Neuropsychology of Emotion: Integrating Theory with Practice

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Learning objectives

(1) To describe five primary components of emotional processing and their neuroanatomic substrates

(2) To be aware of clinical populations that exhibit deficits in emotional processing

(3) To understand how neurocognitive abilities and test performance are affected by strengths and weaknesses in individual components of emotional processing
Components of an emotional event

- Trigger
- Communication
- Reflexive responses
- Regulation
- Awareness

Theoretical background
- Defining the constructs
- Neuroanatomy
- Interplay with cognition

Integrating theory and practice
- Assessment issues
- Daily functioning
- Clinical signs and syndromes
- Clinical populations
THEORETICAL BACKGROUND:
Definition of a trigger

- A brain mechanism
  - NOT stimulus
- Functions
  - Detection of emotionally relevant stimuli
  - Initiation of an emotional response
    - Cascade of cognitive, behavioral, and physiologic events
Emotionally-relevant stimuli

Inherent

Learned
Emotionally-relevant stimuli

- Important dimensions
  - Valence
    - Positive vs. negative
  - Intensity
    - High vs. low arousal

- Orthogonal
- Often confounded
Trigger sensitivity

- Inter-species differences
- Intra-species (individual) differences

- Situational differences
  - Mood states/context
  - Hormonal states
  - Past history
"slow route"

- Thalamus
  - Primary Sensory Cortex
    - Secondary Sensory Cortex
      - Tertiary Sensory Cortex
        - TRIGGER
          - Hippocampus
            - Object
            - Meaning
            - Context

"fast route"

Crude characteristics

Sensory Organs

(LeDoux, 1996)
Empirical support for “fast route”

- Emotional blindsight
- Subliminal perception

de Gelder, Vroomen, Pourtois, & Weiskrantz, 1999; de Gelder, Vroomen, Pourtois, & Weiskrantz, 2000; Morris, de Gelder, Weiskrantz, & Dolan, 2001; Naccache et al., 2005; Ohman, 2002, 2005
THEORETICAL BACKGROUND: Neuroanatomy

- **Primary trigger**
  - Amygdala
    - Bilateral amygdala damage does **not** eliminate autonomic variability in daily life

- **Other triggers?**
  - Hypothalamus
    - Homeostasis
      - Glucose levels
      - Hydration
      - Body temperature

Corrective behavioral actions require autonomic arousal

Baas, Aleman, & Kahn, 2004
Amygdala: Trigger Characteristics

- *Necessary* for detection of emotional stimuli
- *Necessary* for triggering of reflexive emotional responses
- *Capable* of learning associations between affective and neutral stimuli
Amygdala: Detection of Affective Stimuli

- Sensitive to (fMRI activation)
  - Direct exposure to emotionally relevant stimuli
    - Snakes, spiders
    - Loaded guns
    - Emotional faces
    - Emotional body movements
  - Vicarious exposure to emotionally relevant stimuli
    - Observation
    - Verbal account

Kim et al., 2007; LaBar, Crupain, Voyvodic, & McCarthy, 2003; Ohman, 2005; Phelps, Fiske, Kazdin, & Schacter, 2006
Amygdala: Detection of Affective Stimuli (cont’d)

- Is it *necessary*?
  - Damage to the amygdala interferes with understanding of emotional stimuli
    - Affective verbal and facial expressions
    - Emotional music

Kim et al., 2007; LaBar, Crupain, Voyvodic, & McCarthy, 2003; Ohman, 2005; Phelps, Fiske, Kazdin, & Schacter, 2006
Amygdala:
Trigger Characteristics

- *Necessary* for detection of emotional stimuli
- *Necessary* for triggering of reflexive emotional responses
- *Capable* of learning associations between affective and neutral stimuli
Amygdala: Triggering of motor and physiologic responses

- **Necessary?**
  - Animal lesion studies
    - Rats fail to avoid/freeze in response to cats
    - Monkeys fail to exhibit behavioral and physiologic responses to snakes
  - Human lesion studies
    - Fail to exhibit cognitive and physiologic response to
      - Emotional pix, words, music

Kim et al., 2007; LaBar, Crupain, Voyvodic, & McCarthy, 2003; Ohman, 2005; Phelps, Fiske, Kazdin, & Schacter, 2006
Amygdala: Trigger Characteristics (cont’d)

- **Necessary** for detection of emotional stimuli
- **Necessary** for triggering of reflexive emotional responses
- **Capable** of learning associations b/w affective and neutral stimuli
Amygdala: Emotional learning

- Fear conditioning
  - Amygdala activated by fear conditioning
    - Direct
    - Vicarious
      - Verbal accounts
      - Observations

Kim et al., 2007; LaBar, Crupain, Voyvodic, & McCarthy, 2003; Ohman, 2005; Phelps, Fiske, Kazdin, & Schacter, 2006
Emotional learning:
Other structures

- Hippocampus
- Orbitofrontal cortex
Emotional learning: Hippocampus

- Hippocampus
Emotional learning: Hippocampus

Fear conditioning studies: Pairing a neutral stimulus with a shock in a particular context

<table>
<thead>
<tr>
<th>Amygdala</th>
<th>Hippocampus</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intact</td>
</tr>
<tr>
<td>Intact</td>
<td>• Normal physiologic response</td>
</tr>
<tr>
<td></td>
<td>• Normal declarative memory</td>
</tr>
<tr>
<td>Lesioned</td>
<td>• Impaired physiologic response</td>
</tr>
<tr>
<td></td>
<td>• Normal declarative memory</td>
</tr>
</tbody>
</table>

Phelps, 2004; Ito et al., 2006
Emotional learning: Orbitofrontal cortex

- **Encoding** associations between emotional and sensory information (all sensory modalities)
- **Rapid updating** of contingencies as they change

**BUT:**
- Amygdala may be necessary for learning to take place

Rolls, 2004
Amygdala:
Trigger Characteristics (cont’d)

- Necessary and sufficient for detection of affective stimuli
- Necessary for triggering of reflexive emotional responses
- Capable of learning associations b/w affective and neutral stimuli
Thalamus

Sensory Organs

Primary Sensory Cortex

Tertiary Sensory Cortex

Secondary Sensory Cortex

Basolateral Amygdala

Central Nucleus of the Amygdala

Hippocampus

Orbitofrontal Cortex

Crude characteristics

Object

Meaning

Context

Orbitofrontal Cortex
Controversies in amygdala research: Stimulus valence

- Older research
  - Negative emotions only (mainly fear)
  - Only conditioning for fear

Adolphs, Russell, & Tranel, 1999; Adolphs, Tranel et al., 1999; Baxter & Murray, 2002; Burgdorf & Panksepp, 2006; S. Hamann & Mao, 2002; Everitt, Cardinal, Parkinsons, & Robbins, 2003; Lee et al., 2004; Liberzon, Phan, Decker, & Taylor, 2003; Murphy et al., 2003
Controversies in amygdala research: Stimulus valence (cont’d)

- **Explanations**
  - **Functional imaging research**
    - Confounded by intensity
    - Social relevance
  - **Newer research**
    - Positive stimuli
      - Controlling for stimulus intensity/relevance
        - E.g., baby faces
      - Controlling for social relevance

Adolphs, Russell, & Tranel, 1999; Adolphs, Tranel et al., 1999; Baxter & Murray, 2002; Burgdorf & Panksepp, 2006; S. Hamann & Mao, 2002; Everitt, Cardinal, Parkinsons, & Robbins, 2003; Lee et al., 2004; Liberzon, Phan, Decker, & Taylor, 2003; Murphy et al., 2003; Vrticka, Sander, & Vuilleumier, 2012
Controversies in amygdala research: Stimulus valence (cont’d)

○ Explanations
  ● **Functional imaging research**
    ○ Confounded by intensity
    ○ Confounded by social relevance
  ● **Human lesion research**
    ● Avoidance of eyes regions
    ● Compensation?

Adolphs, Russell, & Tranel, 1999; Adolphs, Tranel et al., 1999; Baxter & Murray, 2002; Burgdorf & Panksepp, 2006; S. Hamann & Mao, 2002; Everitt, Cardinal, Parkinsons, & Robbins, 2003; Lee et al., 2004; Libezon, Phan, Decker, & Taylor, 2003; Murphy et al., 2003; Vrticka, Sander, & Vuilleumier, 2012
## Controversies in amygdala research: Laterality

- Contradictory findings

<table>
<thead>
<tr>
<th>Left Hemisphere</th>
<th>Right Hemisphere</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Positive</td>
<td>Negative</td>
<td>Pourtois, De Gelder, Bol, &amp; Crommelick, 2005</td>
</tr>
<tr>
<td>Imagined anticipated, symbolically expressed</td>
<td>Personally experienced</td>
<td>Funayama, Grillon, Davis, &amp; Phelps, 2001</td>
</tr>
<tr>
<td>Verbal</td>
<td>Visual</td>
<td>Anderson &amp; Phelps, 2001; Benuzzi et al., 2004; Johnstone, van Reekum, Oakes, &amp; Davidson, 2006</td>
</tr>
<tr>
<td>Retrieval (memories)</td>
<td>Encoding (memories)</td>
<td>(Sergerie, Lepage, &amp; Armony, 2006)</td>
</tr>
<tr>
<td>Cognitive evaluation</td>
<td>Autonomic activation</td>
<td>Glascher &amp; Adolphs, 2003; Skuse, Morris, &amp; Dolan, 2005</td>
</tr>
</tbody>
</table>
THEORETICAL BACKGROUND:
Interplay with cognition

- Attention
- Memory
- Judgment
- "Emotional" decision making
Amygdala and cognition: Attention

- Attentional blink task
  - Words in a rapid succession on the screen
    - Not possible to perceive all
  - Task: Identify words printed in different color ink (e.g., green)
    - This is easy, but followed by a brief “attentional blink”
Amygdala and cognition: Attention (cont’d)

- Emotional words
  - Abolish attentional blink
  - Temporally reverse attentional blink

- Individuals with bilateral amygdala damage do not show this effect

Anderson & Phelps, 2001
Amygdala and cognition: 

**Memory**

- Amygdala facilitates declarative memory
  - List of words OR series of photos
  - Some emotional, some neutral
  - Recognition memory better for emotional stimuli

- **Individuals with bilateral amygdala damage do not show this effect**

Buchanan, Denburg, Tranel, & Adolphs, 2001; Phelps et al., 1998
Amygdala and cognition: Judgment

- "Mimicking" judgment and behavioral control deficits due to
  - Diminished sensitivity to
    - Changes in contingencies
    - Feedback and punishing/rewarding outcome
Amygdala and cognition: “Emotional” decision making
Somatic Marker Hypothesis (Antonio Damasio, 1991)

- **Basic premise**
  - Brain stores “somatic markers”
    - Markers are implicit memories of physiological/somatic outcomes of actions
  - We use the markers to help us make decisions ("gut feelings")
  - Specific location of “markers” still controversial
    - **BUT:**
      - Amygdala appears necessary for storage to take place
Assessment: Iowa Gambling Task (Antoine Bechara, 1994)

--- $2000.- for 100 trials
--- Not possible to calculate or figure out the odds
--- Have to go by “gut feeling”
Integrating theory and PRACTICE: Amygdala damage and everyday life

- Normal IQ, general cognition
- Normal attention and declarative memory, BUT
  - Noticing the “wrong” stimuli
  - Remembering the “wrong” events
    - Cities, route travelled
    - NOT emotionally salient episodes
- Diminished understanding of affective displays of others

Amat et al., 2008; Huebner et al., 2008; Marsh et al., 2008; Pol et al., 2006; Weller, 2007; Wiest, Lehner-Baumgartner, & Baumgartner, 2006
Integrating theory and PRACTICE: Test performance

- Hyperactive trigger
  - Vigilance, anxiety
  - Over-focusing on emotional stimuli
  - Narrowing of attention
    - exclusion of non-emotional stimuli
  - Consider a “reversed attentional blink” phenomenon
Integrating theory and PRACTICE: Test performance (cont’d)

- **Hypoactive trigger**
  - Failure to benefit from facilitation conferred by amygdala onto emotional stimuli in test material
    - Anna Thompson
    - Reading comprehension

Crouse, 2005; Suchy et al, 2009
Integrating theory and PRACTICE: Clinical Syndromes

- Human Kluver and Bucy syndrome
- Capgras syndrome
Clinical Syndromes: Klüver & Bucy syndrome

Heinrich Klüver (1897-1979)  Paul Bucy (1904-1992)
Klüver & Bucy syndrome (1939)

- Anterior temporal lobectomies on rhesus monkeys
  - Visual agnosia
  - Indiscriminate eating
  - Tameness
  - Hypersexuality
  - Loss of fear and aggression
  - Social disinterest
  - Blunted affect
  - Rejection from social group

Kluver & Bucy, 1937, 1938, 1939
Human Klüver & Bucy syndrome

- **Most common symptoms**
  - Hyperorality
  - Hyperphasia
  - Visual agnosia
  - Inappropriate or excessive sexual behavior

- **Populations**
  - Neurodegenerative disorders
  - Left or bilateral temporal lobe epilepsy
  - TBI

Kluver & Bucy, 1937, 1938, 1939
Capgras syndrome

- Imposter; Delusional Misidentification
  - No autonomic response to familiar faces
    - But normal recognition
    - NOTE: normal autonomic response in prosopagnosia despite lack of recognition
  - Disconnection between conscious recognition and emotional trigger
    - But also impaired reasoning
  - Substrate for disconnection not well understood
    - Often right frontal or right temporal

Edelstyn & Oyebode, 1999; Eren, Civi, & Yildiz, 2005
Capgras syndrome (cont’d)

- Typical populations
  - CVA
  - Neurodegenerative disorder
    - Dementia with Lewy Bodies
    - Alzheimer’s dementia
    - Vascular dementia

Josephs, 2007
Integrating theory and PRACTICE: Clinical Populations

- Medical conditions
- Neurodevelopmental disorders
- Neurodegenerative disorders
- Neuropsychiatric disorders
- Other neurologic conditions

Cendes, Andermann, Dubeau et al., 1993; Cendes, Andermann, Gloor et al., 1993; Gloor & Aggleton, 1992
Medical conditions: Urbach-Wiethe Disease (ǔr′bak vē′tē)

- Lipoid proteinosis
  - Hyaline deposits on skin and other tissue
- Autosomal recessive disorder
- 50% develop bilateral amygdala calcifications
- Usually adult onset
  - Patients benefit from
    - Prior learning
    - Gradual course
  - Affect recognition usually normal
  - Emotional memory deficits

Cendes, Andermann, Dubeau et al., 1993; Cendes, Andermann, Gloor et al., 1993; Gloor & Aggleton, 1992
Neurodevelopmental disorders: Autism

- Amygdala abnormalities demonstrated via
  - Neuroimaging
  - Impaired processing of facial affect

- BUT:
  - Normal facilitation by non-social emotional stimuli
  - Normal fear potentiation and startle

Bernier, Dawson, Panagiotides, & Webb, 2005; Boelte & Poustka, 2003; South, Ozonoff, Suchy, et al., 2008
Neurodevelopmental disorders: 

**Turner syndrome**

- Chromosomal disorder (monosomy X)
- Physical characteristics
  - Short stature, webbed neck, gonadal dysfunction
- Cognitive weaknesses
  - Visual spatial and executive
- Affective abnormalities
  - Poor facial affect recognition
  - Social/interpersonal difficulties
- Structural and functional amygdala abnormalities

Brown et al., 2002; Kesler et al., 2004; Skuse et al., 2005
Neurodevelopmental disorders: Fragile X syndrome

- Most common genetic cause of MR
- Multiple cognitive and emotional abnormalities
  - Abnormal gaze & avoidance of eye contact
- Increased hippocampal and amygdalar volume
- Increased activation in hippo and amygdalar in response to eye contact
- Inconsistency re facial affect recognition

Watson et al, 2008; Dalton et al, 2008; Hagan et al., 2008
Neurodegenerative disorders: FXTAS

○ Fragile X-associated tremor/ataxia syndrome (FXTAS)
  ● Carriers (primarily male) of fragile X gene
    ○ No MR
  ● Adult onset Sx
    ○ Intention tremor, gait ataxia, dementia
  ● Reduced amygdala volume
  ● Childhood Sx
    ○ Social awkwardness, emotional deficits
    ○ Lack of startle potentiation
    ○ Reduced GSR in anxiety-producing situations

Bacalman et al., 2006; Hagerman & Hagerman, 2004; Hagerman et al., 2001; Hessl et al., 2007
## Neurodegenerative disorders: Dementias of old age

<table>
<thead>
<tr>
<th>Dementia type</th>
<th>Kluver-Bucy syndrome</th>
<th>Capgras syndrome</th>
<th>Refs</th>
</tr>
</thead>
</table>
| FTD           | • Up to 20%  
               • More common in a particular familial variant | N/A              | Mendes & Perryman, 2002; Tang-Wai et al., 2002 |
| AD            | Rare except in the “amygdaloid variant” of AD | Occasionally     | Harwood et al., 1999; Kile et al., 2009 |
| DLB           | N/A                  | Occasionally     | Josephs, 2007 |
| Vascular      | N/A                  | Occasionally     | Oyebode et al., 1996 |
| CVA           | N/A                  | Right frontal/temporal lesions | Edelstyn et al., 2005 |
Other neurologic disorders: Seizure disorder

- Prolonged febrile seizures in childhood
  - Amygdala gliosis
  - Volume loss 10 to 30%
  - Usually unilateral

- Intractable temporal lobe epilepsy
  - Amygdalectomy

- Kluver & Bucy syndrome
  - Mainly hyperorality
  - 3% of patients
    - Particularly left temporal lobe

Cendes, Andermann, Dubeau et al., 1993; Cendes, Andermann, Gloor et al., 1993; Gloor & Aggleton, 1992
Neuropsychiatric disorders: Psychopathy

- Diagnostic criteria (Hare PCL-R)
  - Antisocial behavior
  - Lack of long-term goals
  - Failure to achieve adult life-style
  - Shallow affect and callousness
  - Sensation seeking

Hare 1991, 1996
Neuropsychiatric disorders: Psychopathy (cont’d)

- Amygdala signs and symptoms
  - Smaller amygdala
  - Impaired fear conditioning
  - Reduced amygdala responsiveness to fearful stimuli
  - Deficits in recognizing facial affect

Kosson, Suchy, Mayer, & Libby, 2002; Marsh et al., 2008; Suchy, Whittaker, Strassberg, & Eastvold, 2009; Weber, Habel, Amunts, & Schneider, 2008
Neuropsychiatric disorders: Anxiety disorders

- **PTSD**
  - Chronic exposure to stress
    - Hypertrophy of amygdala
    - Atrophy of hippocampus

- **Generalized anxiety disorder**
  - Smaller amygdala volume
    - But hyperactive
    - Even smaller hippocampi

Vyas et al., 2002; Hayano et al, 2009; McClure et al, 2007
Emotional Trigger: Summary and Conclusions

- Amygdala likely represents the primary trigger of emotional responses.
- Amygdala abnormalities can be seen in a variety of neurodevelopmental, neurodegenerative, neuropsychiatric, and other neurologic populations.
- Cognitive deficits in everyday life are relatively subtle, but can present as frustrating personality traits.
Components of an emotional event

- Trigger
- Communication
- Reflexive responses
- Regulation
- Awareness

Theoretical background

- Defining the constructs
- Neuroanatomy
- Interplay with cognition

Integrating theory and practice

- Assessment issues
- Daily functioning
- Clinical signs and syndromes
- Clinical populations
THEORETICAL BACKGROUND:
Defining the construct

- Autonomic/endocrine response
  - Sympathetic/parasympathetic activation
  - HPA axis activation

- Involuntary skeletal responses
  - Facial expressions, posture, bodily movements
  - Vocalization
  - Crying, laughing
  - Growling, hissing
  - Startle, freezing
Motor System

Volitional

Non-volitional (emotional)

Skeletal/Somatic

Autonomic/Endocrine

Enteric

Sympathetic

Parasympathetic
THEORETICAL BACKGROUND: Emotional skeletal-motor system

○ Frontal-opercular syndrome
  ○ Dysarthria, paresis of cranial nerves
  ○ Inability to generate facial expressions volitionally
  ○ Intact non-volitional (genuine) emotional displays

• Typical etiology
  ○ CVA

Wild et al., 2003
Function/purpose of Emotional Skeletal Motor System

- Generation of responses needed for survival
  - Withdrawal
    - Freezing, escape
  - Approach
    - Feeding, sexual behaviors

- Rapid communication
  - Facial expressions
  - Vocalizations
  - Posture, gestures
Motor System

Volitional

Non-volitional (emotional)

Skeletal/Somatic

Enteric

Autonomic/Endocrine

Sympathetic

Parasympathetic
THEORETICAL BACKGROUND: Autonomic/endocrine system

External stimuli (Amygdala) → Hypothalamus → Autonomic (rapid)

Internal stimuli (homeostatic messengers) → Hypothalamus → Endocrine (slow)

Parasympathetic NS 
Sympathetic NS 
Pituitary gland

THEORETICAL BACKGROUND:
Autonomic/endocrine system

External stimuli (Amygdala) → Hypothalamus → Autonomic (rapid)

Internal stimuli (homeostatic messengers) → Hypothalamus → Endocrine (slow)

Parasympathetic NS
Sympathetic NS
Pituitary gland
**Function/purpose of Autonomic Motor System**

- **Sympathetic**
  - Mobilize physiologic states
  - Capture cognitive resources

- **Parasympathetic**
  - Restock
  - Digest
  - Repair
## Autonomic Nervous System

<table>
<thead>
<tr>
<th>Organ</th>
<th>Sympathetic</th>
<th>Parasympathetic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart Rate</td>
<td>Increase</td>
<td>Decrease</td>
</tr>
<tr>
<td>Heart Contraction</td>
<td>Increase</td>
<td>Decrease</td>
</tr>
<tr>
<td>Brochi</td>
<td>Dilate</td>
<td>Constrict</td>
</tr>
<tr>
<td>Salivary glands</td>
<td>Mucous, low enzyme</td>
<td>Watery, high enzyme</td>
</tr>
<tr>
<td>Eye</td>
<td>Dilate</td>
<td>Constrict</td>
</tr>
<tr>
<td>Stomach and intestines</td>
<td>Inhibition of peristalsis</td>
<td>Increased peristalsis</td>
</tr>
<tr>
<td>Adrenal gland</td>
<td>Adrenalin into blood</td>
<td>N/A</td>
</tr>
<tr>
<td></td>
<td>stream</td>
<td></td>
</tr>
<tr>
<td>Liver</td>
<td>Break down glycogen</td>
<td>N/A</td>
</tr>
<tr>
<td>Skin blood vessels</td>
<td>Constriction</td>
<td>N/A</td>
</tr>
<tr>
<td>Muscle blood vessels</td>
<td>Dilation</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Poly-vagal Theory (Porges, 2006)

Parasympathetic NS

OLDER Branch of Vagus Nerve

NEWER Branch of Vagus Nerve

Freezing

Sympathetic NS

Prosocial Approach
THEORETICAL BACKGROUND:

Neuroanatomy

- Hypothalamus
- Mesencephalon
- Lower brainstem
- Cerebral cortex
Neuroanatomic Substrates: Hypothalamus

- Emotional relay
- (1) Initiates **slow** endocrine response
  - Sympathetic facilitation via hormonal cascade
    - HPA axis, stress response
  - Response termination
    - Negative feedback loop
Neuroanatomic Substrates: Hypothalamus (cont’d)

- (2) Initiates rapid autonomic response
  - Sympathetic activation directly via synapses with autonomic nuclei
    - Brainstem
      - Dorsal vagus nucleus
      - Nucleus ambiguous
      - Superior salivary nucleus, etc.
    - Spinal cord
      - Preganglionic sympathetic neurons

- (3) Activates emotional motor nuclei
  - Mesencephalon (VTA, PAG) and Pons
THEORETICAL BACKGROUND:

Neuroanatomy

- Hypothalamus
- **Mesencephalon**
- Lower brainstem
- Cerebral cortex
Neuroanatomic Substrates: Mesencephalon

- Species-specific emotional skeletal responses

Kippin, Sotiropoulos, Badih, & Pfau, 2004; Palmiter, 2007
### Neuroanatomic Substrates:

#### Mesencephalon

<table>
<thead>
<tr>
<th></th>
<th>Predatory aggression</th>
<th>Affective aggression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sympathetic activation</td>
<td>Minimal, except dilation of pupils</td>
<td>Maximal</td>
</tr>
<tr>
<td>Behavioral response</td>
<td>Calm, goal-directed</td>
<td>Frantic</td>
</tr>
<tr>
<td>Vocalization</td>
<td>Minimal to none</td>
<td>Frantic, loud</td>
</tr>
<tr>
<td>Mesencephalon</td>
<td>Ventrolateral PAG; VTA</td>
<td>Dorsal PAG; Dorsal premammilary nucleus</td>
</tr>
<tr>
<td>Hypothalamic n.</td>
<td>Lateral</td>
<td>Medial</td>
</tr>
<tr>
<td>Mutual relationship</td>
<td>Inhibitory reciprocal inter-neurons, preventing occurrence of both responses at the same time</td>
<td></td>
</tr>
</tbody>
</table>

Bhatt, Bhatt, Zalcman, & Siegel, 2008; Folkow, 1993; Siegel & Shaikh, 1997
Neuroanatomic Substrates: Mesencephalon (cont’d)

- Appetitive behaviors
  - Eating, drinking, mating
    - VTA
    - Hypothalamic nuclei
    - Other structures
      - medial forebrain bundle, NAc, striatum/ventral pallidum, ventral prefrontal cortex, cerebellum, anterior cingulate cortex, olfactory bulb, temporal cortex, area postrema

Kippin, Sotiropoulos, Badih, & Pfaus, 2004; Palmiter, 2007
Neuroanatomic Substrates: Mesencephalon (cont’d)

- Species-specific emotional skeletal responses

  - Further autonomic control
    - Projections to lower brain stem
THEORETICAL BACKGROUND:

Neuroanatomy

- Hypothalamus
- Mesencephalon
- **Lower brainstem**
- Cerebral cortex
Neuroanatomic Substrates: Lower brainstem

- **Medulla oblongata**
  - Nucleus ambiguous, salivary nucleus, dorsal motor nucleus
    - Efferents to vital organs and glands

- **Cerebellum**
  - Direct reciprocal projections w/ hypothalamus

- **Pons**
  - Crying, laughing
  - Ascending projections to the cerebral cortex
    - RAS

Schmahmann, 2001; Wild, Rodden, Grodd, & Ruch, 2003; Zhu, Yung, Chow, Chan, & Wang, 2006
THEORETICAL BACKGROUND:

Neuroanatomy

- Hypothalamus
- Mesencephalon
- Lower brainstem
- Cerebral cortex
Neuroanatomic Substrates:  
**Cerebral cortex** and autonomic regulation

- **Anterior cingulate gyrus**
  - Sympathetic regulation of cardiac functions
  - ACC damage related to
    - blunted sympathetic response
    - amotivational syndrome

Critchley, Elliott, Mathias, & Dolan, 2000; Critchley et al., 2003
Neuroanatomic Substrates: Cerebral cortex and autonomic regulation

Andersson & Finset, 1998; Hugdahl, 1996; Oppenheimer, 1992; Spence, Shapiro, & Zaidel, 1996; Wittling, Block, Schweiger, & Genzel, 1998; Yoon, Morillo, Cechetto, & Hachinski, 1997
Hypothalamus

- Pituitary (via hormonal release)
  - Adrenal gland (via blood stream)
- Hindbrain
- Midbrain (PAG & VTA)
- Cortex (Right hemisphere & Anterior cingulate)

Autonomic response

Skeletal response
Integrating theory and PRACTICE

- Test performance
- Clinical syndromes
  - Emotional skeletal motor dysfunction
  - Autonomic/endocrine dysfunction
- Assessment
- Clinical populations
Integrating theory and PRACTICE: Test performance

- Autonomic hypo-activation affects performances on measures of
  - Attention
    - Speed and accuracy on CPT tasks
  - Psychomotor speed
  - Executive abilities
    - Goal-setting facilitates autonomic activation, which in turn facilitates better executive performance

Barry, Clarke, McCarthy, Selikowitz, & Rushby, 2005; Gellatly & Meyer, 1992; Melis & van Boxtel, 2007
Integrating theory and PRACTICE: Test performance (cont’d)

- ACC and right hemisphere
  - Attentional networks
  - Sympathetic activation networks

- Autonomic hyper- and hypo-arousal may represent one mechanism of
  - Poor test performance
  - Personality change

[Graph: Yerkes-Dodson Law (1908)]
Sometimes I think you only married me because I lived next door...
Integrating theory and PRACTICE: Clinical syndromes

- **Skeletal motor dysfunction**
  - Pseudobulbar affect
  - Gelastic seizure
  - Frontal opercular syndrome
  - Facial emotional paresis

- **Autonomic/endocrine dysfunction**
  - Autonomic failure
  - Autonomic (“visceral”) auras
  - PAID
  - Post-traumatic hypo-pituitarism
Clinical Syndromes: Skeletal motor dysfunction

- **Pseudobulbar affect (PDA)**
  - Uncontrollable crying or laughing
  - May be inconsistent with emotional experience
  - Can be associated with a variety of lesion locations
    - Lenticulo-capsular lesions (i.e., putamen, globus pallidus, internal capsule)
    - But also:
      - Frontal-subcortical circuitry
      - Brain stem
      - Bilateral and unilateral

Achari & Colover, 1976; Kim, Choi, Kwon, & Seo, 2002; Rosen & Cummings, 2007
Clinical Syndromes: Skeletal motor dysfunction (cont’d)

- **Gelastic seizures**
  - Brief episodes of laughter (30 ss or less)
  - Occasionally longer, status epilepticus
  - Associated with many types of seizures
    - Partial
    - Generalized
    - Petit mal/ absence
  - Difficult to distinguish from natural laughter

Daly & Mulder, 1957; Glassman, Dryer, & McCartney, 1986; Loiseau, Cohadon, & Cohadon, 1971
Clinical Syndromes: Skeletal motor dysfunction (cont’d)

- **Frontal Opercular Syndrome** (Foix-Chavany-Marie Syndrome)
  - Dysarthria
  - Paresis of cranial nerves
  - Involuntary facial expressions intact
  - Volitional facial displays impaired

- **Facial emotional paresis**
  - Involuntary facial expressions impaired
  - Volitional facial displays intact

Daly & Mulder, 1957; Glassman, Dryer, & McCartney, 1986; Loiseau, Cohadon, & Cohadon, 1971
Clinical Syndromes: Autonomic dysfunction

- Autonomic ("visceral") auras
  - Associated with temporal lobe epilepsy
  - Epigastric or abdominal signs most common
  - Rarely
    - Nausea, vomiting
    - Cardiovascular, papillary, genital, urinary, pilomotor
  - "As if" emotions

Fogarasi, Janszky, & Tuxhorn, 2006
Clinical Syndromes: Autonomic dysfunction (cont’d)

- **Post-traumatic hypo-pituitarism**
  - Traditionally under-diagnosed
  - 15 to 68% of moderate to severe TBI
    - HPA axis dysfunction
    - Hypoadrenalism
    - Others (e.g., hypothyroidism)
  - International panel of endocrinologist
    - Consensus guidelines for assessment (2005)

Behan et al., 2008; Rothman et al., 2007; Schneider et al., 2007
Clinical Syndromes: Autonomic dysfunction (cont’d)

- **Autonomic failure**
  - Typically both branches of ANS affected
    - Exception
      - Postural orthostatic tachycardia syndrome (POTS)
      - Only sympathetic
  - If only peripheral ANS affected
    - Pure autonomic failure
    - E.g., Autoimmune autonomic neuropathy (AAN)
      - Diabetes
Clinical Syndromes: Autonomic dysfunction (cont’d)

- Autonomic failure (cont’d):
  - Symptoms
    - Dysregulation of BP, heart rate, respiration
    - Nausea, dizziness, fainting, syncope
    - Visual disturbance
    - Chest pain
    - Sexual dysfunction
    - Constipation, urinary retention

- Typical populations
  - PD, DLB, MSA, CVA
Integrating theory and PRACTICE: Assessment

- Assessment of autonomic/endocrine dysfunction
  - Composite Autonomic Symptom Scale (COMPASS) (Suarez et al., 1999)
    - 169 item self-report scale
    - COMPASS 31, 8—abbreviated scales
  
- Assessment of PBA
  - Pathological laughter and crying scale (PLACS) (Husain, 2005)
    - 18 item semi-structured interview
Integrating theory and PRACTICE: Clinical Populations

○ Hypothalamic Hamartoma (HH)
  ● Rare, benign tumor
  ● Begins to develop in the first trimester of gestation
  ● Sx
    ○ Gelastic seizures (onset in infancy)
      ● Early childhood—often unnoticed
      ● Pharmacologically intractable
      ● New laser Tx/surgery available
    ○ Cognition varies
    ○ Behavior problems, aggression

Prigatano et al., 2008; Striano et al., 2005; Quigg & Barbaro, 2008
Integrating theory and PRACTICE: Clinical Populations (cont’d)

- **ADHD**
  - **Autonomic hypoactivation**
    - Dysfunction of ACC and right hemisphere
    - Biofeedback training to increase autonomic arousal improves performance on CPT

Crowell et al, 2006; Casey et al., 1997; Colla et al., 2008
Integrating theory and PRACTICE: Clinical Populations (cont’d)

- **CVA**
  - Right hemisphere damage
    - Autonomic hypo-activity
      - Slow, inattentive
      - Consistent with RH as the substrate for attention
    - Cardiac dysregulation
  - Higher fatality rates due to cardiac problems

Aszalos et al., 2002; Andersson and Finset, 1998; Hirashima et al., 2001; Meadows and Kaplan, 1994
Integrating theory and PRACTICE: Clinical Populations (cont’d)

○ CVA (cont’d)
  ● Hypothalamus
    ○ Endocrine and autonomic disruptions
  ● Lower brainstem
    ○ Autonomic disruption
  ● Lenticulo-capsular region (i.e., putamen, globus pallidus, internal capsule)
    ○ Pseudobulbar affect

Aszalos et al., 2002; Andersson and Finset, 1998; Celik at al., 2004; Hirashima et al., 2001; Meadows and Kaplan, 1994; Weddell, 1994
Integrating theory and PRACTICE: Clinical Populations (cont’d)

- Multiple Sclerosis
  - Autonomic dysfunction
  - Pseudobulbar affect

Gunal, Afsar, Tanridag, & Aktan, 2002
Integrating theory and PRACTICE: Clinical Populations (cont’d)

- Amyotrophic Lateral Sclerosis
  - Gradual degeneration of upper motor neurons
  - Pseudobulbar affect common
  - Mild autonomic dysregulation

Dettmers et al., 1993; Brooks et al., 2004
Integrating theory and PRACTICE: Clinical Populations (cont’d)

- **Parkinson’s Disease**
  - **Motor dysfunction**
    - Difficulty with spontaneous facial emotional displays
    - Slowed volitional facial expression
  - **Autonomic dysfunction**
    - Difficult to differentiate from MSA

Rinn, 2007; Bowers et al., 2006;
Integrating theory and PRACTICE: Clinical Populations (cont’d)

- **Multiple System Atrophy**
  - Umbrella term for
    - Striatonigral degeneration
    - Shy Dragger syndrome
    - Olivopontocerebellar atrophy

- **Progressive degeneration**
  - Basal ganglia, Pons, Medulla oblongata, Autonomic neurons in the brain stem and spinal cord
Integrating theory and PRACTICE: Clinical Populations (cont’d)

○ MSA (cont’d)
  ● Sx
    ○ Autonomic failure
    ○ Parkinsonims
    ○ Ataxia

Tada et al., 2009;
Clinical Populations: MSA vs PD

<table>
<thead>
<tr>
<th>Causes of AF</th>
<th>MSA</th>
<th>PD with AF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Degeneration of preganglionic neurons; Medullary dysfunction</td>
<td>Degeneration of postganglionic neurons</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Subjective AF complaints</th>
<th>Present</th>
<th>Present</th>
</tr>
</thead>
<tbody>
<tr>
<td>AF Sx progression</td>
<td>Fast</td>
<td>Slow</td>
</tr>
<tr>
<td>Orthostatic Hypotension</td>
<td>Almost always present</td>
<td>Common</td>
</tr>
<tr>
<td>Anhidrosis</td>
<td>Diffuse</td>
<td>Absent or distal regions of limbs (fingers, toes)</td>
</tr>
</tbody>
</table>

Ziemssen & Reichmann, 2010
Reflexive Emotional Response: Summary and Conclusions

- Reflexive responses rely on skeletal motor and autonomic/endocrine systems.
- Reflexive responses involve complex CNS networks including the frontal lobes, the cerebral hemispheres, diencephalon, mesencephalon, and lower brain stem.
- Autonomic arousal facilitates memory and attentional processing, as well as motivation.
- Wide array of clinical populations are affected.
Components of an emotional event

- Trigger
- Communication
- Reflexive responses
- Awareness
- Regulation

Theoretical background

- Defining the constructs
- Neuroanatomy
- Interplay with cognition

Integrating theory and practice

- Assessment issues
- Daily functioning
- Clinical signs and syndromes
- Clinical populations
THEORETICAL BACKGROUND: Components of awareness

○ **Interoceptive awareness**
  - Ability to detect own physiologic reactions
  - Correlates with intensity of experience
  - Pure autonomic failure
    - Deficits in subjective feeling states

THEORETICAL BACKGROUND: Components of awareness (cont’d)

- **Emotional (feeling) awareness**
  - Includes the ability to
    - Feel
    - Understand
    - Discuss
  - Dissociable from interoceptive awareness
THEORETICAL BACKGROUND:

Neuroanatomy

- Interoceptive awareness
  - Functional imaging
  - Heart beat detection paradigm
Neuroanatomic Substrates: Interoceptive awareness

- Attention to heartbeat
  - Right anterior insula and operculum
  - Right somatosensory cortex

Critchley et al., 2004; Pollatos, Gramann, & Schandry, 2007
Correlations were found among:
- fMRI activation in insula/operculum
  - Gray matter volume
  - Accuracy of heart beat detection
  - Self-reported trait anxiety and depression
- Gray matter volume in the insula and mindfulness meditation practice

Critchley et al., 2004; Hoelzel et al., 2008; Pollatos, Gramann, & Schandry, 2007
Neuroanatomic Substrates: Interoceptive awareness (cont’d)

- Right anterior insula activation also related to
  - Electrodermal activity
  - Cardiovascular/respiratory activity
  - Perception of skin temperature
  - Heart beat evoked potentials (HEP)
    - Brain wave that is contingent on heart beat

Cameron & Minoshima, 2002; Davis, Pope, Crawley, & Mikulis, 2004; Fredrikson et al., 1998; Pollatos, Kirsch, & Schandry, 2005
THEORETICAL BACKGROUND: Neuroanatomy

Emotional (feeling) Awareness

- Functional imaging in normals
  - Wide-spread activation
    - Method dependent and emotion-specific
  - Common networks
    - Thalamus
    - Hypothalamus
    - Midbrain
    - Medial PFC
    - Anterior, mid, and posterior cingulate
    - Orbitofrontal

Berthoz, Blair, Le Clec'h, & Martinot, 2002; Gerrards-Hesse, Spies, & Hesse, 1994; Reiman et al., 1997; Weiss, Salloum, & Schneider, 1999; Lane, et al., 1997; Reiman et al., 1997
THEORETICAL BACKGROUND: Neuroanatomy (cont’d)

- Emotional Awareness (cont’d)
  - Functional imaging in **alexithymics**
    - Greater activation in the anterior insula (bilateral)
    - Decreased activation in
      - Posterior and anterior cingulate gyrus
      - DLPFC
      - Pons and cerebellum
  - Slower inter-hemispheric transfer

Karlsson, Naaanen, & Stenman, 2008; Mantani, Okamoto, Shirao, Okada, & Yamawaki, 2005; Moriguchi et al., 2007; Moriguchi et al., 2007; Richter et al., 2006
Integrating Theory and PRACTICE

- Clinical syndromes
  - Alexithymia
- Clinical populations
- Assessment
Alexithymia: Definition

- Inability to
  - Consciously experience
  - Identify
  - Describe

- Normal ability to
  - Exhibit
  - Be aware of

Taylor, 1984; Warnes, 1986
Alexithymia: Interoceptive awareness

- Interoceptive Awareness
- Feeling Awareness

- Low
- Impaired

- High

- Anxiety

- Normal Awareness

- Alexithymia
Alexithymia: Processing Deficits

- Usage of emotional words to describe emotional situations
- Matching emotional stimuli with emotional self-report
- Identifying emotional expressions of others
- Understanding seriousness of emotional situations
- Empathy

Guttmann & Laporte, 2002; Lane, 1996; Luminet, Rime, Bagby, & Taylor, 2004; Mann, Wise, Trinidad, & Kohanski, 1994; Moriguchi et al., 2007; Parker, Prkachin, & Prkachin, 2005; Vanman, Dawson, & Brennan, 1998
Alexithymia: Processing Deficits (cont’d)

- Deficits cannot be explained by
  - Verbal impairment
    - Normal emotional word fluency (out of emotional contexts)
  - Deficient trigger mechanism
    - Normal startle response
  - Deficient reflexive responsiveness
    - Normal facial emotional expressiveness
    - Normal physiologic arousal
      - Sometimes hyperactive arousal
      - Explaining physiologic symptoms in physical terms

Intrasca, 1997; Luminet et al., 2004; Stone & Nielson, 2001; Vanman et al., 1998
Alexithymia: Comorbid characteristics

<table>
<thead>
<tr>
<th>Alexithymia</th>
<th>Asperger Syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Difficulty describing feelings to others</td>
<td>A failure to share personal feelings and experiences</td>
</tr>
<tr>
<td>Awkwardness in nonverbal behavior</td>
<td>Impairment in the use of nonverbal communication</td>
</tr>
<tr>
<td>Constricted imagination and fantasy</td>
<td>Interest restricted to one or few topics</td>
</tr>
<tr>
<td>Externally oriented or stimulus-bound thinking</td>
<td>Preoccupation with parts of objects</td>
</tr>
</tbody>
</table>

Bagby et al., 1994; American Psychiatric Association, 2000
Alexithymia: 
Physical and mental health

- Higher rates of
  - Depression and anxiety
  - Stress
  - Psychosomatic illnesses
  - Chronic illnesses
  - Death due to chronic illness

- Chronic illnesses associated with increased rates of alexithymia
  - Direction/causality unclear

Alexithymia:
Prevalence in clinical populations

- General public: 15% prevalence
- TBI: 30 to 60% prevalence
  - Poor relationship between severity of injury and alexithymia Sx
- CVA: 30% prevalence
- MS: same as general population
  - But independently contributes to fatigue
  - Over-focusing on bodily sensations

Koponen et al., 2005; Wood & Williams, 2007
Alexithymia: Prevalence in clinical populations (cont’d)

- Neuropsychiatric populations
  - Depression
  - Schizophrenia
  - OCD
  - Somatization
  - Addiction
Integrating Theory and PRACTICE: Clinical Correlates of Interoceptive awareness

○ Cognitive deficits?
  ● None known

○ Everyday life
  ● Correlates with
    ○ Emotional IQ
    ○ Job and relationship satisfaction
    ○ General sense of well-being

Extremera & Fernandez-Berrocal, 2002; Gallagher & Vella-Brodrick, 2008; Schneider, Lyons, & Williams, 2005; Singh & Woods, 2008; van Heck, den Oudsten, Vingerhoets, Nykicek, & Denollet, 2008
Integrating Theory and PRACTICE: Assessment

- Toronto Alexithymia Scale (TAS-20)
  - Factors
    - Difficulty identifying emotions
    - Difficulty describing emotions
      - More susceptible to cultural and familial norms
    - Externally oriented thinking
  - Scores stable across five years
  - Available for purchase
    - http://www.gtaylorpsychiatry.org/tas.htm

Bagby, Parker et al., 1994; Fukunishi, Kawamura, Ishikawa, & Ago, 1997; Le, Berenbaum, & Raghavan, 2002; Parker, Taylor, & Bagby, 2003; Saarijarvi, Salminen, & Toikka, 2006; Taylor, Bagby, & Parker, 2003
Awareness:
Summary and conclusions

- Awareness of emotional responses depends on two unrelated processes: Interoceptive and emotional awareness.
- Impaired awareness appears unrelated to cognition, but is associated with poor physical and mental health.
- Increased rates of alexithymia in some neurologic populations may in part explain patients’ somatic and psychiatric complaints.
Components of an emotional event

- Trigger
- Reflexive responses
- Communication
- Regulation
- Awareness

Theoretical background

- Defining the constructs
- Neuroanatomy
- Interplay with cognition

Integrating theory and practice

- Assessment issues
- Daily functioning
- Clinical signs and syndromes
- Clinical populations
THEORETICAL BACKGROUND:
Defining affective communication

- **Direction**
  - Expressive
  - Receptive

- **Mode**
  - Linguistic
  - Paralinguistic
  - Situational

- **Volitional control**
  - Nonvolitional
  - Posed

**Specific emotions**
- Happiness
- Sadness
- Fear
- Anger
- Disgust
- Surprise
### THEORETICAL BACKGROUND: Volitional vs. non-volitional comm.

<table>
<thead>
<tr>
<th>Dependant variables</th>
<th>Type of communication</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Volitional</td>
<td>Non-volitional</td>
</tr>
<tr>
<td>Physiologic arousal</td>
<td>Absent or minimal</td>
<td>Present</td>
</tr>
<tr>
<td>Emotional experience</td>
<td>Absent or minimal</td>
<td>Present</td>
</tr>
<tr>
<td>Facial symmetry</td>
<td>Less symmetric</td>
<td>More symmetric</td>
</tr>
<tr>
<td>Ease of recognition</td>
<td>Easier</td>
<td>More difficult</td>
</tr>
<tr>
<td>Facial muscles</td>
<td>Somewhat different muscle groups used in each</td>
<td>Boiten et al., 1996</td>
</tr>
</tbody>
</table>
THEORETICAL BACKGROUND:
Neuroanatomy

Affective Communication

Linguistic
- Receptive
- Expressive

Paralinguistic (volitional branch)
- Receptive
- Expressive

Situational
- Receptive
  - Emotional Empathy
  - Cognitive Empathy
Neuroanatomy: Linguistic communication

○ Construct not well defined

○ Expressive and Receptive neuroanatomy
  ● Both hemispheres
    ○ Basal ganglia
    ○ Inferior frontal
    ○ Posterior superior temporal

Beaucousin et al., 2007; Blonder et al., 2005; Borod et al., 2002; Karow et al., 2001; Pick, 2002; Sherratt, 2007
THEORETICAL BACKGROUND: Neuroanatomy

Affective Communication

Linguistic
- Receptive
- Expressive

Paralinguistic (volitional branch)
- Receptive
- Expressive

Situational
- Receptive
- Emotional Empathy
- Cognitive Empathy
**Neuroanatomic Substrates: Paralinguistic Communication**

- Elliot Ross, 1981
  - Right hemisphere lesions
  - Bed-side evaluations

--- anterior -- expressive
--- posterior -- receptive

Gorelick and Ross, 1987
Testing Ross’ Paralinguistic Theory

- **Receptive abilities and laterality (affect recognition)**
  - Overwhelming support for right hem.
    - Both lesion and imaging support
    - Both facial affect and prosody
    - Not explained by perceptual or conceptual cognitive deficits
  - But not unanimous (Buchanan et al., 2000, Pell, 1998)
    - Aspects of prosody (pitch vs. stress and emphasis)

Blonder, Burns, Bowers, Moore, & Heilman, 1993; Blonder et al., 2005; Borod et al., 2002; Borod et al., 1998; Bowers, Bauer, Coslett, & Heilman, 1985; Bowers, Blonder, Feinberg, & Heilman, 1991; Gandour et al., 2004; Gandour et al., 2003; Harciarek, Heilman, & Jodzio, 2006; Kucharska-Pietura, Phillips, Gernand, & David, 2003; Orbelo, Grim, Talbott, & Ross, 2005; Ross, Thompson, & Yenkosky, 1997; Wildgruber et al., 2005
Testing Ross’ Paralinguistic Theory (cont’d)

- **Receptive abilities and caudality**
  - Posterior temporal not supported

- **Most findings** (both facial and prosodic)
  - Orbitofrontal
  - Fronto-opercular
  - Anterior cingulate
  - Basal ganglia

- **Additional regions**
  - Temporal-parietal
  - Bilateral frontal poles
  - Frontal-parietal
  - LEFT frontal operculum

Blood, Zatorre, Bermudez, & Evans, 1999; Breitenstein, Daum, & Ackermann, 1998; Buchanan et al., 2000; Cancelliere & Kertesz, 1990; Frey, Kostopoulos, & Petrides, 2000; Hornak et al., 2003
Testing Ross’ Paralinguistic Theory (cont’d)

- **Expressive abilities**
  - **Laterality** not fully supported
    - Most studies
      - No differences between right and left
  - **Caudality**
    - Right basal ganglia, medial frontal, inferior frontal gyrus
  - Deficits tend to be transient and resolve with time

Baum & Pell, 1999; Bradvik, Dravins, Holtas, & Rosen, 1991; Cancelliere & Kertesz, 1990; Heilman, Leon, & Rosenbek, 2004; Karow et al., 2001; Lee et al., 2006
Testing Ross’ Paralinguistic Theory (cont’d)

<table>
<thead>
<tr>
<th></th>
<th>Receptive</th>
<th>Expressive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Anterior</td>
<td>Right</td>
<td>Right and left</td>
</tr>
<tr>
<td>Posterior</td>
<td>Right</td>
<td></td>
</tr>
</tbody>
</table>

- **Receptive abilities located anteriorly**
  - Anomaly in functional neuroanatomy
  - Provides support for
    - Facial feedback hypothesis (Tomkins, 1962, 1963)
    - Emotional contagion model (Doherty, 1997; Hatfied et al., 2008)
    - Embodied emotions (Niedenthal et al., 2009)
THEORETICAL BACKGROUND:
Neuroanatomy

Affective Communication

Linguistic
- Receptive
- Expressive

Paralinguistic (volitional branch)
- Receptive
- Expressive

Situational
- Receptive
  - Emotional Empathy
  - Cognitive Empathy
Neuroanatomic Substrates: Situational Communication

- **Empathy Networks**
  - **Emotional Empathy**
    - *Feel* what others feel
    - Relies on the Mirror Neuron System (MNS)
      - Imitation, processing, and observation of emotional expressions of others
    - Inferior frontal and posterior parietal
      - Co-activation within this network correlates with self-report of empathy

Carr, Iacoboni, Dubeau, Mazziotta, & Lenzi, 2003; Schulte-Ruether, Markowitsch, Fink, & Piefke, 2007
Neuroanatomic Substrates: Situational (cont’d)

- **Empathy Networks**
  - **Cognitive Empathy**
    - *Know* what others feel
    - Relies on the Theory of Mind networks (MNS)
      - Perspective taking
    - Medial prefrontal, temporal poles
      - Activated during cognitive empathy tasks

Premack & Woodruff, 1978; Schulte-Ruether et al., 2007
Theory of Mind (ToM) network, implicated in *cognitive* empathy

Mirror Neuron System (MNS) network, implicated in *emotional* empathy

Heavy outline denotes regions thought to be *necessary* for empathy
Integrating Theory and PRACTICE

- Test performance
- Populations
  - Neurodevelopmental
  - Neuropsychiatric
  - Neurodegenerative
  - Other neurologic
Integrating theory and PRACTICE: Test performance

○ **Affect recognition** associated with
  - Visual-spatial memory and learning
  - Visual recognition memory
  - Visual-spatial scanning

○ **BUT also**
  - Verbal abilities (e.g., vocabulary)
  - Executive functions
  - Even after IQ is accounted for

Bozikas et al., 2006; Bozikas, Kosmidis, Anezoulaki, Giannakou, & Karavatos, 2004; Sachs, Steger-Wuchse, Kryspin-Exner, Gur, & Katschnig, 2004; Suchy et al, 2009; Summers, Papadopoulou, Bruno, Cipolotti, & Ron, 2006; Whittaker, Deakin, & Tomenson, 2001
Integrating theory and PRACTICE: Test performance (cont’d)

- Affective communication deficits may mimic other deficits
  - Emotionally loaded stimuli on
    - Reading comprehension tests (E.g., PIAT)
    - Aphasia exams
    - Picture arrangement
    - Etc.

Suchy et al., 2009
Integrating theory and PRACTICE: Test performance (cont’d)

- **Cognitive empathy** associated with
  - Cognitive Flexibility

Shamay-Tsoory, Tomer, Goldsher, Berger, & Aharon-Peretz, 2004
Integrating theory and PRACTICE: Clinical populations

- Interpretive considerations
  - Most research examined only facial affect
  - Most populations exhibit deficits in recognizing some, but not all, emotions
    - Many studies do not examine individual emotions
Clinical Populations: Neurologic disorders

- CVA
  - Depending on the lesion site
  - Most often right frontal, right frontal opercular, basal ganglia

- TBI
  - Affect recognition
  - Cognitive and emotional empathy

Radice-Neumann, Zupan, Babbage, & Willer, 2007; Shamay-Tsoory et al., 2004
Clinical populations: Neurodevelopmental disorders

- Autism
- Down syndrome/Intellectual dis.
- Williams syndrome
  - Poorer than autism
- FAS
- ADHD

Bozikas, Kosmidis, Anezoulaki, Giannakou, & Karavatos, 2004; Davis & Gibson, 2000; Jaeger, Borod, & Peselow, 1986; Monnot, Nixon, L ovallo, & Ross, 2001; Weniger, Lange, Rather, & Irle, 2004; Williams et al., 2008; Wishart, Cebula, Willis, & Pitcairn, 2007
Clinical populations: Neuropsychiatric disorders

- Bipolar Disorder
- Major Depression
- Substance abuse
- Antisocial personality, criminality, psychopathy
- Schizophrenia—only posed emotions

Bozikas, Kosmidis, Anezoulaki, Giannakou, & Karavatos, 2004; Davis & Gibson, 2000; Kosson & Suchy, 2002; Monnot, Nixon, Lovallo, & Ross, 2001; Suchy et al., 2009; Weniger, Lange, Rather, & Irle, 2004; Williams et al., 2008; Wishart, Cebula, Willis, & Pitcairn, 2007
Clinical Populations: Criminal Offenders

- FAR deficits and/or receptive prosody
  - Criminals in general
  - ASPD
  - Child molesters
  - Psychopaths
  - Overlap with substance abuse

- Specific emotions
  - Deficit in fear and disgust recognition
  - Tendency to mislabel other emotions as anger

Carr et al., 2003; Dolan & Fullam, 2006; Hastings, Tangney, & Stuewig, 2008; Foisy et al., 2005; Kornreich et al., 2001; Kosson, Suchy, Mayer, & Libby, 2002; McCown, Johnson, & Austin, 1986; McCown, Johnson, & Austin, 1988; Monnot, Nixon, Lavallo, & Ross, 2001; Monnot, Lavallo, Nixon, & Ross, 2002; Suchy, Whittaker, Strassberg, & Eastvold, 2008; Uekermann, Daum, Schlebusch, & Trenckmann, 2005
Clinical populations: Neurodegenerative disorders

○ AD, ALS, FTD, HD, PD

○ Unique profiles with respect to
  ● Type of emotional communication deficits
  ● Specific emotions affected
  ● Cognitive or psychiatric correlates of deficits
Clinical Populations: Alzheimer’s dementia

○ Type of deficit
  ● FAR
  ● Empathy

○ Specific emotions
  ● All, but *disgust sometimes spared*
    ○ Presumably due to sparing of the putamen

○ Other correlates
  ● MMSE and/or progression of illness
  ● Interpersonal behavior problems

Lavenu & Pasquier, 2004; Rankin, Kramer, & Miller, 2005; Shimokawa et al., 2000; Shimokawa et al., 2003; Spoletini et al., 2008
Clinical Populations: Huntington’s Dementia

- Type of deficit
  - FAR
- Specific emotions
  - Primarily disgust
    - Presumably due to putamen involvement

Snowden et al., 2008
Clinical Populations: Parkinson’s Disease

○ Type of deficit
  ● Receptive and expressive facial affect
  ● Receptive and expressive prosody

○ Specific emotions
  ● All emotions, but primarily disgust and anger

○ Other
  ● NOT related to motor symptoms
  ● Evident early in the disease
  ● Greater deficits in unmedicated patients

Dujardin et al., 2004; Goberman, Coelho, & Robb, 2005; Kan, Kawamura, Hasegawa, Mochizuki, & Nakamura, 2002; Lawrence, Goerendt, & Brooks, 2007; Pell & Leonard, 2005; Sprengelmeyer et al., 2003
Clinical Populations: ALS, bulbar variant

- Type of deficit
  - Facial affect recognition
  - Some prosody
- Specific emotions
  - All
- NOT related to
  - Depression
  - Dementia

Zimmerman, Eslinger, Simmons, & Barrett, 2007
Clinical Populations: Frontotemporal lobar degeneration

- **Type of deficit**
  - FAR
  - Receptive prosody
  - Cognitive empathy

- **Specific emotions**
  - All, but primarily negative (fear, anger, disgust)

- **Other correlates**
  - Greater in frontal, as compared to temporal, variants

Fernandez-Duque & Black, 2005; Keane, Calder, Hodges, & Young, 2002; Lavenu & Pasquier, 2004; Lough et al., 2006; Rankin et al., 2005; Rosen et al., 2004; Snowden et al., 2008
Integrating theory and PRACTICE: Assessment

- **WAIS-IV: Advanced Clinical Solutions**
  - Social Cognition Test
    - Facial Expressions
    - Social Interactions
    - Prosody

- **The Awareness of Social Inference Test (TASIT)**
  - Emotion Evaluation
  - Social Inference

Wechsler, 2008; McDonald et al., 2002
Emotional Communication: Summary and Conclusions

- Both receptive and expressive abilities rely primarily on anterior networks.
- Many neurodevelopmental, neurodegenerative, neuropsychiatric, and neurologic populations show impairment.
- Impairments may be specific to particular domain of processing or particular emotion.
- Impairments are often associated with verbal, visuospatial, and executive deficits.
- Impairments may mimic other deficits due to affectively loaded content of test materials.
Components of an emotional event

Trigger → Reflexive responses
Communication → Awareness

Regulation

Theoretical background

Defining the constructs → Neuroanatomy → Interplay with cognition

Integrating theory and practice

Assessment issues → Daily functioning → Clinical signs and syndromes → Clinical populations
THEORETICAL BACKGROUND: Definition of emotion regulation

- Modulating

Emotional experience          Behavioral output

(Gross et al., 2006)
Utility of emotion regulation:

- Interpersonal relationships and physical well-being are deleteriously affected by
  - Strong negative emotions
  - Suppression of affective expression

Denollet, Nyklicek, & Vingerhoets, 2008; Williams, Suchy, & Rau, 2009
Methods of emotion regulation: *Proactive*

- Deliberate avoidance of situations
  - Self-distraction
  - Self-assertion

(Gross et al., 2006)
Methods of emotion regulation: 

**Reactive**

Cognitive reappraisal

Suppression of overt affective response

(Gross et al., 2006)
THEORETICAL BACKGROUND:
Neuroanatomy

○ Methodology
  ● Lesion studies
  ● Functional imaging
    ○ View films or photos
    ○ Suppress or exaggerate
      ● Feelings
      ● Facial expressions
Neuroanatomic substrates: Functional imaging

- Common networks
  - Anterior cingulate gyrus
  - Dorsolateral prefrontal cortex
  - Ventral and ventromedial prefrontal cortex

Abler, Hofer, & Viviani, 2008; Ochsner & Gross, 2008; Ohira et al., 2006
Neuroanatomic substrates: Functional imaging (cont’d)

- Cognitive reappraisal
  - Left dorsolateral

- Suppression
  - Ventral prefrontal /orbitofrontal
  - Habitual suppressors—ventromedial rCBF

Abler, Hofer, & Viviani, 2008; Ochsner & Gross, 2008; Ohira et al., 2006
Neuroanatomic substrates:

Lesion studies

- Ventral & Ventromedial Frontal Cortex
  - Disinhibited syndrome
  - Irritability, aggression
  - Mania

- Left Dorsolateral/frontopolar
  - Catastrophizing, depression
  - Inability to reframe
THEORETICAL BACKGROUND: Interplay with Cognition

- **Executive functioning (EF)**
  - EF and ER emerge together in childhood
  - EF and ER correlate
  - Engaging in ER depletes EF and vice versa

- **Memory**
  - Engaging in ER decreases the amount of remembered material

Richards & Gross, 2000; Schmeichel, 2007
Integrating Theory and PRACTICE

- Syndromes
- Populations
- Assessment
Integrating Theory and PRACTICE: Clinical syndromes

- Secondary depression
- Secondary mania and bipolar disorder
- Secondary psychopathy
- Secondary anxiety
Secondary depression

- Similar to endogenous depression
- Generally responds to pharmacotherapy and CBT
- Left frontal lesions
  - Severity correlates with distance from frontal pole
- Populations
  - CVA, TBI, dementia, epilepsy, MS

Narashima et al., 2003; Vataja et al., 2004
Secondary mania/bipolar disorder

- Right hemisphere lesions
  - Ventral/anterior temporal for mania
  - Basal ganglia and thalamus for bipolar
- Mood disorder vs. disinhibition
- Responds to traditional treatments
- Populations
  - TBI, CVA, brain tumors, dementia, epilepsy, HIV infection

Narashima et al., 2003; Vataja et al., 2004
Secondary psychopathy

- Acquired sociopathy, pseudopsychopathic syndrome
- Most common populations
  - TBI (ventral frontal lesions)

<table>
<thead>
<tr>
<th></th>
<th>Primary</th>
<th>Secondary</th>
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<tbody>
<tr>
<td>Treatment</td>
<td>Non-responsive</td>
<td>Responsive</td>
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<td>Anxiety</td>
<td>Low</td>
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<td>Emotions</td>
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<tr>
<td>Aggression</td>
<td>Instrumental</td>
<td>Reactive</td>
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Instrumental Aggression

- Parallels predatory aggression in animals
  - Little autonomic activation
- Not related to ER deficits

Vitiello & Stoff, 1997
Reactive Aggression

- Parallels defensive aggression in animals
- Impulsive-Emotional
  - Intense autonomic activation
  - Related to poor ER

Vitiello & Stoff, 1997
Secondary anxiety

- All types of anxiety reported
- Lesion location
  - Inconsistencies in the literature
  - Possibly ventromedial and orbitofrontal
- Populations
  - TBI and CVA

Hiott & Labbate, 2002; Moore, Terryberry-Spohr, & Hope, 2006; Williams & Evans, 2003
Secondary anxiety and Pediatric TBI

- Ventral frontal lesions associated with
  - decreased anxiety
  - greater antisocial tendencies
- A possible pathway to presumed “primary” psychopathy

Vasa et al., 2004
Integrating Theory and PRACTICE: Clinical populations

- Dementias
- TBI
- CVA
- Epilepsy
- MS
Populations: 

Dementias

- Depression most common across all dementias (50%)
- Dementia-specific ER problems:
  - FTD
    - Mostly disinhibition and lability
  - AD
    - Verbal and physical aggression
  - PD and VD
    - Mostly depression

Engelborghs et al., 2005; Lind, Edman, Sjogren, Wallin, & Karlsson, 2002; Ritchie & Lovestone, 2002
Populations: Traumatic Brain Injury (TBI)

- Most common symptoms of ER dysfunction
  - Depression
  - Anxiety
  - Irritability/aggression
  - Social inappropriateness

American Psychiatric Association, 1994; Fann et al., 2004
Populations: TBI (cont’d)

- Etiology of ER deficits
  - Neurogenic vs. psychogenic
    - Exacerbation of premorbid psychopathology?
    - Litigation

Ruff, 2005
Populations: TBI (cont’d)

- Evidence of *neurogenic* ER deficits
  - Greater frequency of *new* onset mood/anxiety disorders than expected in general population

Sagduyu, 2002; Schwartz et al., 2003
Populations: TBI (cont’d)

- Evidence of *psychogenic* ER deficits
  - Greater rate of *premorbid* psychopathology and life stress among the “miserable minority”

For review of the relevant issues, see Ruff (2005)
Populations: TBI (cont’d)

- Reconciling neurogenic vs psychogenic interpretations
  - Re-appraisers vs. Suppressors
    - Different substrates
      - Cognitive reappraisal: left dorsolateral
      - Suppression: ventral frontal
EMOTIONAL EVENT

Individual Differences

 Preferential Suppressor
  Orbitofrontal Cortex
  Suppression of Behavior
  Appropriate Behavioral Control

 Preferential Re-appraiser
  Dorsolateral Prefrontal Cortex
  Re-appraisal of Situation
  Decrease in Emotional Arousal
EMOTIONAL EVENT

Individual Differences

Preferential Suppressor
- Orbitofrontal Cortex
- Suppression of Behavior

Preferential Re-appraiser
- Dorsolateral Prefrontal Cortex
- Re-appraisal of Situation

Injury
- Behavioral Dyscontrol

Appropriate Behavioral Control
- Decrease in Emotional Arousal
Populations: TBI (cont’d)

- Reconciling neurogenic vs psychogenic interpretations
  - Re-appraisers vs. Suppressors
    - Different substrates
      - Cognitive reappraisal: left dorsolateral
      - Suppression: ventral frontal
    - Different success in coping
      - Cognitive reappraisers: healthy, adjusted
      - Suppressors: stressed, interpersonal problems
Populations: Cerebrovascular accident (CVA)

- Most common ER symptoms
  - Post-stroke depression
  - Post-stroke anxiety

- Rarely
  - Post-stroke mania/bipolar
CVA:  
Post-stroke Depression

- 30 to 60% of cases
- Unrelated to prior history
- Decreases somewhat spontaneously within one year
- Associated with
  - Poor functional recovery
  - Poor ADLs/IADLs
  - Higher mortality rate within 10 years

Jorge, Robinson, Arndt, & Starkstein, 2003; Morrison, Pollard, Johnston, & MacWalter, 2005; Narushima & Robinson, 2003; Paolucci, 2008; Williams, Ghose, & Swindle, 2004
Effective treatments

- Pharmacotherapy
- CBT
- rTMS
- High-intensity light

Bhogal, Teasell, Foley, & Speechley, 2005; Jorge et al., 2004; Khan-Bourne & Brown, 2003; Sondergaard, Jarden, Martiny, Andersen, & Bech, 2006; Turner-Stokes & Hassan, 2002
CVA: Post-stroke Depression (cont’d)

- Effective *prophylactic* treatments
  - Positive effect on mood and rehabilitation
  - Survival rate within 10 years
  - Earlier treatment associated with higher functionality

Guang’an, Jinfang, & Lixin, 2004; Jorge et al., 2003; Niedermaier, Bohrer, Schulte, Schlattmann, & Heuser, 2004; Pomerantz, 2008; Robinson et al., 2008
CVA: Post-stroke Anxiety

- Often comorbid with depression
- When alone, associated with right frontal lesions

Robinson, 1997
CVA: Post-stroke Mania

- Rare (<1%)
- Associated with family history of mood disorder

Goyal et al., 2006; Robinson, 1997; Robinson et al., 1988
Integrating Theory and PRACTICE: Assessment

- Emotion regulation depletes EF resources (and vice versa)
- Depletion may last for many hours
  - Consider
    - Stereotype threat
    - Grieving
    - Anxiety
    - “bad day”
Emotion Regulation: Summary and Conclusions

- Different ER styles are associated with different neuroanatomic substrates and different health outcomes.
- Frontal lobe lesions are the primary cause of ER deficits in neurologic populations.
- Different ER styles may explain the premorbid psychopathology among the TBI “miserable minority.”
- Prophylactic treatment of post-stroke depression may have both short-term and long-term benefits.
GENERAL Conclusions

- Examination of emotional processing at the level of five primary domains proves useful for the study of:
  - functional neuroanatomy
  - clinically relevant deficits in cognition/test performance
  - clinically relevant issues related to mental and physical health

- Efforts should be taken to enhance assessment of emotional processing