The Emotional Brain

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Outline

A. What are emotions and do they have a purpose?

B. How do we study emotions in the laboratory?

C. What brain circuits support emotion processing and regulation?

D. How does emotion go awry in psychiatric conditions?
What are emotions and do they have a purpose?
What is emotion?

• “one of the most significant things ever said about emotion may be that everyone knows what it is until they are asked to define it”
What is emotion?

- e·mo·tion (from Latin outward motion)
- Feeling?
- State of mind?
- Bodily state?
- Expression?
- Behavior?
Criteria for “Basic Emotions”  
(Ekman et al. 1994)

- Distinctive universal signals
- Presence in other primates
- Distinctive physiology
- Distinctive universals in antecedent events
- Rapid onset
- Brief duration
- Automatic appraisal
- Unbidden occurrence
“Basic” Emotions

Fearful
Angry
Sad

Happy
Disgusted
Surprised
“Basic” Emotions

(a) show me what your face would look like if you were about to fight.

(b) show me what your face would look like if you learned your child had died.

(c) show me what your face would look like if you met friends.
“Basic” Emotions

- Anger
- Fear
- Sadness
- Enjoyment
- Disgust
- Surprise

- Contempt
- Shame
- Guilt
- Embarrassment
- Awe
- Amusement
- Satisfaction
- Excitement
- Pride
- Relief
- Sensory Pleasure
- Love
- Jealous

That’s it?!
Evolutionary Theory of Emotion

• Charles Darwin proposed emotions evolved because they are adaptive

• Certain emotions are universal

1872, The Expression of the Emotions in Man and Animal
James-Lange Theory of emotion (late 1800s)

Physiology $\rightarrow$ Appraisal

“*My heart is pounding, so I must be afraid.*”
Cannon-Bard Theory of emotion (1920s)

Appraisal → Physiology

“I feel afraid, so my heart pounds.”
Where these theories fall short

• J-L: Assumes there is a unique physiological signature to each emotion.

• C-B: Physiological responses are generated so quickly, it’s unlikely that we could have perceived the emotion first.
Schachter Two Factor Theory

Schachter's Two-Factor Theory

 Emotional stimulus (snake)  \[\rightarrow\]  Arousal plus label ("I am afraid.")  \[\rightarrow\]  Emotional feelings (fear)  \[\rightarrow\]  Behavior (run)

(d) Arousal causes the brain to find a reason for the arousal. Once the arousal is labeled, the emotion occurs.
Schachter & Singer’s classic study

• Shot of adrenaline to participants
  – Explained as having arousing side effects, misinformed side effects or not mentioned

• Placed in room with happy or angry confederate
  – Participants with no explanation for arousal experienced happiness or anger

Schachter and Singer, 1962
Adaptive purpose of emotions

- Emotions induce *motivation*
  - Spring us into action
  - Lower sensory thresholds
  - Facilitates learning
    - Enhance memory
    - Modulates appropriate approach/avoidance behavior
    - The arousal associated with emotions facilitates performance (to a certain extent)

Yerkes-Dodson law
How do we study emotions?
Affective Neuroscience Toolbox

- Animal models (especially fear)
- Lesion studies
- Psychophysiology
  - Heart Rate
  - Skin conductance (ANS arousal)
- Neuroimaging:
  - fMRI (Hemodynamic response)
  - fNIRS (portable)
- Various other electrophysiology techniques
  - Electroencephalography
  - Single unit recordings
  - Transcranial magnetic stimulation
How to study emotion in the lab?

• Tapping into emotional *experiences and perception*

  – Make people emotional in the lab
  – Mood inductions
  – Paradigms that induce fear or anxiety (threat-of-shock) or other emotions (displaying evocative imagery)
  – Measure responses to emotional cues (facial expressions)
How to study emotion in the lab?

• Tapping into emotional *regulation* and the *outcome* of experiencing emotion
  – Induce emotion → measure subjects’ ability to dampen
  – Measure how emotions facilitate secondary behaviors (memory, action)

• Directly test individuals who experience emotional *dysregulation*
  – Psychiatric illnesses involving fear, anxiety, depression
  – Disorders understanding emotions
What brain circuits support emotion processing and regulation?
The amygdalae are almond-shaped bodies located in bilateral medial temporal lobe.
Pavlovian Conditioning

Conditioned Stimulus (CS)

Unconditioned Stimulus (US)
Information about the CS is integrated with information about the US within the amygdala.
Fear conditioning in humans

CS

US

Amygdala critical for responding to the conditioned stimulus

LaBar et al., 1998
Click on AMYGDALA to ENTER

Insights on the role of the amygdala in appraising emotions from Patient SM
Insights on the role of the amygdala in appraising emotions from Patient SM

Adolphs et al. 1994
Adolphs et al., 1995

- Subject with bilateral amygdala lesions was asked to draw facial expressions of emotions.
Processing emotional cues in the environment is important

Something really bad is happening…and you probably want to know what I know!
Amygdala response to facial expressions of emotion

Breiter et al., 1996
What conclusions can we draw about the role of the amygdala in emotional processing?

• An intact amygdala is necessary for the acquisition and expression of fear (animal, lesion patients)
How **crucial** is the amygdala for emotional processing?

**Emotional Enhancement for Memory (EEM)**
- Enhanced memory for emotional events

![Negative and Neutral Images](image)

Anderson et al. 2006
Negative Scenes versus Fearful Faces

Anderson et al. 2006
The Amygdala

Amygdala

Hippocampus
What conclusions can we draw about the role of the amygdala in emotional processing?

• An intact amygdala is *necessary* for the acquisition and expression of fear (animal, lesion patients)

• Amygdala is *not necessarily sufficient* to enhance memory for emotional events
Most people, including many scientists, believe that emotions are distinct, locatable entities inside us – but they’re not.
Emotion Processing: The Prefrontal Cortex

• The capacity to modify an emotional experience is important for adapting to our environment.
  - Fear Extinction
  - Emotion Regulation

Fear extinction

Conditioned Response
Extinction and the MPFC

- The ventromedial prefrontal cortex is critical to emotion regulation
- Enables *new learning of a* positive interpretation of the once-negative stimulus
- Dampens amygdala response via direct inhibitory gating
- Behavior: no response to previous fear cue
VMPFC recruitment facilitates retention of extinction memory
Phelps et al., 2004
Neural Circuits for Emotion Processing

• Coordinated activation between the amygdala and the prefrontal cortex allows for regulation of fear

• Emotion regulation is reliant on neural systems – not one brain region
How does emotion go awry in psychiatric conditions?
PTSD: failure to extinguish?

PTSD:
Hyper-responsive amygdala

Hypo-responsive VMPFC

Summary by Milad et al., 2006
Autism: Diagnostic Criteria

• “Deficits in social-emotional reciprocity, ranging, for example, from abnormal social approach and failure of normal back-and-forth conversation; to reduced sharing of interests, emotions, or affect; to failure to initiate or respond to social interactions.”

• “Deficits in nonverbal communicative behaviors used for social interaction, ranging, for example, from poorly integrated verbal and nonverbal communication; to abnormalities in eye contact and body language or deficits in understanding and use of gestures; to a total lack of facial expressions and nonverbal communication.”
Amygdala Growth in Autism vs. Typical Development

Nordahl et al. 2012
Difficulties with Emotion Recognition in Autism

Uljarevic et al. 2013
Can emotions to be taught?

Teaching emotion recognition skills to young children with autism: a randomised controlled trial of an emotion training programme

Beth T. Williams, Kylie M. Gray, and Bruce J. Tonge
Centre for Developmental Psychiatry and Psychology, School of Psychology and Psychiatry, Monash University, Clayton, Vic., Australia

Research in Autism Spectrum Disorders

Teaching social–emotional skills to school-aged children with Autism Spectrum Disorder: A treatment versus control trial in 41 mainstream schools

Belinda Ratcliffe, Michelle Wong, David Dossetor, Susan Hayes

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Take-home points

• Emotions are complex reactions involving feelings, physiological reactions, and contextual interpretations.

• The generation and experience of emotion is primarily modulated through interactions between subcortical and cortical brain structures including the amygdala and subregions of the prefrontal cortex.

• The amygdala plays a critical role in emotional learning and generating appropriate responses to environmental cues.

• The VMPFC interacts with subcortical structures like the amygdala to modulate emotional responses.

• Dysfunctional subcortical-cortical interactions play an important role in the pathophysiology of many psychiatric illnesses.
Thank you!

Sacklerinstitute.org
nyp.org/autism/