: Memory

-Amygdala: The primary player in the emotional experience

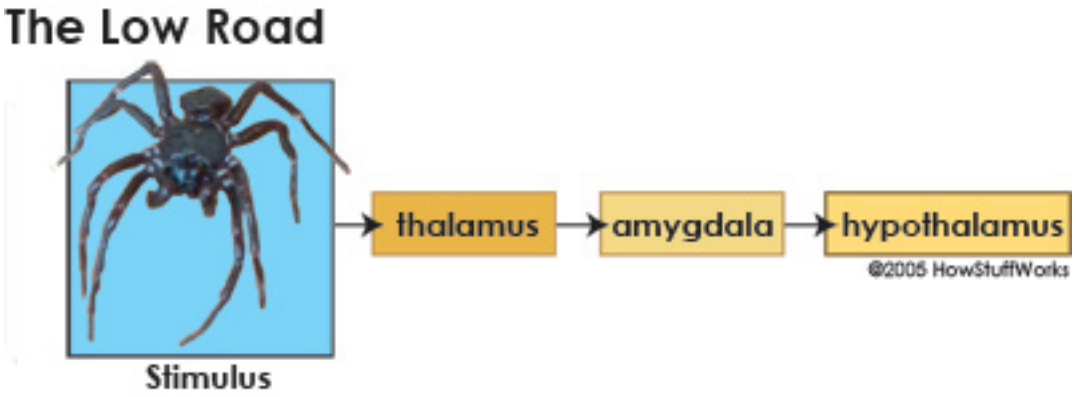
-Thalamus: Sensory information processing

But lots of other brain regions can be included



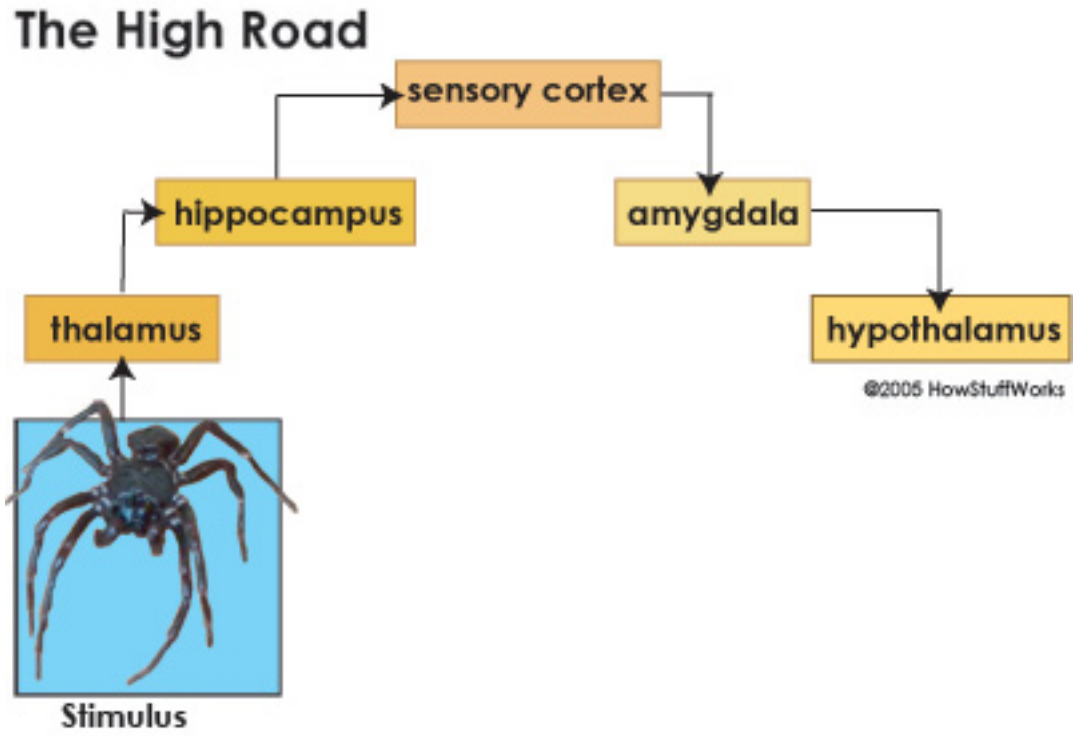
Fear: Both an important emotion and a case study

Two fear pathways in the brain

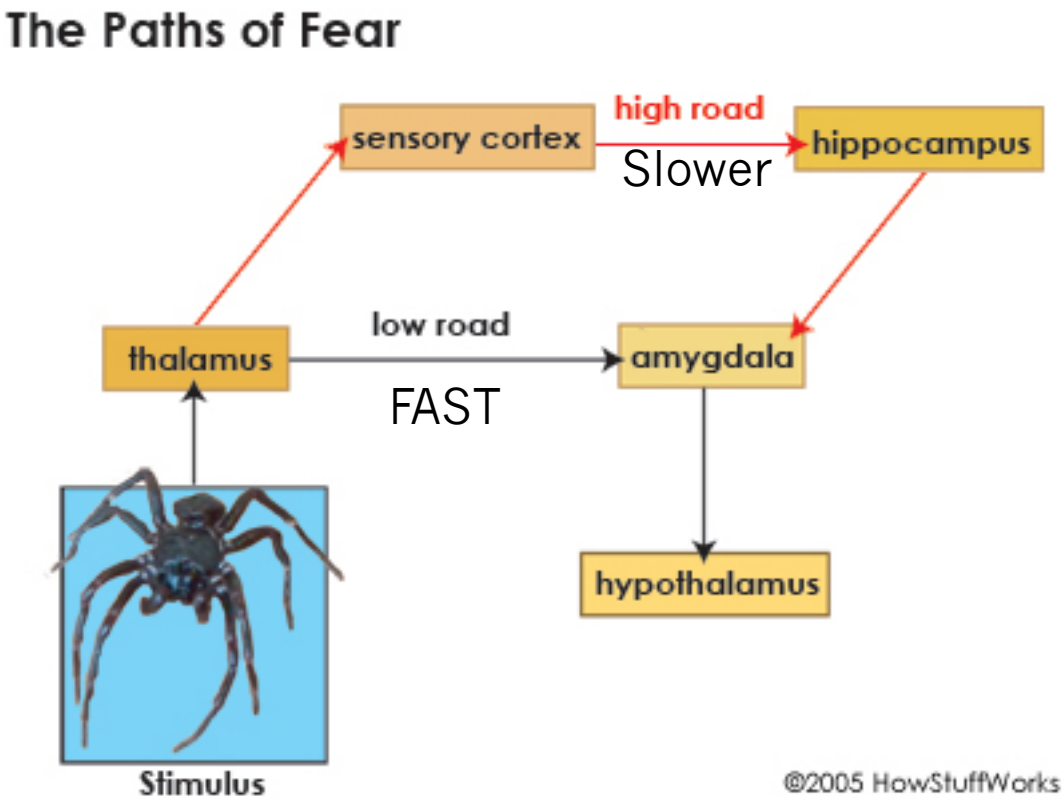


The low road

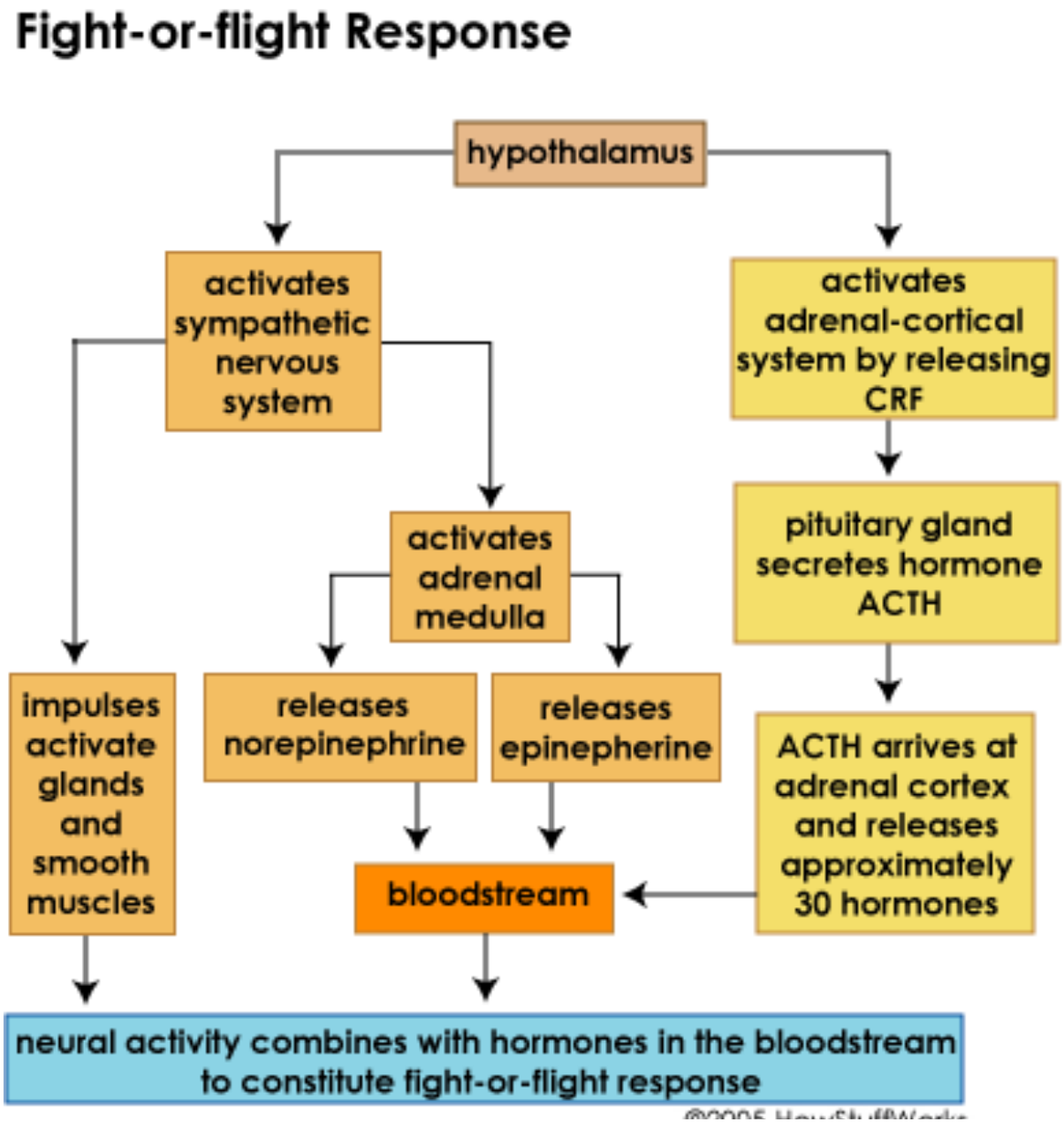
The high road



Two fear pathways in the brain

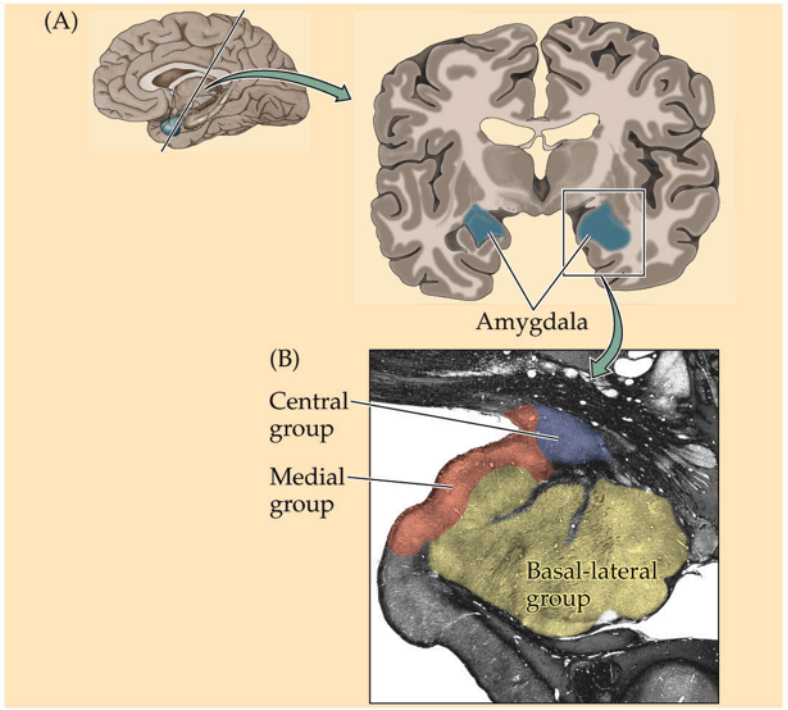


All roads lead to the hypothalamus



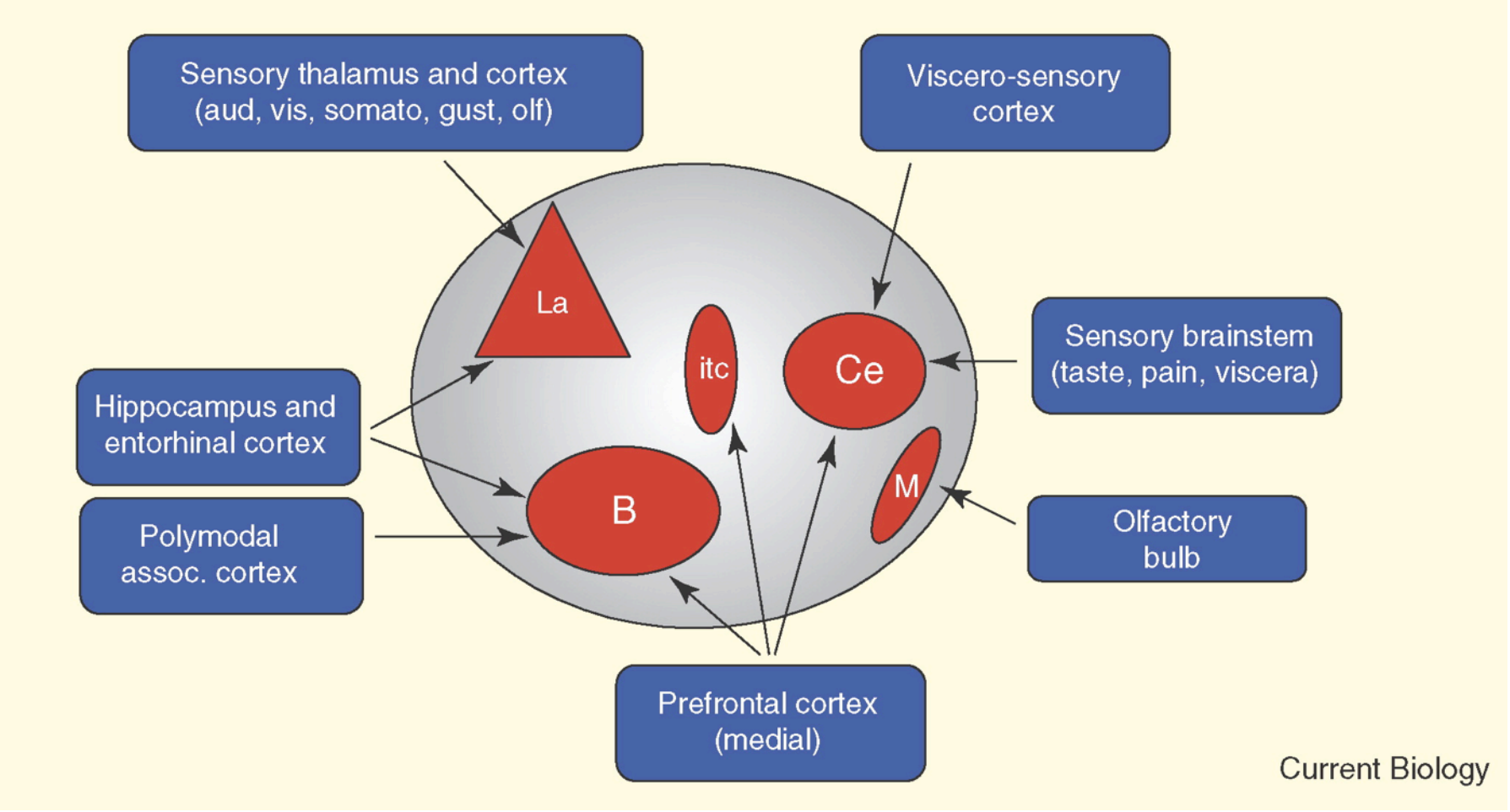
Fear and the amygdala

- Fear is fairly well characterized because in many ways it is easiest to study
- Innate fears and learned fears
- Learned associations (fear conditioning) is a good system for studying memory

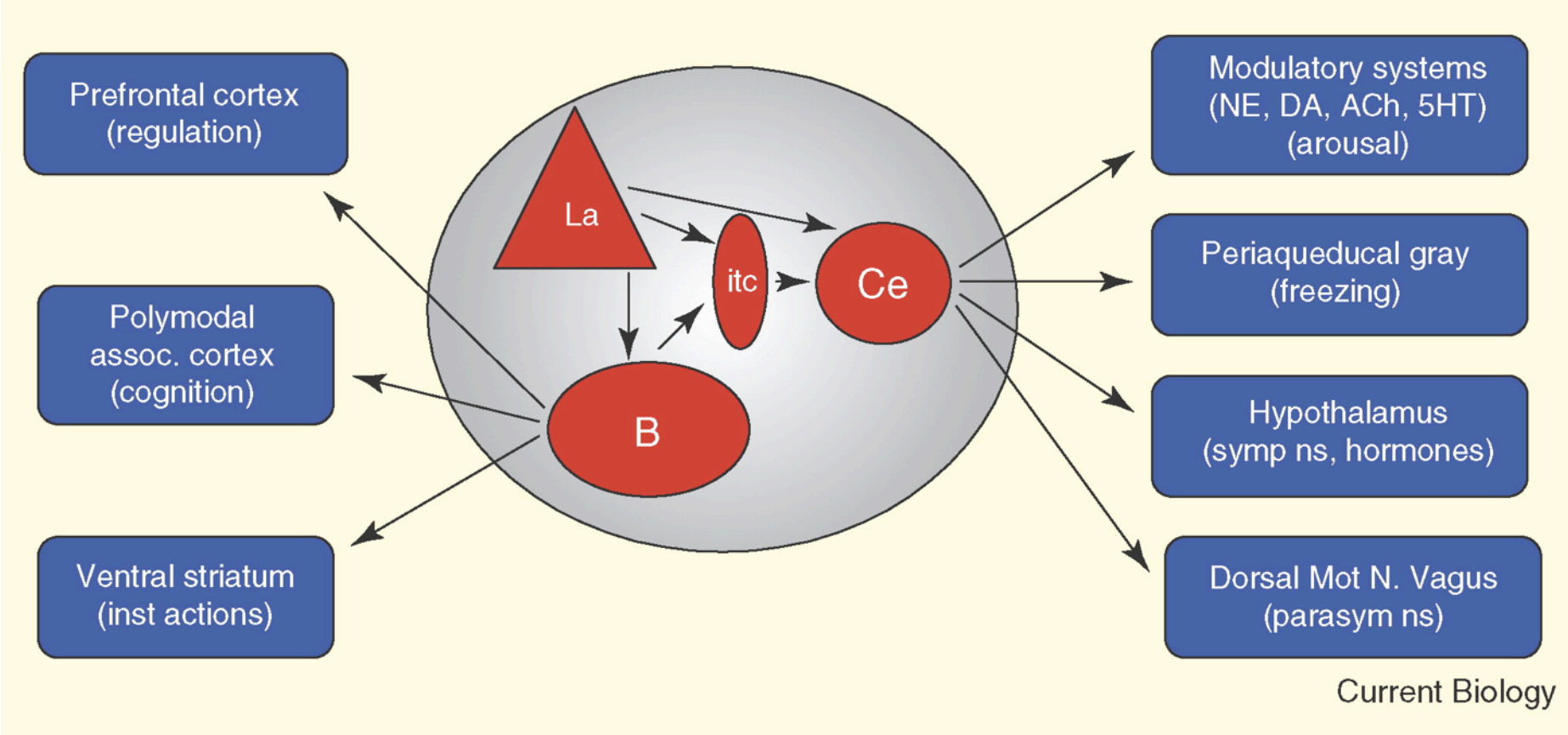


NEUROSCIENCE, Fourth Edition, Box 29B (1)

Inputs to the amygdala



Outputs of the amygdala



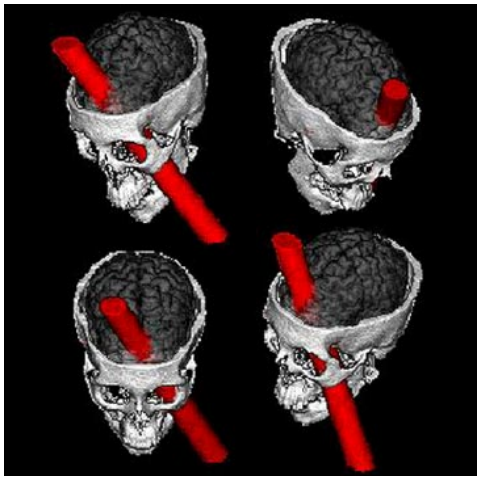
The amygdala

The amygdala also plays a role in aggressive, maternal, sexual, and appetative behaviors, but these are less well characterized

Prefrontal cortex: Rational control?

Phineas Gage

"Remembers passing and past events correctly, as well before as since the injury. Intellectual manifestations feeble, being exceedingly capricious and childish, but with a will as indomitable as ever; is particularly obstinate; will not yield to restraint when it conflicts with his desires." Dr Harlow reports that Gage's employers, "who regarded him as the most efficient and capable foreman ... considered the change in his mind so marked that they could not give him his place again.... He is fitful, irreverent, indulging at times in the grossest profanity (which was not previously his custom), manifesting but little deference for his fellows, impatient of restraint or advice when it conflicts with his desires.... A child in his intellectual capacity and manifestations, he has the animal passions of a strong man.... His mind was radically changed, so decidedly that his friends and acquaintances said he was 'no longer Gage.'"

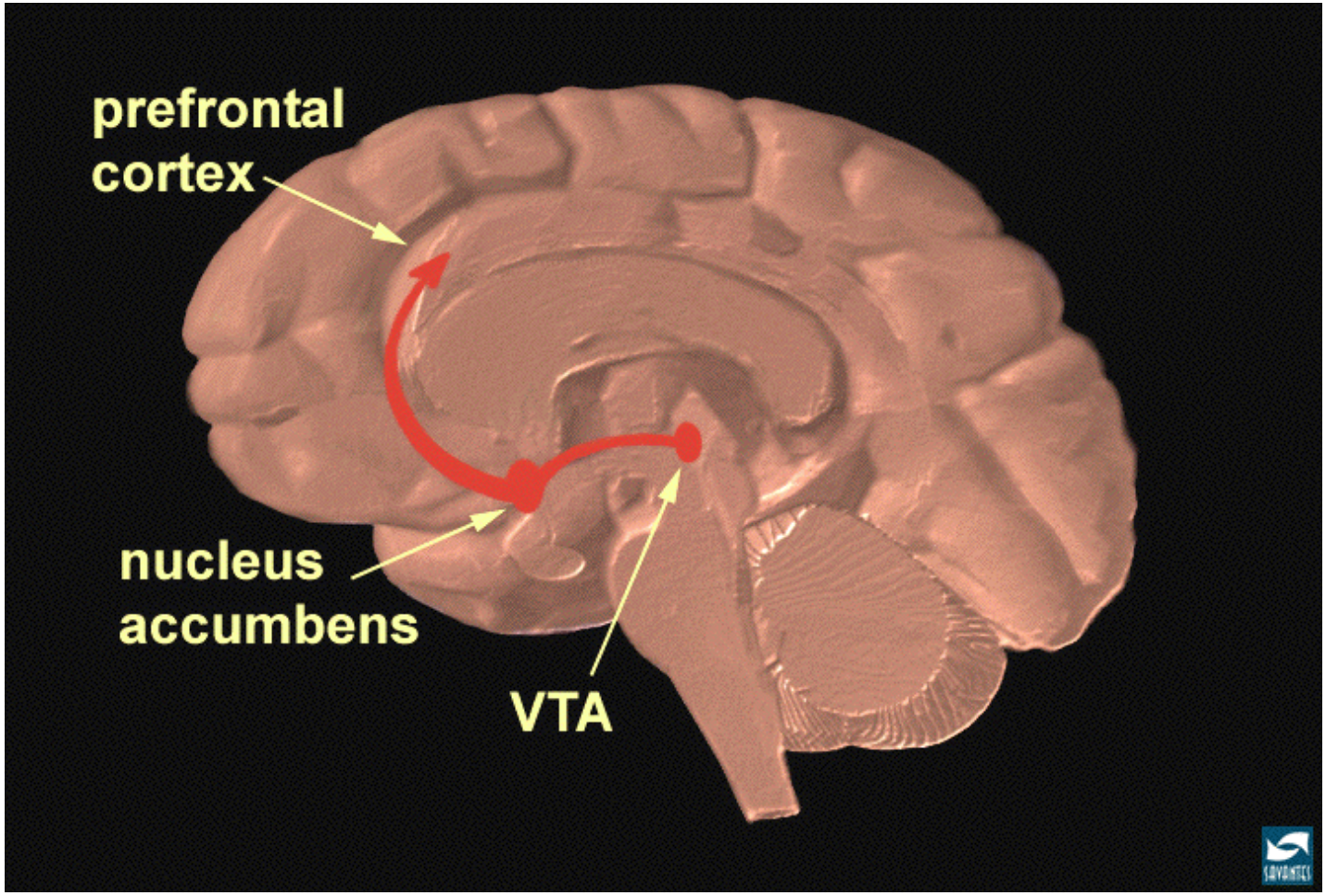


Ventromedial frontal cortex damage

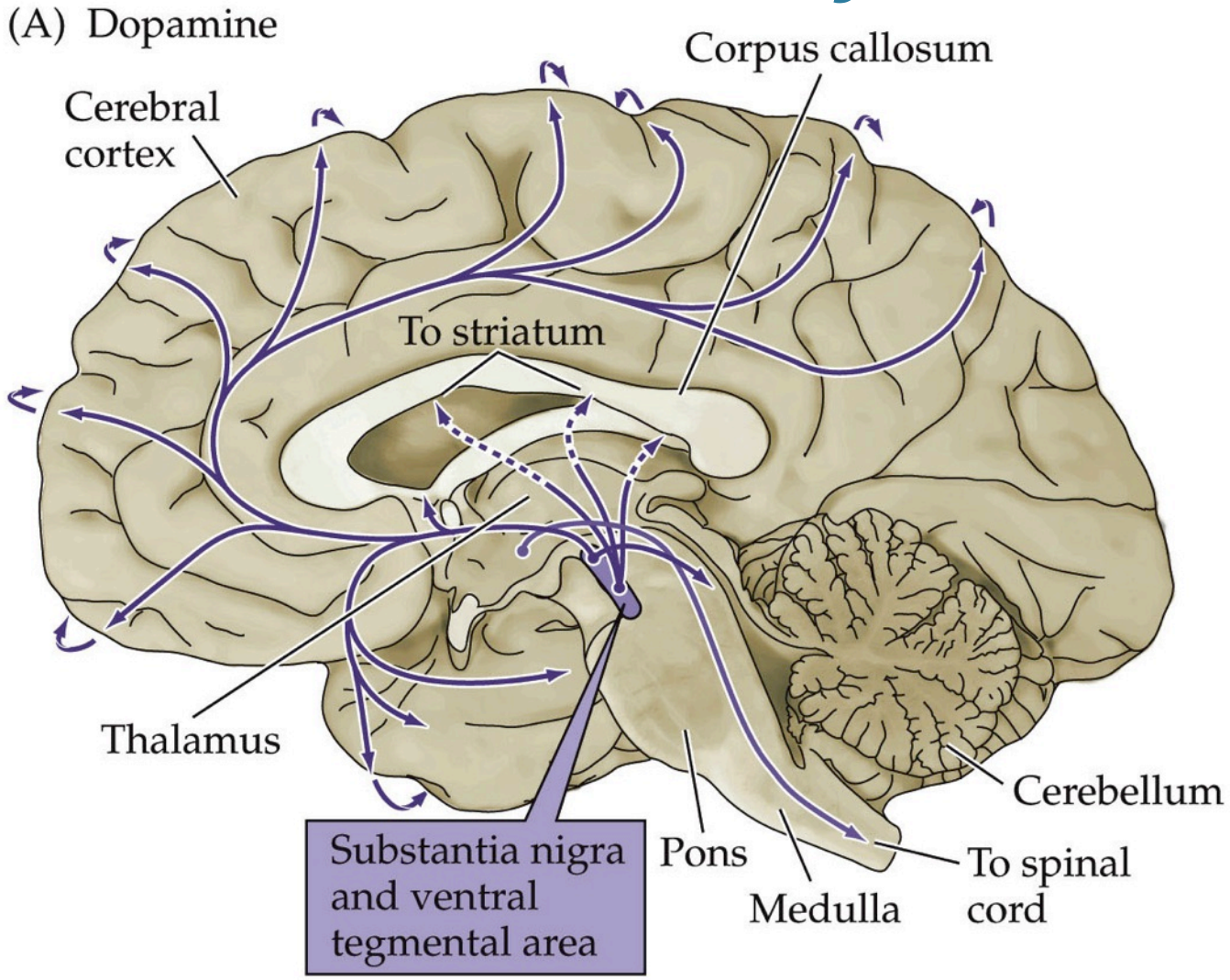
What about the love!

Are there any positive emotions?

The “reward” pathway
or maybe the “motivation” pathway



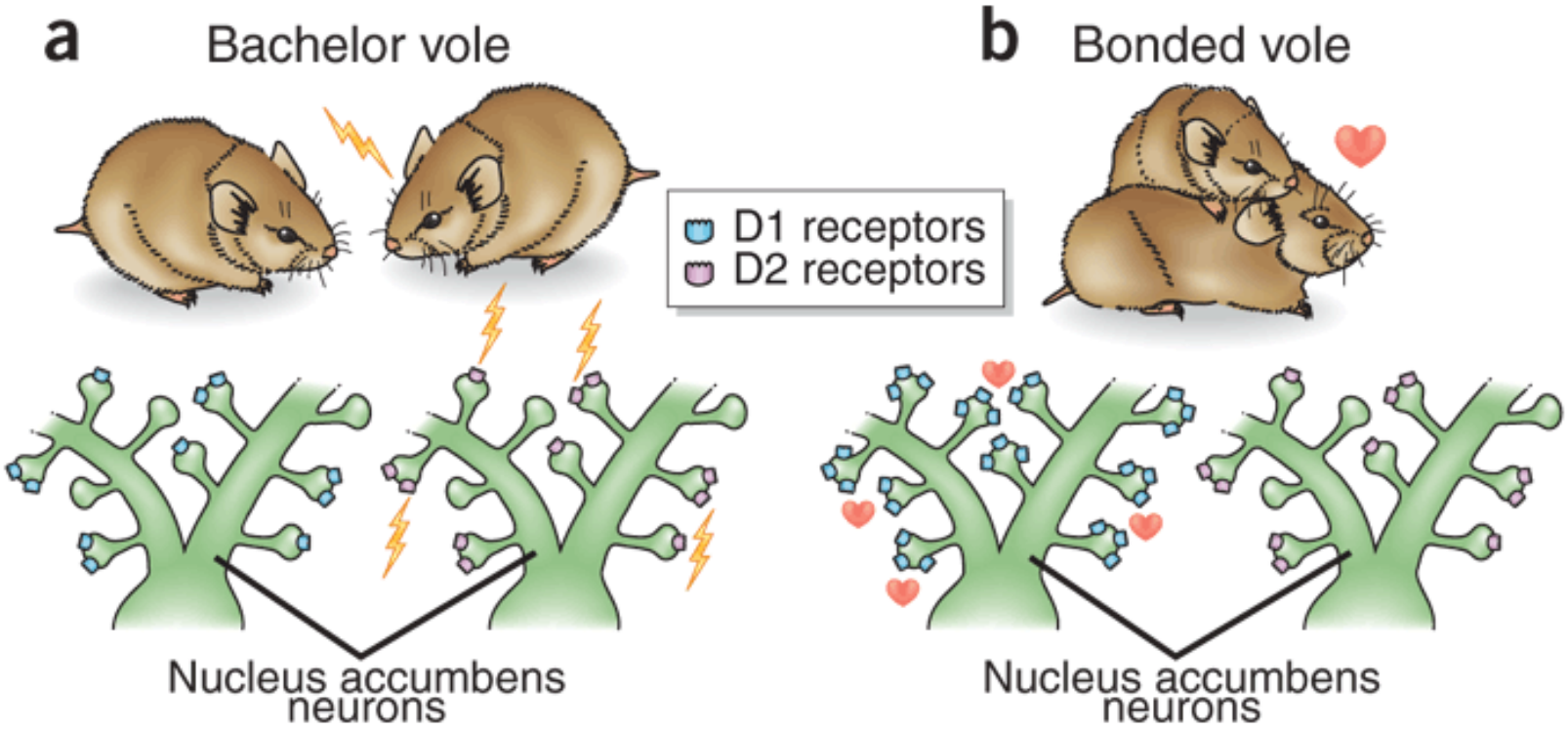
Dopamine is the neurotransmitter in the reward system



***NEUROSCIENCE, Fourth Edition,* Figure 6.11 (Part 1)**

Love

Dopamine and prairie voles

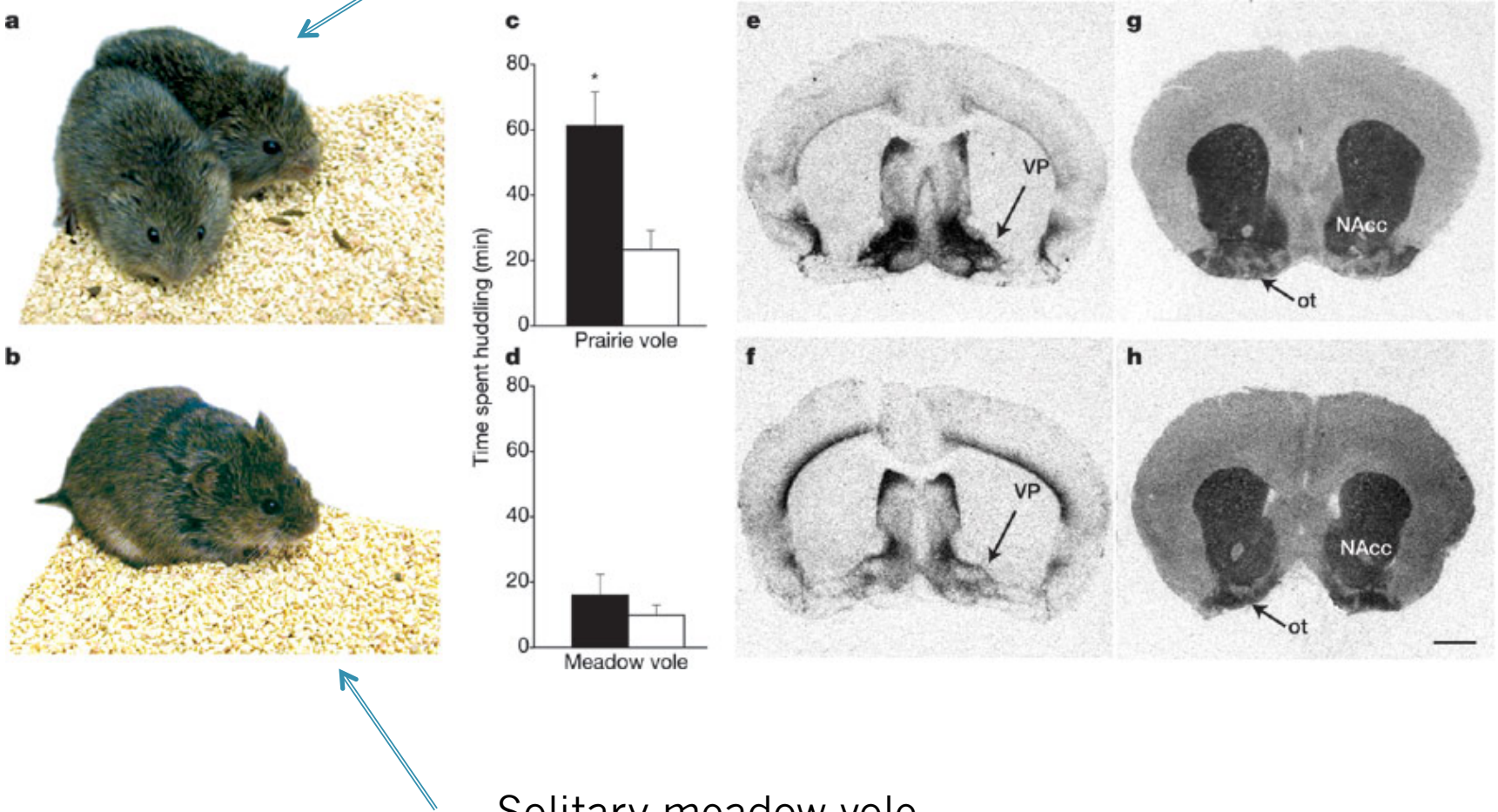


D1-like dopamine receptors (blue) are upregulated in the shell and core of the nucleus accumbens once a pair bond has formed. An established pair bond is maintained by selective aggression toward unfamiliar females, and D1 receptor antagonists block this behavior

Vasopressin and bonding

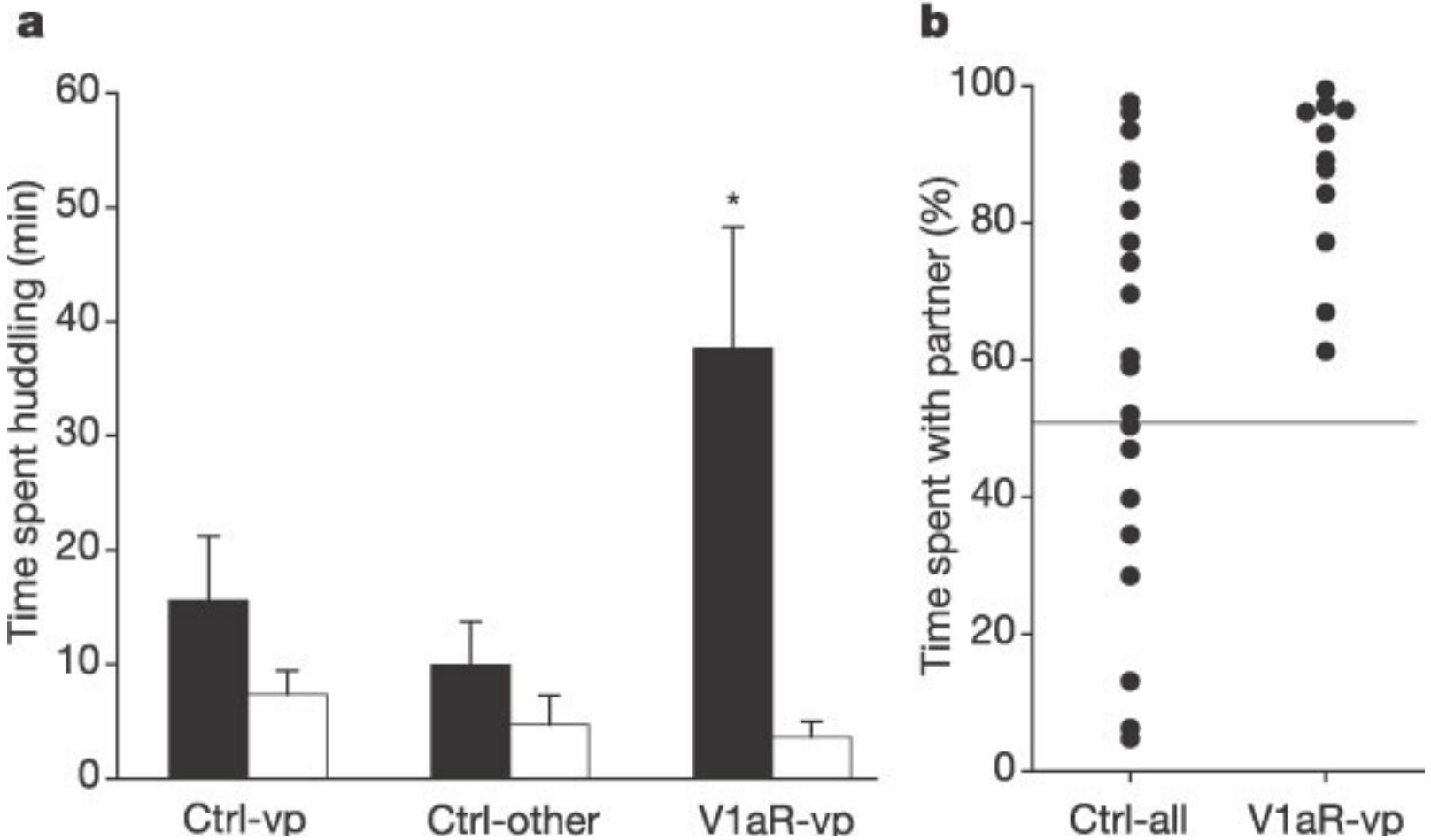
Romantic prairie vole

Vasopressin receptor levels



Solitary meadow vole

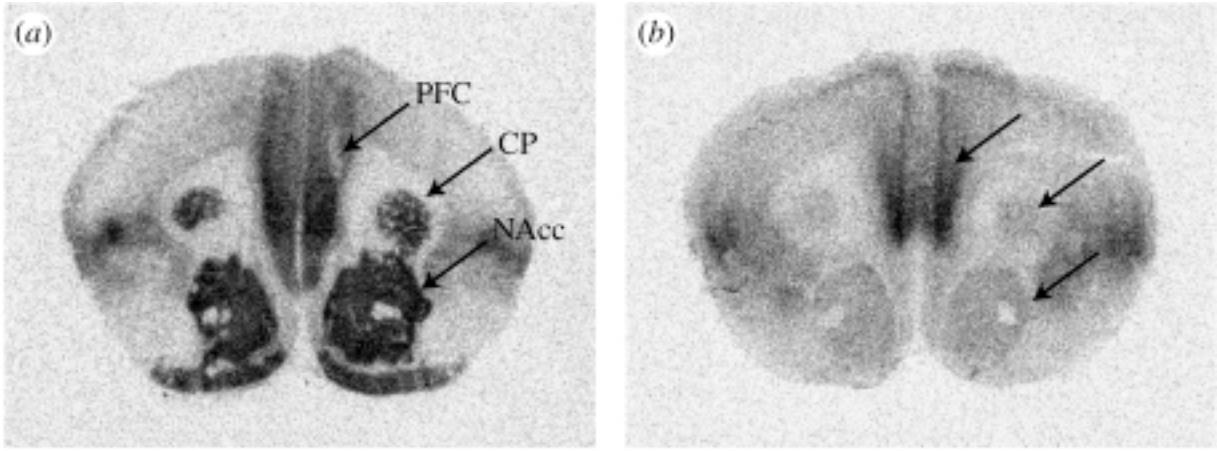
Overexpression of the vasopressin receptor in one region switched the meadow voles from solitary to monogamous



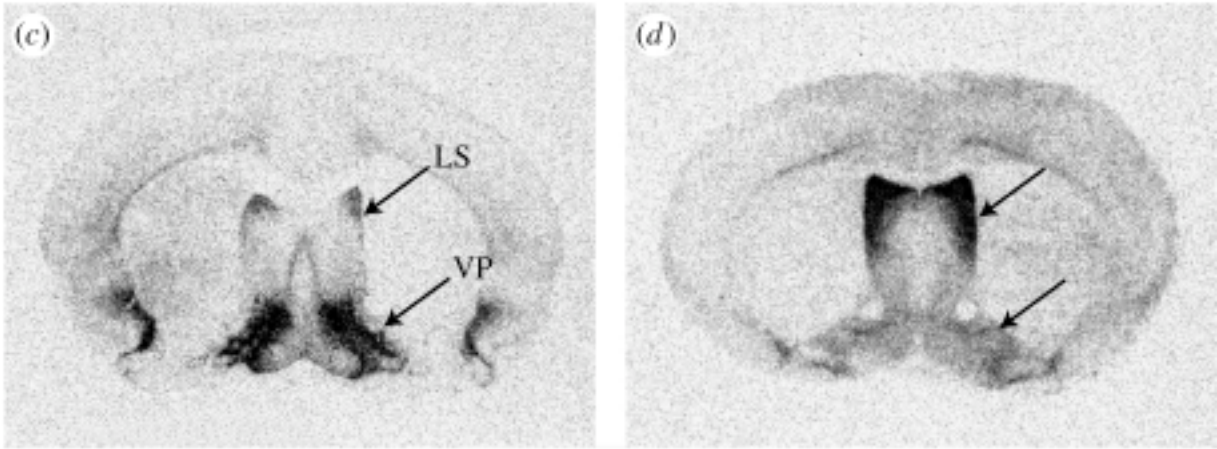
Oxytocin

Monogamous prairie vole Non-monog. Meadow vole

Oxytocin



Vasopressin



OXYTOCIN

Social contact induction ↑

Partner preference formation ↑

Pair and social bonding ↑

Aggression ↓ (♀ > ♂)

Relaxation and well-being ↑

Anxiety ↓

Stress ↓ (HPA axis regulation)

Glucocorticoid release ↓

Pulsatile release (e.g., necessary for birth)

↳ Muscular contractions during birth ↑

Reproduction, sexual behaviors ↑

Sensory processing ↑

Memory processes and functions ↑

Parasympathetic autonomic functions ↑

VASOPRESSIN

Positive social behaviors ↑

Partner selection ↑

Social attachment formation ↑

Territorial behaviors ↑ ('fight or flight'; ♂ > ♀)

'Attraction' ↑

Anxiety ↓

Blood pressure ↑

Modulating corticoid release

Component of the stress response

Oxytocin agonist, partial antagonist

Sexual behaviors ↑

Reward and limbic processing ↑

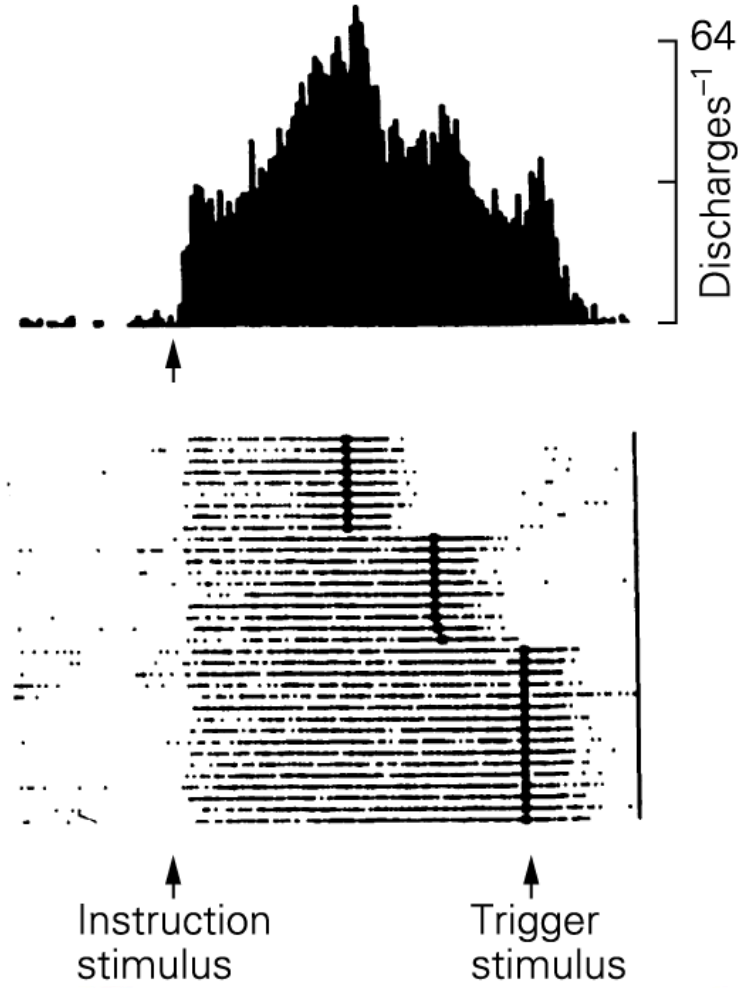
Attention, learning, memory ↑

Sympathetic and parasympathetic regulation ↑

How do we study the biological basis of higher-level cognitive functions?

How do we study the biological basis of higher-level cognitive functions?

Primates:
Electrode Recordings

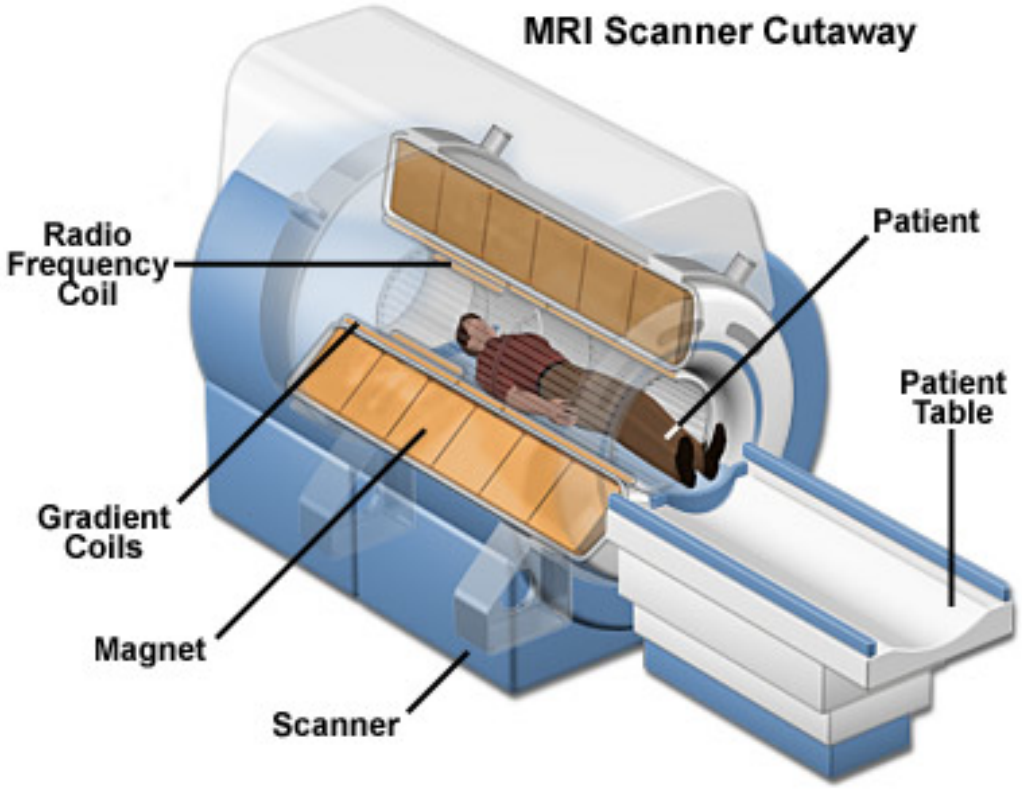


Humans:
fMRI

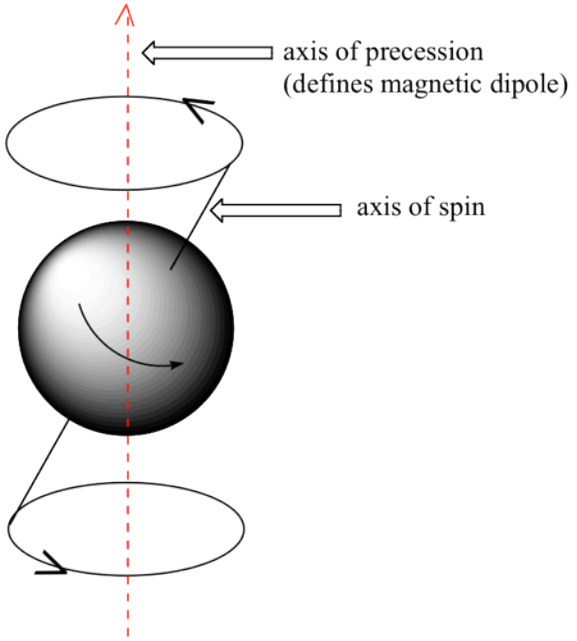
?

MRI

magnetic resonance imaging



proton spin



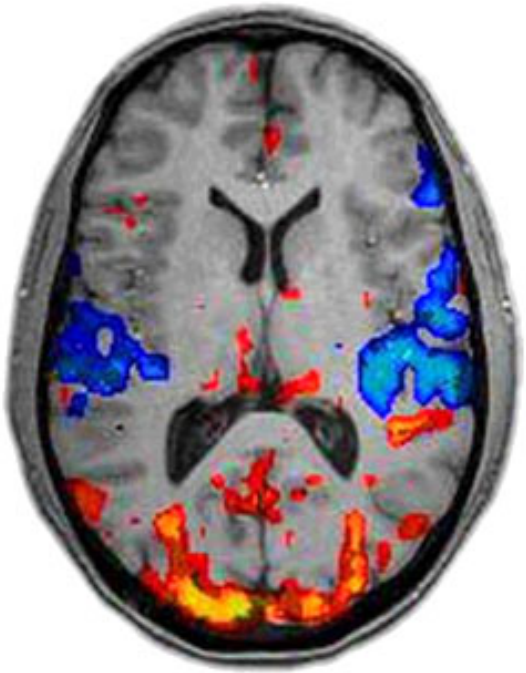
MRI Applet

fMRI

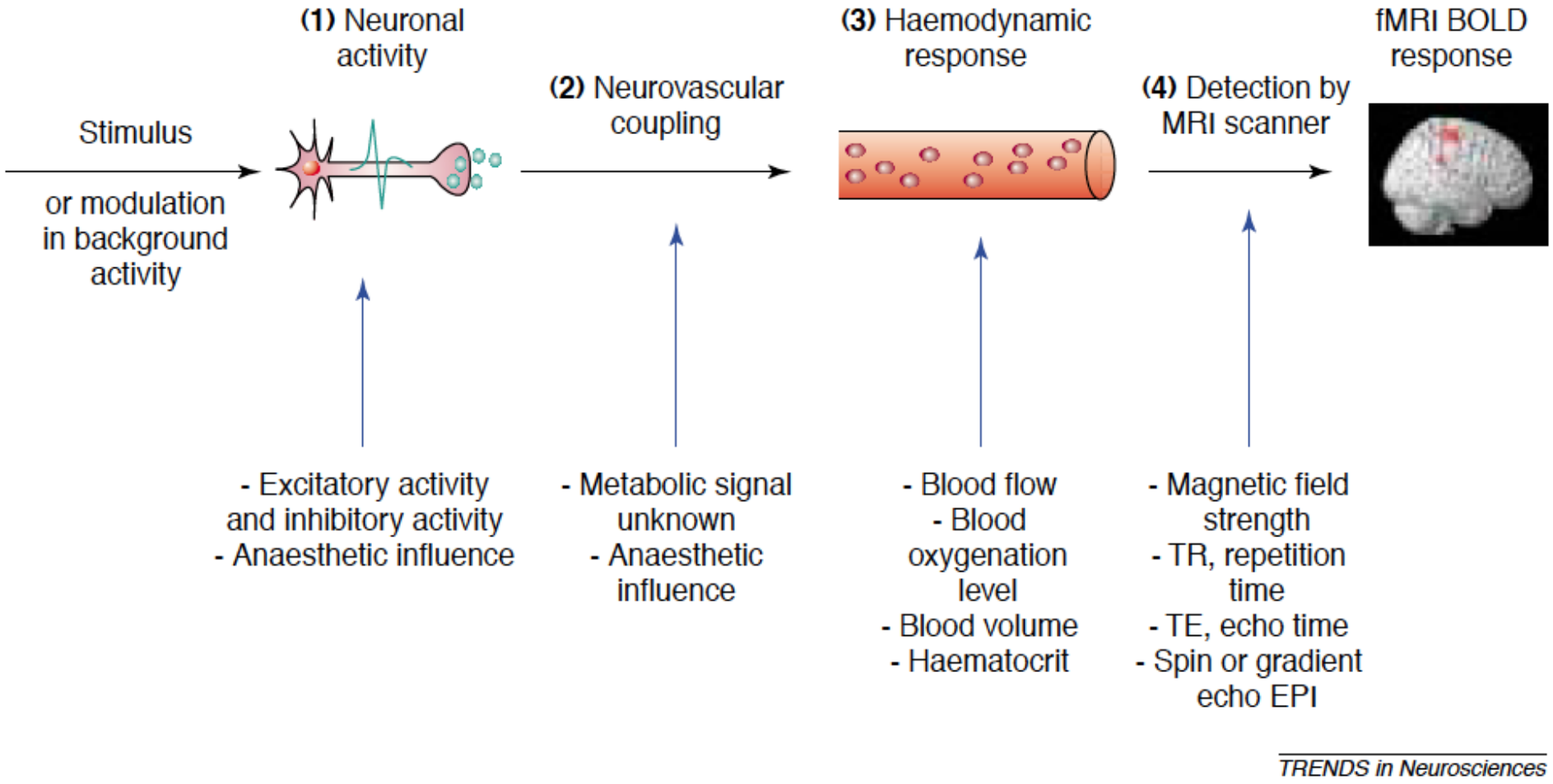
functional magnetic resonance imaging

oxyhemoglobin = diamagnetic
deoxyhemoglobin = paramagnetic

∴ well-oxygenated blood has a different signal than poorly-oxygenated blood



BOLD **b**lood **o**xygen **l**evel **d**ependent changes the ***functional*** in fMRI



Arthurs & Boniface, 2002

fMRI

strengths:

- can be used to study neural activity in humans (non-invasive)
- can be used to pinpoint (roughly) areas where complex processing occur

weaknesses:

- relatively low resolution (millimeters)
- unclear how BOLD correlates to neural activity
- slow (blood signal is relatively slow)

The Brain and Social Behavior

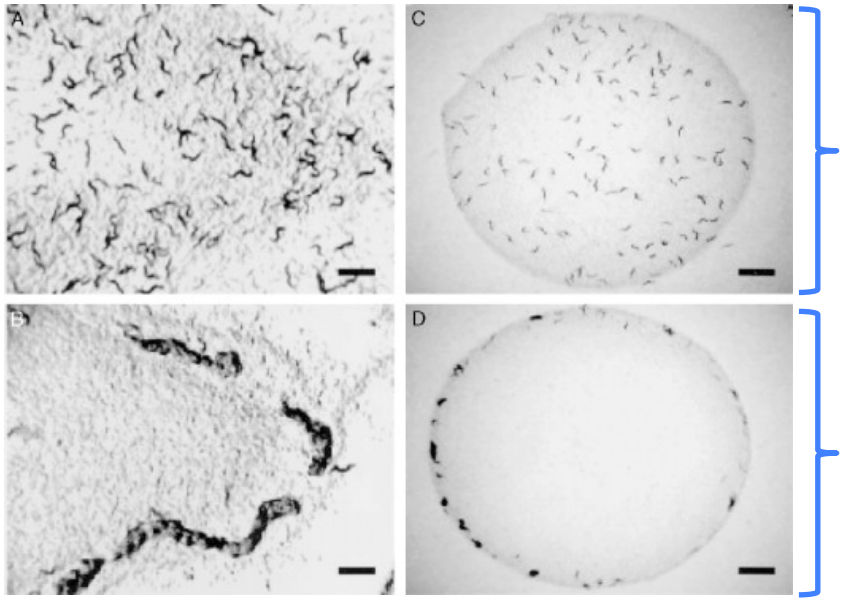
Social behavior:

Any behavior on the part of an organism stimulated by, or acting upon, another member of the same species (conspecifics).

Social Behavior in Simple Organisms

Worms *C. elegans* (nematode) → 302 neurons

adult worm

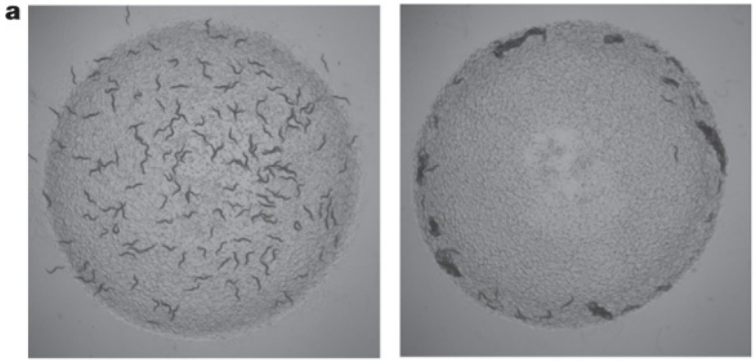


solitary feeding

social feeding
(bordering & aggregation)

Differences in social behavior linked to a single gene – ***npr-1***

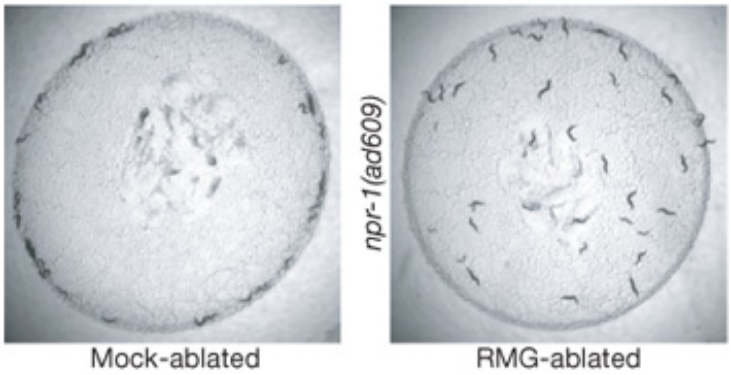
low activity or defective *npr-1* = social feeders
high activity *npr-1* = solitary feeders

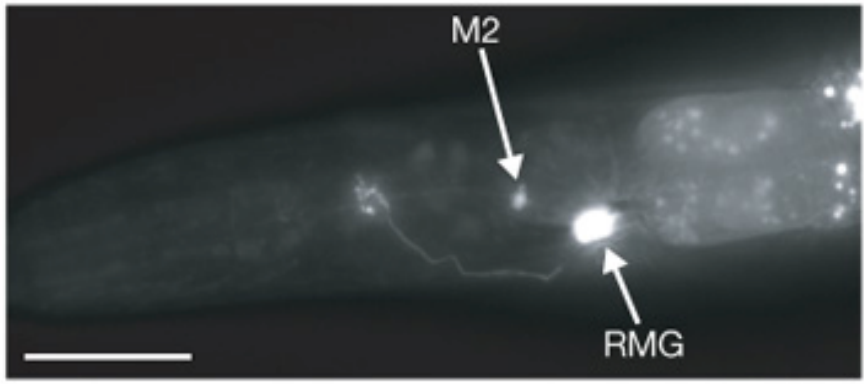


defective npr-1

restoration of npr-1 ←

Killing “RMG” neurons abolishes social behavior

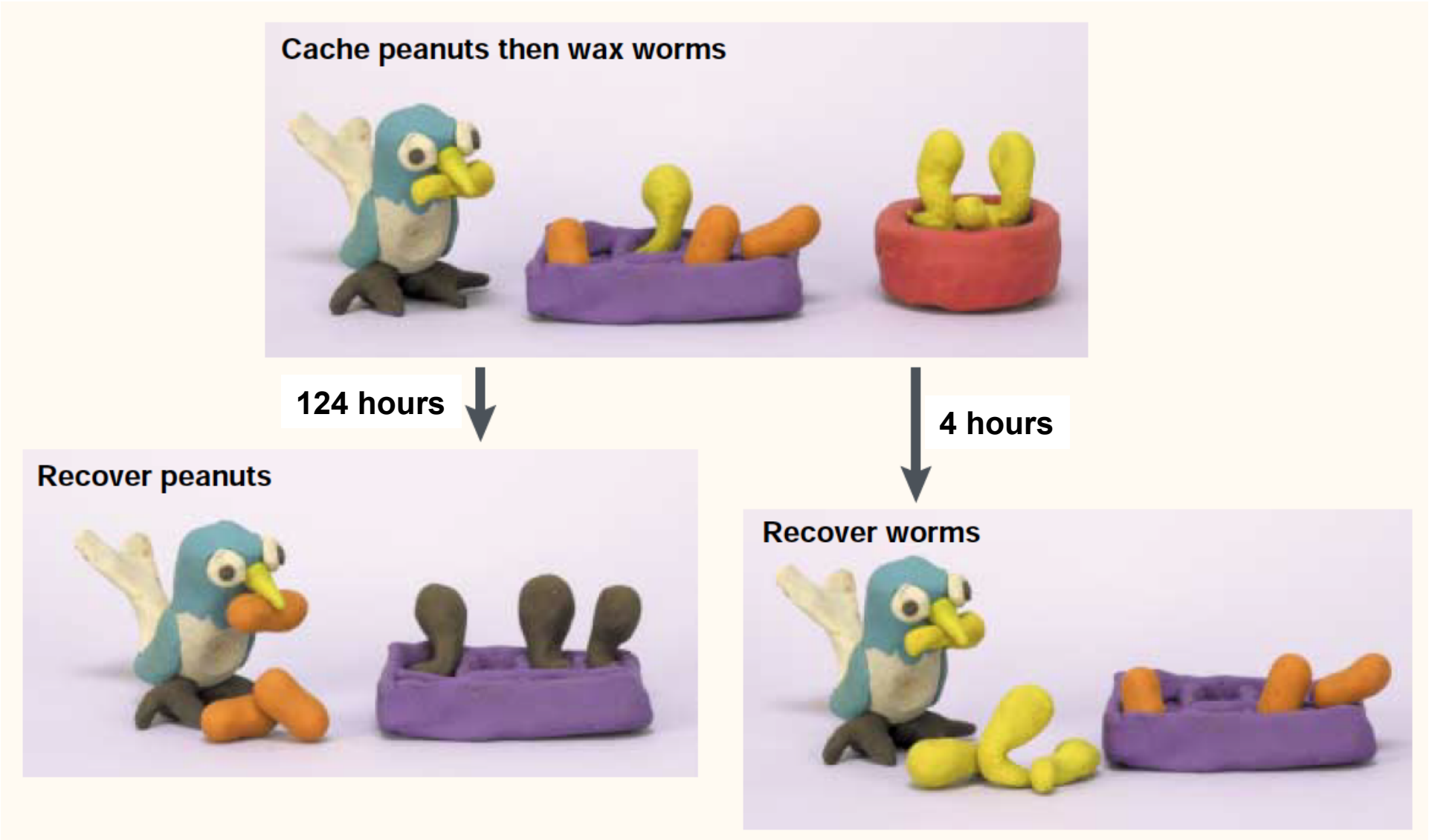




Social Cognition in Corvid Birds

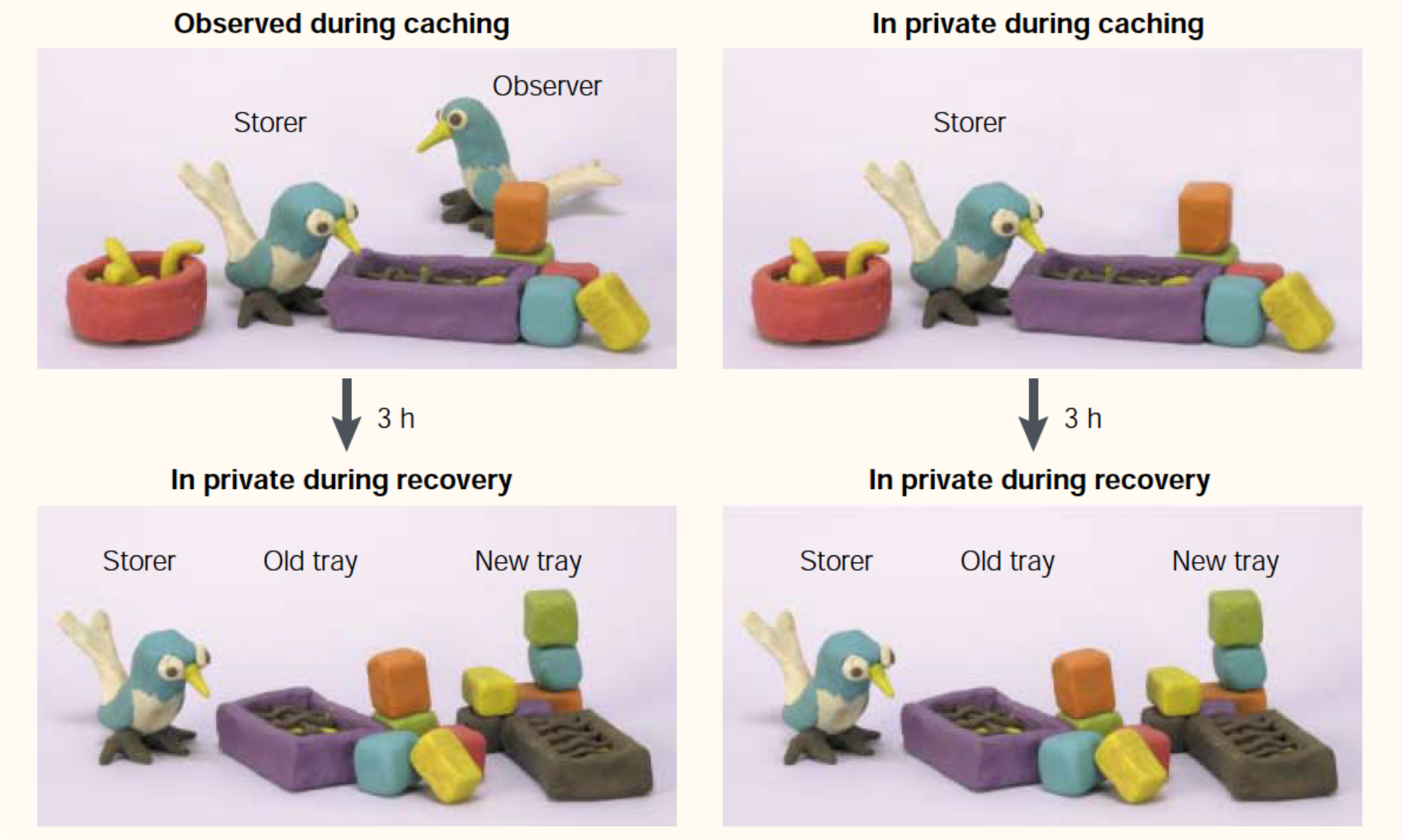
Western Scrub Jay (*Aphelocoma californica*)

Corvid birds have a sense of time

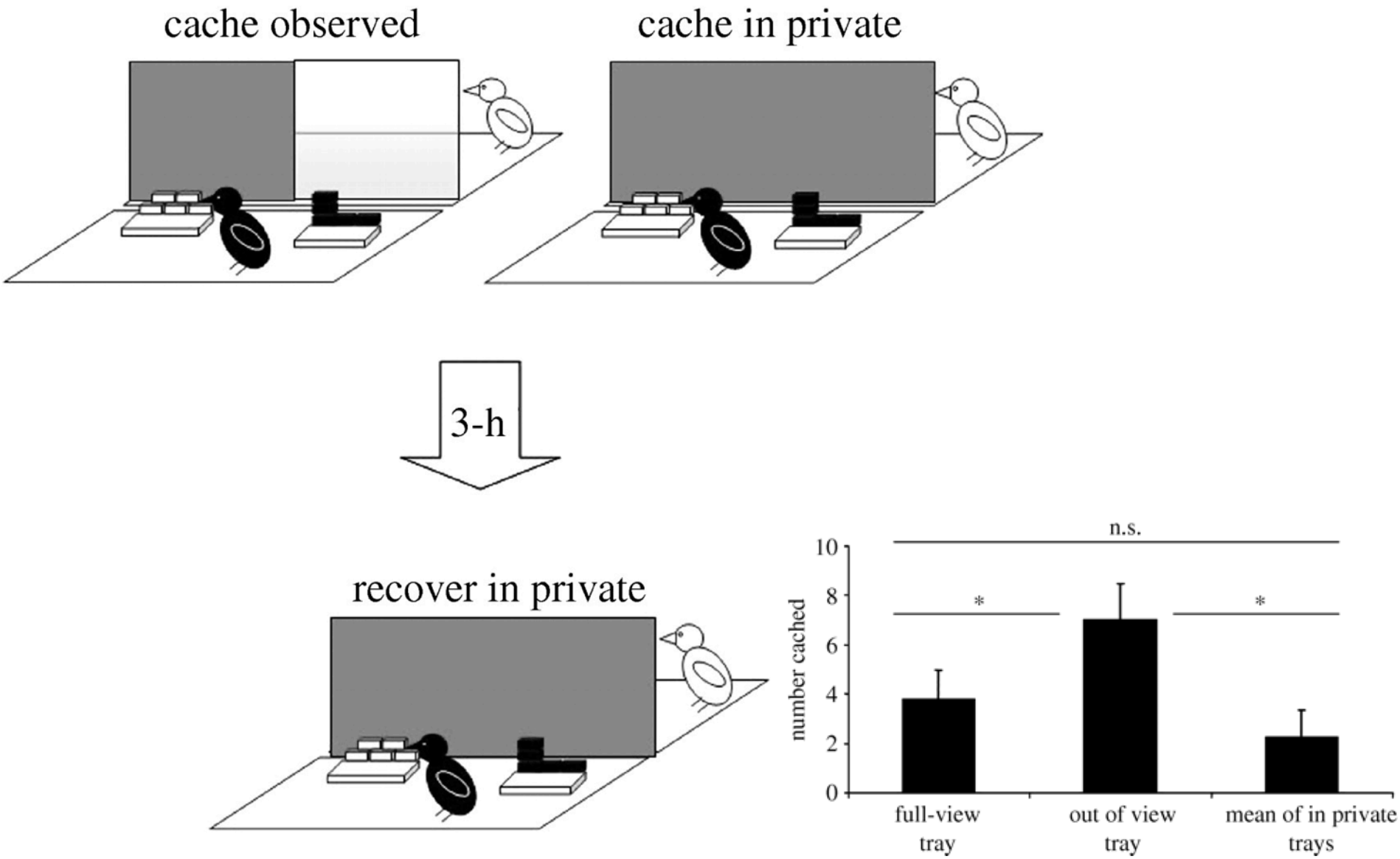


Clayton, Bussey, & Dickinson 2013

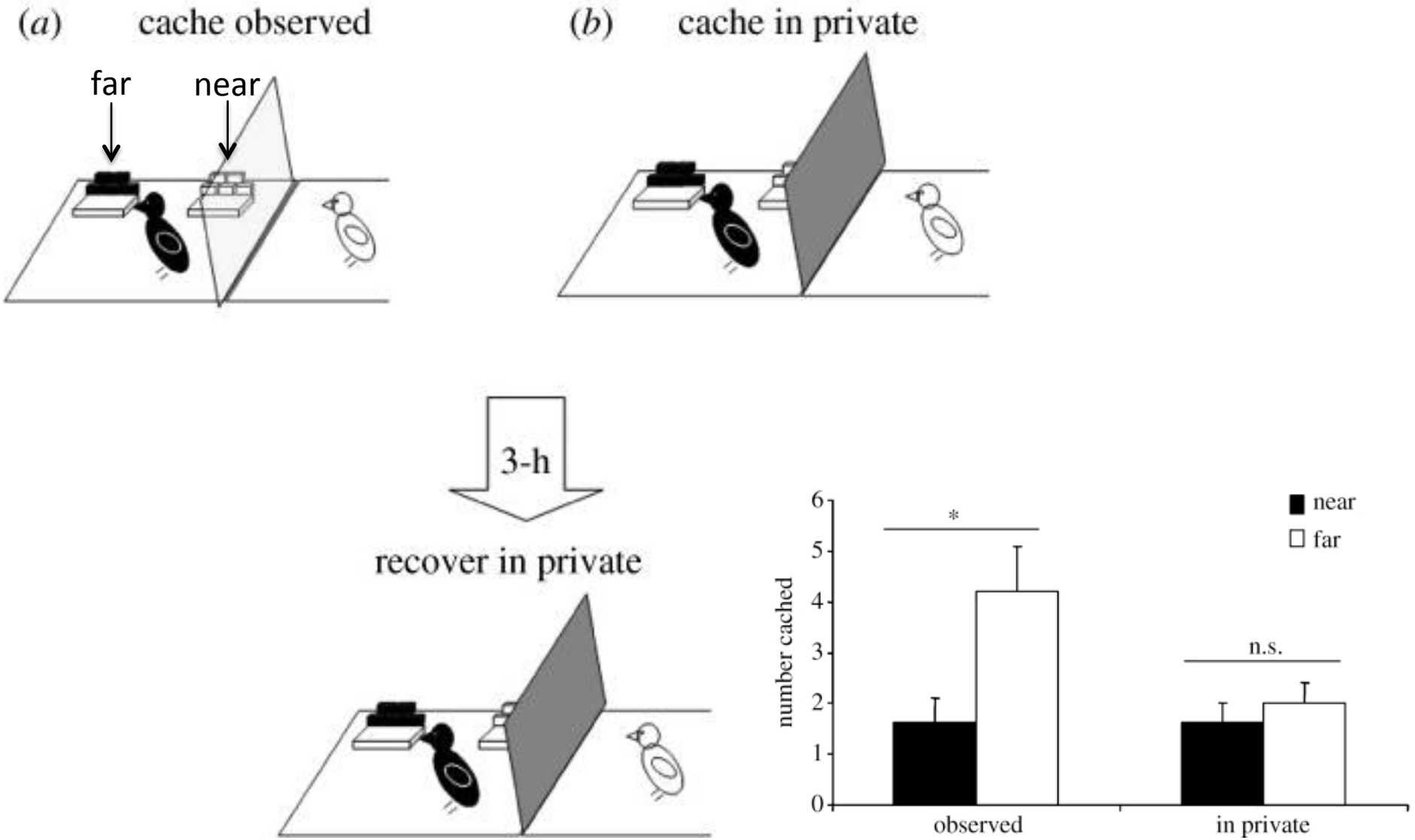
Corvids are aware of other birds and their ‘observations’ or ‘intentions’



Clayton, Bussey, & Dickinson 2013

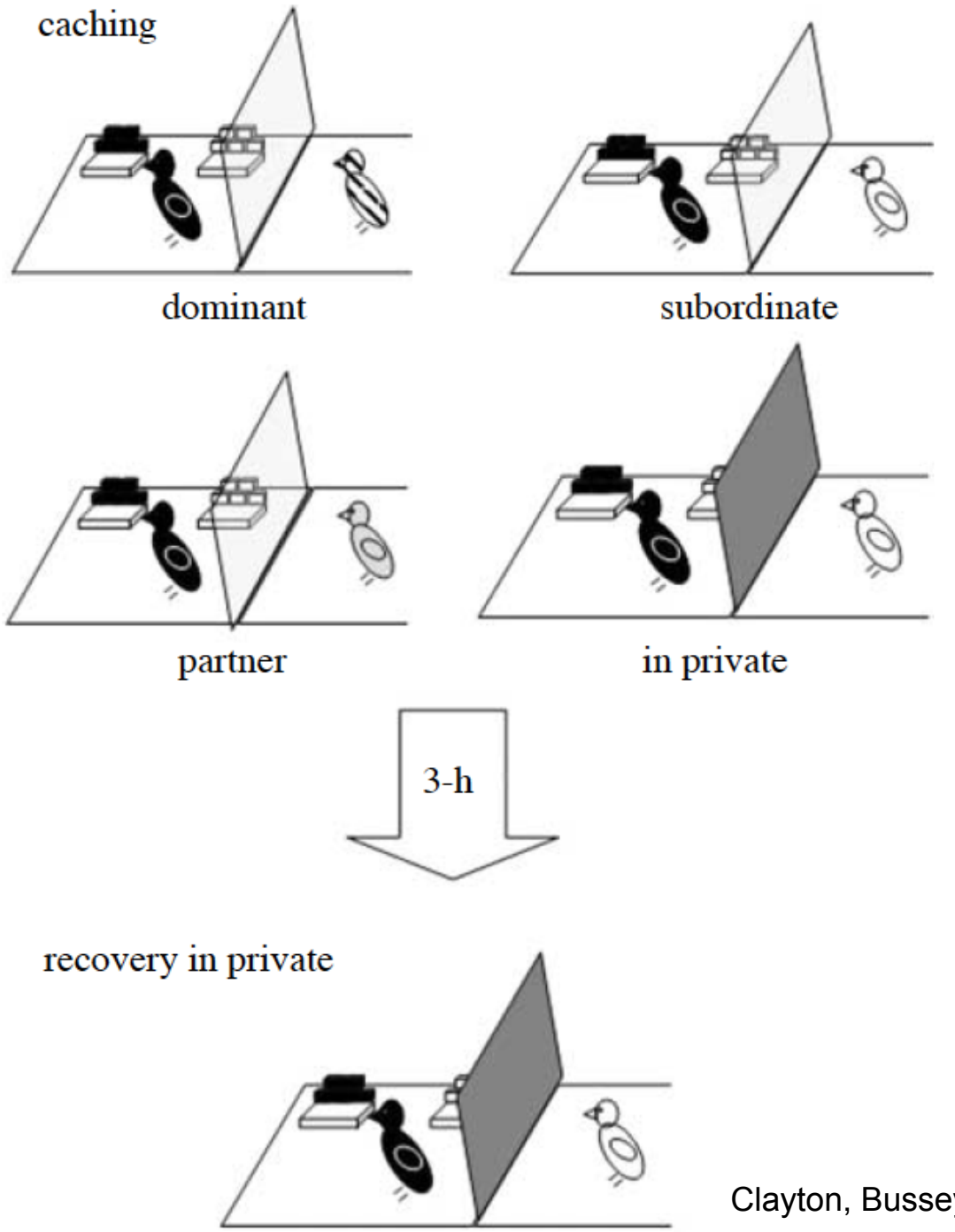


Clayton, Bussey, & Dickinson 2013

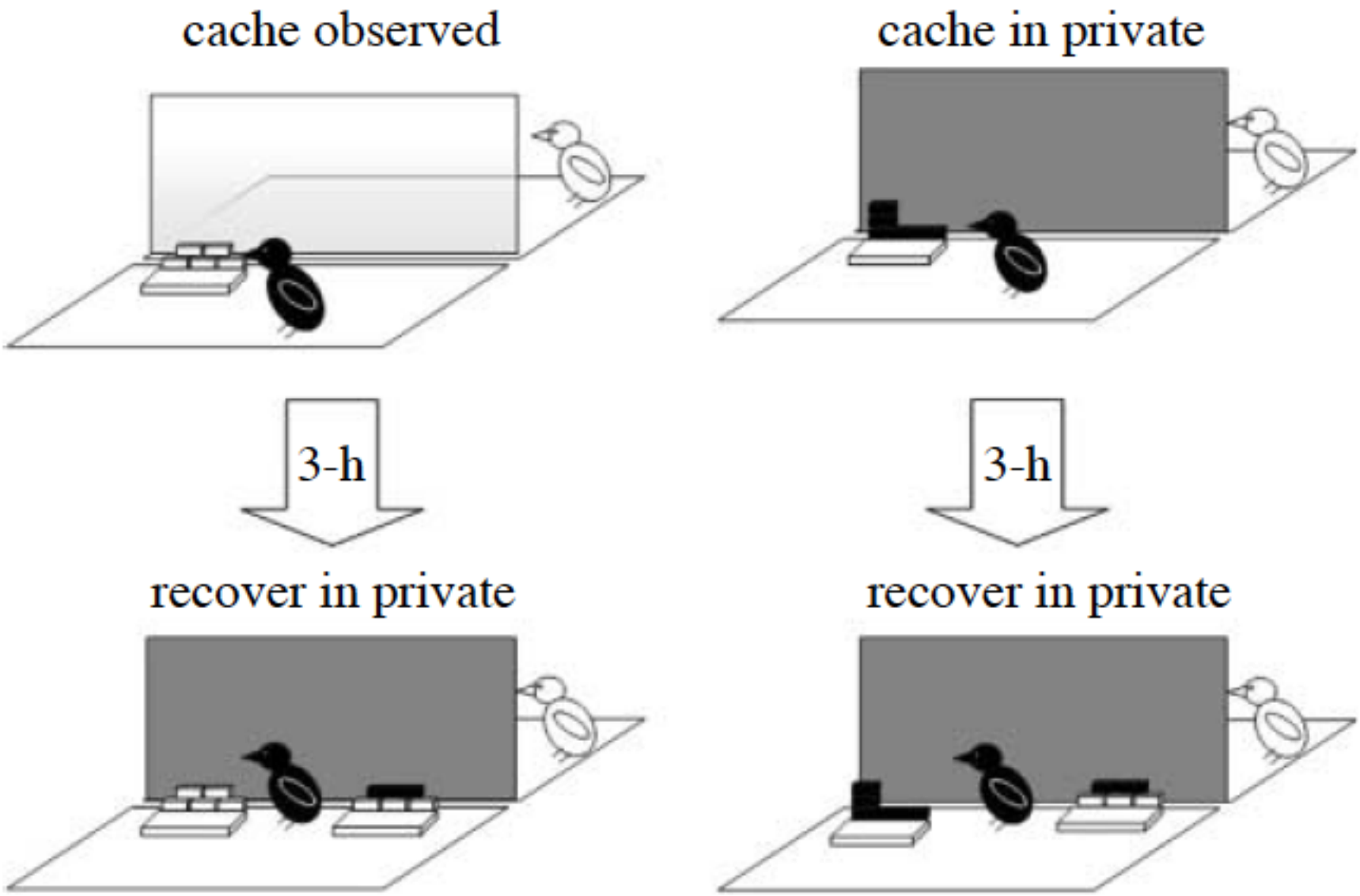


Clayton, Bussey, & Dickinson 2013

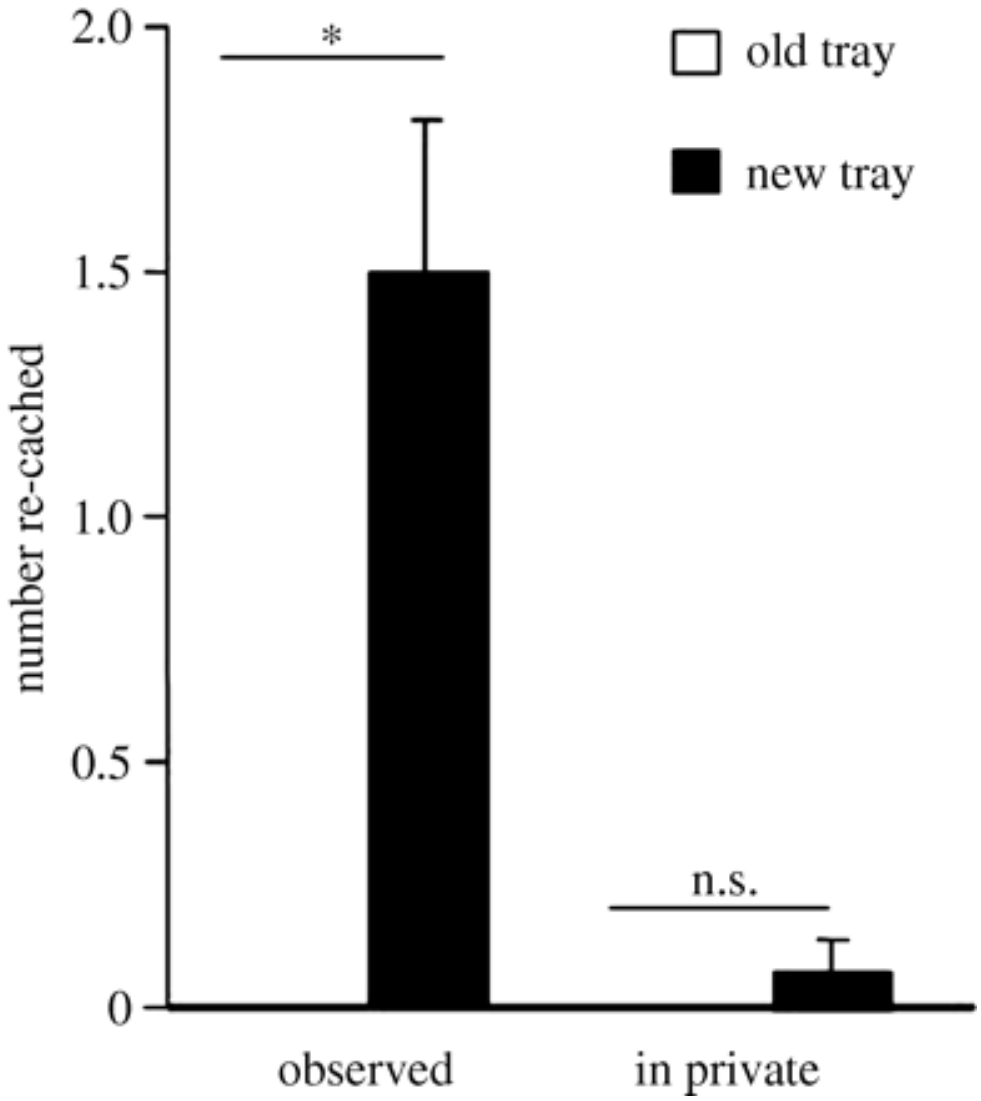
Attention to social heirarchy



Clayton, Bussey, & Dickinson 2013



Clayton, Bussey, & Dickinson 2013



Clayton, Bussey, & Dickinson 2013

Fairness, Cooperation, & Sharing

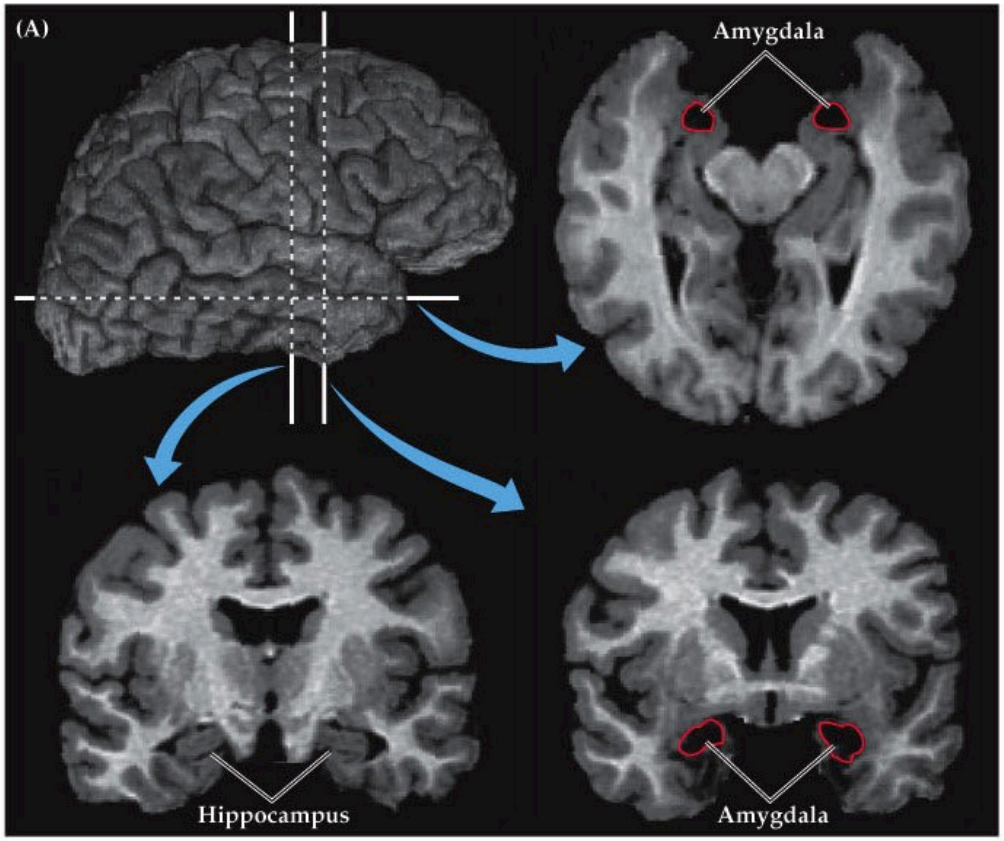
Dogs were trained to perform a simple trick, “give paw.” The dogs were normally happy to repeatedly give the paw, whether they got a reward or not. **But,** that changed if they saw that another dog was being rewarded with a piece of food, while they received nothing.

Monkeys had to hand a small rock to researchers to get a piece of food in return. Monkeys were happy to do this to get a piece of cucumber. But the monkeys would refuse to continue to help if they saw that another monkey was getting a more delicious reward, a grape, for doing the same job.

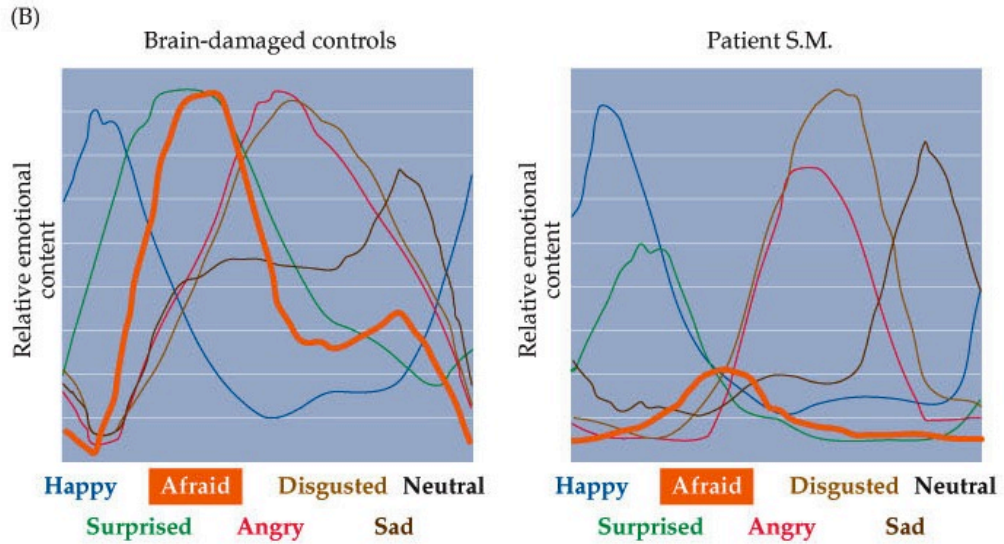
Nell Greenfieldboyce, npr.org

Patient S.M.

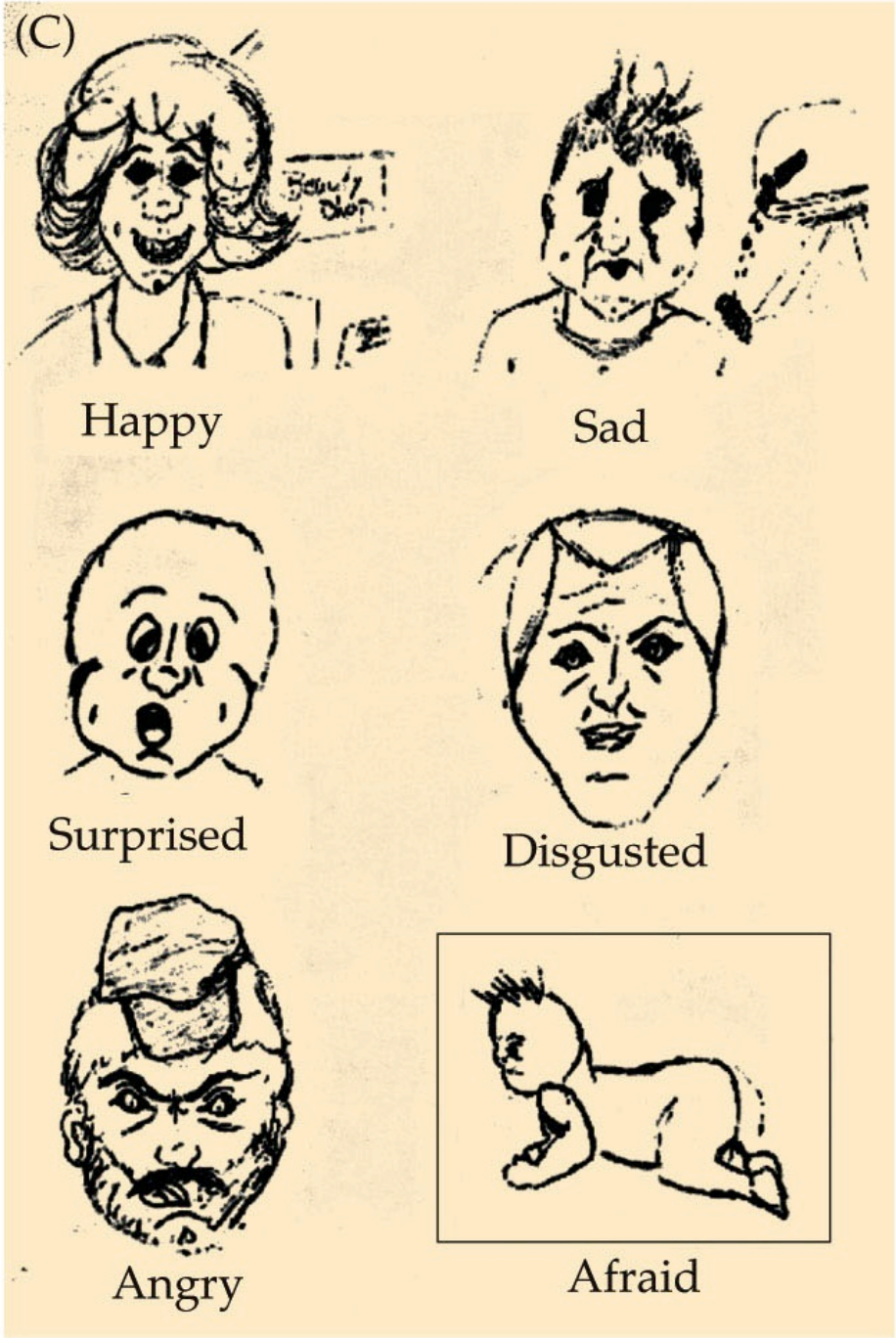
- Rare disease: Urbach-Wiethe
- Bilateral calcification/atrophy of temporal lobes
- Extensive damage of amygalas



Unable to recognize fear among facial expressions



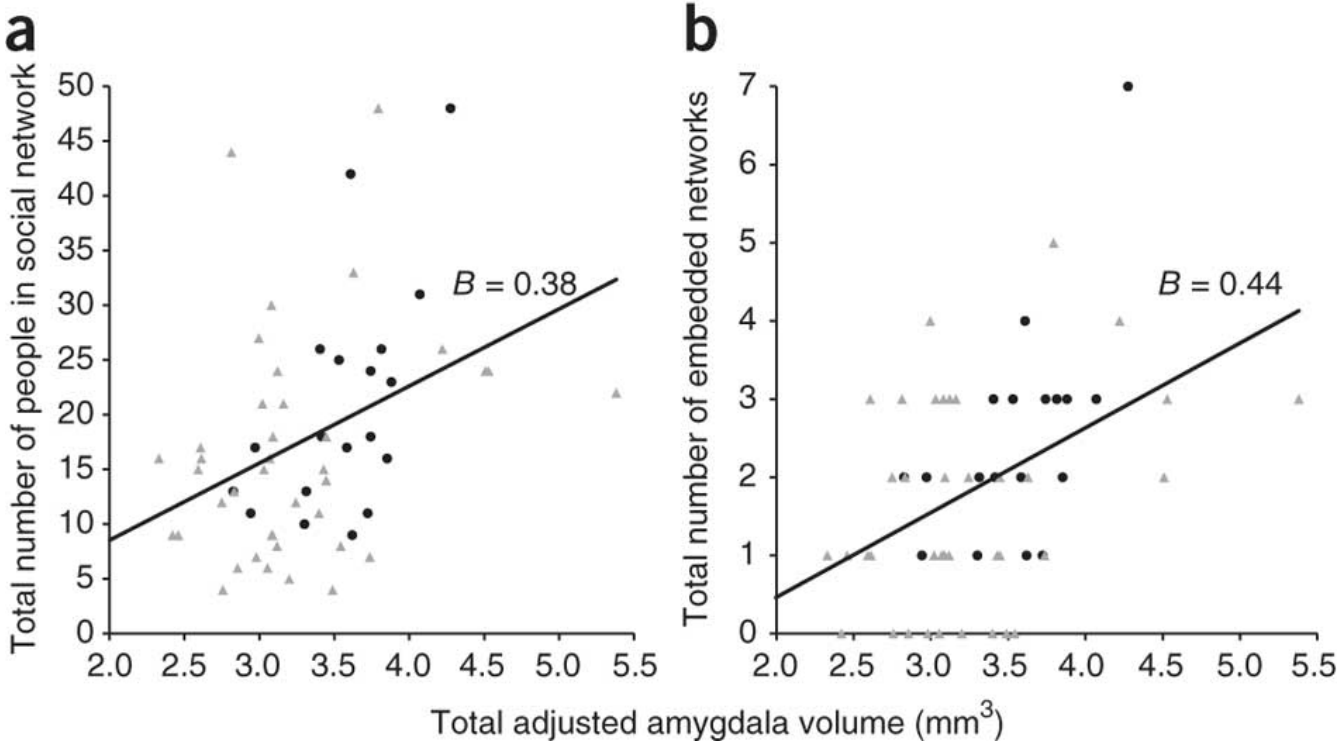
Drawings by S.M.

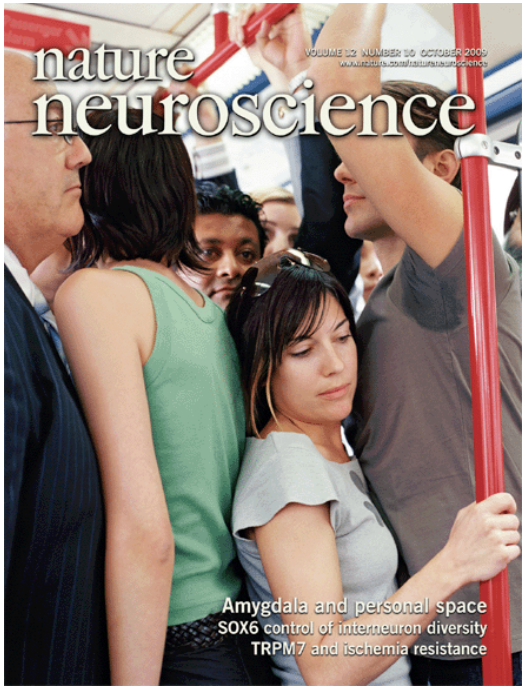


nature neuroscience

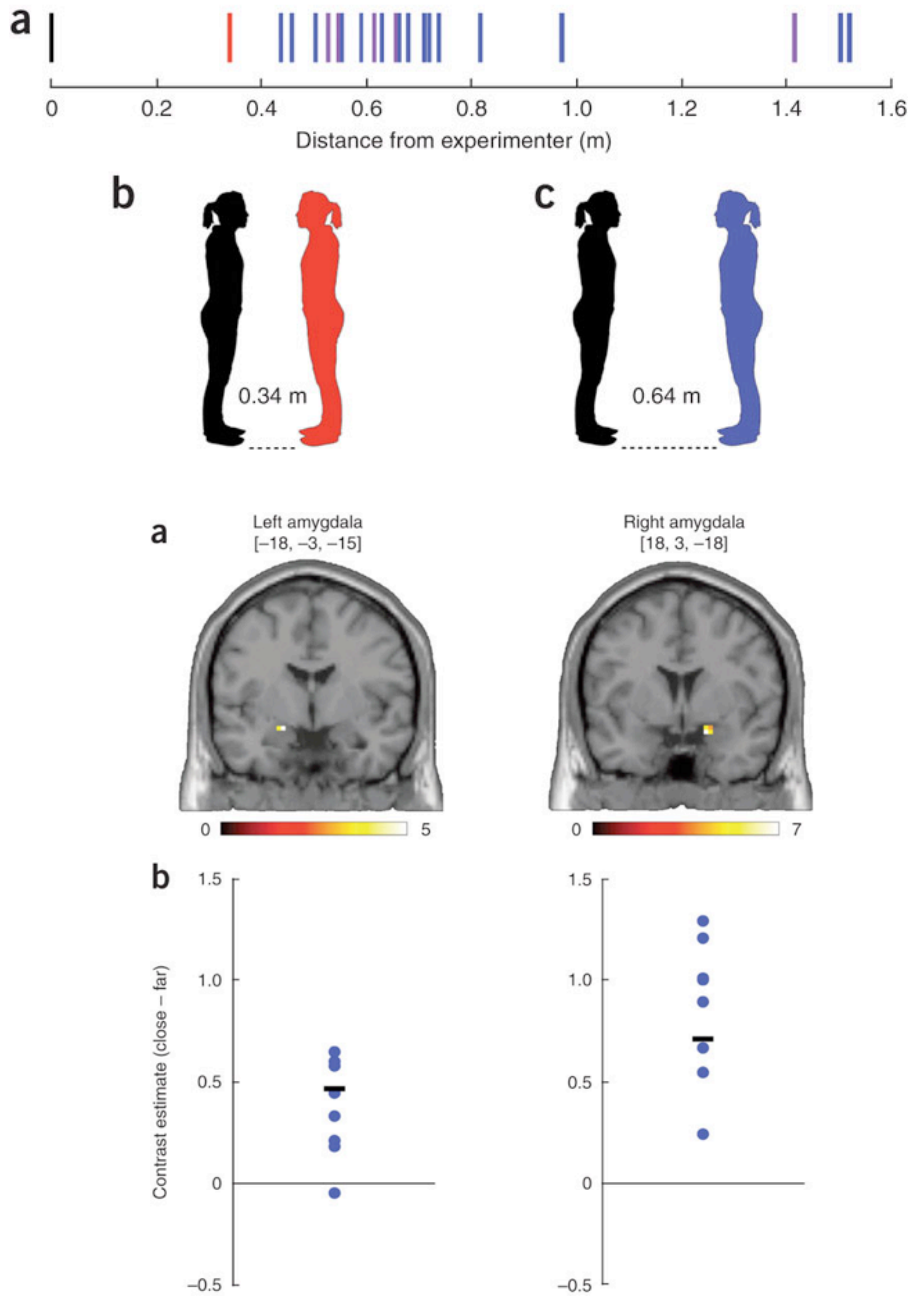
Amygdala volume and social network size in humans

Kevin C Bickart[1], Christopher I Wright[2,3], Rebecca J Dautoff[2,3], Bradford C Dickerson[2–4] & Lisa Feldman Barrett[2,3,5]



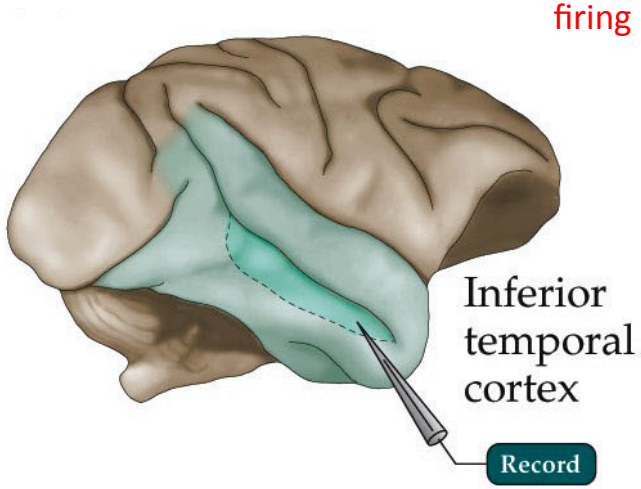


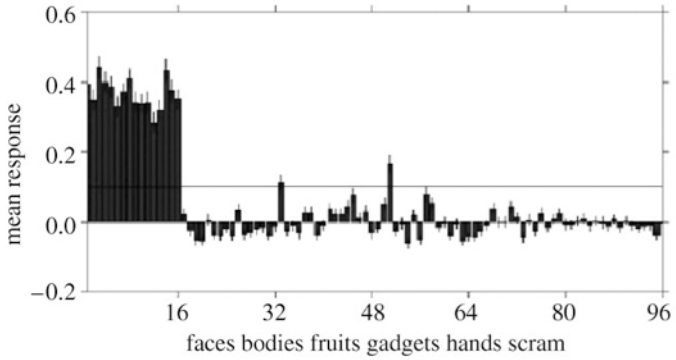
Kennedy *et al.* 2009



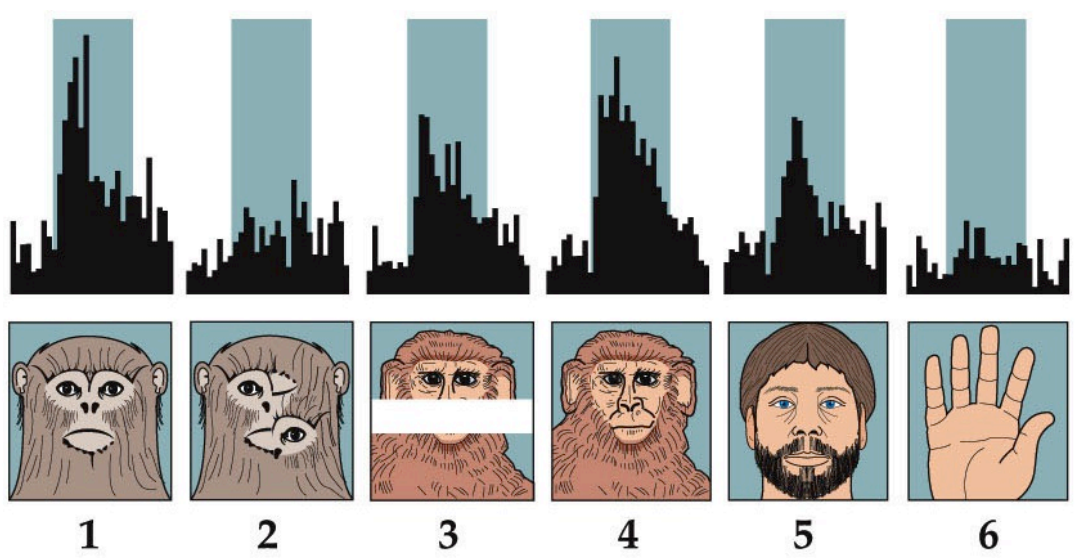
thingswithfaces.net

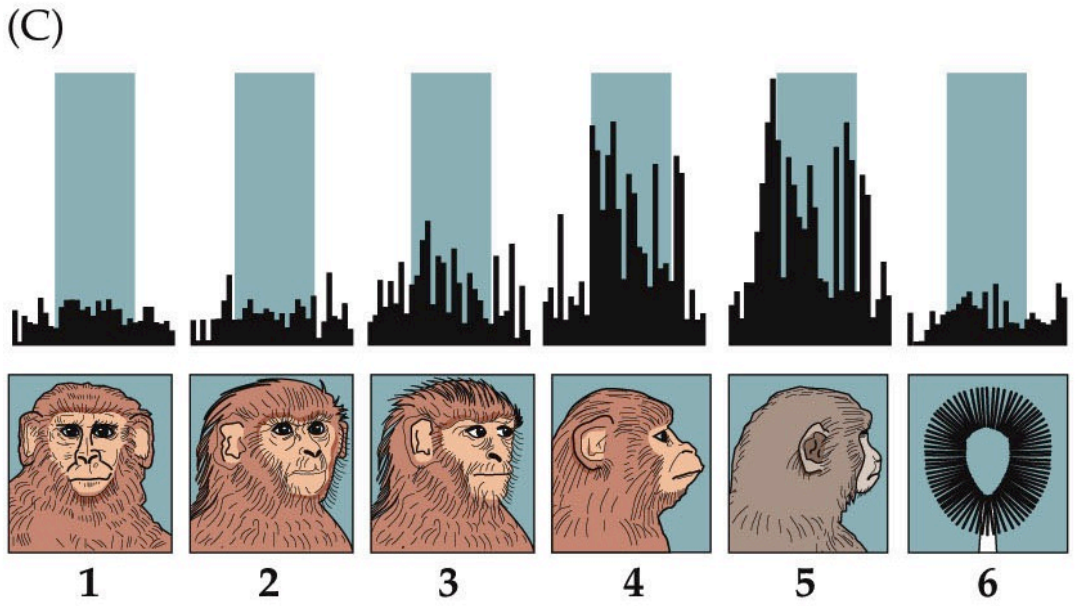
An area of primate cortex is “tuned” to faces

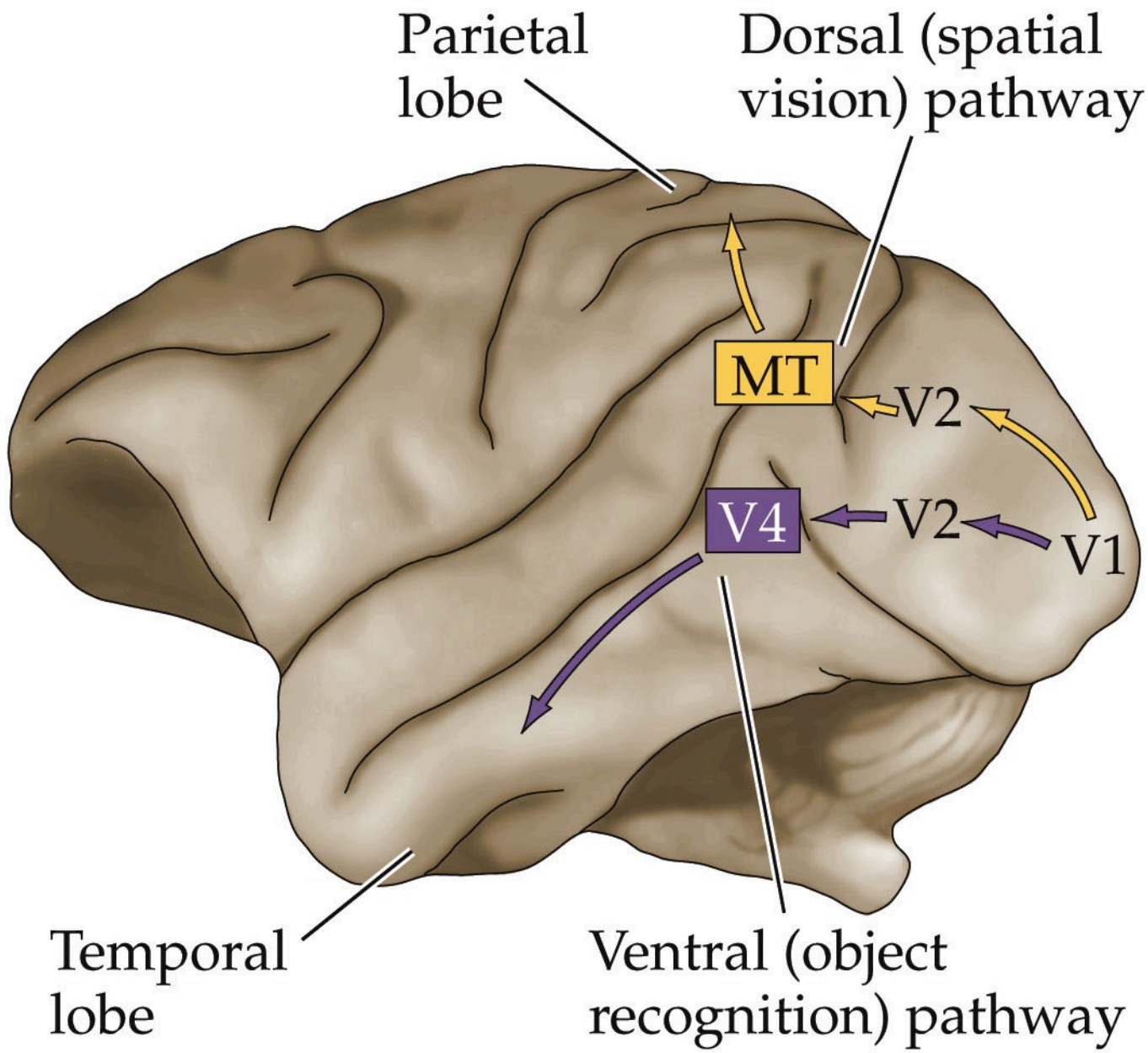




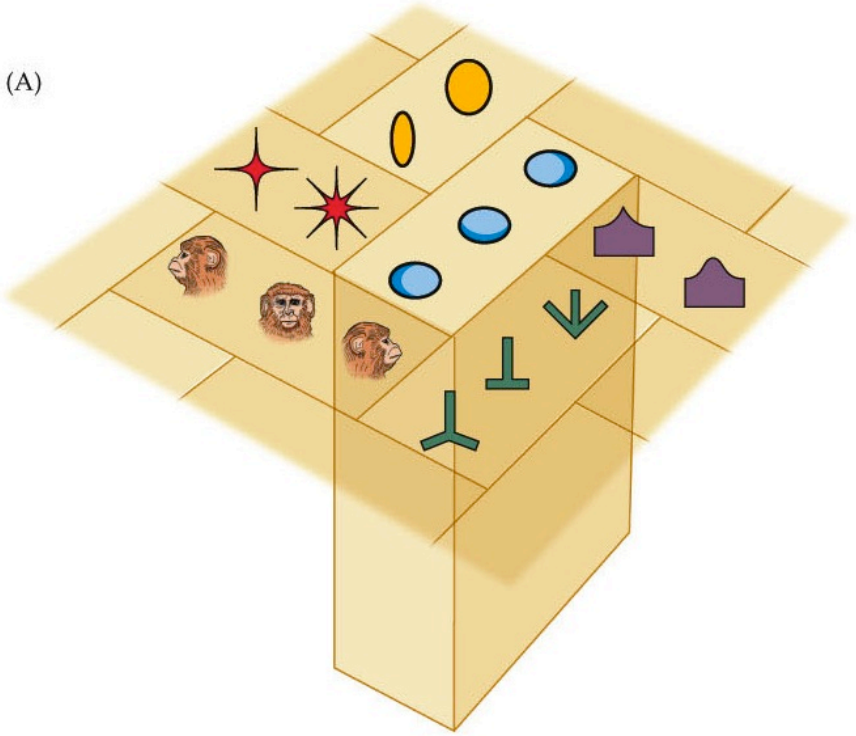
Tsao *et al.*

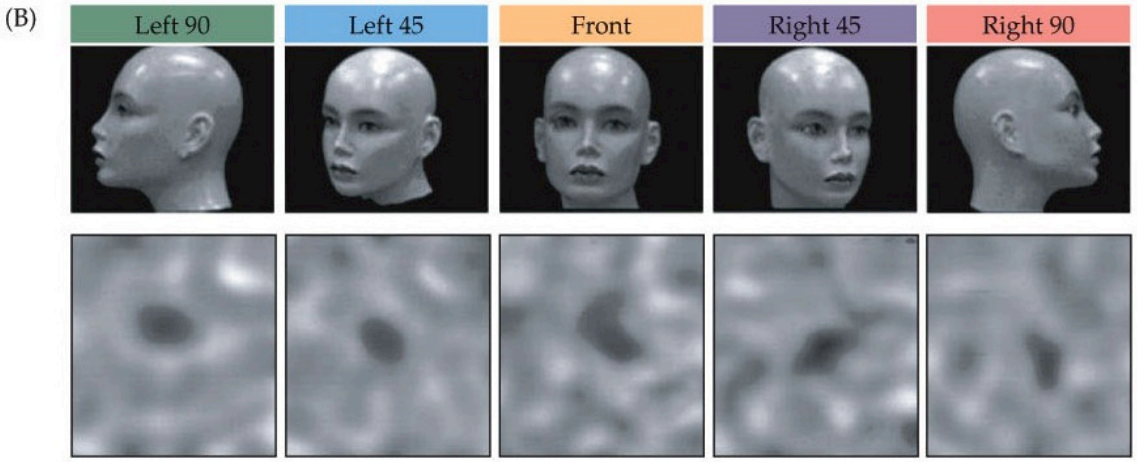


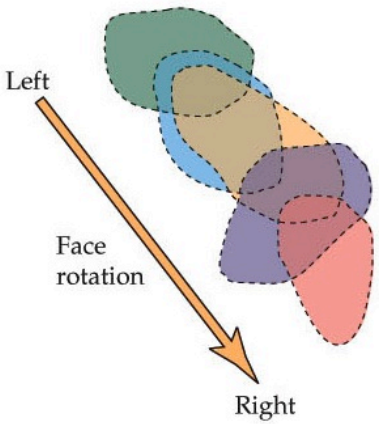



Parietal lobe
Dorsal (spatial vision) pathway
MT
V2
V4
V2
V1
Temporal lobe
Ventral (object recognition) pathway

Inferior Temporal Cortex the visual "what" pathway

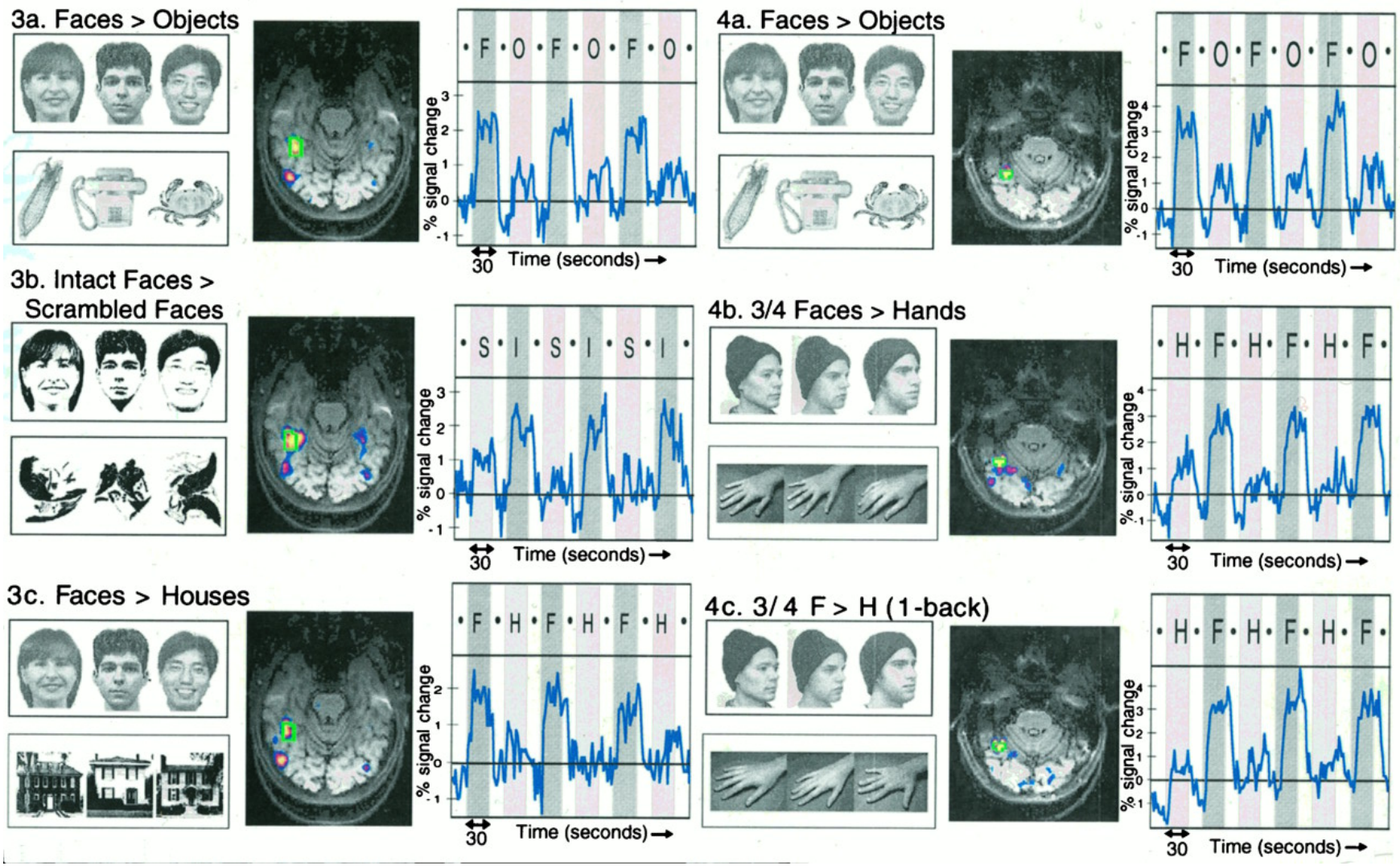




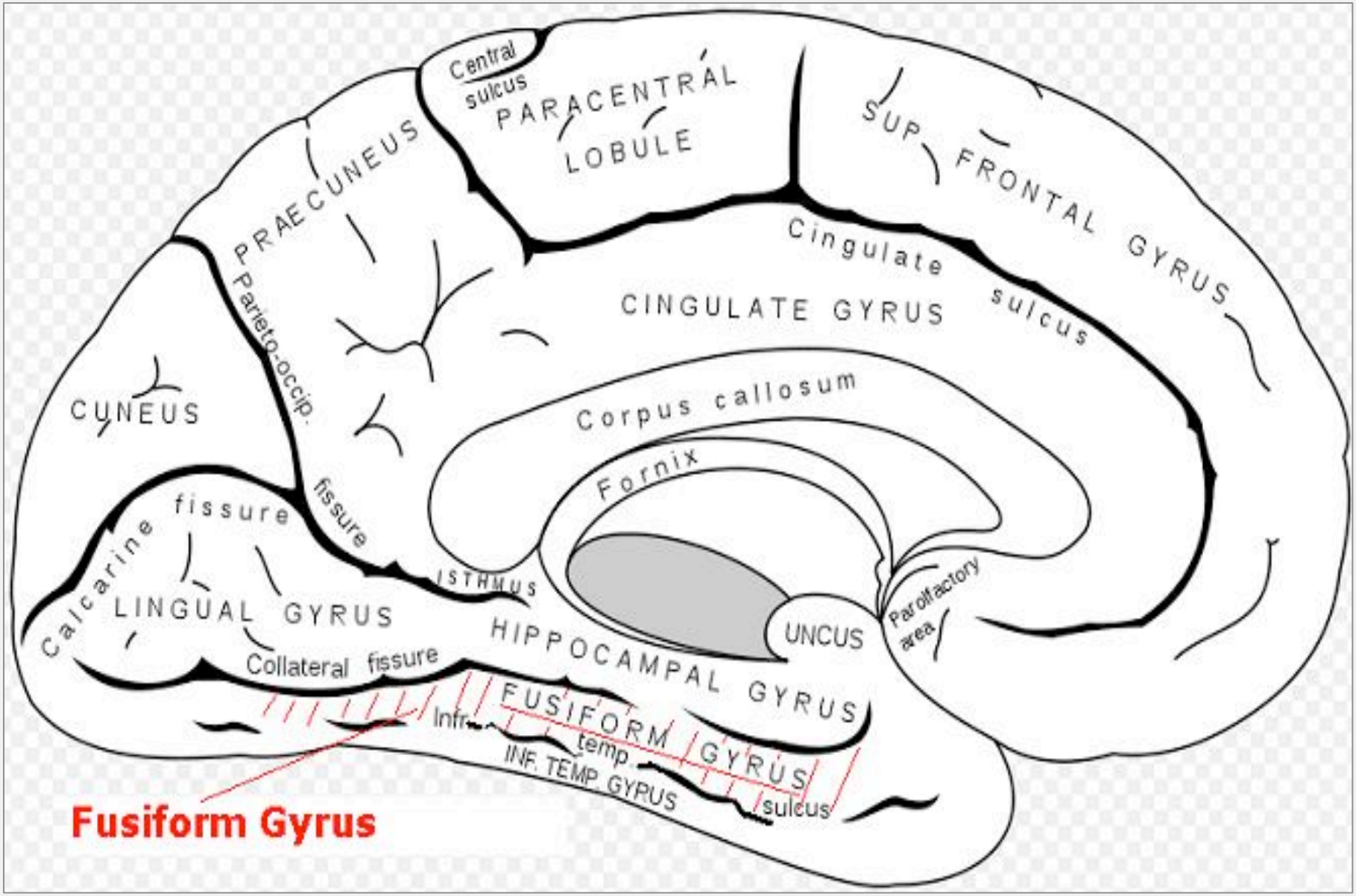


Fusiform face area

a region selectively involved in perception of faces

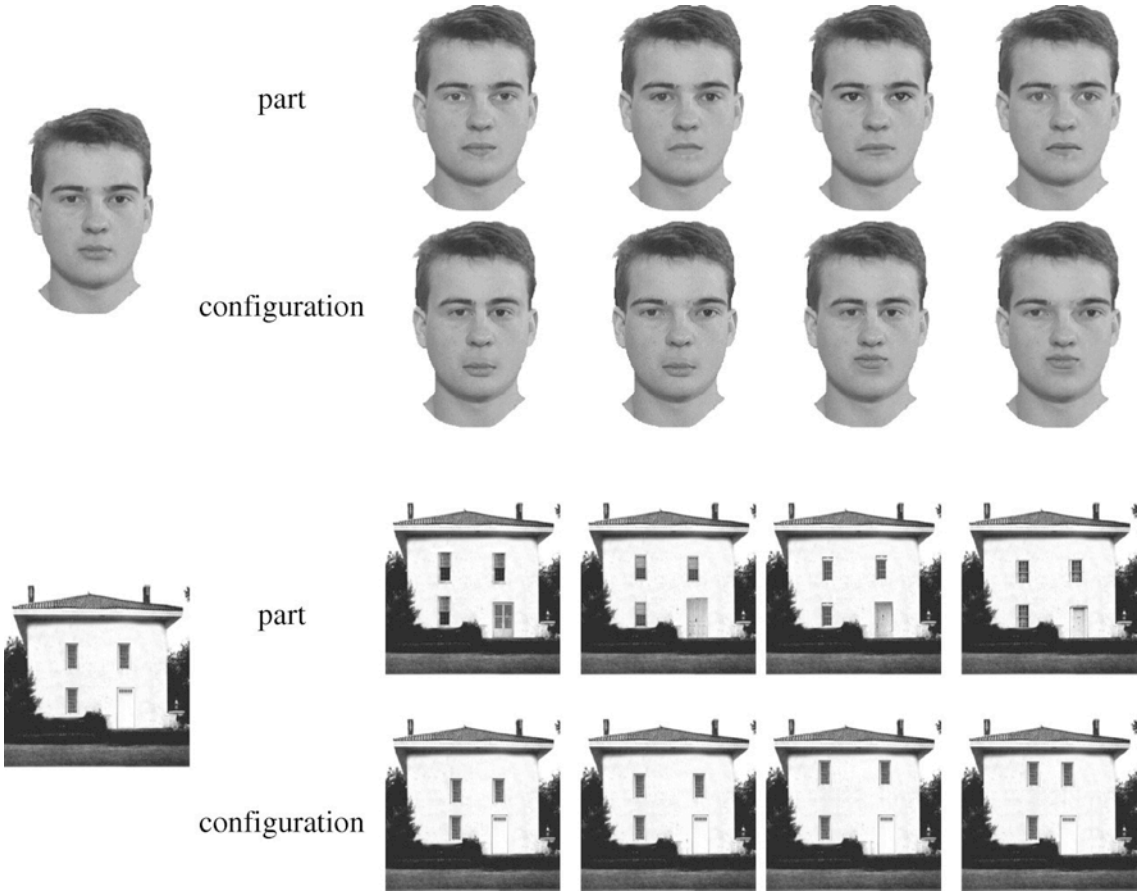


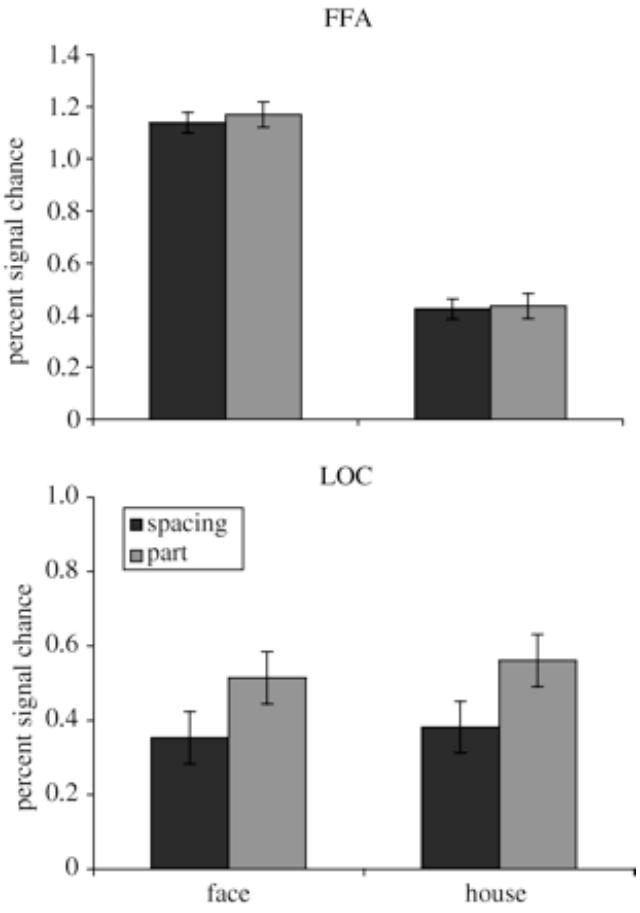
Kanwisher *et al.* 1997


Central sulcus
PARACENTRAL LOBULE
SUP. FRONTAL GYRUS
PRAECUNEUS
Cingulate sulcus
CINGULATE GYRUS
Parieto-occip. fissure
CUNEUS
Corpus callosum
Fornix
Calcarine fissure
ISTHMUS
LINGUAL GYRUS
HIPPOCAMPAL GYRUS
UNCUS
Parolfactory area
Collateral fissure
FUSIFORM GYRUS
Infr. temp.
INF. TEMP. GYRUS
sulcus
Fusiform Gyrus

Facial Discrimination by FFA

FFA = fusiform face area
LOC = lateral occipital cortex (objects)

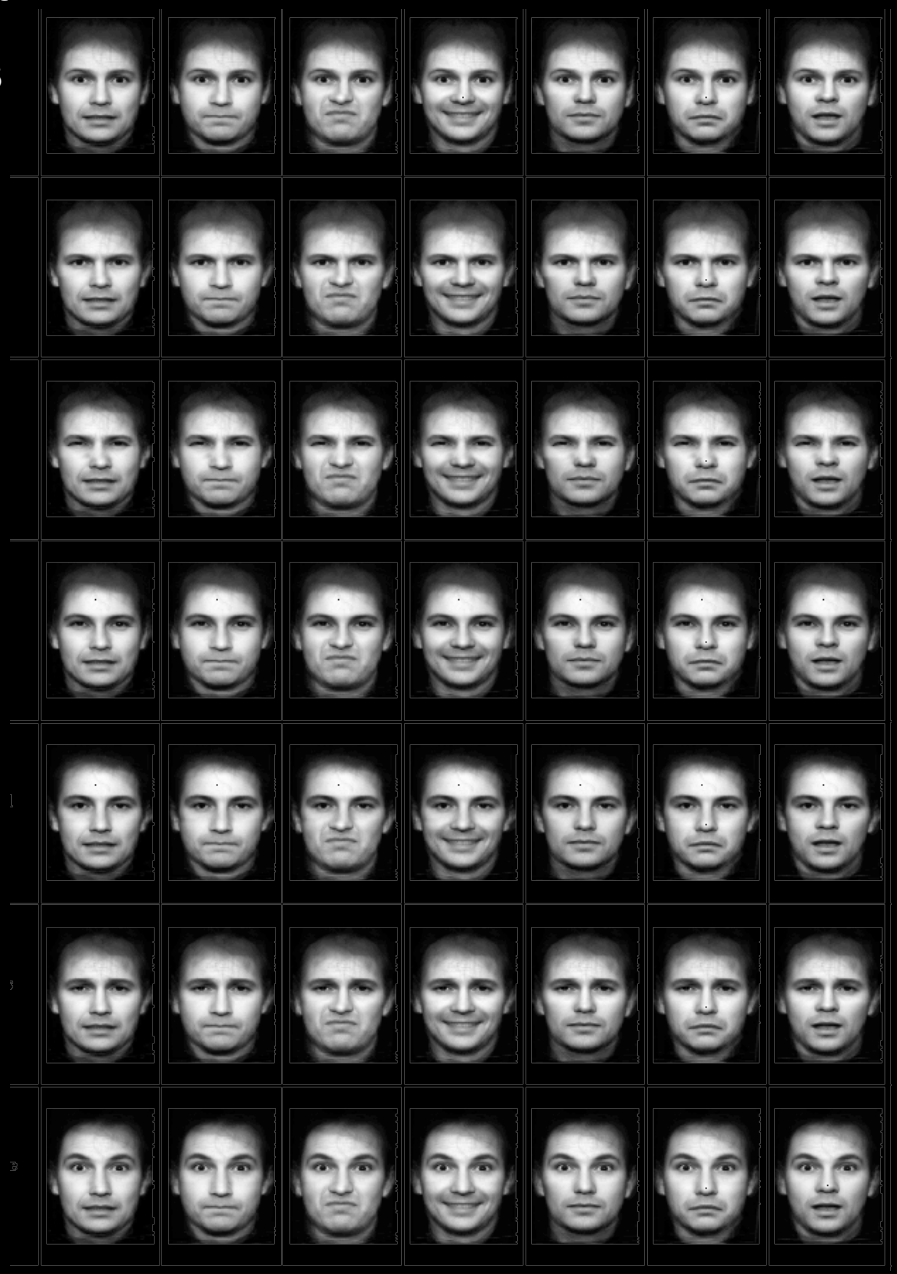


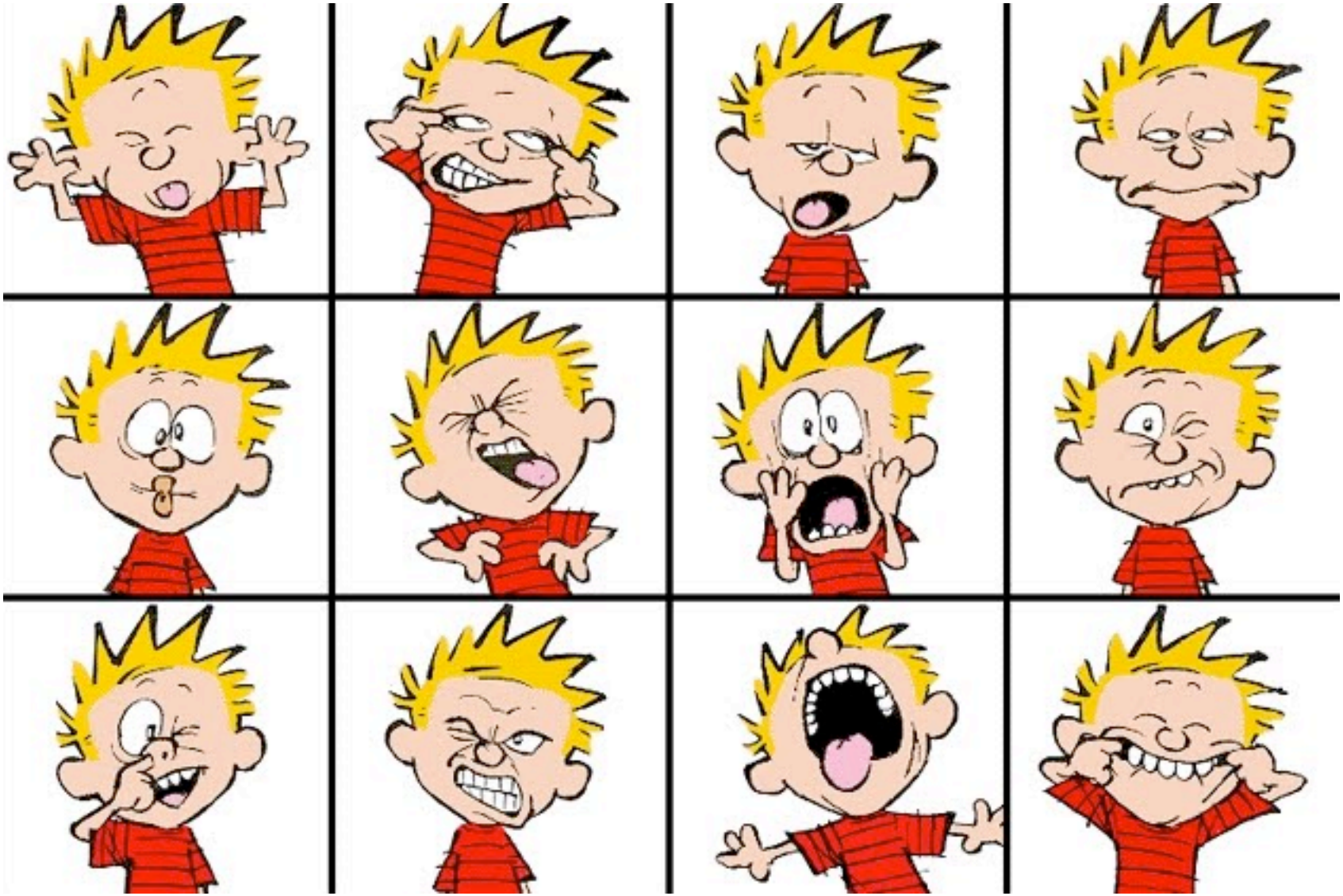


Combinatorial representation of emotions by the face

mouth →

eyes ↓

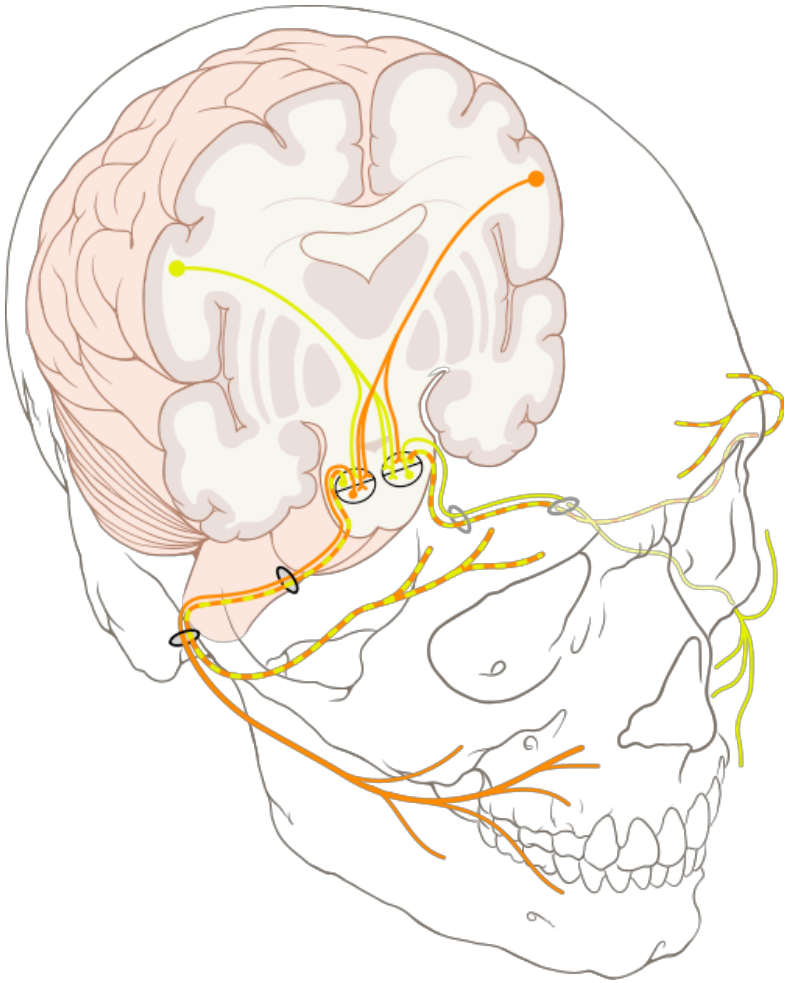




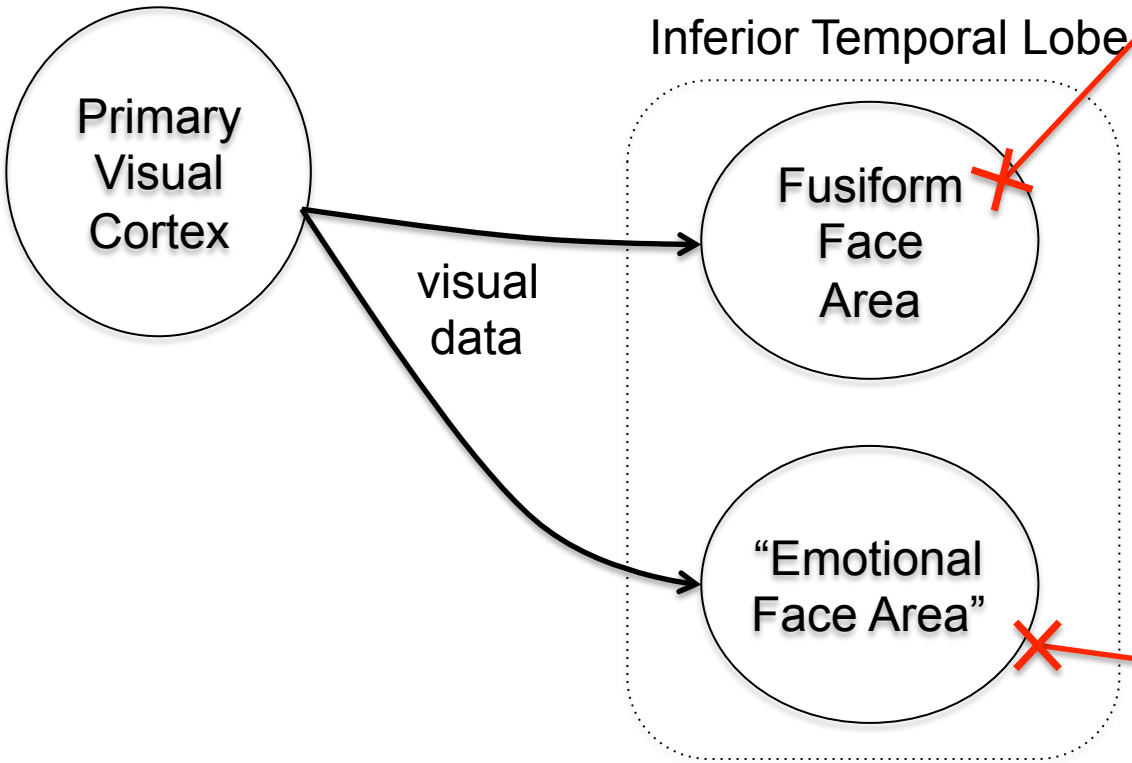
The Face as a Social Tool

≈ 43 Facial Muscles

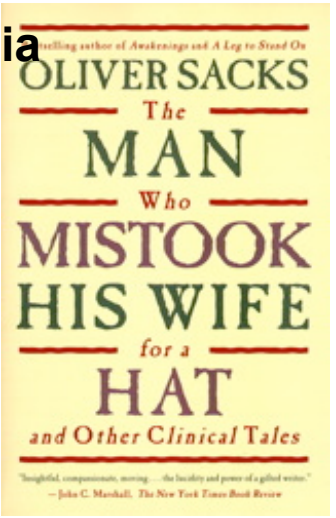
Cranial Nerve VII



Pathology of Facial Recognition



Prosopagnosia



Capgras syndrome

Most people are left-faced!