260-2017-10-25-happiness-reward-fear

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Don't You Worry 'Bout a Thing

Stevie Wonder - Don't you worry bout a thing

Today's Topics

- Happiness, pleasure, and the reward system
- Fear & stress
- Quiz 3 Friday

Components of happiness

- Aristotle
- Hedonia
  - Pleasure
- Eudaimonia
  - Life satisfaction
  - Relates to motivation

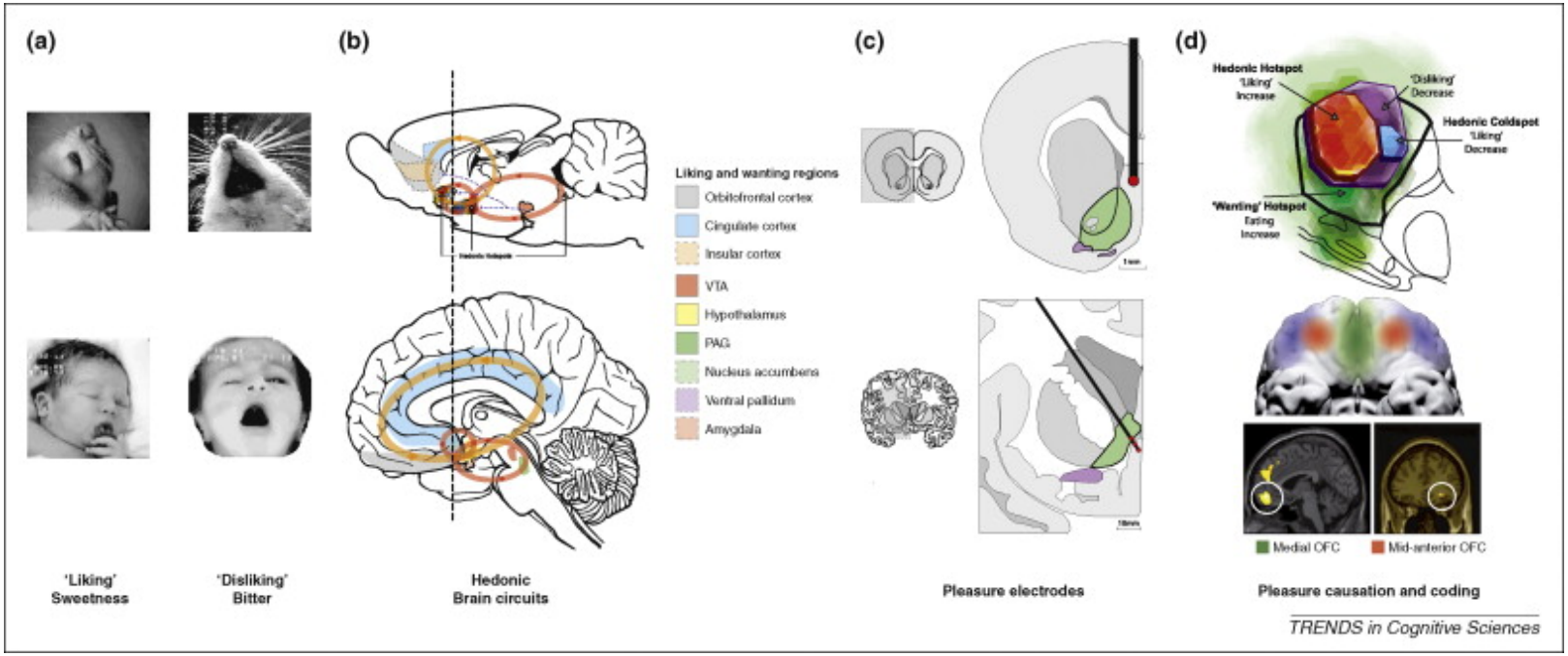
"Computing" 'happiness'

- Inputs
  - External
  - Internal
- Processing
- Outputs
  - Feelings
  - Actions

Brain mechanisms

- Circuits for signaling pleasure and pain
- Similarities across animal species
- Dopamine and endogenous opioid neurotransmitter systems involved

Neuroanatomy of 'happiness'



(Kringelbach and Berridge 2009)

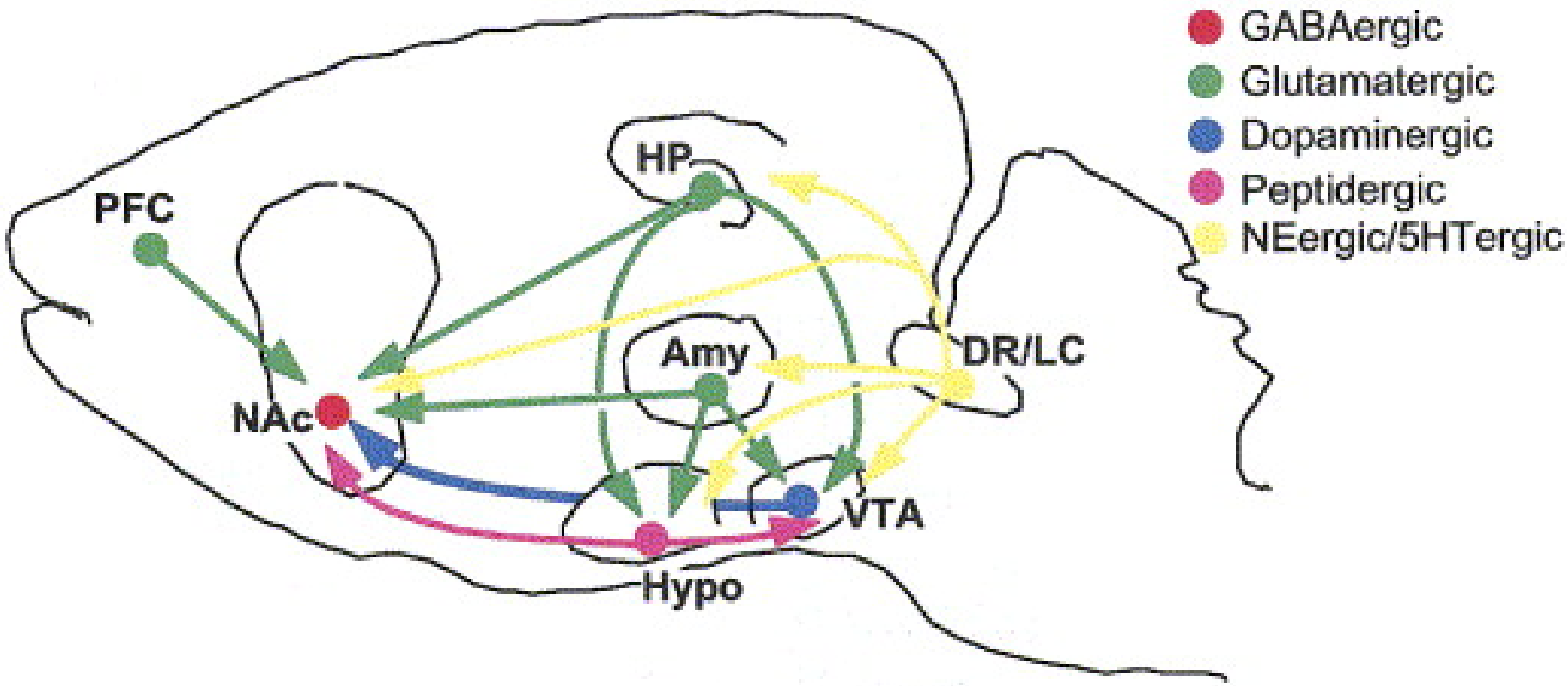
Rewards

- A *reward* reinforces (makes more prevalent/probable) some behavior
- Milner and Olds (Milner 1989) discovered 'rewarding' power of electrical self-stimulation
- (Heath 1963) studied effects in human patients.

Electrical self-stimulation

Brain Mechanisms of Pleasure and Addiction

"Reward" circuitry in the brain

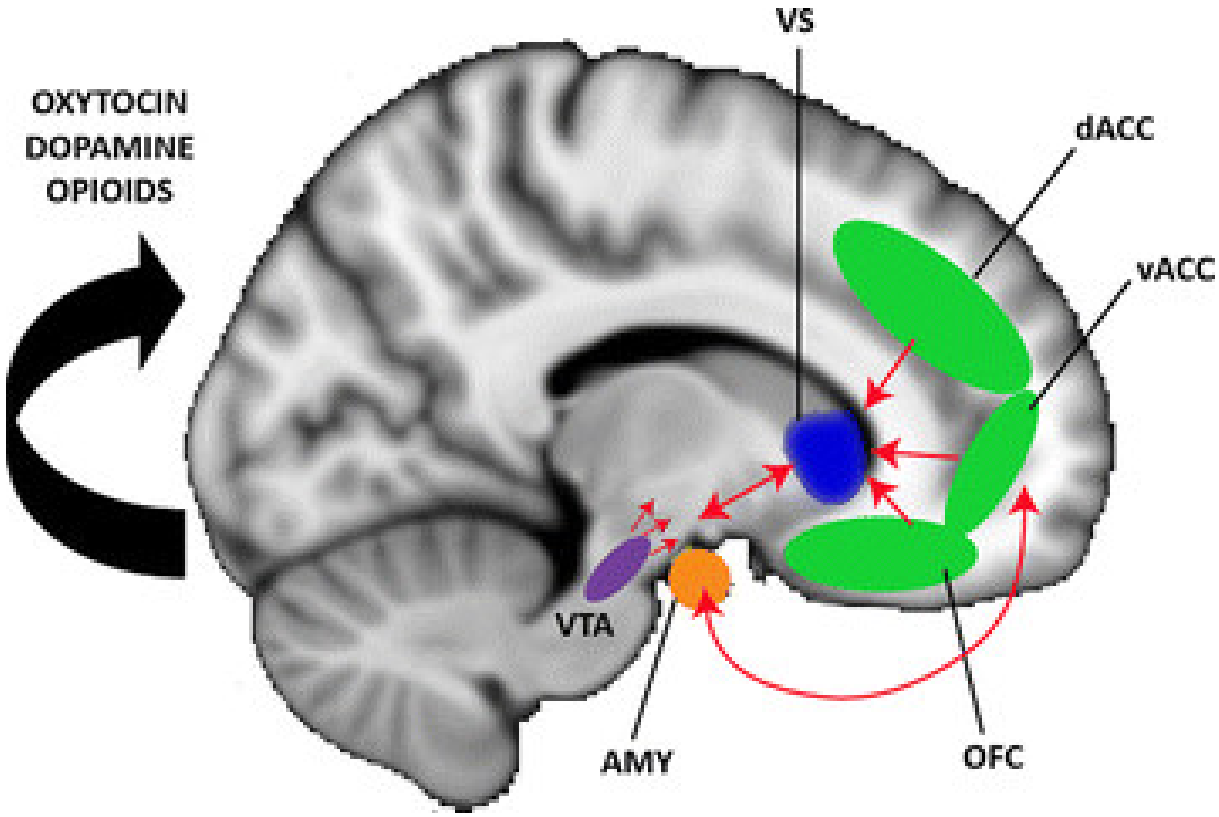


(Nestler and Carlezon 2006)

Nodes in the "reward" circuit

- Ventral tegmental area (VTA) in midbrain
- Nucleus accumbens (nAcc), ventral striatum
- Hypothalamus (Hyp)
- Amygdala (Amy)
- Hippocampus (HP)
- Dorsal Raphe Nucleus/Locus Coeruleus (DR/LC)
- Prefrontal cortex (PFC)

Nucleus accumbens and dorsal striatum

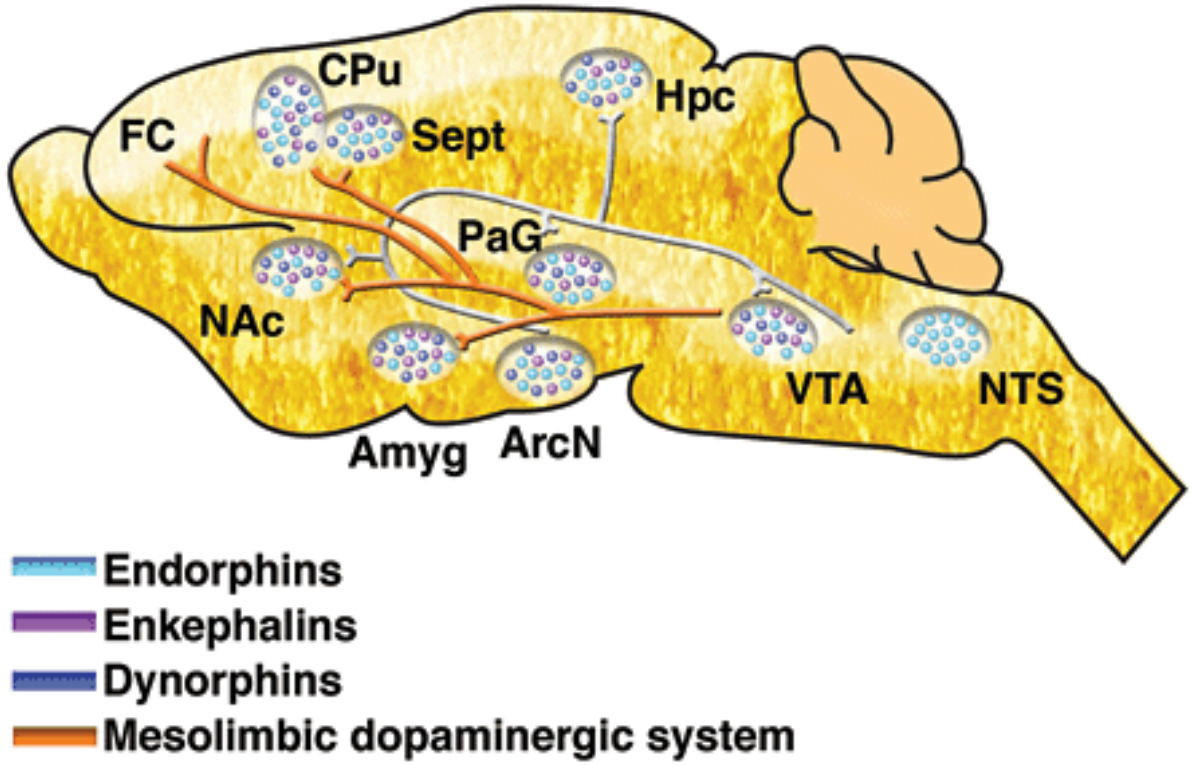


(Kohls et al. 2012)

Psychopharmacology of 'happiness'

- Dopamine
- Opioids
- Cannabinoids
- Serotonin, Norepinephrine
- ACh

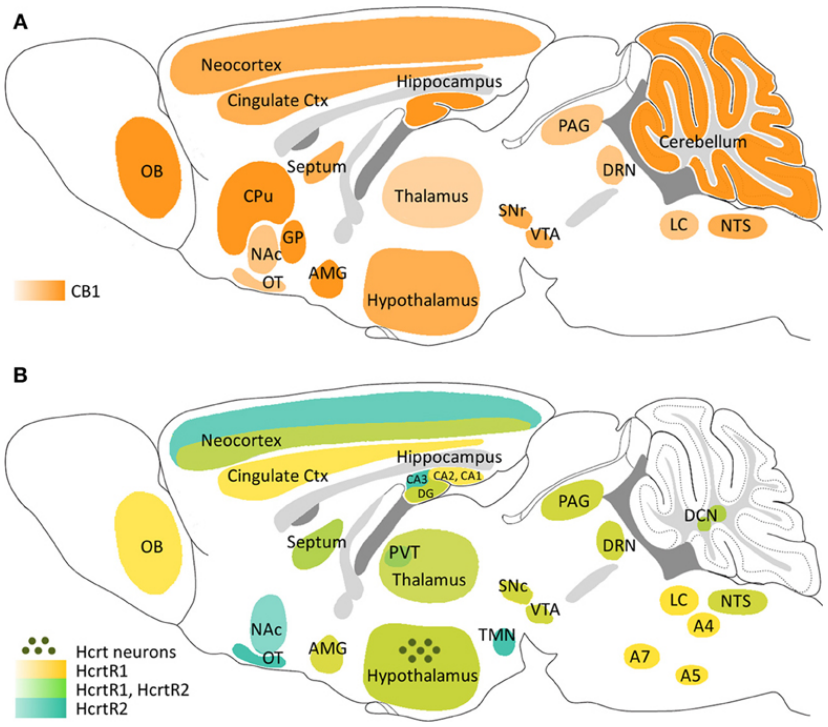
Endogenous morphine-like NTs (endorphins) from hyp, NST



(Clapp, Bhave, and Hoffman, n.d.)

Endogenous cannabinoid system

- Cannabinoids == psychoactive compounds found in cannibis
- Cannabinoid receptors, CB1 in CNS; CB2 in body, immune system

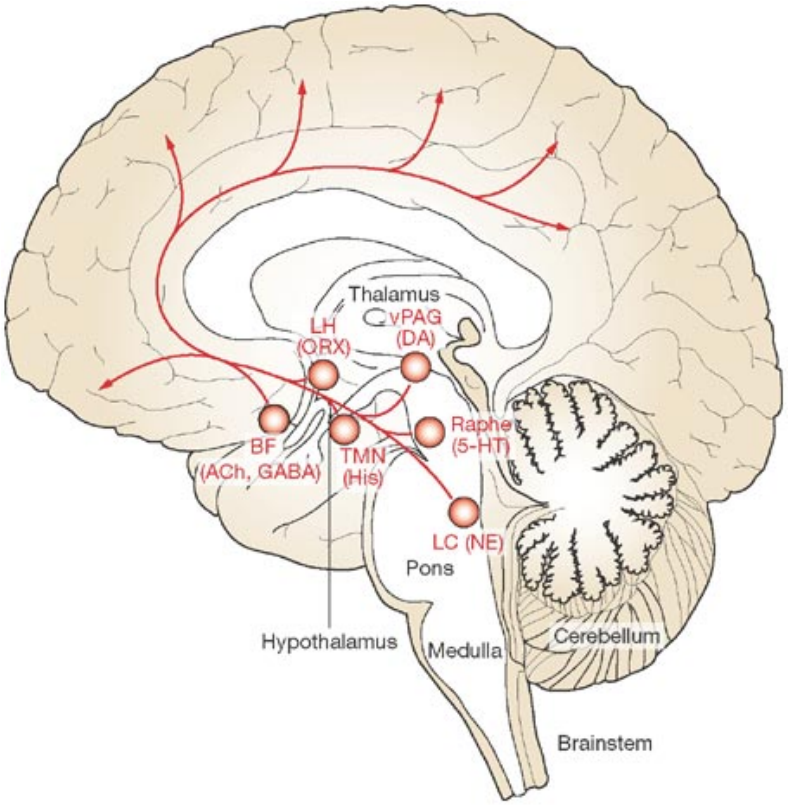


(Flores, Maldonado, and Berrendero 2013)

Brain contains its own systems for binding drugs associated with 'pleasure'

- Endogenous opioids (endorphins)
- Endogenous cannabinoids

ACh projections in the CNS



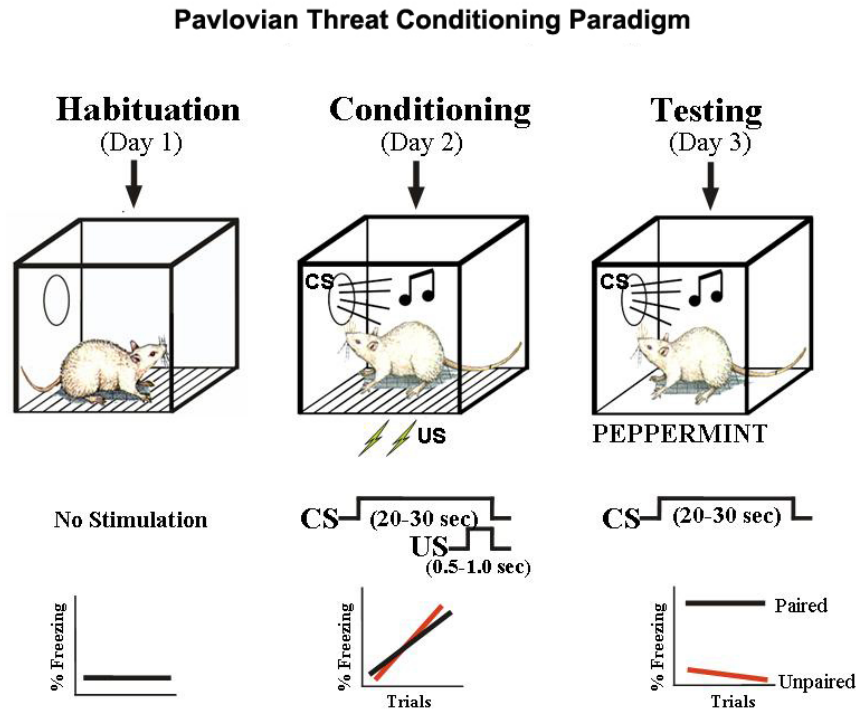
(Cock, Vidailhet, and Arnulf 2008)

Generalizations about happiness/pleasure

- Types of pleasure activate overlapping areas
- Pleasure/happiness engage a network of brain areas
- Pleasure/happiness signaling involves multiple neuromodulators, but DA especially important
- “Reward” pathways activated by many different inputs.

The neuroscience of fear and stress

Inducing "fear-like" behavior in animals



http://www.cns.nyu.edu/labs/ledouxlab/images/image_research/fear_conditioning.jpg

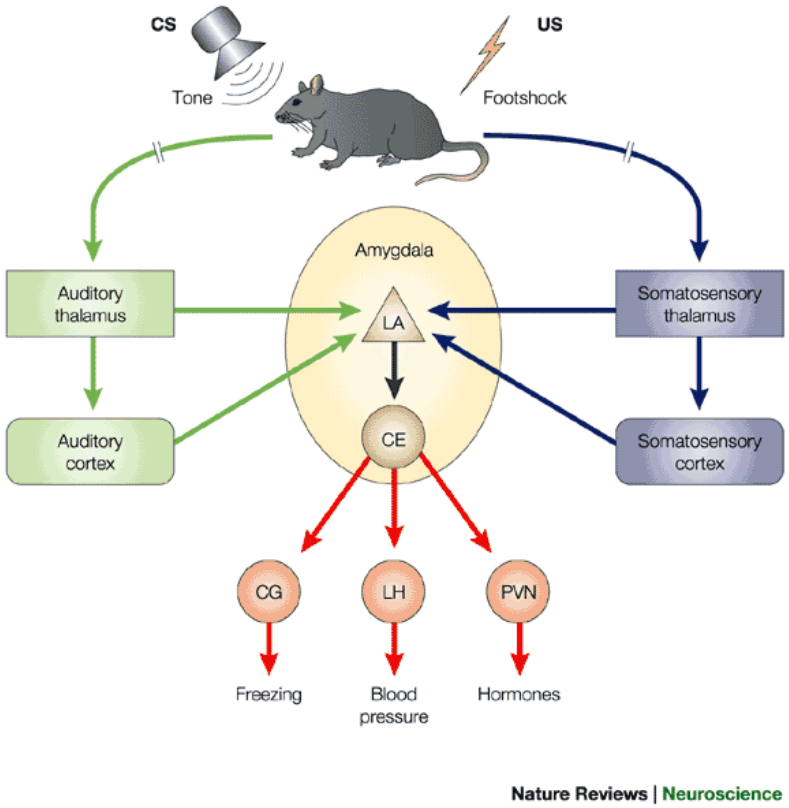
Rat vs. Human

Measures in Animal Model	DSM-III: Generalized Anxiety
Heart rate increase	Heart pounding
Salivation decrease	Dry mouth
Stomach ulcers	Upset stomach
Respiration change	Respiration increase
Scanning & vigilance	Scanning & vigilance
Startle response increase	Jumpiness, easy startle
Urination	Frequent urination
Defecation	Diarrhea
Grooming	Fidgeting
Freezing	Apprehensive expectation

Adapted from (Davis 1992)

Your thoughts: Can we use an animal model to study 'emotion'?

Amygdala circuits



(Medina et al. 2002)

Amygdala's inputs

- Convergent inputs
  - Thalamus ("direct" or "fast"")
  - Cerebral cortex ("indirect" or "slow")

Amygdala's outputs

- Project to
  - CG (central gray matter) of tegmentum: behavior
  - LH (lateral hyp): ANS
  - PVN (paraventricular n. of hyp): hormones
- Fast-acting, involuntary responses
- Lesions of amygdala impair 'fear conditioning'

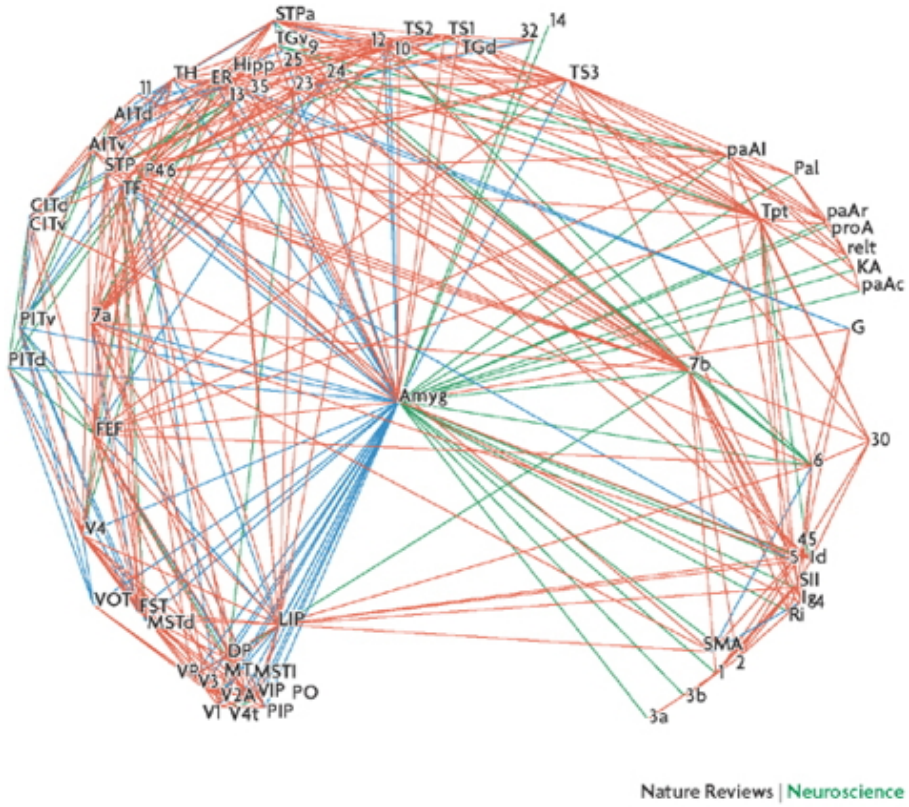
Cerebral cortex role

- Response discrimination?
  - Cortex lesions cause generalized not cue-specific fear response
- Fast, crude responses vs. slower, detailed ones
  - That’s a stick, not a snake!
  - Prefrontal cortex and response inhibition

But, are we really studying learned 'fear'?

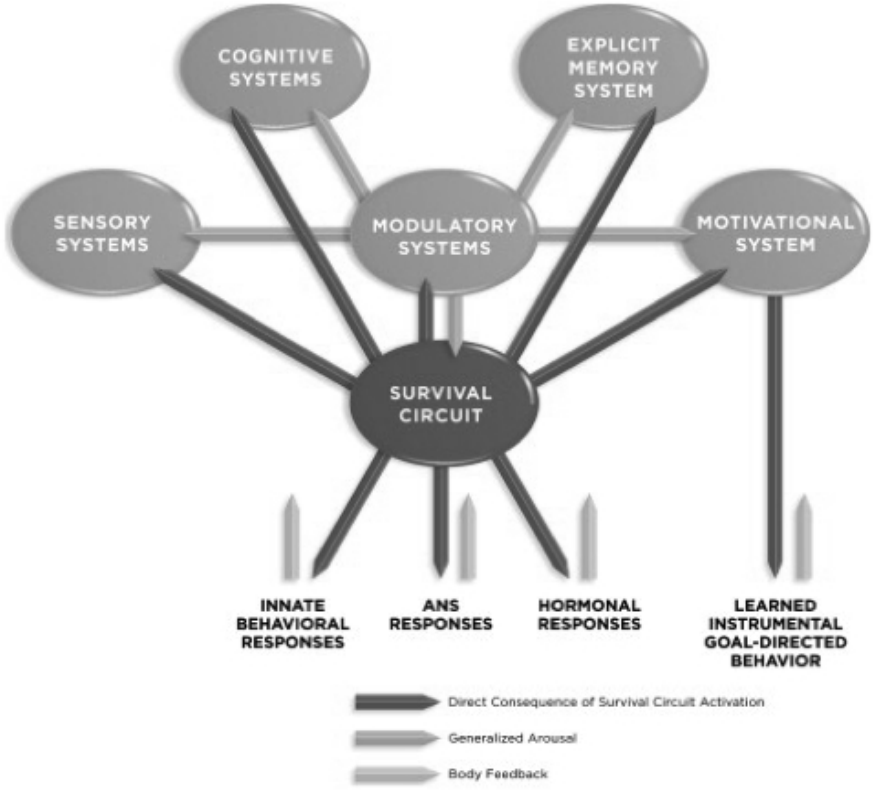
- Amygdala connected to other 'affective' nodes in neural network
- Emotion not just about subjective feelings

Amygdala as processing hub



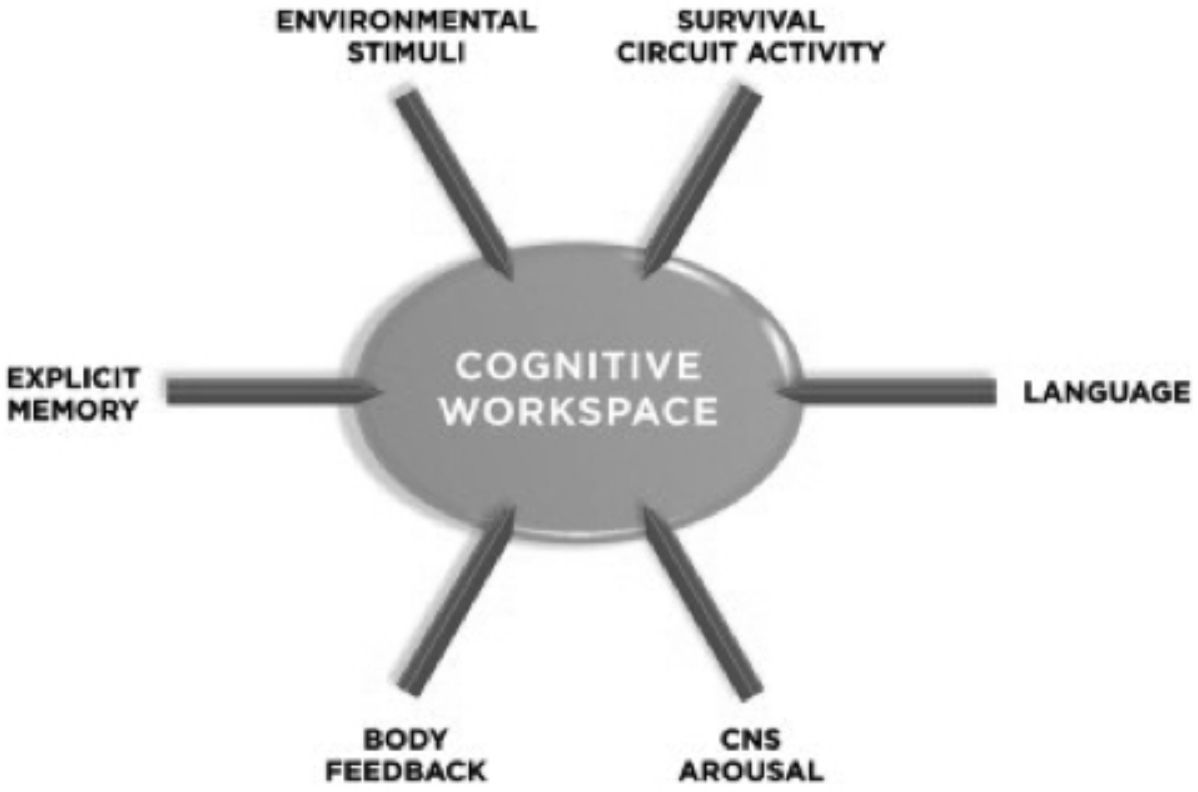
(Pessoa 2008)

Amygdala as key hub in circuit for survival



(J. LeDoux 2012)

Emotion as global physiological/behavioral "state"



(J. LeDoux 2012)

"Emotional" stimuli serve multiple roles

Table 1. Multiple Roles for So-Called "Emotional" Stimuli	
1. Survival Circuit Trigger Stimulus	Activates a specific survival circuit
Innate (Unconditioned) trigger	Elicits innate responses to stimuli without the need for prior exposure to the stimulus and mobilizes other brain resources to deal with the opportunity or challenge presented by the innate trigger
Learned (Conditioned) trigger	Potentially elicits innate responses to stimuli after being associated (via Pavlovian conditioning) with an innate trigger; more generally, mobilizes brain resources to deal with the challenge or opportunity signaled by the learned trigger
2. Incentive	Modulates instrumental goal-directed behavior to help meet the opportunity or challenge signaled by the stimulus that is triggering activation of a specific survival circuit
Innate (unconditioned or primary) incentive	Increases approach toward or avoidance of the stimulus in an effort to resolve the challenge or opportunity present
Learned (conditioned or secondary) incentive	Invigorates and guides behavior toward situations where the challenge or opportunity present can be resolved
3. Reinforcer	Supports the learning of Pavlovian or instrumental associations
Innate (unconditioned or primary) reinforce	Induces the formation of associations with neutral stimuli that occur in its presence (through Pavlovian conditioning) and to the formation of associations with responses that lead to the presentation (appetitive stimuli) or removal (aversive stimuli) of the stimulus (through instrumental conditioning)
Learned (conditioned or second-order) reinforce	Induces formation of associations with other stimuli (through Pavlovian second-order conditioning) or with goal directed responses (through second-order instrumental conditioning)

(J. LeDoux 2012)

Stress

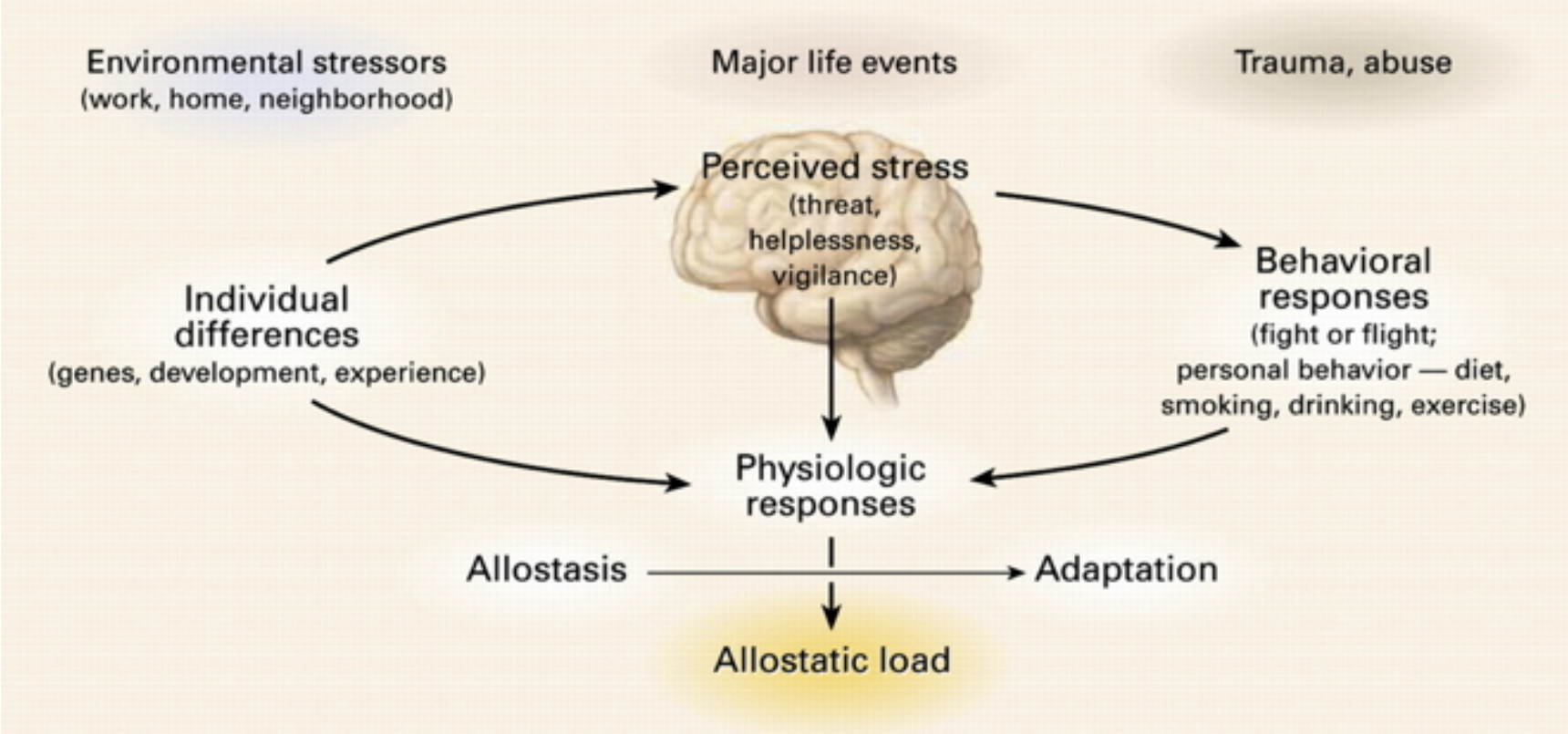
Stressors linked with biological imperatives

- Sustenance
  - Hunger, thirst
- Well-being/defense
  - Threat

Stressors linked with biological imperatives

- Reproduction
  - Rejection
- Affiliation
  - Loneliness

Stress and the brain



(McEwen 2007)

Brain under stress

- **Acute** stress
  - Short duration
  - Fast action required
  - HPA (Cortisol), SAM (NE/Epi) axes
- Brain detects threat
- Mobilizes physiological, behavioral responses

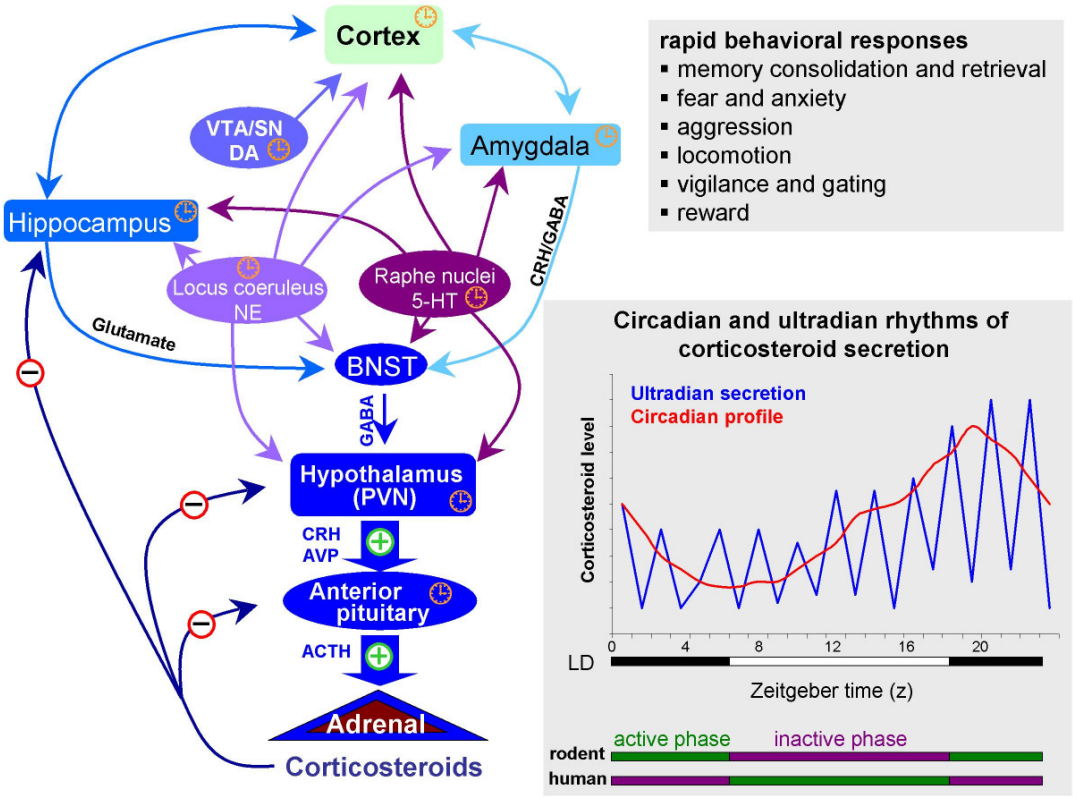
Brain under stress

- vs. **Chronic** stress
    - Long duration, persistent

Glucocorticoids

- Adrenal cortex releases hormones
  - Cortisol (hydrocortisone)
    - Increases blood glucose levels
    - Suppresses immune system
    - Reduces inflammation
    - Aids in metabolism
  - Receptors in brain and body

Cortisol and the brain



http://www.molecularbrain.com/content/figures/1756-6606-3-2-1-l.jpg

Glucocorticoid cascade hypothesis

- Cort receptors in hippocampus, amygdala, hypothalamus
    - Hippocampus regulates HPA axis via hypothalamus
- Prolonged cortisol exposure reduces hippocampus response
    - Reduces volume, connectivity in hippocampus
- Hip critical for long-term memory formation
    - Chronic stress impairs long-term memory

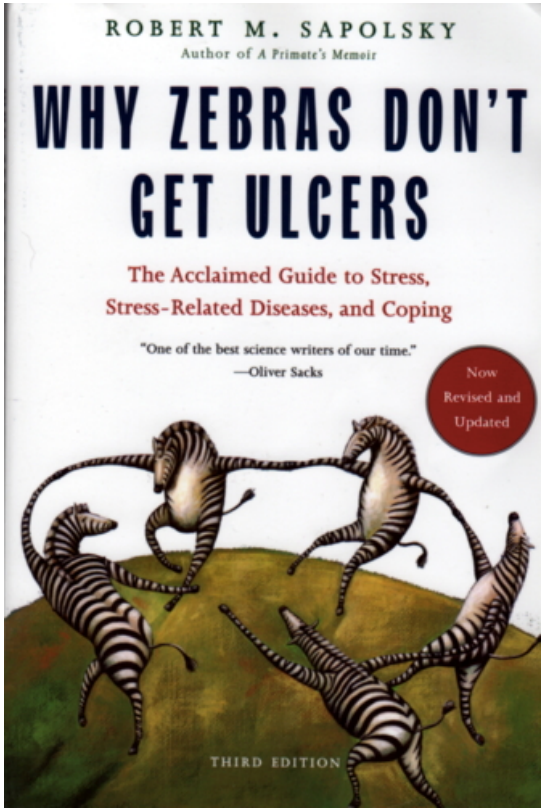
But, cortisol -> stress link not straightforward

(Å. Faresjö et al. 2013)

Stress and coping across the animal kingdom

- Pain thresholds lower (sensitivity greater) when a mouse's cage mate is also in pain
- Rats will cooperate to release distressed cage mage, foregoing food rewards
- (Sapolsky 2016)

Why Zebras Don't Get Ulcers



Your stress ain't like mine

- Phasic (short-term) vs. Chronic (long-term)
- Physical stress (hunger, thirst, injury, disease) vs. social stress

Main points

- Biological approach to emotion
  - Behavior
  - Physiological states
  - Subjective feelings
  - Adaptive function
- Networks of brain systems, multiple NT systems

Next time

- Quiz 3
- Review Exam 2

References

Clapp, Peter, Sanjiv V. Bhave, and Paula L. Hoffman. n.d. “How Adaptation of the Brain to Alcohol Leads to Dependence.” http://pubs.niaaa.nih.gov/publications/arh314/310-339.htm.

Cock, Valérie Cochen De, Marie Vidailhet, and Isabelle Arnulf. 2008. “Sleep Disturbances in Patients with Parkinsonism.” *Nature Clinical Practice Neurology* 4 (5): 254–66. doi:10.1038/ncpneuro0775.

Davis, Michael. 1992. “The Role of the Amygdala in Fear-Potentiated Startle: Implications for Animal Models of Anxiety.” *Trends in Pharmacological Sciences* 13. Elsevier: 35–41. doi:10.1016/0165-6147(92)90014-W.

Faresjö, Åshild, Elvar Theodorsson, Marios Chatziarzenis, Vasiliki Sapouna, Hans-Peter Claesson, Jenny Koppner, and Tomas Faresjö. 2013. “Higher Perceived Stress but Lower Cortisol Levels Found Among Young Greek Adults Living in a Stressful Social Environment in Comparison with Swedish Young Adults.” *PLoS ONE* 8 (9): e73828. doi:10.1371/journal.pone.0073828.

Flores, África, Rafael Maldonado, and Fernando Berrendero. 2013. “Cannabinoid-Hypocretin Cross-Talk in the Central Nervous System: What We Know so Far.” *Neuropharmacology* 7: 256. doi:10.3389/fnins.2013.00256.

Heath, Robert G. 1963. “Electrical Self-Stimulation of the Brain in Man.” *American Journal of Psychiatry* 120 (6). Am Psychiatric Assoc: 571–77. doi:10.1176/ajp.120.6.571.

Kohls, Gregor, Coralie Chevallier, Vanessa Troiani, and Robert T Schultz. 2012. “Social ‘Wanting’dysfunction in Autism: Neurobiological Underpinnings and Treatment Implications.” *Journal of Neurodevelopmental Disorders* 4 (10). BioMed Central Ltd: 1–20. doi:10.1186/1866-1955-4-10.

Kringelbach, Morten L, and Kent C Berridge. 2009. “Towards a Functional Neuroanatomy of Pleasure and Happiness.” *Trends in Cognitive Sciences* 13 (11). Elsevier: 479–87.