Emotion II: Reward, pleasure, and desire

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Outline

• Reward, pleasure, and desire, and relevant brain substrates
• Overlap between brain substrates of positive and negative emotions
• Recapitulation
Rewards and associated emotional states

A reward is an object or event that elicits approach and is worked for.

Reward is associated with wanting and liking. Wanting is characterised by ‘feeling’ of desire and approach behaviours. Liking is characterised by ‘feeling’ of pleasure (explicit liking) and other objective responses (implicit liking), e.g. facial expressions.

Alterations in the brain substrates of reward-related processes are likely mechanisms underlying addiction.
‘Classical’ techniques to identify brain substrates of reward

Instrumental conditioning (appetitive)

Motor response (lever press) → Reward (food)

Intracranial electrical self-stimulation

Suspension elastic band

Intracranial drug self-administration

Reservoir
Injection cannula
Guide cannula

Intracerebral microdialysis to measure neurotransmitters associated with rewarding stimuli

Westerink (1995) *Behav Brain Res* 70:103

Nucleus accumbens dopamine and reward

Electrical stimulation of self-stimulation sites in the VTA increases accumbal dopamine levels measured by in vivo microdialysis

Fiorino et al. (1993) Behav. Brain Res. 55:131

Food increases accumbal dopamine

Drugs of abuse increase accumbal dopamine


And in humans?

Robust activation of human (dopamine-receiving) striatum by rewards

<table>
<thead>
<tr>
<th>Money</th>
<th>Reward prediction error</th>
<th>Beautiful faces</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thut (Leenders, Schultz) et al. 1997</td>
<td>O’Doherty (Dolan) et al. 2003</td>
<td>Aharony (Breier) et al. 2001</td>
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<tr>
<td>Sports cars</td>
<td>Pleasant music</td>
<td>Humor</td>
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<tr>
<td>Placebo</td>
<td>Romantic love</td>
<td>Altruistic punishment</td>
</tr>
</tbody>
</table>

Schott et al. (2008), J. Neurosci. 28:14311-14319

Nucleus accumbens dopamine release during reward anticipation

[^11C]Raclopride replacement measured by PET imaging

http://www.scholarpedia.org/article/Reward
Selected elements and connectivity of brain reward circuitry

Meso-corticolimbic dopamine system:
- Rewards increase NAC dopamine
- Systemic and intra-NAC dopamine antagonists block responses normally maintained by reward

Cholinergic projection from PPTg to VTA:
- Electrical self-stimulation
- Cholinergic drugs are self-administered into VTA

Glutamate projections from mPFC to VTA:
- Electrical self-stimulation
- Stimulate dopamine release in NAc

A good idea?
Rewarding stimuli increase dopamine transmission in NAc, animals work to increase dopamine stimulation within NAc, and dopamine antagonists block some behavioural effects of rewards (such as approach or lever pressing). These findings are consistent with which hypothesis?

a) NAc dopamine causes ‘pleasure’ (liking).

b) NAc dopamine causes ‘desire’ (wanting).

c) Both a) and b).
Directly into the brain’s pleasure centers: measuring ‘liking’

How much a subject works for reward may not directly reflect the ‘liking’ or ‘pleasure’ induced by the reward, but rather ‘wanting’ of or ‘desire’ for the reward.

Facial expressions to sweet or bitter tastes may serve as objective and direct measures of ‘liking’.

‘Liking’ expression – sweet

‘Disliking’ expression – bitter


Nucleus accumbens shell: role of opioid receptors in ‘liking’ and of dopamine receptors in ‘wanting’

Morphine or amphetamine injection into NAC shell

Morphine increases ‘liking’

Hedonic (sucrose)

Amphetamine decreases ‘liking’

Amphetamine increases ‘wanting’


Overlap between brain substrates of positive and negative emotions

Brain substrates of emotional states associated with aversive stimuli and appetitive stimuli (rewards) have originally been studied separately, but more recently it has come to the fore that there is an overlap.

- Dopamine and nucleus accumbens play important roles in fear-related processes, in addition to role in reward-related states and responses.

**Forebrain dopamine in classical fear conditioning**

Suggested involvement of dopamine transmission in amygdala, mPFC and nucleus accumbens in fear conditioning

<table>
<thead>
<tr>
<th>Substrate</th>
<th>Formation</th>
<th>Retrieval/Expression</th>
<th>Extinction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Amygdala</td>
<td>E (++)</td>
<td>E (++)</td>
<td>?</td>
</tr>
<tr>
<td>mPFC</td>
<td>Ø</td>
<td>E (++)</td>
<td>E (+)</td>
</tr>
<tr>
<td>Nucleus Accumbens</td>
<td>E (+)</td>
<td>E (+)</td>
<td>?</td>
</tr>
</tbody>
</table>

Ø: No involvement; ?: not yet investigated; E (+): some evidence for involvement (neurochemical and/or lesion studies); E (++): strong evidence (neurochemical, lesion, and microinfusion studies using specific dopaminergic compounds) for involvement.


- Amygdala, apart from playing key role in fear-related responses, has also been implicated in responses to appetitive stimuli (Baxter & Murray, 2002, *Nature Rev Neurosci* 3:563).


- DNQX injection into nucleus accumbens elicits both appetitive and defensive behaviours . . .

  . . . effects are mediated by dopamine (i.e., blocked by co-infusion of dopamine receptor antagonists) (Faure et al., 2008, *J Neurosci*. 28:7184).

**Functional implications:**

- A ‘common currency’ of emotion may enable brain to generate adaptive responses based on integrated assessment of positive and negative stimuli.
- Brain substrates, such as dopamine, nucleus accumbens, and amygdala, may not play specific role in emotion per se, but may contribute to fundamental cognitive processes that are associated with both aversive and appetitive stimuli (e.g., salience signalling and attention or associative learning).
Emotion I and II: Recapitulation

• Emotional responses can be measured objectively, enabling the scientific study of emotions in animals and humans.

• In animal experiments, the measurement of emotional responses can be combined with a variety of techniques to manipulate and monitor brain function in order to reveal brain substrates of emotions and their dysfunctions (example: fear/anxiety and related disorders).

• The detailed information from animal experiments can be confirmed by appropriate research on human emotions in healthy subjects and clinical populations.
Obviously, we cannot explain everything about human emotions by studying animals. But, . . ., we have been able to come to a very good understanding of some basic emotional mechanisms that are common to humans and other animals. With this information in hand, we are in a much better position to understand how newly evolved functions, like language and consciousness, contribute to emotions, and particularly how language and consciousness interact with the underlying nonverbal and unconscious systems that make up the heart and soul of the emotional machine.

LeDoux (1996) The emotional brain, p. 72
Reward, pleasure (liking), and desire (wanting) – selected reading

**Textbook chapter:**
Carlson NR (any recent edition) The physiology of behavior. Chapter 14, Reinforcement.

**Review articles:**

Emotion II: Reward, pleasure, and desire
– Some questions for revision

• What is the relation between reward, wanting (‘desire’), and liking (‘pleasure’)?

• How can we experimentally dissociate the brain substrates of wanting from those of liking in animals?

• Somebody calls dopamine a ‘pleasure molecule’ and the nucleus accumbens the ‘seat of pleasure in the brain’. What do you think about these statements after consideration of available scientific evidence?