Emotions: Normal and Abnormal
Outline

• Amygdala

• Orbitofrontal Cortex & Emotions and Decision Making
  – Schizophrenia

• Lateralization
  – Depression
Basic emotions

- Universally-recognized
Further Characterization

- **Dimensions**
  - Valence (good - bad)
  - Intensity (high arousal - low arousal)

- **Actions (Davidson)**
  - Approach (happiness, surprise)
  - Withdraw (fear, disgust)
Emotional Responses

- Direct/Explicit

- Indirect
  - Response facilitation/inhibition
  - Psychophysiological
    - Heart rate/blood pressure
    - Sweat gland activation
    - Enhanced startle
Neuroanatomy of Emotion
Cognition & Emotion

• Independent vs. Interdependent

  – Affect precedes cognition (Zajonc, 1980 & 1984)

  – Affect can not occur without cognitive appraisal (Lazarus, 1981, 1984)
Cognitive Neuroscience

• Independent AND Interdependent
  – Specific brain areas/structures process emotion
  – These emotion systems interact with other neurocognitive systems
James Papez, 1937

Mechanism of Emotion

- Hypothalamus
- Cingulate gyrus
- Anterior thalamus
- Hippocampus
Paul MacLean (1949, 1952)

Limbic System
• Amygdala
• Orbitofrontal cortex
• Basal ganglia
Current “emotion” structures

- Amygdala
- Orbitofrontal cortex
- Hypothalamus

- Complex interactions with other neural systems
Amygdala

**Corticomedial**
- Piriform cortex
- Hypothalamus

**Basolateral**
- Cortical regions
- Basal forebrain
- Medial thalamus
- Hippocampus

**Central**
- Hypothalamus
- Brain stem
Amygdala

- Physiological Fear Responses
- Memory
- Fear recognition
Kluver & Bucy 1939

• Bilateral amygdala ablation in monkeys

• Psychic blindness
  – Approach objects that normally elicited fear
  – Passive behavior
  – Disinhibited behaviors
    • Hypersexuality
    • Hyperorality

• NOT SUPPORTED BY RECENT FOCAL LESION STUDIES
Implicit Emotional Learning

• Fear conditioning
Patient S.P. (Phelps et al., 1998)

- Bilateral amygdala resection
- SCR impaired
- Verbal report intact

- Opposite pattern seen in patients with hippocampal damage
Explicit Learning

- In healthy people
- Emotion elicited from episodic memory
- Experience not necessary
Two Routes to the Amygdala

Autonomic response to aversive stimulus is rapid

Cortical processing of stimulus is not necessary but sufficient
Amygdala ➔ Hippocampus

• Emotion enhances recall

• Adaptive significance
Consolidation Account

• Stressor/arousal immediately after learning enhances consolidation

• Animal studies
• Human studies
• Physical stressor/arousing drug
Mediated by cortical arousal?

• Greater sensitivity in perceiving/processing emotional stimuli

• amygdala increases vigilance/readiness to respond in presence of emotional stimuli
Support from Humans

- Attentional blink reduced for emotionally charged words (Anderson & Phelps, 2001)
  - Facilitation not observed in patients with amygdala damage

- Morris et al. (1998)
  - Visual cortex activation is enhanced for fearful faces compared to neutral faces
  - Strength of visual cortex response correlated with amygdala activation

- Canli et al., 2000
  - Activation of amygdala greater for emotional stimuli
  - Successful recall correlated with amygdala activity
Support from Animal Studies

- Kapp et al. (1994) - single cell recordings of amygdala (for cells that respond to fearful stimuli) correlated with spontaneous increase in cortical cell activity
Chronic vs. Episodic Activity?

- Difficult to reconcile with Sapolsky’s (1992) work showing chronic stress impairs learning/hippocampus
Recognition of Fear Expression

- Deficit is specific for fear and faces
- Also reported for fear anger prosody (Scott et al., 1997)
- R amygdala
Support from Neuroimaging

- Breiter et al., 1996
  - Amygdala showed greater activation to fearful expressions
  - Activation observed even for subliminal presentation!!
Amygdala Summary

- Implicit psychophysiological responses to aversive stimuli
  - Acquired through experience
  - Acquired through the hippocampus

- Facilitates explicit memory
  - Consolidation
  - Cortical arousal

- Fear identification
Orbitofrontal Cortex
Phineas Gage

- Reduced social concern
- Risky behavior
- Flat affect
- Lacked empathy
“Elliot” (Damasio)

- Bilat orbitofrontal tumor
- “Acquired psychopathy”
- Normal IQ
- Abstract reasoning vs personal/social reasoning
Orbitofrontal cortex is essential for physiological responses.

- How does this mediate decision making?
Somatic Marker Hypothesis

• Personal/social reasoning is guided by emotional evaluation of consequences

• Potential outcomes are linked to bodily states based on past experience or social norms

• Activation of bodily states narrows options quickly and efficiently (unconsciously biases behavior)
What are you going to do now?
Gambling Task

- Start 2000
- 4 decks of cards; 100 selections
- Deck A & B - higher gains and paybacks
- Deck C & D - lower payback and gain but best in the long run
Covert vs. Overt?
Orbitofrontal Cortex Summary

• Orbital cortex associates external stimuli to internal states

• Orbital cortex triggers internal state upon consideration of “risky” behavior
  – Implicit
  – Explicit

• When damaged, options must be reviewed consciously and decisions may be impulsive or random
Schizophrenia

- Poor social judgment
- Impaired decision making
- Risky behaviors
- Reduced initiation
Schizophrenia

Reduced PFC activation on PET
lateral PFC
medial PFC
Social/Emotional Decision Making

• Top-down vs. bottom-up flexibility
  – Habitual response triggered by stimulus
  – Responses governed by internal goal

• Top-down plans are shaped by social and emotional cues
Extreme Bottom-up Driven Behavior

• Internal goals fail to drive behavior

• Lhermitte (1983, 1986)
  – Utilization behavior
  – Imitative behavior
  – Unawareness
Circumscribed Bottom-Up Driven Behavior
High Level Deficit in Schizophrenia

• **Reduced cognitive (top-down) control**
  – Poor response inhibition
  – Impulsivity
  – Reduced sustained attention
  – Reduced initiation
  – Poor task switching (WCST)
  – Inability to multitask (divide attention)

• **Environmental control of behavior**
  – Increased distractibility
  – Stimulus- bound behavior
  – Utilization behavior
Laterality

• Emotional Communication
• Affective Style
Emotion Communication

- Comprehension
- Production

- Facial expressions
- Language prosody
Comprehension

Facial Expressions

• Fear - R amygdala (Anderson et al., 2000)
• Other emotions - R > L hemisphere activation

Language prosody

• Aphasia patients comprehend prosody
Production

• Facial expressions
  – Subcortical
    • Spontaneous
    • Bilateral
  – Cortical
    • Willful
    • Contralateral only

• Language prosody
  – R hemisphere advantage
Affective Style

- Clinical Observation
  - R hemisphere CVA/lesion
    - Indifference to deficit
    - Inappropriate happiness
  - L hemisphere CVA/lesion
    - Greater risk for depression
    - Catastrophic reaction
Richard Davidson

- Healthy subjects
- Baseline prefrontal EEG activation
- (PANAS) measure of personality (happy, anxious, etc.)
External Stimuli

• Positive/negative film clips

• L frontally active (L > R) report more positive affect to positive clips

• R frontally active subjects report more negative affect to negative clips
Temperament

- Davidson & Fox, 1989
- 10 month-old infants
- Right dominant activity - more likely to cry in response to maternal separation compared to L active subjects

- Davidson & Rickman, 1999
- Toddlers
- R active toddlers show more behavioral inhibition and weariness
Depression

- Laterality effects are inconsistent, but…

- EEG and PET studies show R > L frontal activation in patients with major depression

- R > L activation disappears after successful treatment of depression

- PET - depressed subjects - R > L amygdala correlated with negative affect (PANAS scale)
Anxiety

• Social phobics show increased R > L PFC activity prior to public speech (Davidson et al., 2002)

• Rauch et al., 1997
TMS

magnetic field applied to skull at a specified pulse frequency

Low frequency - inhibits functioning - “virtual lesion”

High frequency - stimulates cortex
High Frequency TMS

• Effects purported to last hours to weeks

• L prefrontal cortex - subjects report increase of negative emotions

• R prefrontal cortex - subjects report increase of positive emotions/reduced depression