Lecture 41: The Social Brain

Dr. Andrew Bass

Pre-lecture Preparation

Watch Pre-class video if posted on the website, though not all Bass lectures may use them.

Required Reading:

Bear et al. Chapter 17: pp. 590-595.

Further Optional Reading

Bear et al. Chapter 15: pp. 524-527.

Rilling, J.K and Young, L.J. 2014. The biology of mammalian parenting and its effect on offspring social development. Science 345(6198):771-776.

Learning Objectives

1. Be able to define what it means to be social for both humans and non-humans.
2. Be able to provide examples of abnormal social behaviors in humans.
3. Be able to discuss the evidence in humans for the roles of different brain regions in processing social information and producing social behavior.
4. Be able to evaluate the use of animal models to research hypotheses about the biological basis of social behavior and related disorders in humans

Lecture Outline

1. What does it mean to be social?
    a. What aspects of social behavior do humans and other animals share?
    b. What are uniquely human social behaviors?
    c. Based on what you know so far, what brain areas might be involved in the processing of and directing of social behavior?

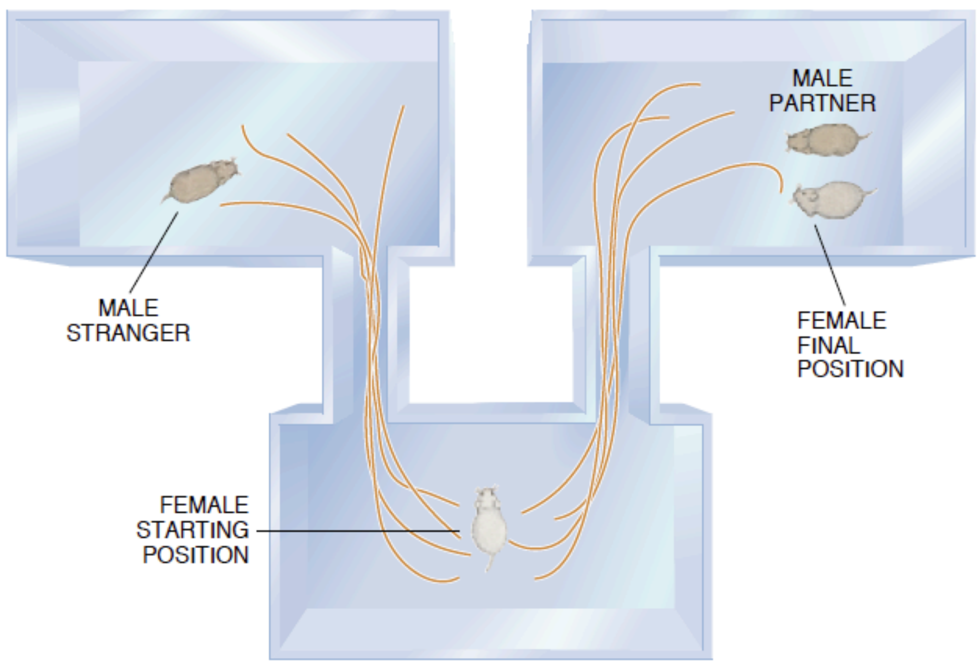
2. What kinds of abnormal social behaviors do humans exhibit?
    a. Prosopagnosia or face blindness – unable to recognize faces
    b. Williams Syndrome – genetic disorder that leads to elfin appearance, low IQ and enhanced motivation to be social
    c. Autism spectrum disorders – a range of symptoms and impairments related to persistent deficits in social communication that have an early developmental onset

3. What are the research strategies that a neuroscientist might use to map the "social brain" in humans?

a. Evidence for the involvement of single brain regions in humans – dependence on deficits following localized regions of brain damage.
b. Evidence for the involvement of multiple brain regions forming a network in human brain – imaging data.
   - *Social Perception Network* – amygdala is central player here – active when engaged in social decision-making, social affiliation behaviors, fear response to threatening stimuli
   - *Mentalizing Network* – active when thinking about oneself or others
   - *Empathy Network* – active when imagining the emotions of others by observing them
   - *Mirror Network* – active when learning by observing the actions of others
   -

4. How have non-human species served as models for human social behavior?
   a. What behaviors should a non-human species display to serve as a good model for human sociality?
   b. Why have voles emerged as a major model to assess the neural basis of social attachment? See http://www.youtube.com/watch?v=pA4w--HP7tc

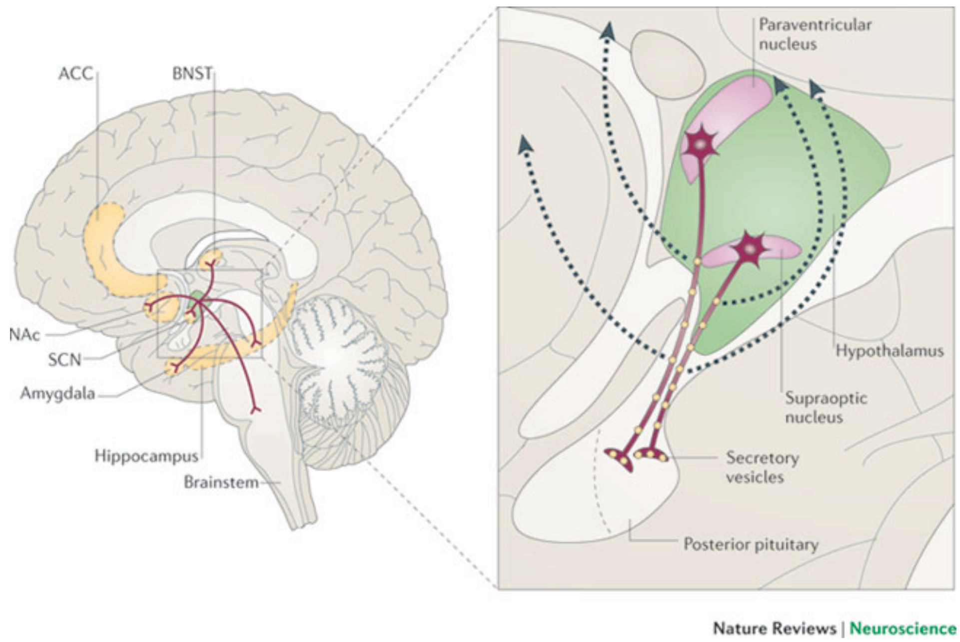
   - What are the social behaviors that have been studied in voles?



CHOICE TEST given to female prairie voles in the laboratory reveals a social preference for the mated males. Initially, females enter the cages of both strangers and their partners (*represented by brown lines*) and will mate with both. Within about 30 minutes, however, females tend to remain near the familiar male.

From Carter & Getz, 1993, Scientific American

- Where are the neuropeptides oxytocin and vasopressin synthesized in the brain? Figure from Meyer-Lindenberg et al., 2011, Annual Review of Neuroscience.



- What regions of the brain have been implicated in social behavior and why? Figure 49-4 from Kandel et al., 2013.

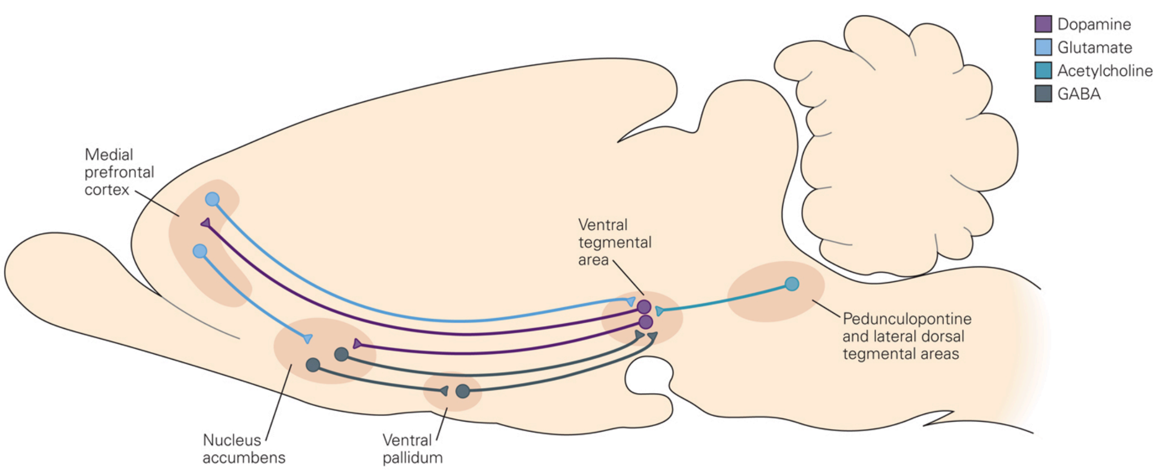


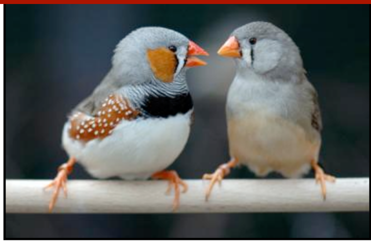
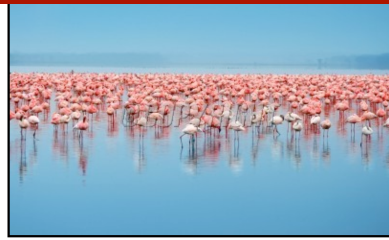
Figure 49–4 Neural pathways and structures implicated in reward. The dopaminergic pathways from the ventral tegmental area to the nucleus accumbens, medial prefrontal cortex, and other forebrain structures are a central component of reward circuitry. The neurons in the ventral tegmental area are regulated by cholinergic neurons in the brain stem, by inhibitory GABA-ergic (γ-aminobutyric acid) neurons in the nucleus accumbens and ventral pallidum, and by excitatory glutamatergic neurons in the prefrontal cortex.

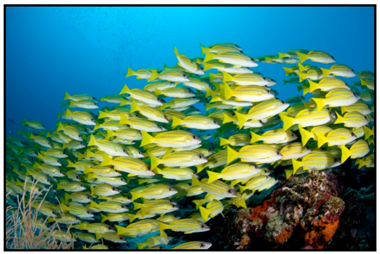
Study Questions

1. Be able to identify two major criteria that would define what it means to be social.
2. Be able to discuss the evidence for the involvement of single or multiple brain regions in the performance of social behavior.
3. Be able to discuss the use of non-human models to investigate the neural basis of social behavior and related disorders in humans.

Lecture 41: The Social Brain

May 06, 2019 - Andrew Bass










Learning Objectives

Be able to:

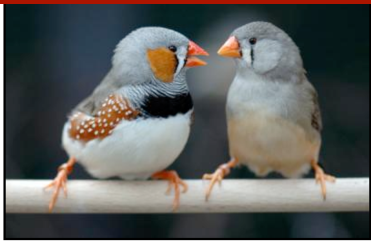
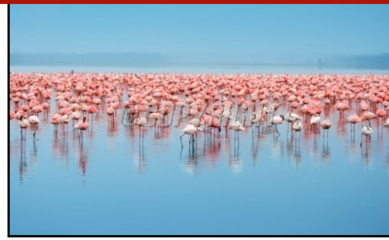
1. define what it means to be social for humans &non-humans

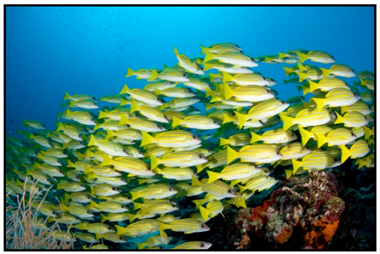
2. provide examples of abnormal social behaviors in humans

3. discuss evidence in humans for the roles of different brain regions in processing social information and producing social behavior

4. evaluate the use of animal models to research hypotheses about biological basis of social behavior and related disorders in humans

What social behaviors might humans and non-human animals share?










Many uses of the word SOCIAL

A. Sociality – group living

B. Social Behavior – interactions between individuals

C. Social Cognition – CNS processing underlying social ability or behavior (memory, attention, reasoning, motivation, decision-making)

D. Social Brain – brain regions underlying the above

Objective 2: Social Behavior Disorders in Humans
(Kennedy & Adolphs, 2012, *Trends in Cognitive Sciences*)

Autism spectrum disorders
Williams syndrome
Schizophrenia
Behavioral-variant frontotemporal dementia (**FTD)**: early & progressive
changes in personality; loss of empathy; socially inappropriate;
widely varies in age of onset (typically ~50)
Prosopagnosia – face blindness (2-3% of the population)
Alzheimer's syndrome (dementia; problems with memory, thinking
Anxiety disorders (OCD, PTSD, panic attacks, social phobia)
Down's syndrome (genetic)
Fragile-X syndrome (genetic)
Rett's syndrome (genetic)
Mood disorders (major depressive disorder, bipolar, seasonal affective
disorder)

Clicker Question 1

Which of the following is(are) symptom(s) of Autism Spectrum Disorder?

a. Typically goes unrecognized until after the age of 5.
b. Unusual attachment to objects.
c. Repetitive patterns of behavior.
d. a and b
e. b and c

Clicker Question 1

Which of the following is(are) symptom(s) of Autism Spectrum Disorder?

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b. Unusual attachment to objects.
c. Repetitive patterns of behavior.
d. a and b
e. b and c

Autism Spectrum

The term “spectrum” refers to the wide range of symptoms, skills, and levels of impairment or disability that people with Autism Spectrum Disorder (ASD) can have.

Latest stats: 1:68 school age children
5 Times more common in males than females

Typically recognized in the first two years of life.
Repetitive patterns of behavior, interests, or activities.
Unusual attachment to objects.
Persistent deficits in social communication and social interactions.
Language delay.
Lack of eye contact.

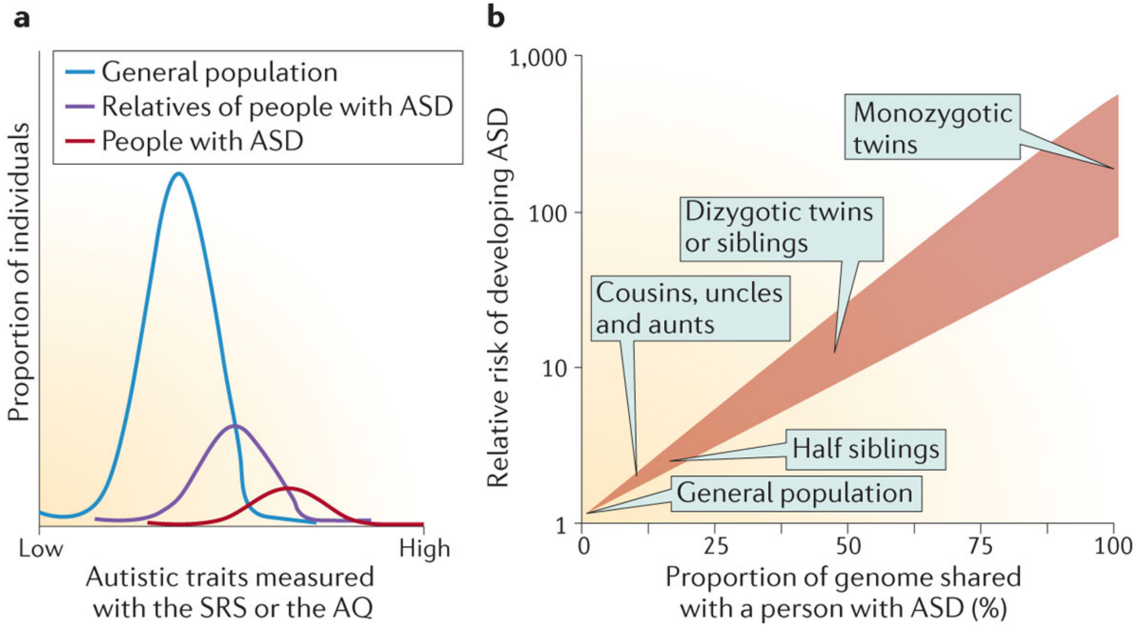
Autism Spectrum

John Elder Robison: individual with Asperger's - part of a Harvard study using transcranial magnetic stimulation (TMS) treatments.
https://www.youtube.com/watch?v=OEQKvrILN3U

[also see https://www.youtube.com/watch?v=RvUgFoHsEmU]

Temple Grandin (Colorado State Univ professor)
https://www.youtube.com/watch?v=eGGpzEyIDq8

Autism Spectrum



Nature Reviews | Neuroscience

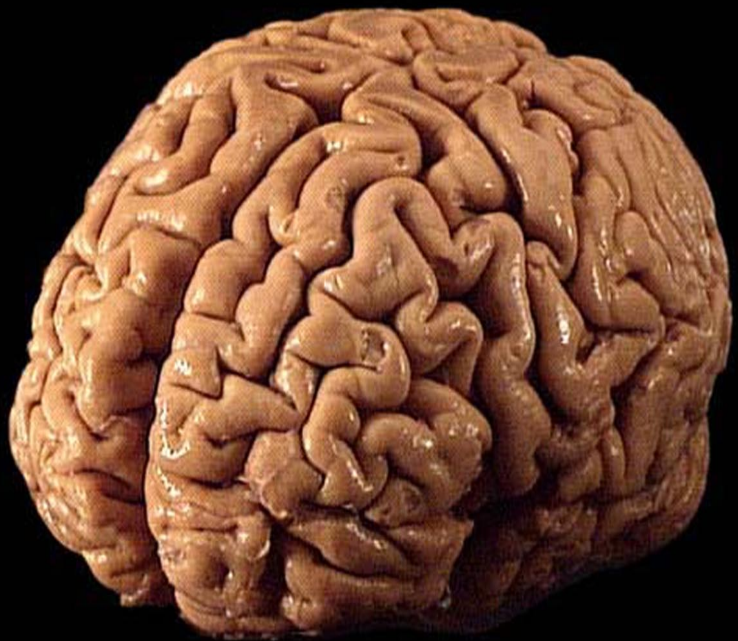
a | Autistic traits can be measured using tests such as the social responsiveness scale (SRS) and the autism spectrum quotient (AQ). The SRS and the AQ are questionnaires that can measure the severity of social impairment across clinical cases and in the general population. A high SRS or AQ score indicates the presence of autistic-like traits. The scores are normally distributed in the general population and in individuals diagnosed with autism spectrum disorder (ASD) and their relatives, although these scores may be shifted to the right and thus to higher values in the latter two groups. **b** | Twin and familial studies revealed that the relative risk of an individual developing ASD is proportional to the percentage of the genome shared with an individual diagnosed with ASD.

Objective 3: What is the evidence in humans for the roles of different brain regions in processing social information and producing social behavior?

1. Effects of brain damage
2. Brain Imaging: Measure neural activity in networks
3. Brain stimulation (e.g. John Robison)

[Also see lecture 38]

What brain areas might be involved in the control of social behavior?



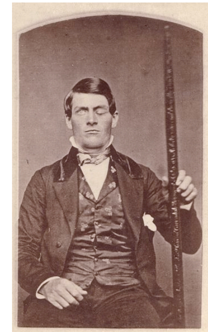
What brain areas might be involved in the control of social behavior?

Your ideas:

-- Amygdala

-- Prefrontal cortex

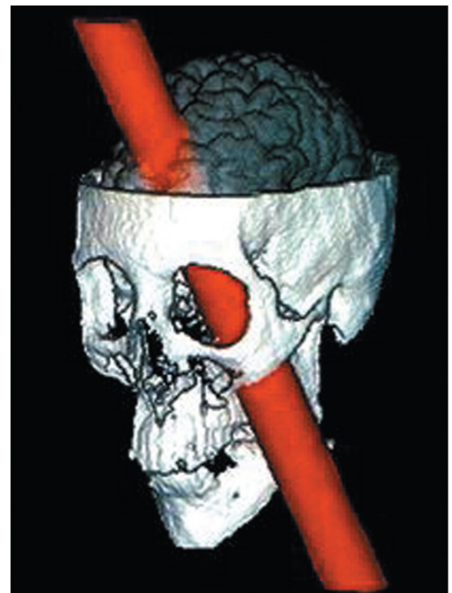
Effects of Lesions: Prefrontal Lobe Damage



Phineas P. Gage

"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'."

JM Harlow, "Recovery from the passage of an iron bar through the head" (1868)



Source: Caplan and Gould in Squire et al., 2003.

From Lecture 37

Hallmarks of prefrontal dysfunction

Disinhibition and lack of behavioral control

Lack of goal-directedness

Impulsive

Quick to anger

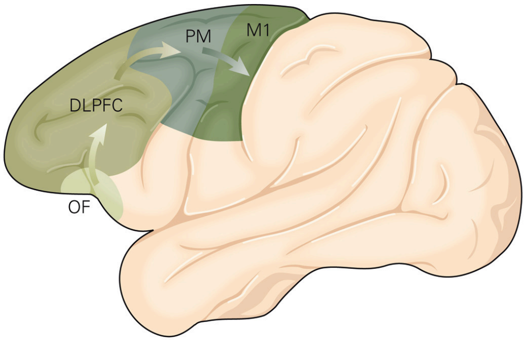
Prone to making rude remarks

Emotionally shallow and indifferent to their condition

Apathetic

Unable to organize behavior

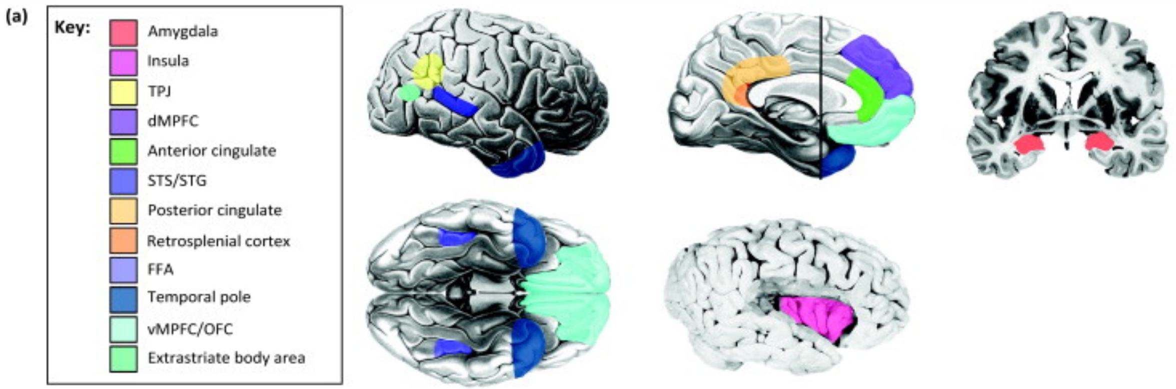
From Lecture 37



Prefrontal Cortex
DLPFC: Dorsolateral prefrontal cortex
OF: Orbito-ventromedial prefrontal cortex

PM: Premotor cortex
M1: Primary motor cortex
[see Fig. 18-8 Bear et al.]

Regions proposed to underlie social processing



(b)

Lesion site	Social deficit
Occipitotemporal cortex/ FFA (R>L)	Face agnosia
Temporal Pole (L > R)	Naming people
Amygdala (bilateral)	Fear recognition
Ventromedial prefrontal cortex (R > L)	Social emotions, social decisions
Insula	Empathy, social context
Somatosensory cortex (not shown) (R > L)	Emotion recognition

(From: Kennedy and Adolphs, 2012, *Trends in Cognitive Sciences*)

Imaging Normally Behaving Brain: Paternal Brain Function

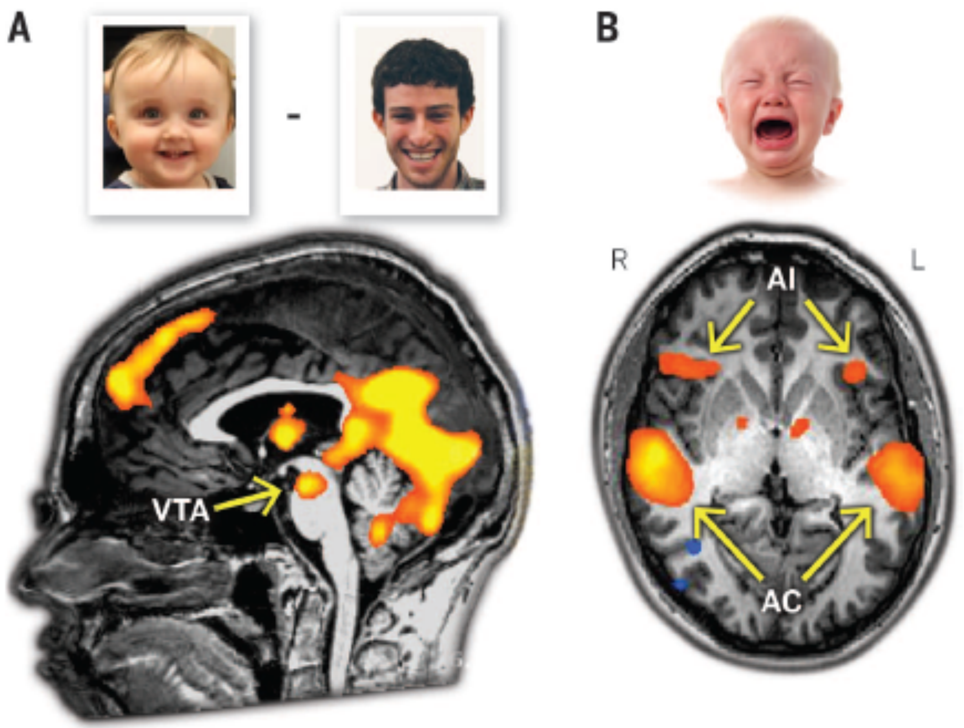
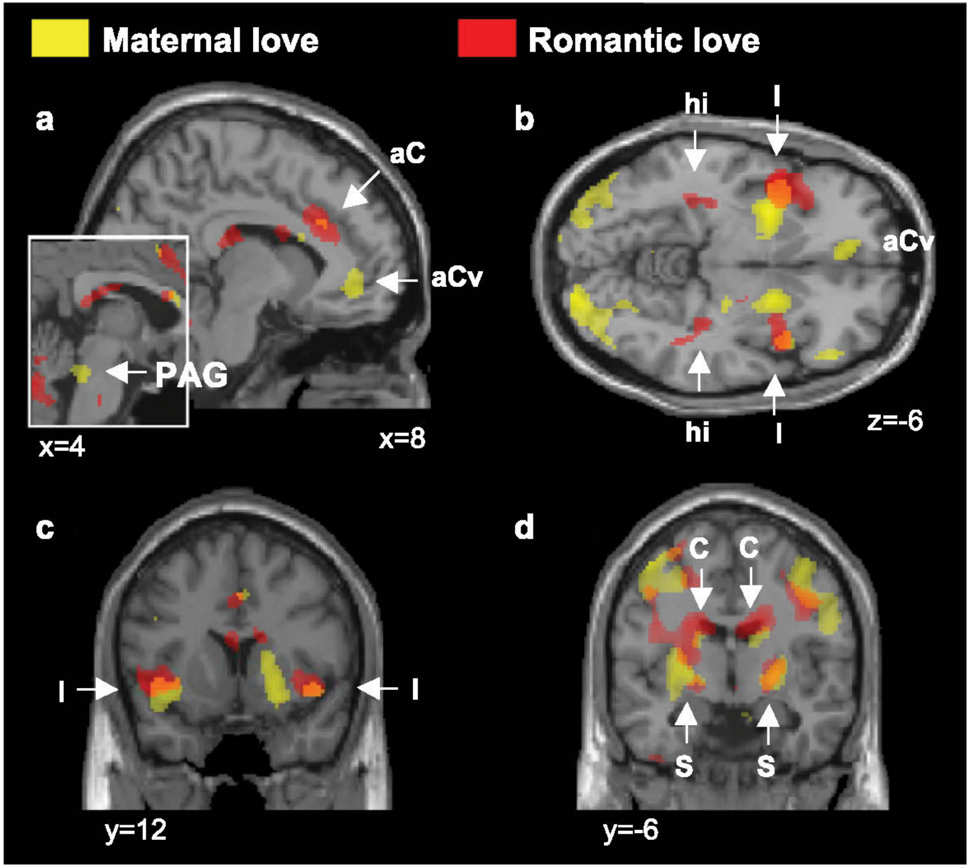


Fig. 3. Paternal brain function in humans revealed by fMRI. (**A**) The VTA in fathers is activated to a greater extent when viewing pictures of their own children compared with pictures of unknown adults. (**B**) The anterior insula in fathers is activated to a greater extent when listening to infant-cry stimuli compared with an auditory control tone. AC, auditory cortex.

Rilling & Young, Science, 2014

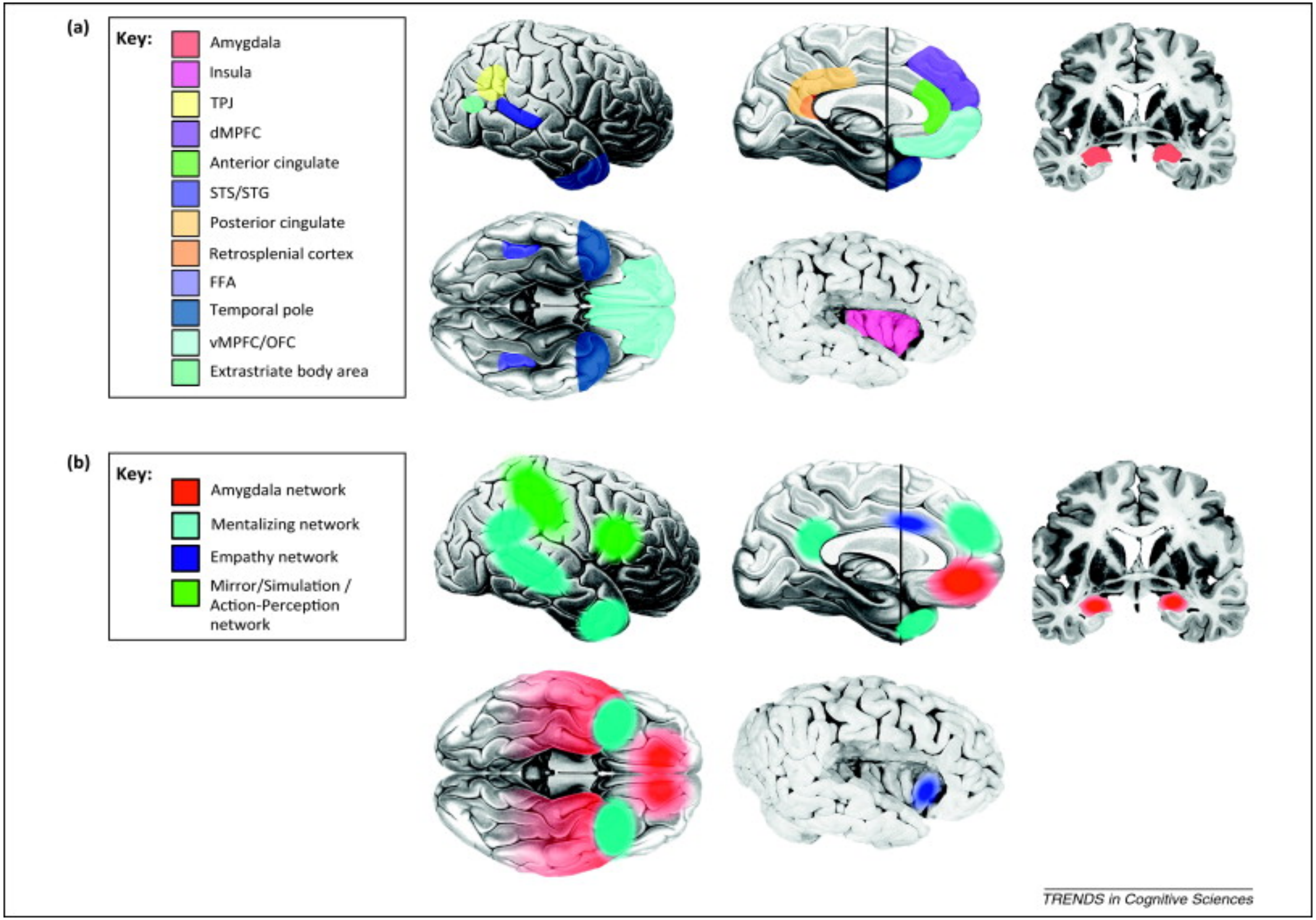
Imaging Normally Behaving Brain: Maternal and Romantic Love



Bear et al. Fig. 17.12

Abbreviations: PAG, midbrain periaqueductal gray; aC, anterior cingulate cortex; hi, hippocampus; I, insula; C, caudate nucleus; S, striatum

Imaging: networks of extensively connected brain regions



(From: Kennedy and Adolphs, 2012, *Trends in Cognitive Sciences*)

"Social Brain": Networks of extensively connected brain regions

Social Perception Network – active when engaged in **social decision-making, social affiliation behaviors**

Mentalizing Network – active when **thinking about oneself or others**

Empathy Network – active when **imagining the emotions of others** by observing the actions of others

Mirror Network – active when **learning by observing the actions of others**

(From: Kennedy and Adolphs, 2012, *Trends in Cognitive Sciences*)

Objective 4: How Have Non-human Species Provided Models for Human Social Behavior?

How might we use non-human models to investigate social processing centers in the brain &
the biological basis of social disorders?

A Tale of Two Voles

Social affiliation behavior, monogamy, biparental care

Prairie Vole

Montane Vole

Clicker Question 2

After mating, a female prairie vole:

a. Spends more time with its partner than a stranger.
b. Spends more time with a stranger than its partner.
c. Prefers to be alone.
d. None of the above.

Clicker Question 2

After mating, a female prairie vole:

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c. Prefers to be alone.
d. None of the above.

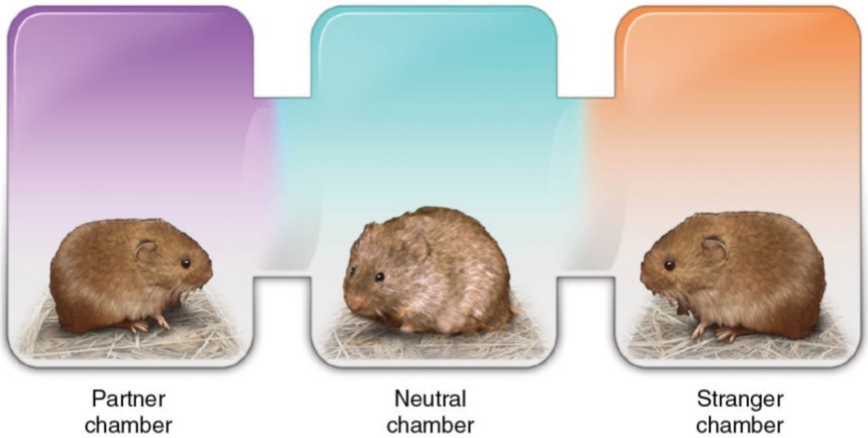
Mammalian Mating Strategies

- **Monogamy – Prairie Vole**

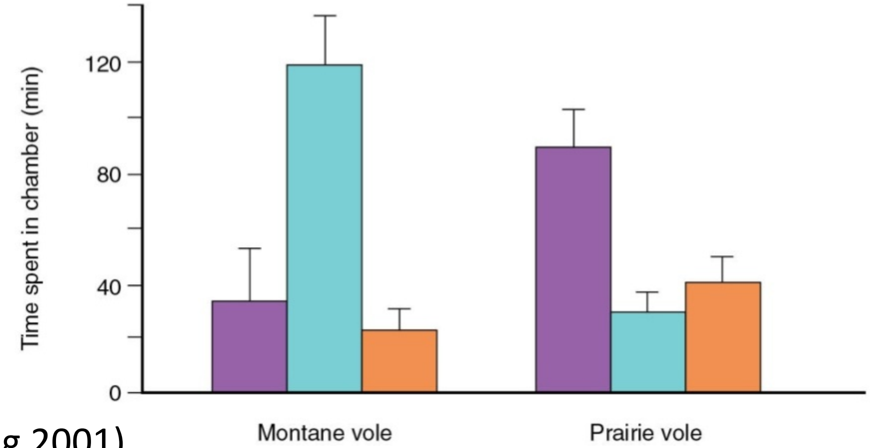
- **Polygamy – Montane Vole**

https://www.youtube.com/watch?v=5ddlKQwDIe8

Partner Preference Test: Prairie and Montane Voles Differ in Affiliative Behavior



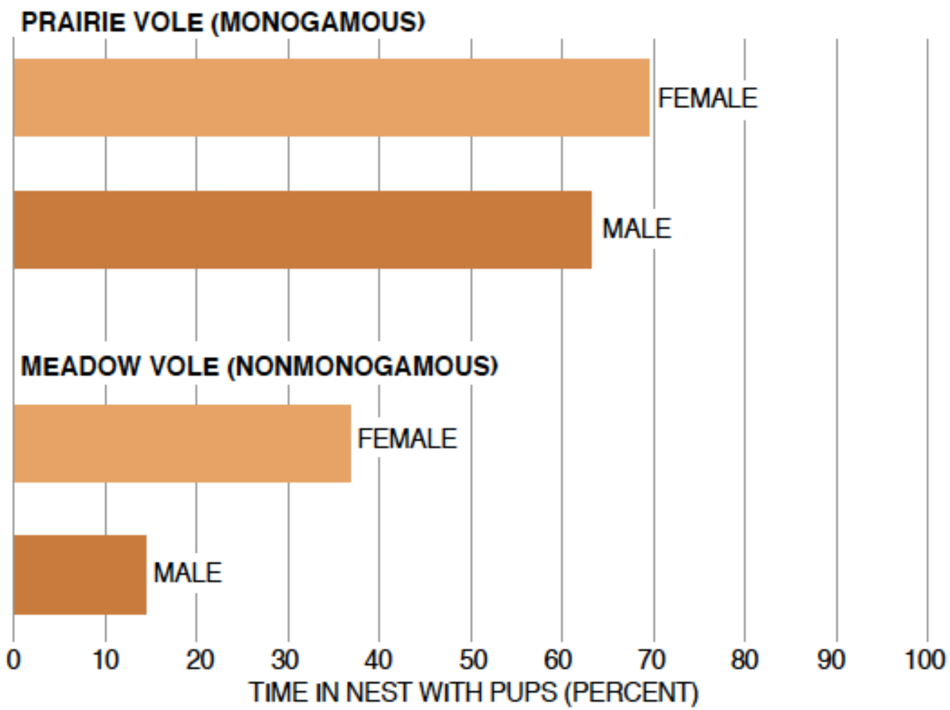
(a)



(b)

Bear et al. Fig. 17.10
(based on Insel & Young 2001)

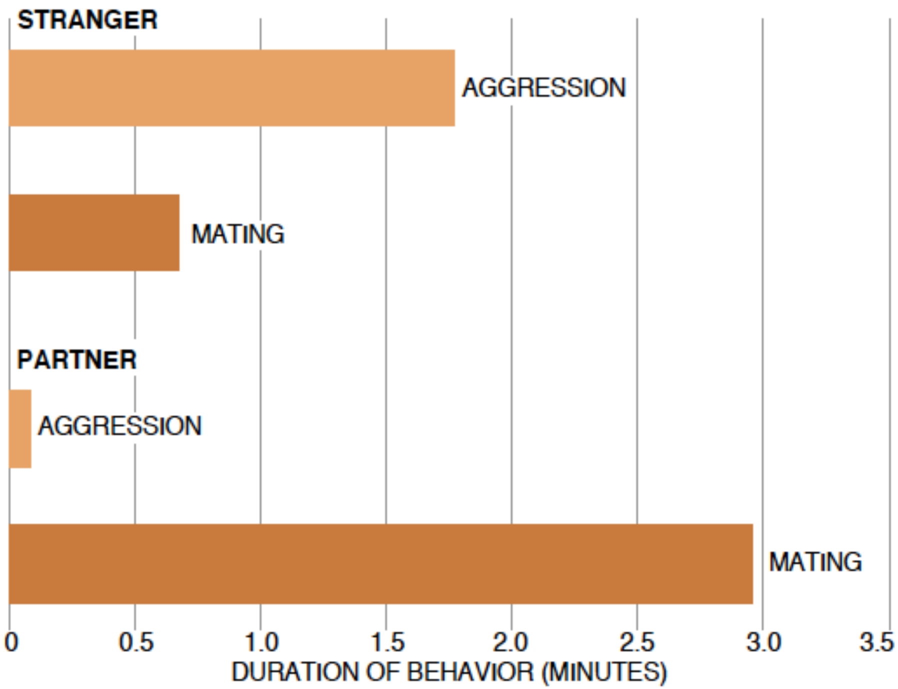
Monogamous Prairie Vole Shows Greater Degree of Biparental Care than Polygynous Meadow Vole (like Montane vole)



PARENTAL CARE demonstrated by prairie voles far exceeds that shown by nonmonogamous meadow voles. The difference is most apparent with male prairie voles, which are with the pups four times as often as male meadow voles are.

Carter and Getz 1993, Scientific American

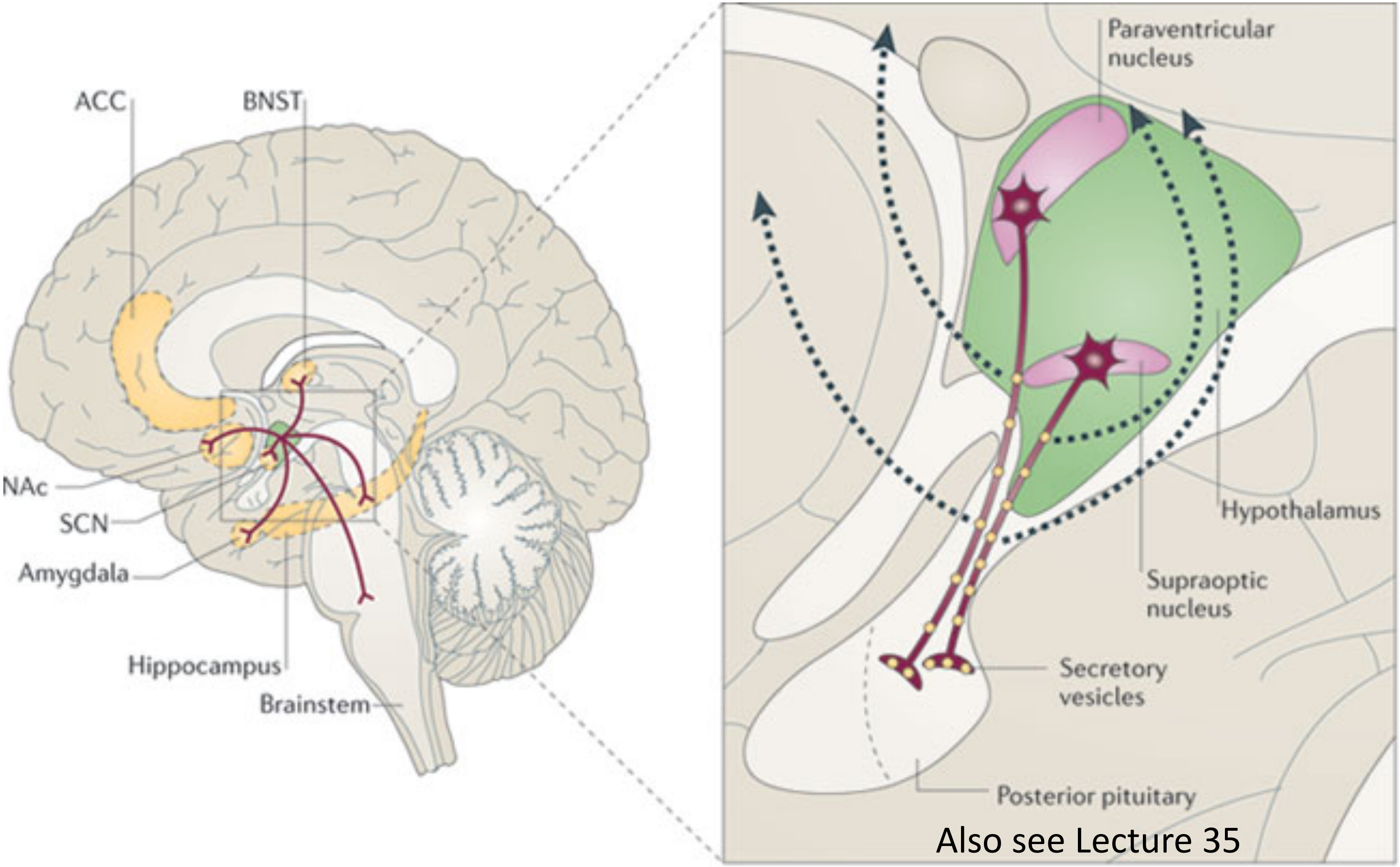
Female Prairie Vole Spend More Time Attacking Strangers Than Mating With Them



AGGRESSION by female prairie voles is revealed in 10-minute tests comparing hostility with mating preference. Females spent more time attacking strangers rather than mating with them. In contrast, they show little aggression toward their partners.

Carter and Getz 1993, Scientific American

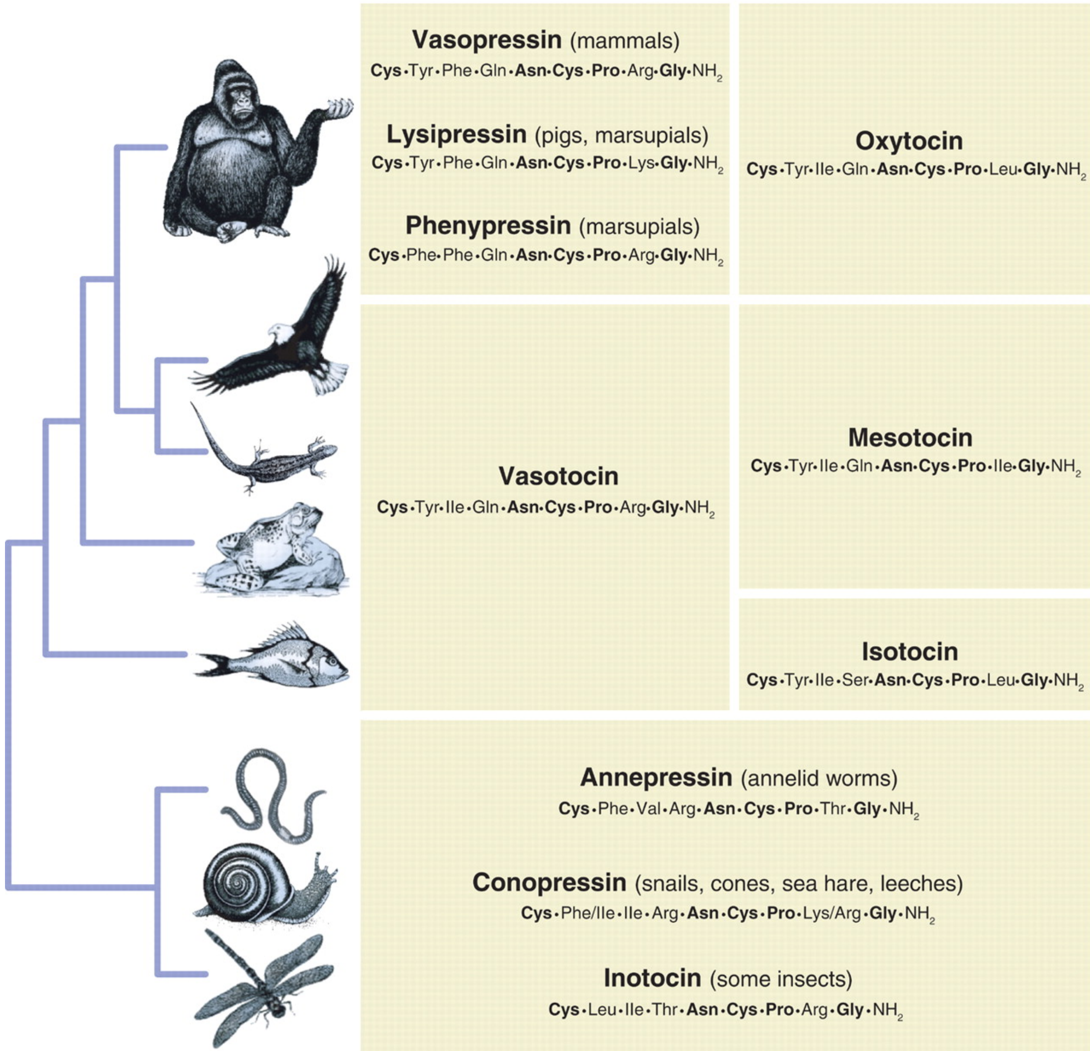
Neuropeptides for Social Behavior: Hypothalamic Oxytocin & Vasopressin



Also see Lecture 35

From Meyer-Lindenberg, Domes, Kirsch, Heinrichs; 2011, *Nature Neuroscience Reviews*

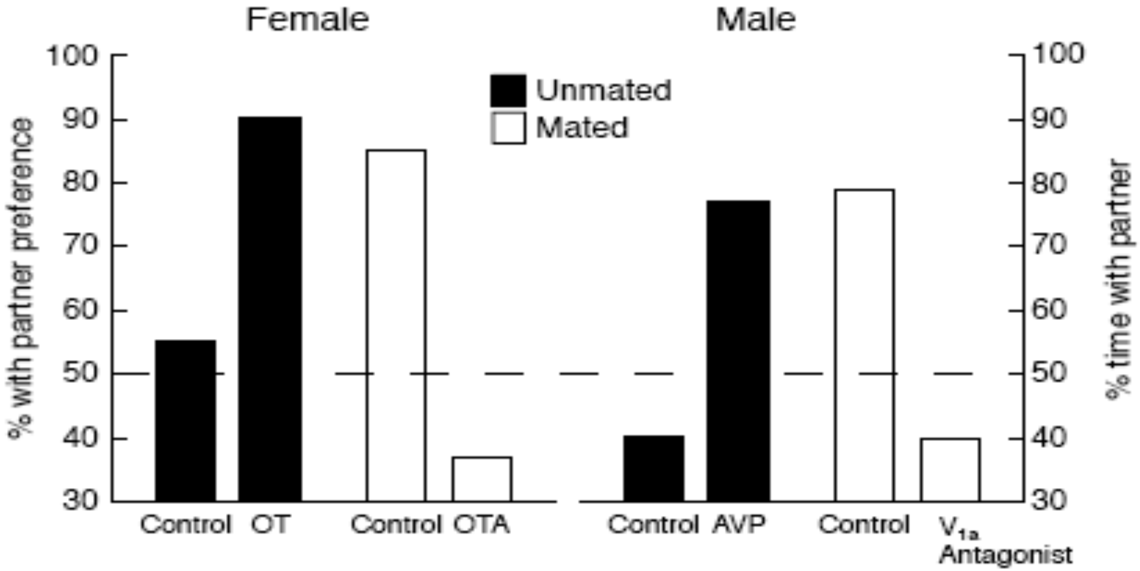
Oxytocin and vasopressin homologs



Zoe R. Donaldson, and Larry J. Young Science 2008;322:900-904

Published by AAAS

Intracerebroventricular injections of oxytocin (OT) & vasopressin (AVP), or their receptor antagonists



Young, Wang and Insel 1998

OT = oxytocin

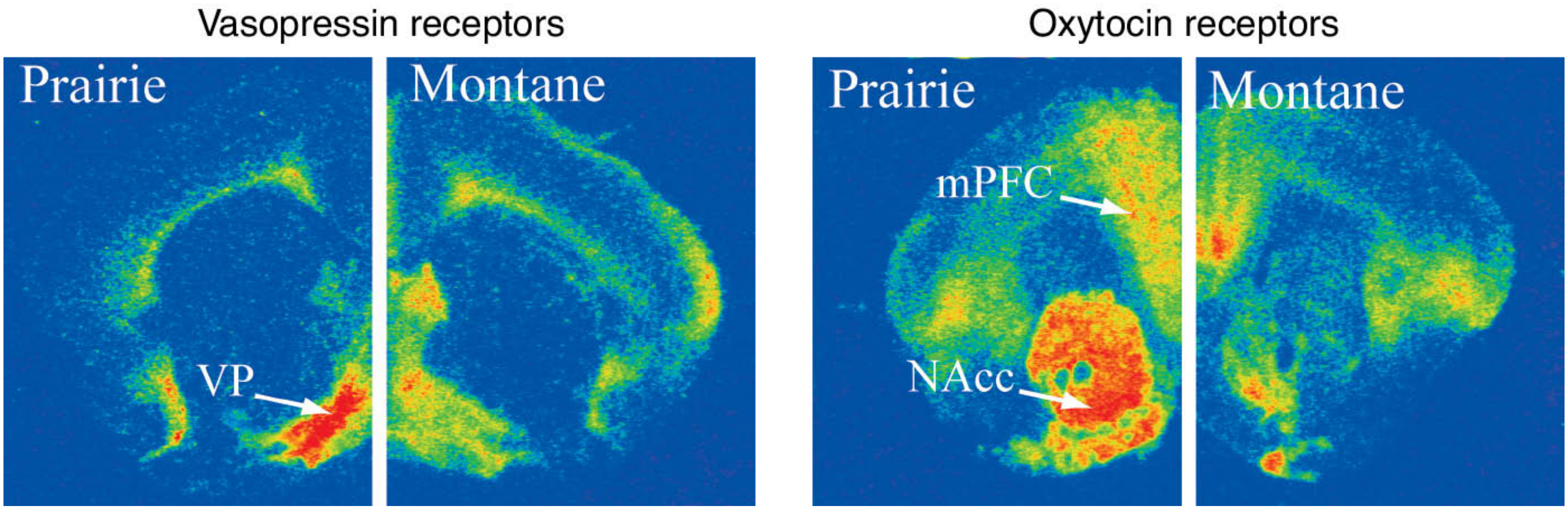
AVP = arginine vasopressin

OTA – oxytocin receptor antagonist

V1a antagonist = AVP receptor antagonist

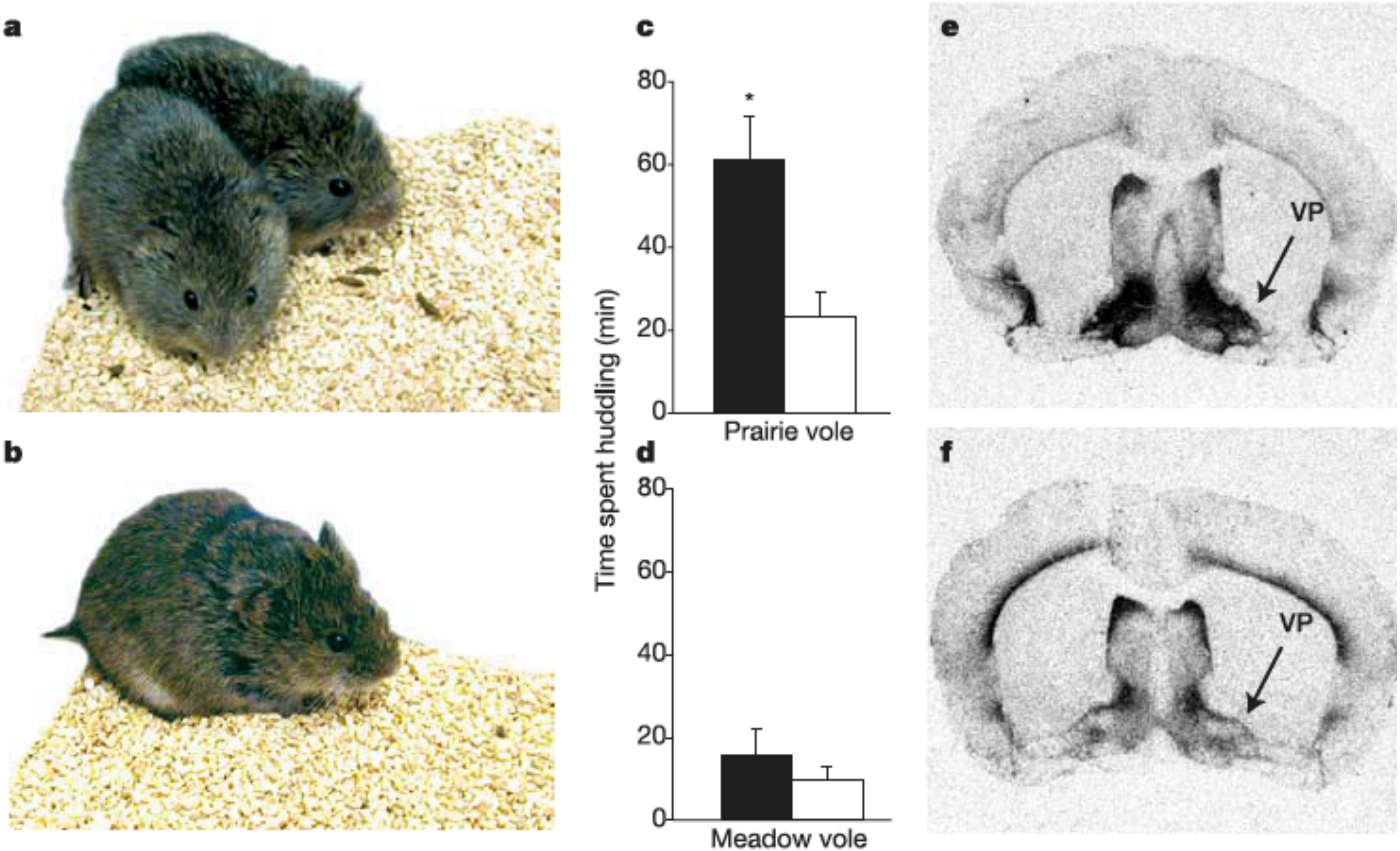
Oxytocin and vasopressin receptors in voles

- Prairie voles have more oxytocin (female) and vasopressin (males) compared to Montane voles



Bear et al. Fig. 17.11 (based on Young et al., 2011)

Promiscuous male meadow voles have both lower AVP receptor gene expression and lower partner preference than do prairie voles



Lim, Wang,… Young., Nature, 2004

Filled: partner; Open: stranger

Increase AVP receptor gene expression in polygynous male meadow vole

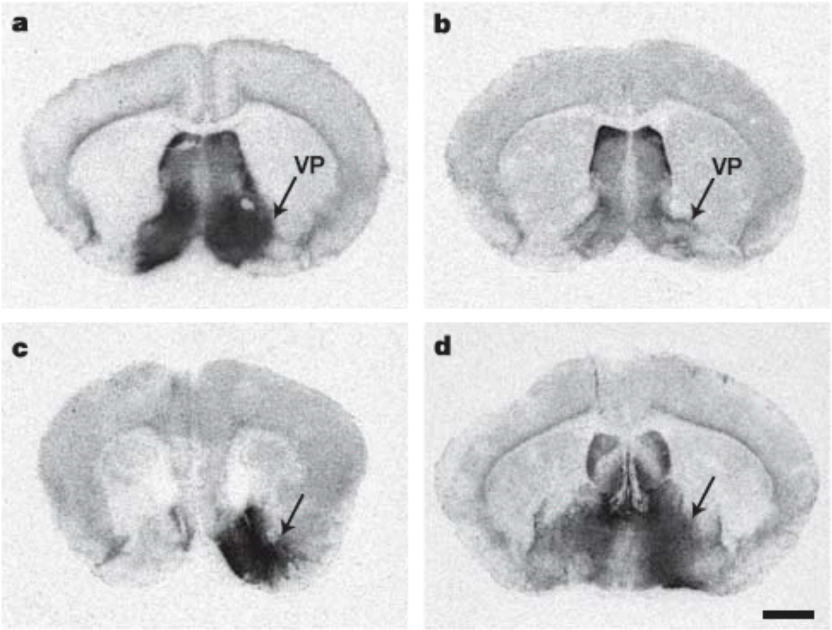


Figure 2 V1aR autoradiography at the level of the ventral pallidum. **a**, Meadow vole overexpressing the *V1aR* gene in the ventral pallidum by AAV-mediated gene transfer (V1aR-vp). **b**, Meadow vole infused with the AAV control vector expressing the *lacZ* gene into the ventral pallidum (Ctrl-vp). **c**, A stereotactic injection inadvertently placed too rostral to the ventral pallidum, in this case located just ventral to the nucleus accumbens. **d**, A stereotactic injection placed too caudal to the ventral pallidum, in this case just ventral to the fornix. Arrows depict ectopic AAV-mediated *V1aR* expression in **c** and **d**. Animals with AAV vector placement outside the ventral pallidum were placed in a second control group (Ctrl-other). Scale bar, 1 mm.

Lim, Wang,… Young., Nature, 2004

Partner preference increases in male meadow voles after increased AVP receptor expression

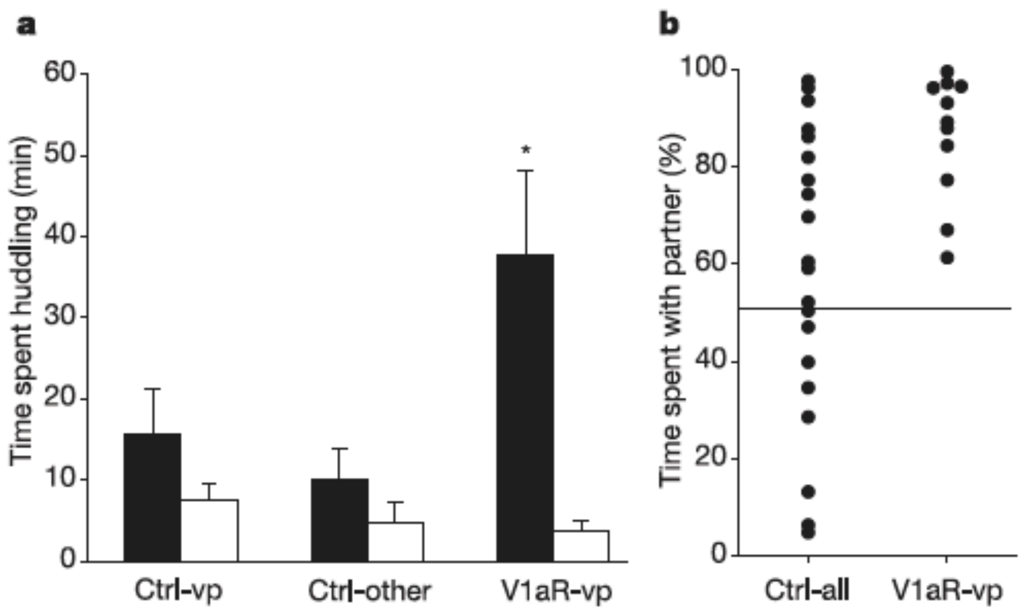
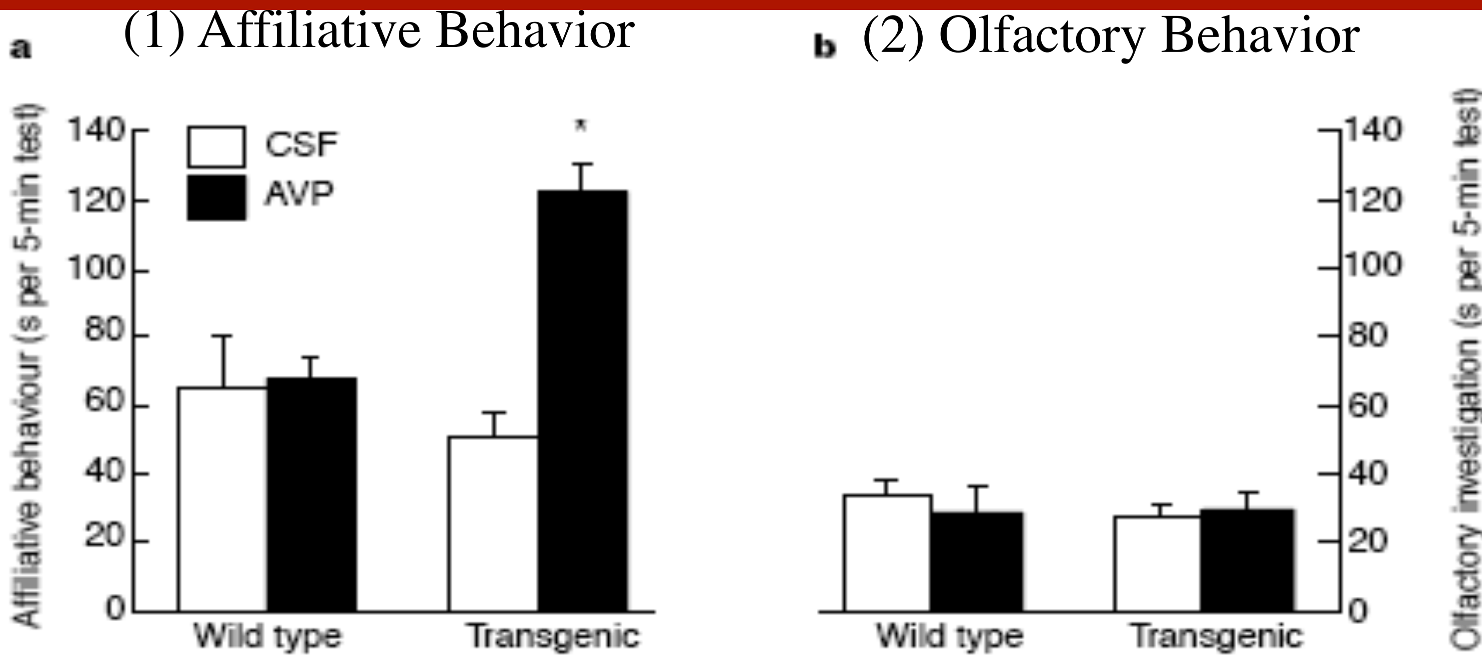


Figure 3 Partner preference test. **a**, V1aR-vp meadow voles spent significantly more time huddling with the partner (filled column) than the stranger (open column), whereas control animals (Ctrl-vp) and stereotactic misses (Ctrl-other) did not ($P < 0.01$, Student's t-test). Error bars, standard error. **b**, A plot of the percentage of time spent with the partner for each subject indicates a shift from randomly distributed preferences in the control groups to 100% of animals preferring the partner in the V1aR-vp group ($P < 0.001$, χ^2 analysis). The y axis was calculated as the time spent huddling with the partner divided by the total time spent huddling with the partner and stranger, multiplied by 100.

Lim, Wang,… Young., Nature, 2004

Behavior of Wild type (WT) & Transgenic (overexpressed V1aR) Mice

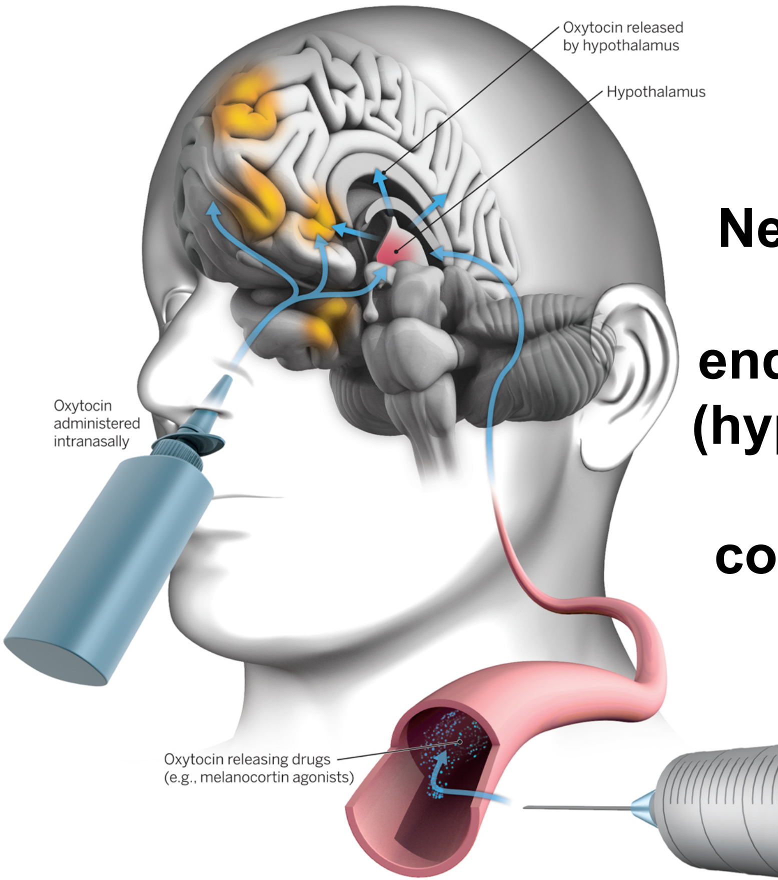


(1) Behavior directed towards an ovariectomized female mouse by a male transgenic with a prairie vole pattern of V1a receptor expression.

(2) Olfactory investigation of cotton balls soiled with bedding from an ovariectomized female's cage.

Young et al., Nature, 1999

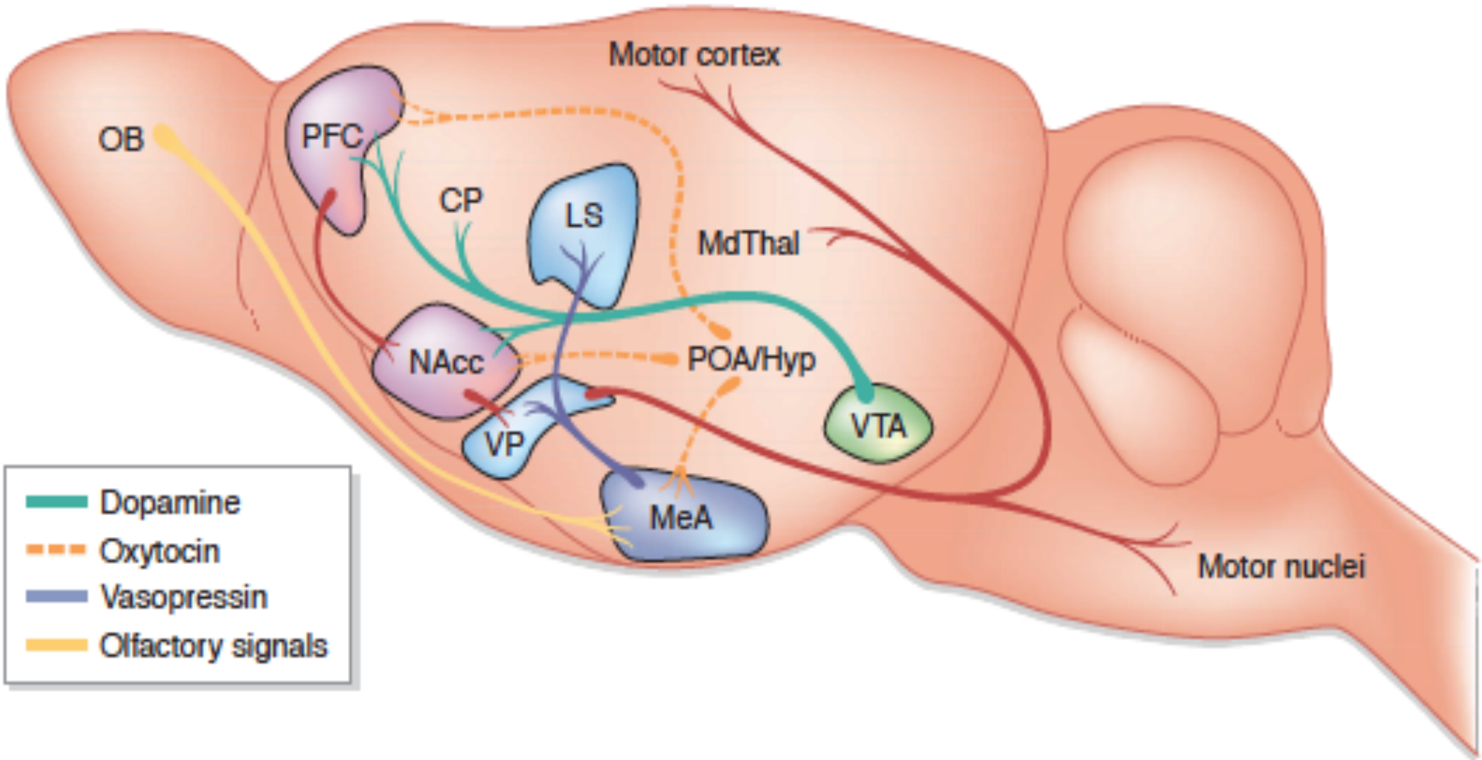
Oxytocin therapeutic strategies



Next-generation techniques that stimulate the release of endogenous oxytocin in the brain (hypothalamus) could evoke more potent and targeted effects compared to intranasal oxytocin treatment.

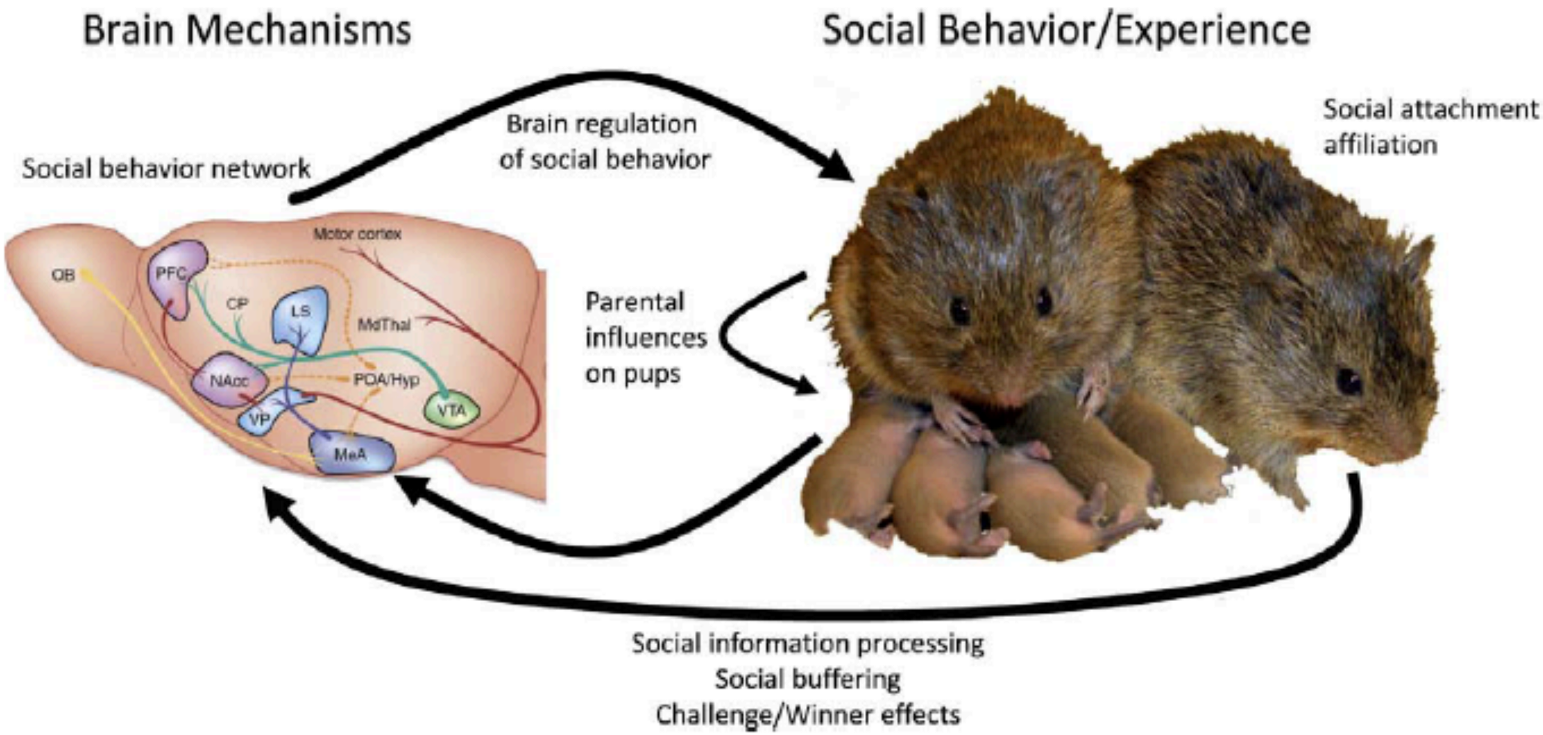
Larry J. Young, and Catherine E. Barrett
Science 2015;347:825-826

Neuropeptides & Reward Circuitry



Young and Wang, Nature Neuroscience Vol 7 (10) October 2004

The Neuroendocrinology of the Social Brain: Voles as a Model System



Young, 2009, Frontiers in Neuroendocrinology 30: 425-428

Is Being Social Addictive?

Congratulations and Farewell!

See you at office hours!