Medical Neuroscience | Tutorial Notes

Neurobiology of Emotion

MAP TO NEUROSCIENCE CORE CONCEPTS[1]

NCC1. The brain is the body's most complex organ.

NCC5. Intelligence arises as the brain reasons, plans, and solves problems.

NCC7. The human brain endows us with a natural curiosity to understand how the world works.

LEARNING OBJECTIVES

After study of the assigned learning materials, the student will:

1. Characterize emotion as associative learning.
2. Differentiate the role of the amygdala and the orbital-medial prefrontal cortex in emotion.
3. Discuss involvement of limbic forebrain circuitry in decision-making.

TUTORIAL OUTLINE

I. Emotion and body state

- A. William James's view of emotion (ca. 1900)
  - 1. Emotion is the product of changes in body state
    - a. emotion-provoking stimuli activate somatic and visceral sensory receptors
    - b. peripheral autonomic and skeleto-muscular activities are engaged
    - c. peripheral responses are detected
    - *d. emotion elicited by peripheral feedback*
  - 2. thus, as James put it, *"we are afraid because we tremble"*
- B. modern theories affirm the importance of changes in body state, but question whether the "body-loop" is obligatory for emotional experience

II. Emotion as associative learning

- A. emotions are produced by the **association** of sensory stimuli (secondary reinforcers) with primary reinforcers (rewards and punishers) (see **Figure 29.6**[2])

[1] Visit **BrainFacts.org** for *Neuroscience Core Concepts* (©2012 Society for Neuroscience) that offer fundamental principles about the brain and nervous system, the most complex living structure known in the universe.

[2] Figure references to Purves et al., *Neuroscience, 5th Ed.*, Sinauer Assoc., Inc., 2012. [click here]

1. rewards: anything for which we will work (e.g., pleasant taste or tactile sensation)
2. punisher: anything that an animal we will avoid (e.g., aversive taste or pain)

B. emotions are the states of body and brain signaling the anticipation of reward or punishment

STUDY QUESTION

What change in excitatory synapses is a major factor in sustaining long-term potentiation?

A. the insertion of additional voltage-gated calcium channels in presynaptic terminals
B. the insertion of additional GABA-A receptors in postsynaptic membranes
C. the removal of excess NMDA glutamate receptors from postsynaptic membranes
D. the removal of excess D1 dopamine receptors from postsynaptic membranes
E. the insertion of additional AMPA receptors in postsynaptic membranes

III. Brain systems for emotional processing (where emotional learning takes place)

A. two main structures in the ventral and medial forebrain—the so-called "limbic" forebrain—are critically involved in emotional processing: the **amygdala** and the **orbital-medial prefrontal cortex** (see **Figure 29.4**)

B. output to "downstream" effector systems involves both classical motor pathways (pyramidal system) and less-well defined (extrapyramidal) pathways that mediate emotional expression (recall the parallel pathways that govern emotional and volitional facial expressions) (see **Figure 29.2**)

C. amygdala (see **Box 29B**; **Figure 29.9**)

1. associates sensory stimuli with rewards and punishers
2. especially important in threat/fear processing and fear-based social assessments
3. deficits produced by amygdala lesions can be understood in terms of a failure of emotional associative learning and an absence of threat/fear signaling

D. orbital-medial prefrontal cortex

1. involved in emotional processing, interpretation of social cues, planning appropriate social behavior, and formation of advantageous decisions in real-life circumstances (≈ reason)
2. emotional learning, especially when primary reinforcers are scents and food
3. involved in ongoing analysis and modification of behavior when reinforcement contingencies are rapidly changing (emotional re-learning)
4. necessary for the assessment of future consequences and the implementation of advantageous decisions (see below)

IV. Emotion and reason

A. when the orbital-medial prefrontal cortex is damaged ...

1. no impairments in sensorimotor control

2. no impairments on standard neuropsychological assessment; but

3. impaired emotional experience and expression

B. impaired rational decision making, especially in personal and social affairs (exemplified by the famous case of Phineas Gage)

C. pathological inability to make advantageous decisions in real life situations

D. suggests that *emotional processing is essential for rational decision making*

E. **somatic marker hypothesis** (A. Damasio, 1994)

1. rational decision making entails covert (subconscious) evaluation of future consequences

2. mental images representing possible outcomes trigger somatic states that 'mark' the mental images with emotional valence

3. somatic states may be truly somatic (involve activity of visceral and somatic motor effector systems) or vicarious (involve only neural representations of sensory activity at the level of the somatic sensory cortex)

4. thus, somatic markers bias deliberations toward implementation of advantageous decisions and away from disadvantageous decisions