Neuropsychology of Emotion: Integrating Theory with Practice

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Yana Suchy, Ph.D., ABPP-CN

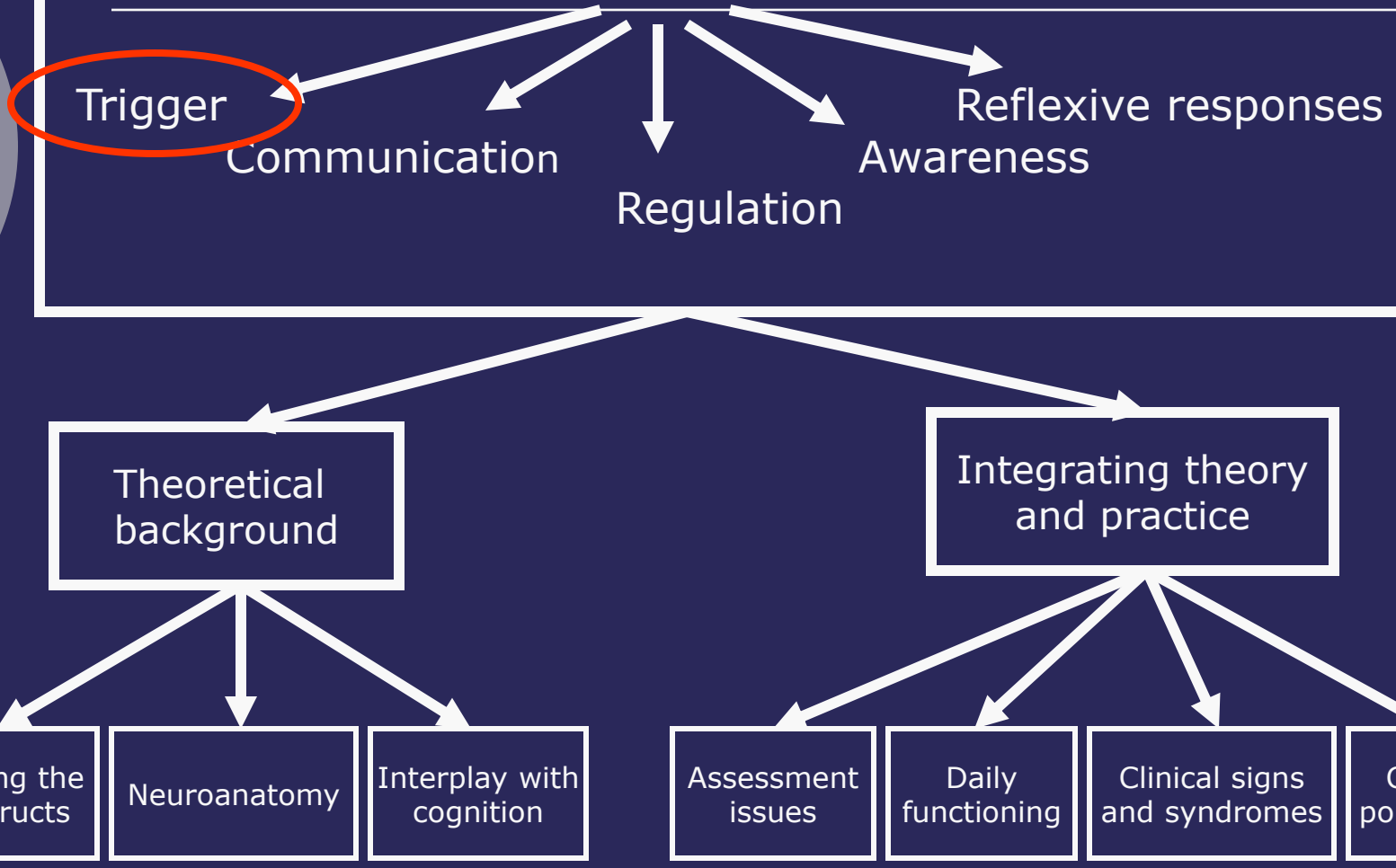
Learning objectives

(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

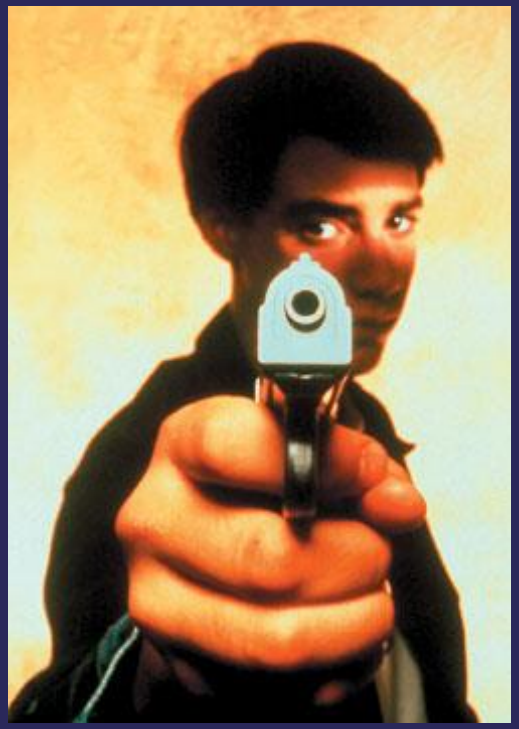
Components of an emotional event



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

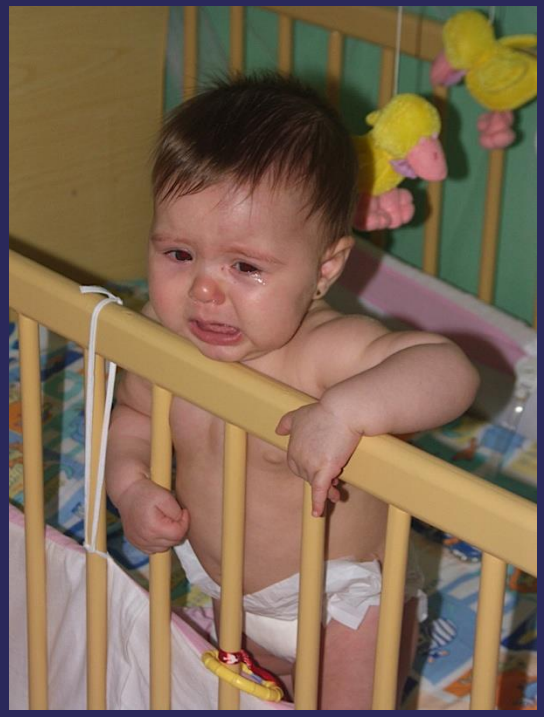
- Important dimensions
  - Valence
    - Positive vs. negative
  - Intensity
    - High vs. low arousal

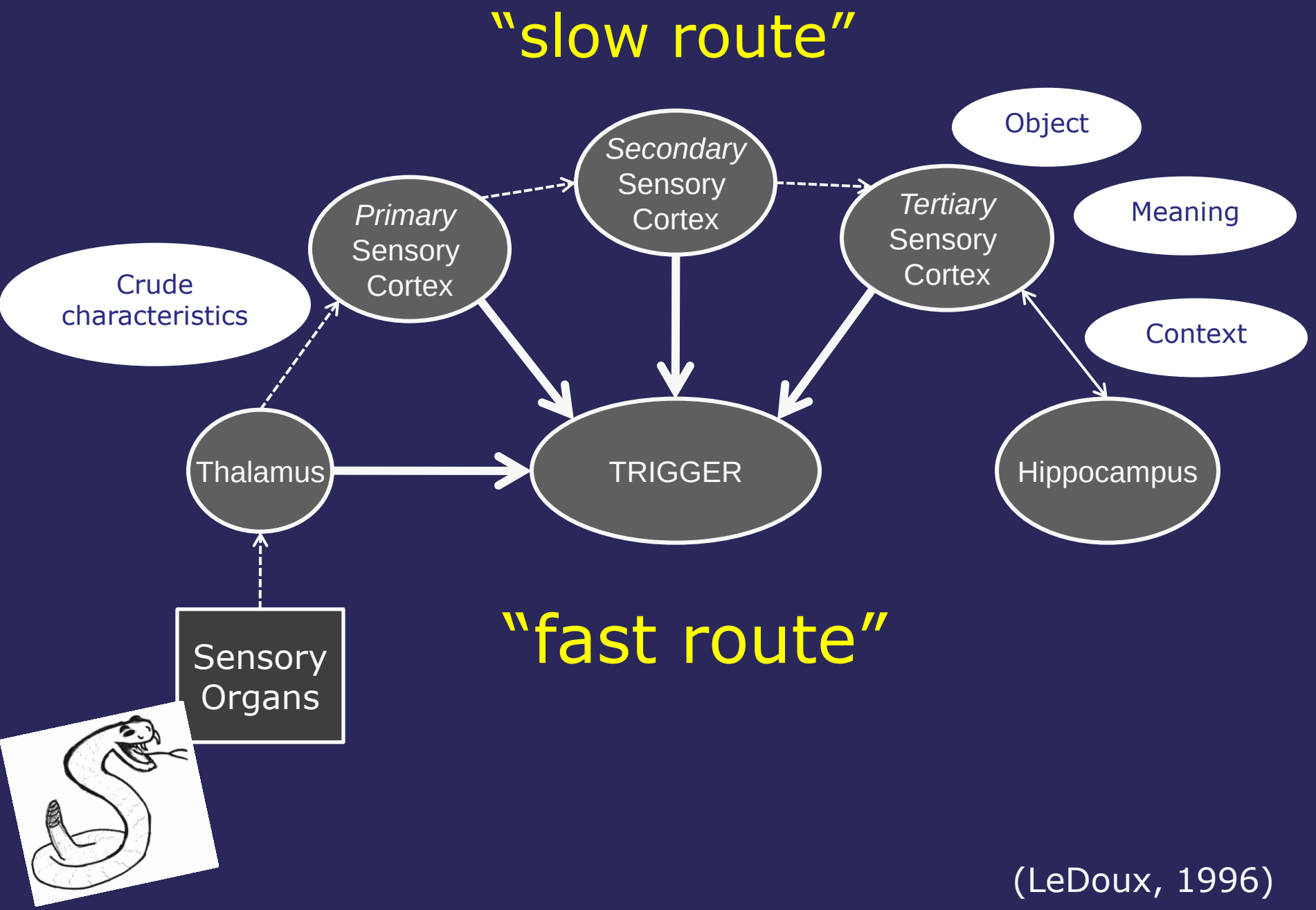
- Orthogonal
- Often confounded

Trigger sensitivity

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

- Situational differences
  - Mood states/context
  - Hormonal states
  - Past history




"slow route"
Object
Secondary Sensory Cortex
Meaning
Primary Sensory Cortex
Tertiary Sensory Cortex
Crude characteristics
Context
Thalamus
TRIGGER
Hippocampus
"fast route"
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 b/w 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

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- *Necessary* for triggering of reflexive emotional responses
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Amygdala: Triggering of motor and physiologic responses

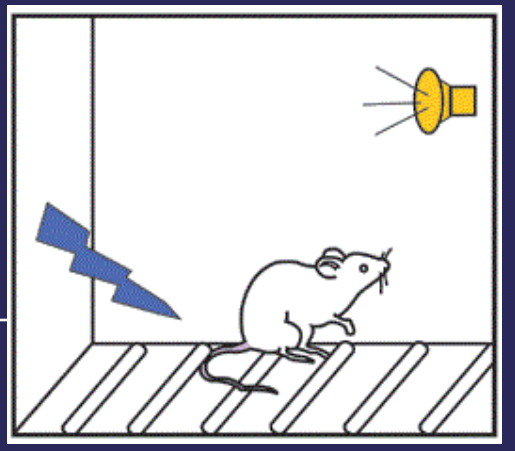
- *Necessary?*
  - Animal lesion studies
    - Rats fail to avoid/freeze in response to cats
    - Monkeys fail to exhibit behavioral and physiologic responses to snakes
  - Human lesion studies
    - Fail to exhibit cognitive and physiologic response to
      - Emotional pix, words, music

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

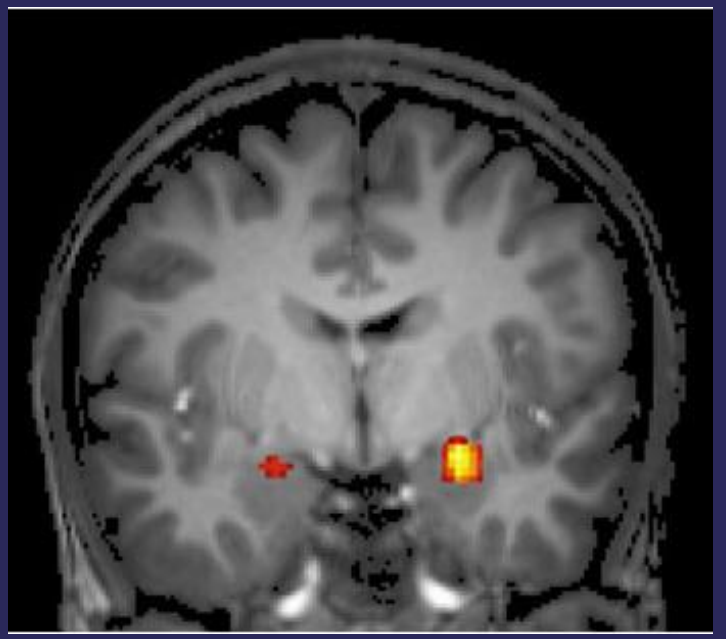
Amygdala: Trigger Characteristics (cont'd)

- √ *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

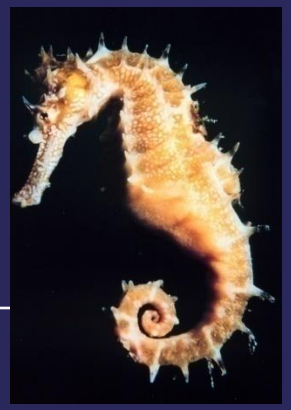


Kim et al., 2007; LaBar, Crupain, Voyvodic, & McCarthy, 2003; Ohman, 2005; Phelps, Fiske, Kazdin, & Schacter, 2006

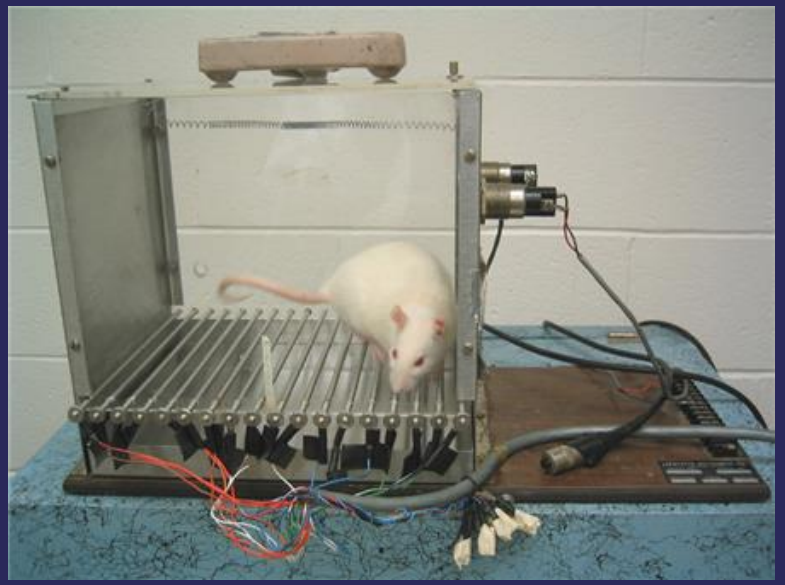
Emotional learning: Other structures

- Hippocampus
- Orbitofrontal cortex

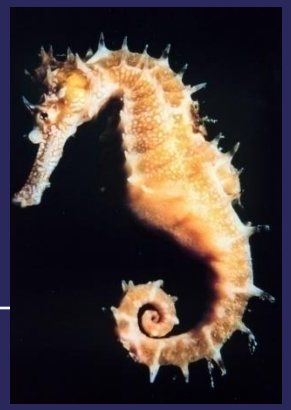
Emotional learning: Hippocampus



- Hippocampus



Emotional learning: Hippocampus



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

Amygdala	**Hippocampus**	
	Intact	Lesioned
Intact	• **Normal** physiologic response • **Normal** declarative memory	• **Normal** physiologic response • **Impaired** declarative memory
Lesioned	• **Impaired** physiologic response • **Normal** declarative memory	• **Impaired** physiologic response • **Impaired** declarative memory

Phelps, 2004; Ito et al., 2006

Emotional learning: Orbitofrontal cortex

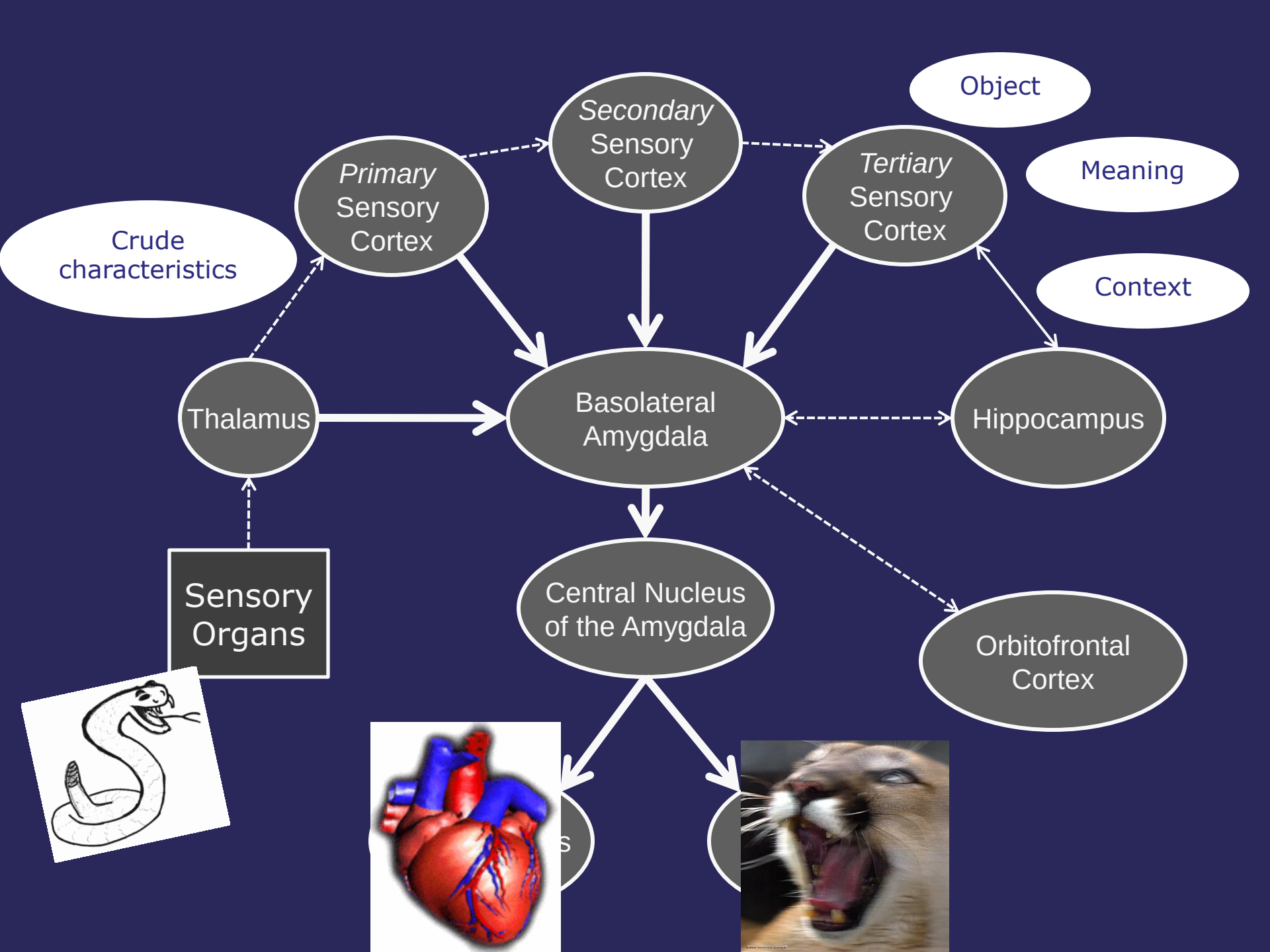
- Encoding associations between emotional and sensory information (all sensory modalities)
- Rapid updating of contingencies as they change

- 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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Meaning
Crude characteristics
Context
Thalamus
Basolateral Amygdala
Hippocampus
Sensory Organs
Central Nucleus of the Amygdala
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; Liberzon, Phan, Decker, & Taylor, 2003; Murphy et al., 2003; Vrticka, Sander, & Vuilleumier, 2012

Controversies in amygdala research: Laterality

- Contradictory findings

Left Hemisphere	Right Hemisphere	References
Positive	Negative	Pourtois, De Gelder, Bol, & Crommelick, 2005
Imagined anticipated, symbolically expressed	Personally experienced	Funayama, Grillon, Davis, & Phelps, 2001)
Verbal	Visual	Anderson & Phelps, 2001; Benuzzi et al., 2004; Johnstone, van Reekum, Oakes, & Davidson, 2006
Retrieval (memories)	Encoding (memories)	(Sergerie, Lepage, & Armony, 2006
Cognitive evaluation	Autonomic activation	Glascher & Adolphs, 2003; Skuse, Morris, & Dolan, 2005

THEORETICAL BACKGROUND: Interplay with cognition

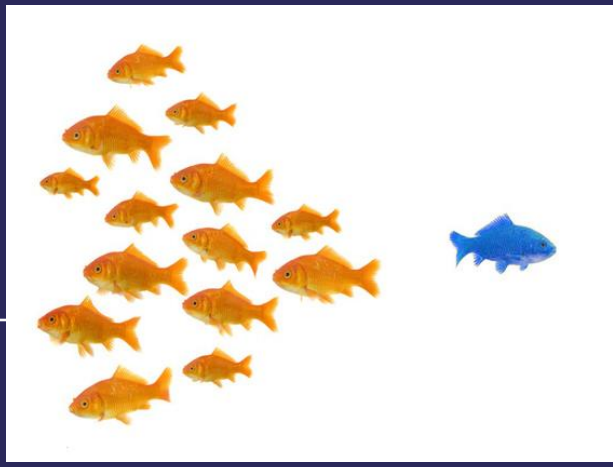
- Attention
- Memory
- Judgment
- “Emotional” decision making

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"

Table
Cow
Street
Chair
Bank
House
Dog
Farm
Tree
Pencil
Country
Wall
Class
Window
River
Flower
Bacon
Hand
Mouse
Moon
Woman
Fish
Hair

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

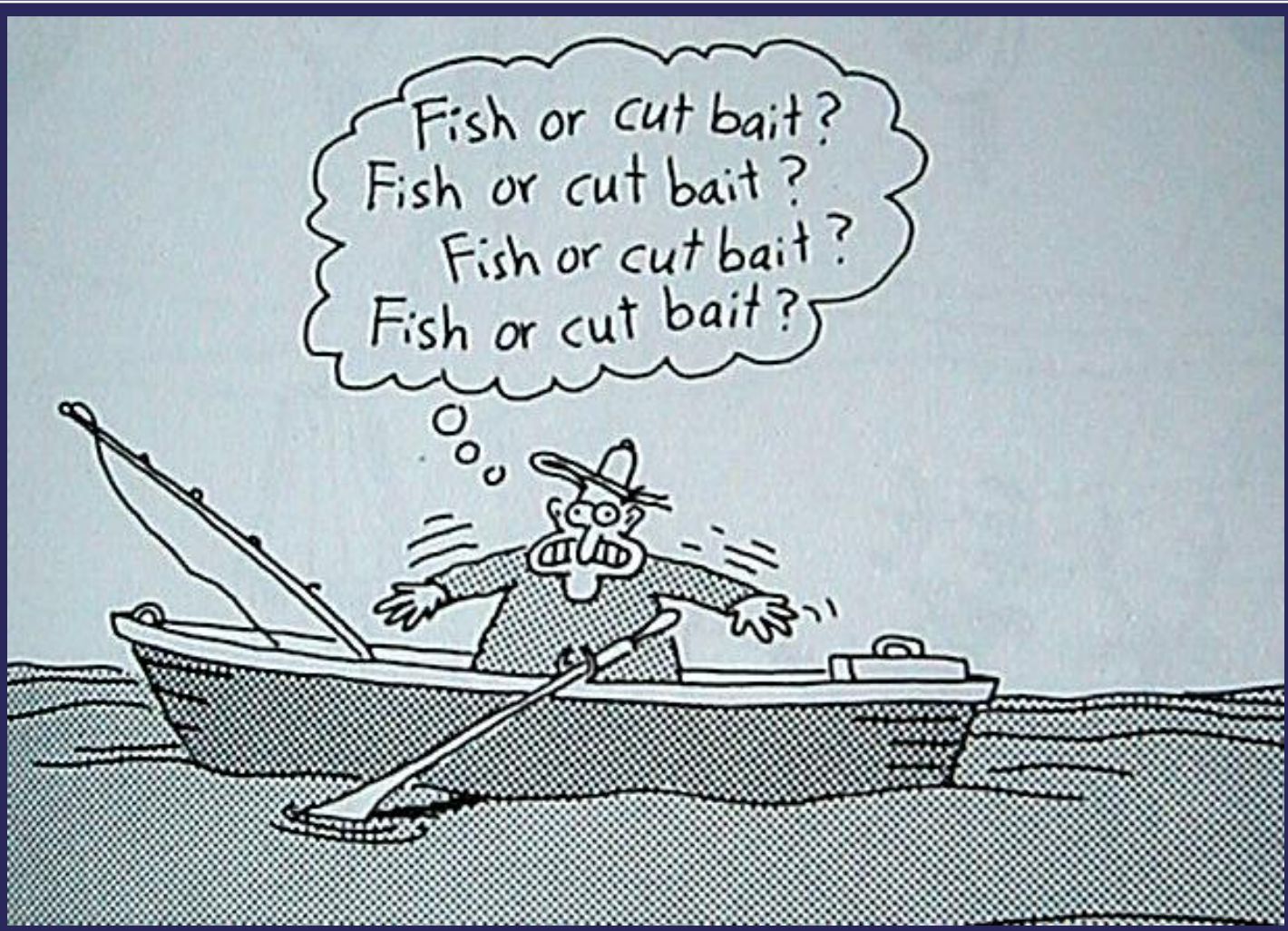
- Amygdala facilitates declarative memory
  - List of words OR series of photos
  - Some emotional, some neutral
  - Recognition memory better for emotional stimuli
- Individuals with bilateral amygdala damage do *not* show this effect

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)

A B C D

--- $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

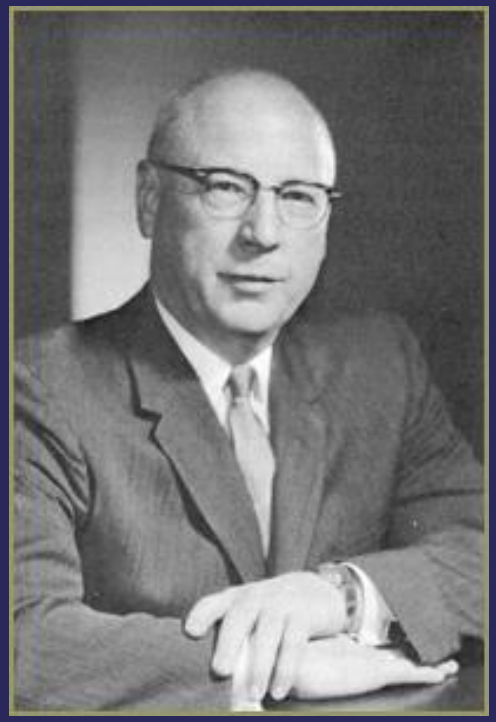
Integrating theory and PRACTICE: Clinical Syndromes

- 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
  - Indisriminate 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 (ŭr′bak vē′tĕ)

- 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 amyg abnormalities

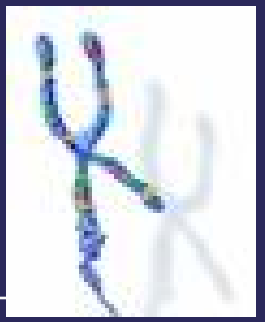
Brown et al., 2002; Kesler et al, 2004; Skuse et al., 2005

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 amyg 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



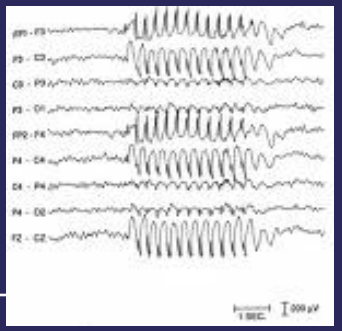
- Fragile X-associated tremor/ataxia syndrome (FXTAS)
  - Carriers (primarily male) of fragile X gene
    - No MR
  - Adult onset Sx
    - Intention tremor, gait ataxia, dementia
  - Reduced amygdala volume
  - Childhood Sx
    - Social awkwardness, emotional deficits
    - Lack of startle potentiation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

Dementia type	Kluver-Bucy syndrome	Capgras syndrome	Refs
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

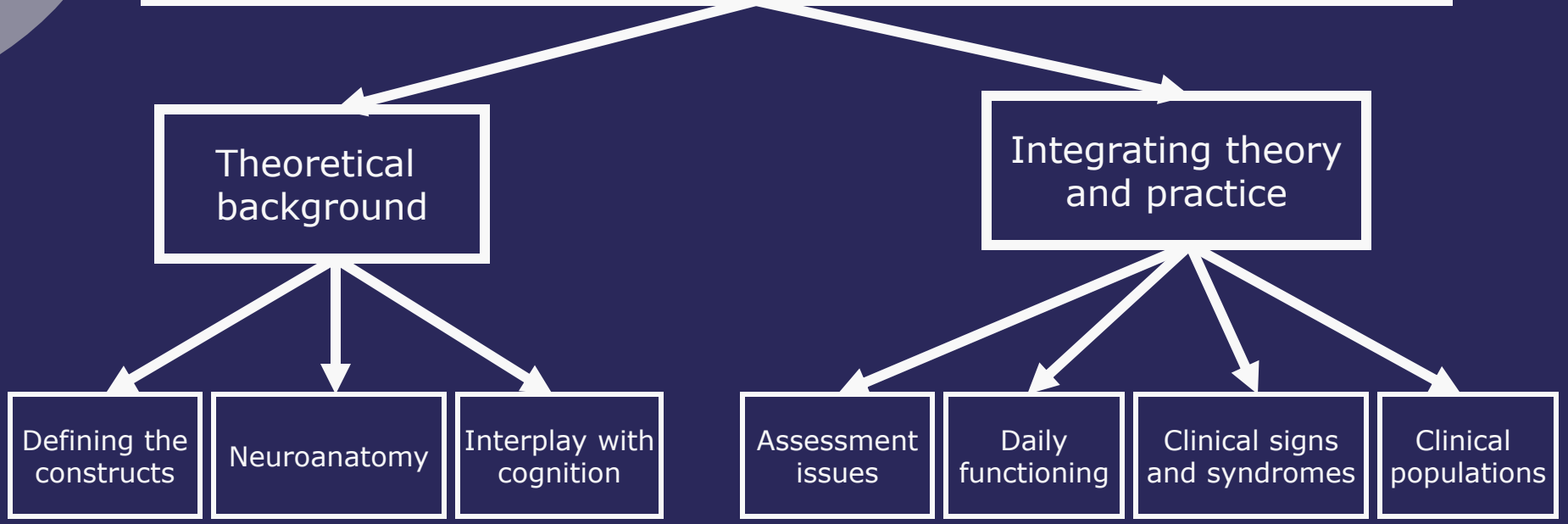
- PTSD
  - Chronic exposure to stress
    - Hypertrophy of amygdala
    - Atrophy of hippocampus
- Generalized anxiety disorder
  - Smaller amygdala volume
    - But hyperactive
    - Even smaller hippocampi

Vyas et al., 2002; Hayano et al, 2009; McClure et al, 2007

Emotional Trigger: Summary and Conclusions

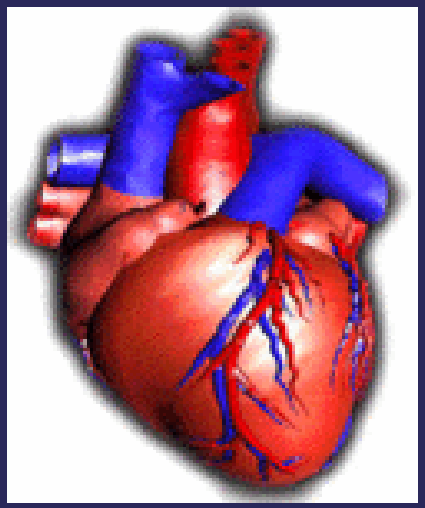
- Amygdala likely represents the primary trigger of emotional responses
- Amygdala abnormalities can be seen in a variety of neurodevelopmental, neurodegenerative, neuropsychiatric, and other neurologic populations
- Cognitive deficits in every day life are relatively subtle, but can present as frustrating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

Components of an emotional event



THEORETICAL BACKGROUND: Defining the construct

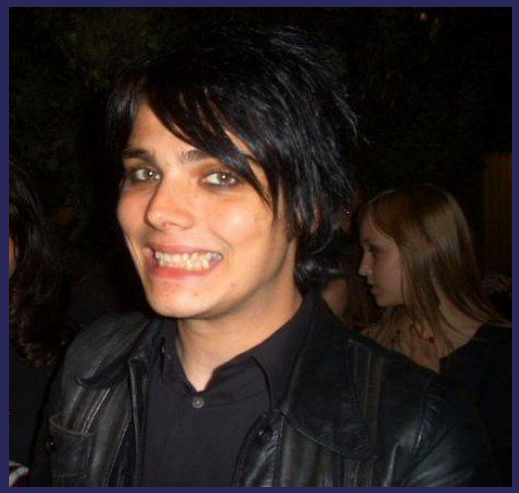
- Autonomic/endocrine response
  - Sympathetic/parasympathetic activation
  - HPA axis activation
- Involuntary skeletal responses
  - Facial expressions, posture, bodily movements
  - Vocalization
  - Crying, laughing
  - Growling, hissing
  - Startle, freezing



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

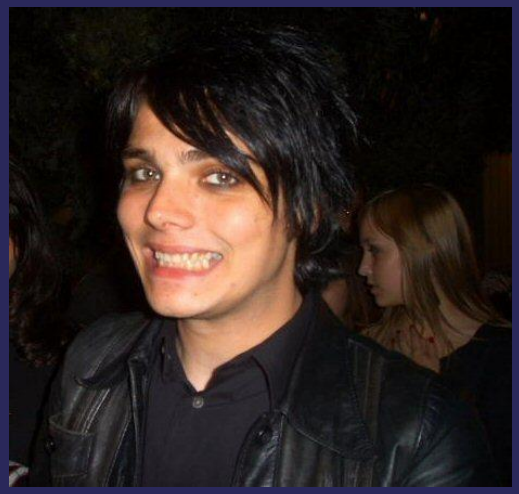
Function/purpose of Emotional Skeletal Motor System

- 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

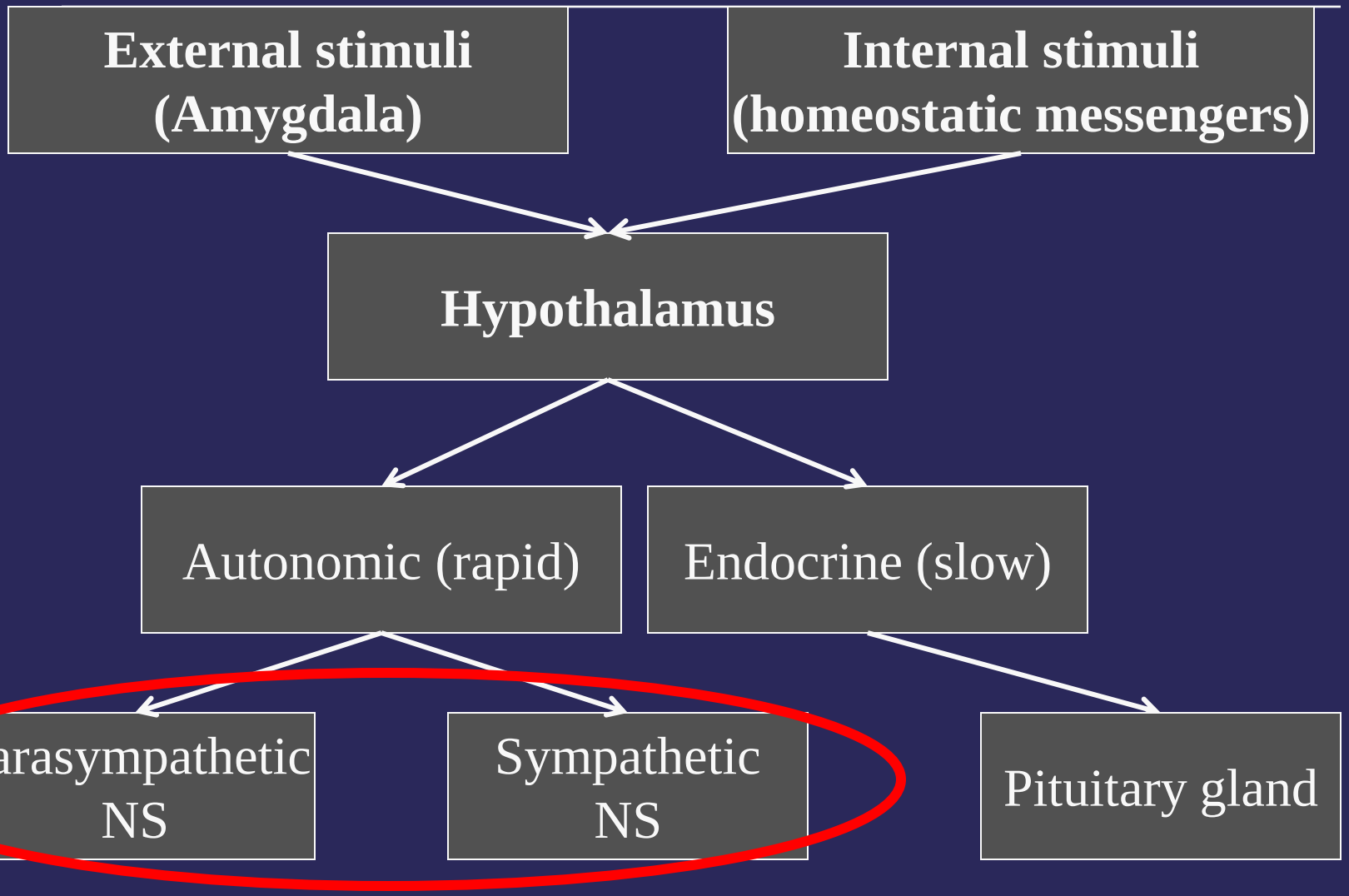
Autonomic/ Endocrine

Enteric

Sympathetic

Parasympathetic

THEORETICAL BACKGROUND: Autonomic/endocrine system



Function/purpose of Autonomic Motor System

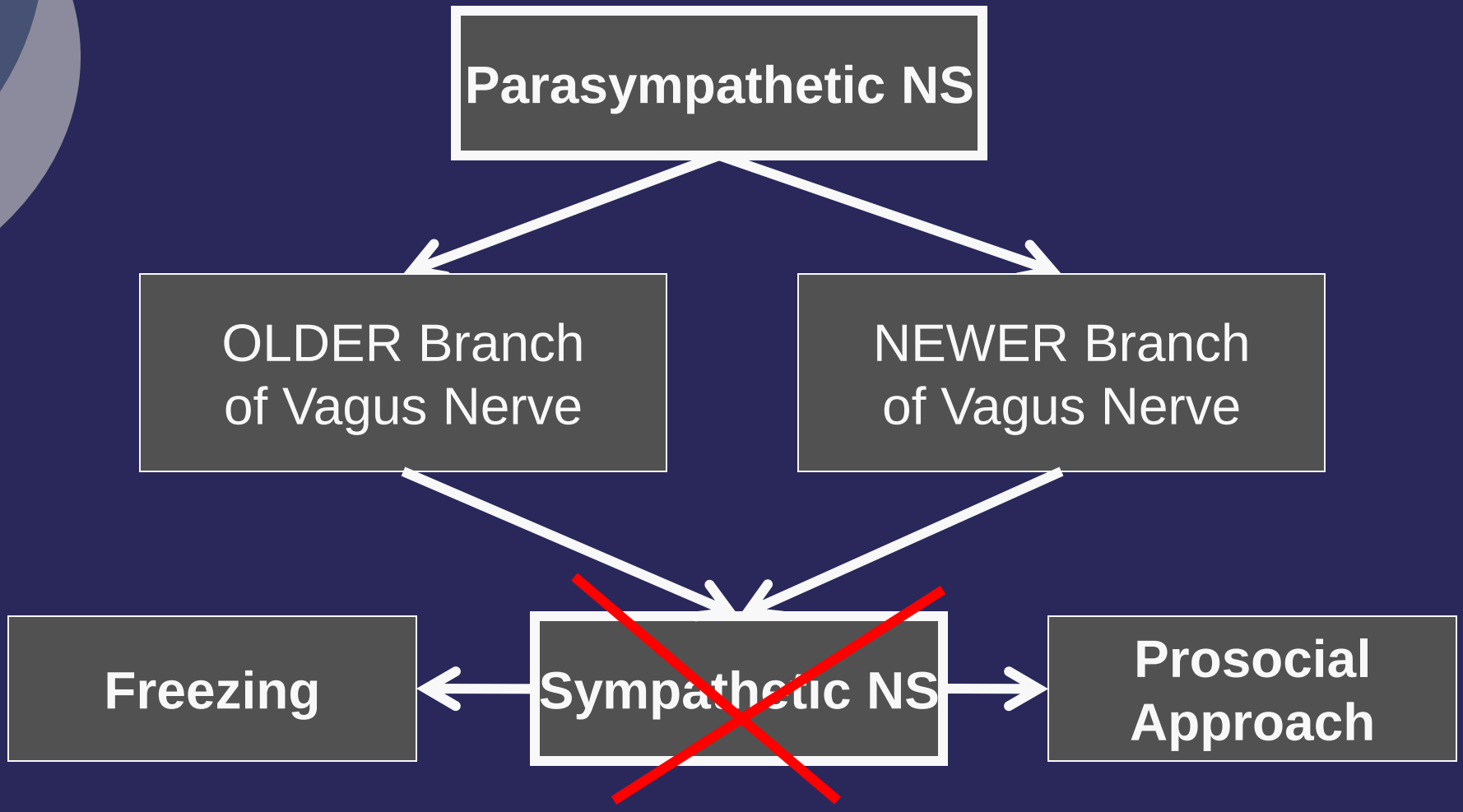
- Sympathetic
  - Mobilize physiologic states
  - Capture cognitive resources

- Parasympathetic
  - Restock
  - Digest
  - Repair

Autonomic Nervous System

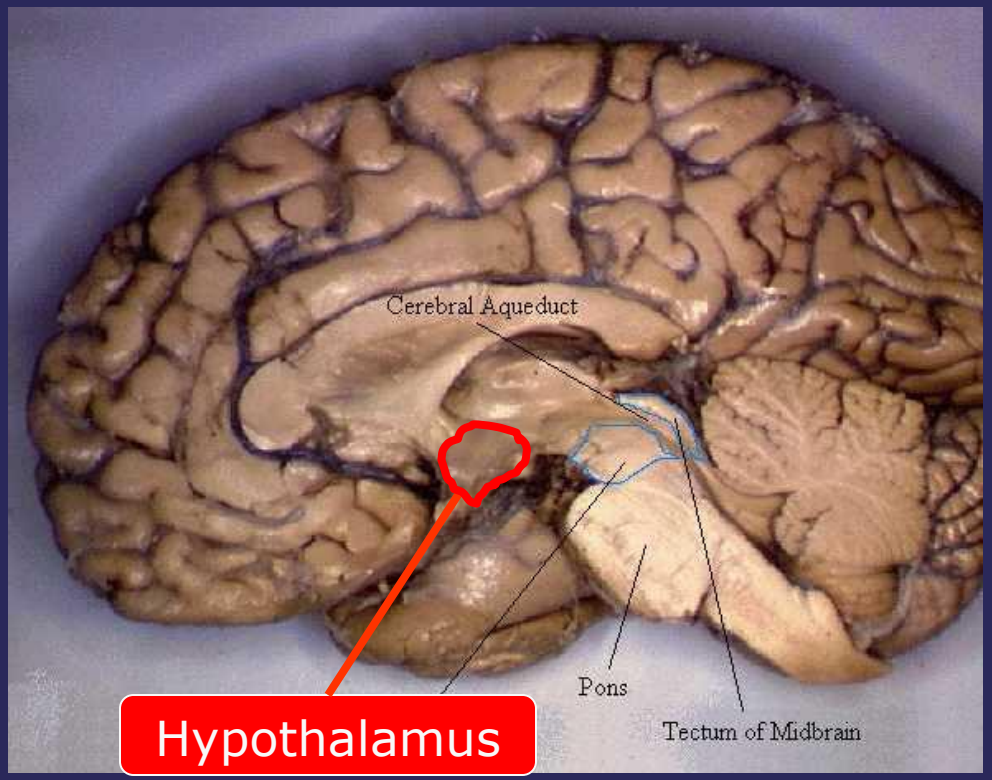
Organ	Sympathetic	Parasympathetic
Heart Rate	Increase	Decrease
Heart Contraction	Increase	Decrease
Brochi	Dilate	Constrict
Salivary glands	Mucous, low enzyme	Watery, high enzyme
Eye	Dilate	Constrict
Stomach and intestines	Inhibition of peristalsis	Increased peristalsis
Adrenal gland	Adrenalin into blood stream	N/A
Liver	Break down glycogen	N/A
Skin blood vessels	Constriction	N/A
Muscle blood vessels	Dilation	N/A

Poly-vagal Theory (Porges, 2006)



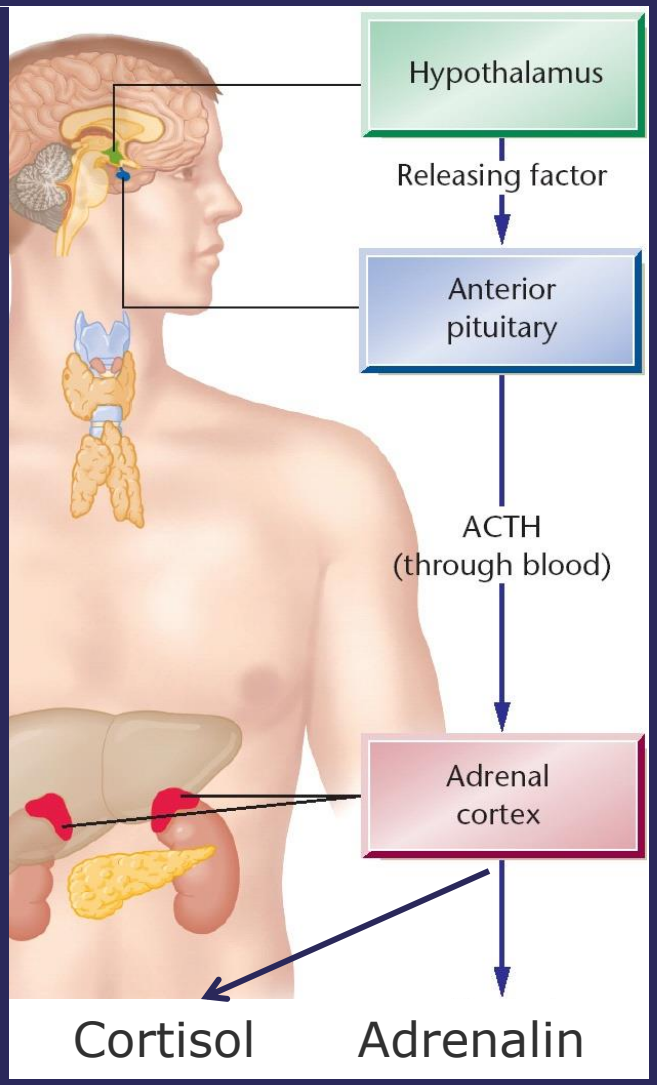
THEORETICAL BACKGROUND: Neuroanatomy

- 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

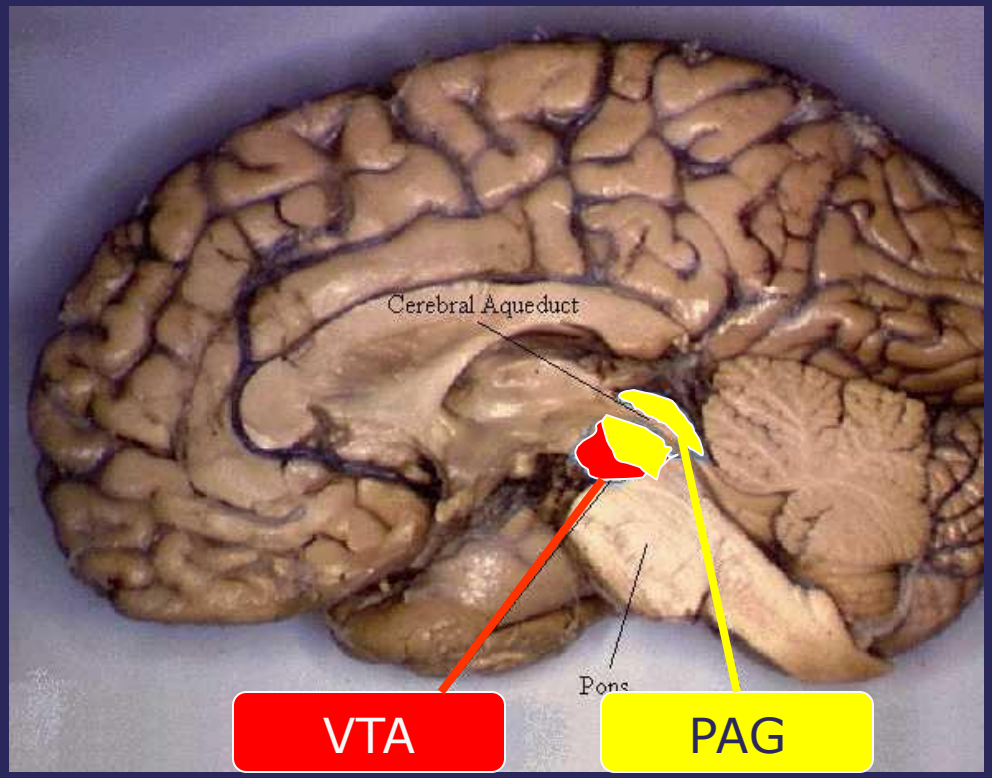


Neuroanatomic Substrates: Hypothalamus (cont'd)

- (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, & Pfaus, 2004; Palmiter, 2007

Neuroanatomic Substrates: Mesencephalon

	Predatory aggression	**Affective aggression**
Sympathetic activation	Minimal, except dilation of pupils	Maximal
Behavioral response	Calm, goal-directed	Frantic
Vocalization	Minimal to none	Frantic, loud
Mesencephalon	Ventrolateral PAG; VTA	Dorsal PAG; Dorsal premammilary nuclesus
Hypothalamic n.	Lateral	Medial
Mutual relationship	Inhibitory reciprocal inter-neurons, preventing occurence of both responses at the same time	

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

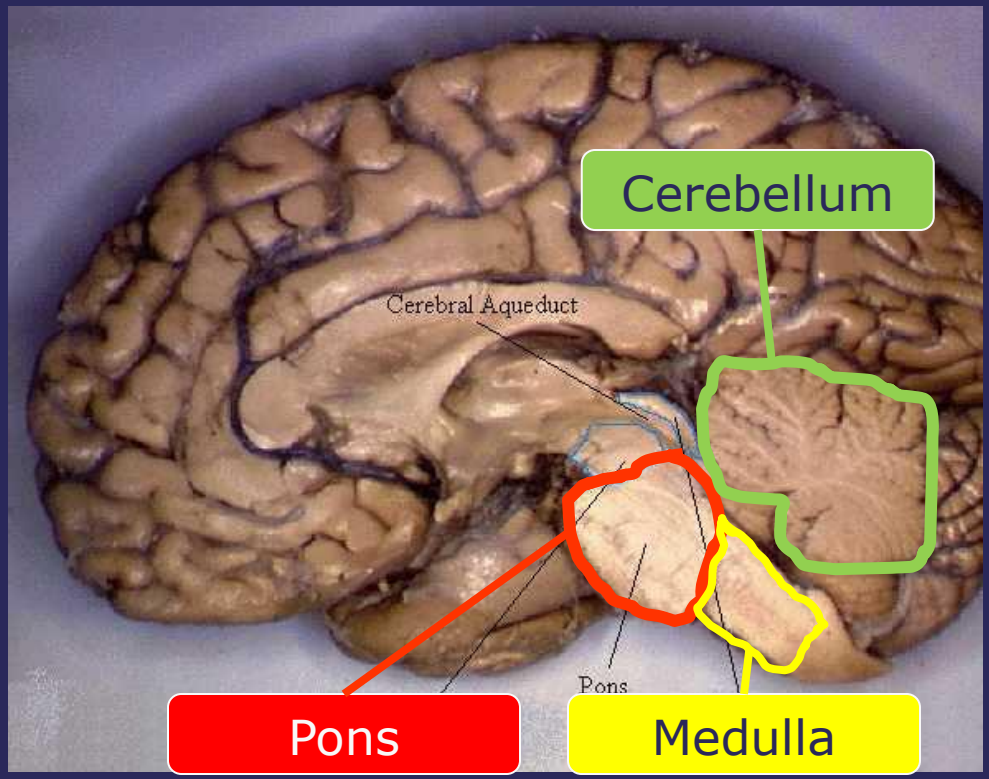
Kippin, Sotiropoulos, Badih, & Pfaus, 2004; Palmiter, 2007

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

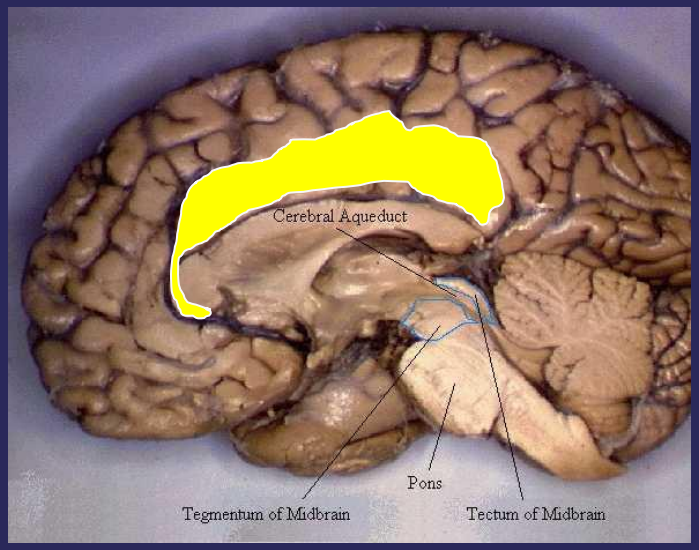
Schmahmann, 2001; Wild, Rodden, Grodd, & Ruch, 2003; Zhu, Yung, Chow, Chan, & Wang, 2006

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



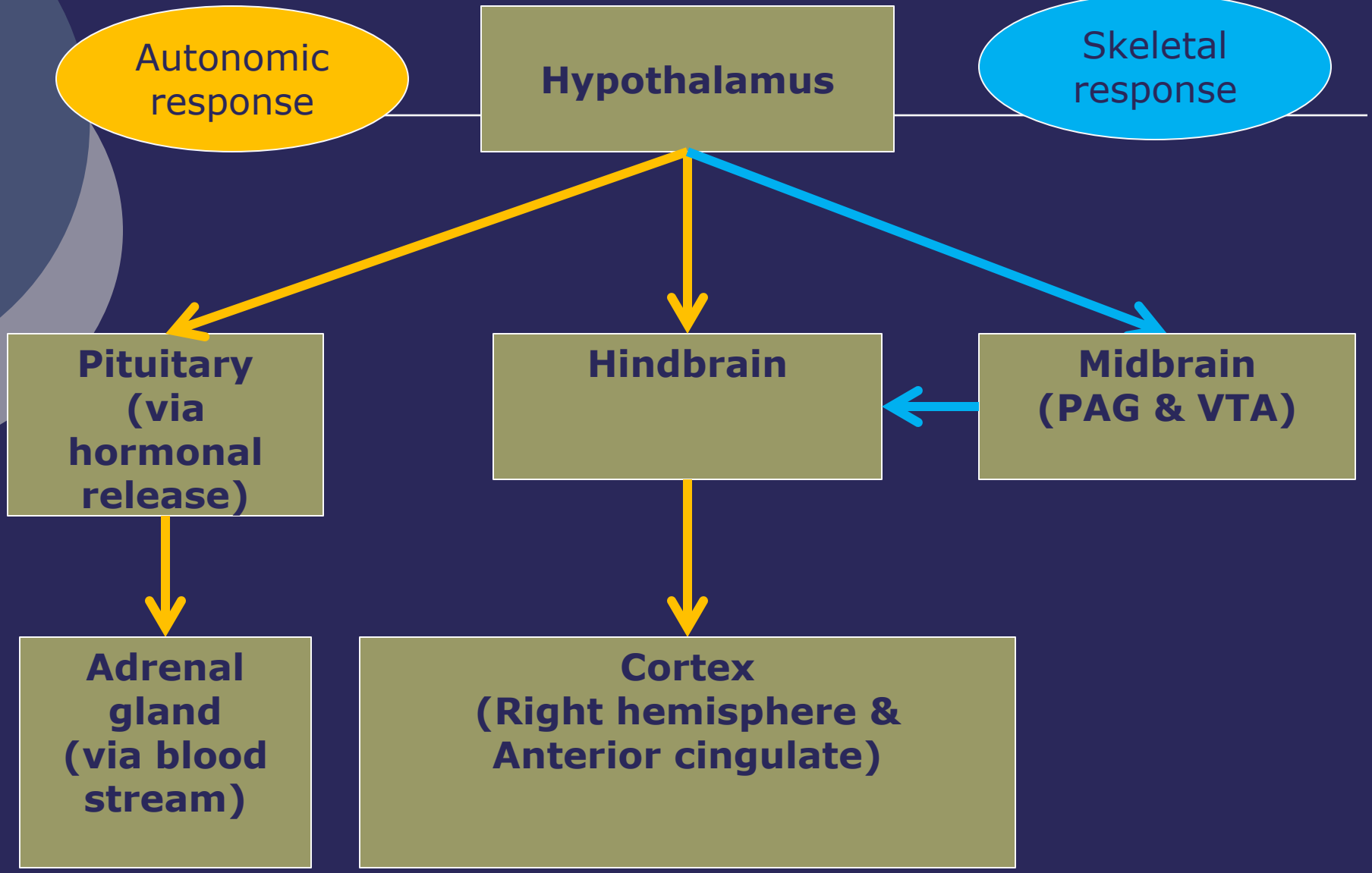
Critchley, Elliott, Mathias, & Dolan, 2000; Critchley et al., 2003

Neuroanatomic Substrates: Cerebral cortex and autonomic regulation

LEFT: Parasympathetic

RIGHT: Sympathetic

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


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

Integrating theory and PRACTICE

- Test performance
- Clinical syndromes
  - Emotional skeletal motor dysfunction
  - Autonomic/endocrine dysfunction
- Assessment
- Clinical populations

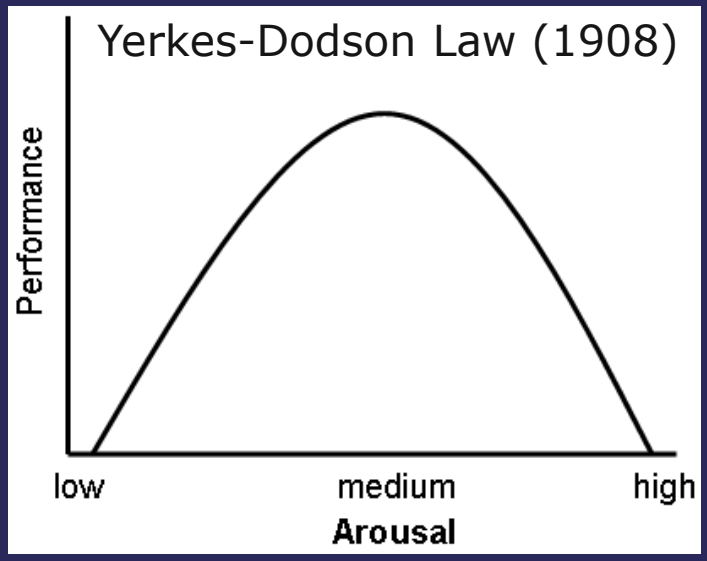
Integrating theory and PRACTICE: Test performance

- 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



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 associate 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, pillomotor
  - "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

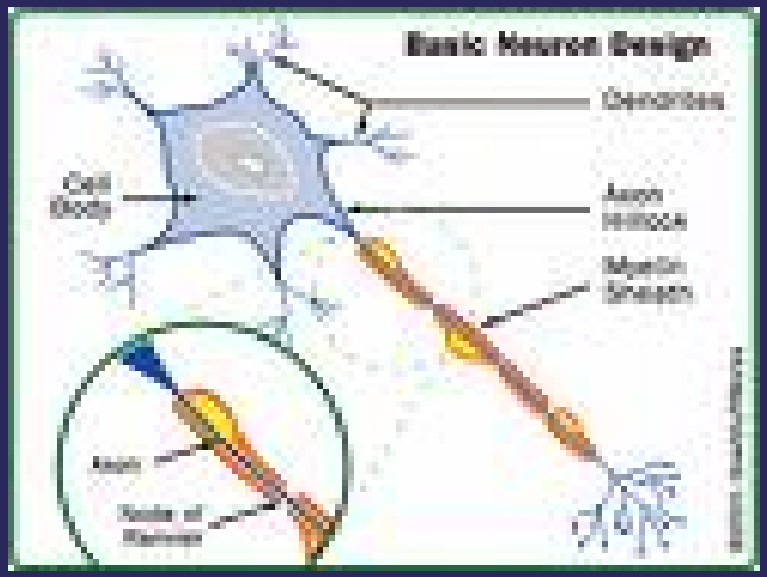
Integrating theory and PRACTICE: Clinical Populations (cont'd)

- 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

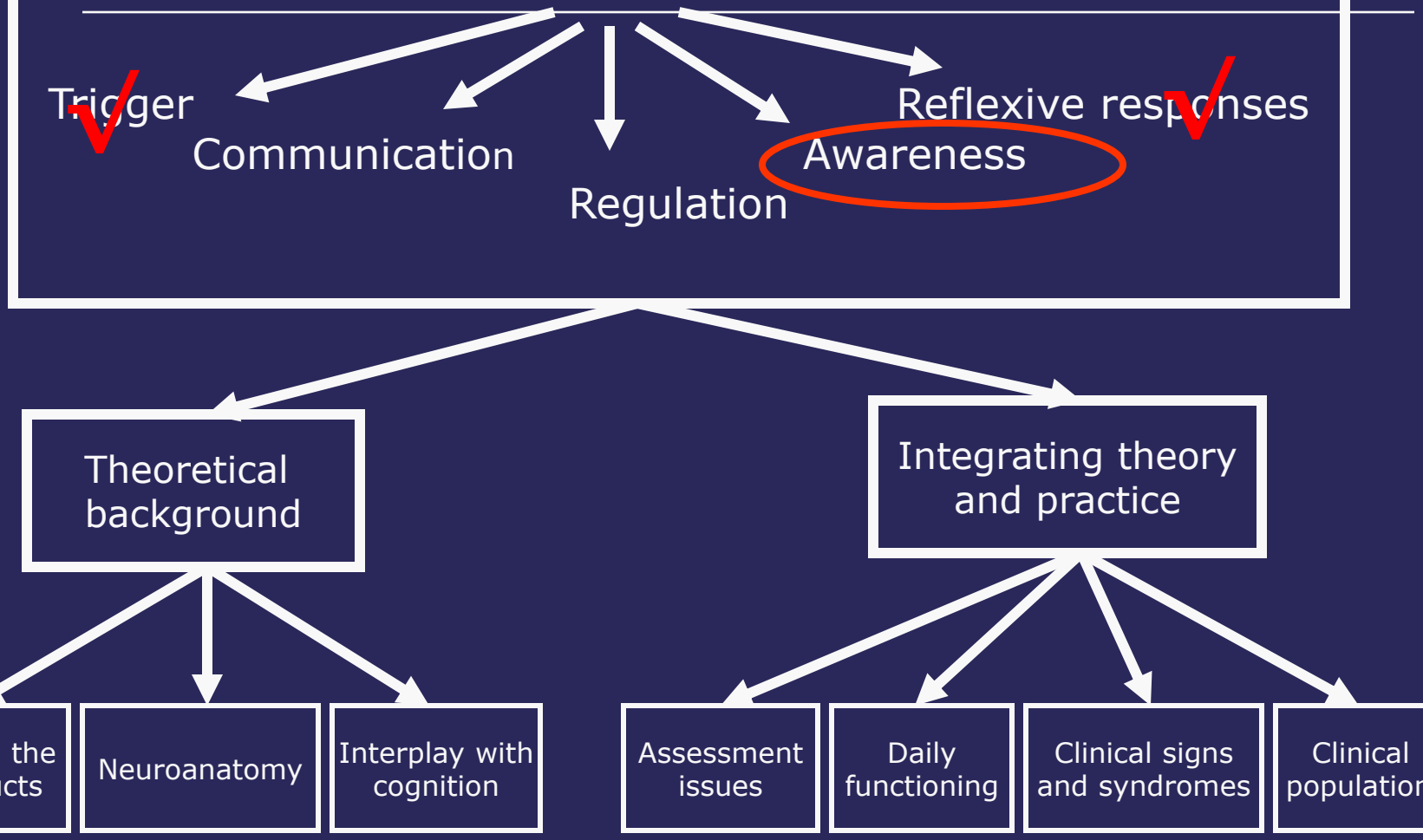
	MSA	PD with AF
Causes of AF	Degeneration of *pre*ganglionic neurons; Medullary dysfunction	Degeneration of *post*ganglionic neurons
Subjective AF complaints	Present	Present
AF Sx progression	Fast	Slow
Orthostatic Hypotention	Almost always present	Common
Anhidrosis	Diffuse	Absent or distal regions of limbs (fingers, toes)

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



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

Critchley, Wiens, Rotshtein, Ohman, & Dolan, 2004; Heims, Critchley, Dolan, Mathias, & Cipolotti, 2004; Pollatos, Kirsch, & Schandry, 2005; Pollatos, Schandry, Auer, & Kaufmann, 2007

THEORETICAL BACKGROUND: Components of awareness (cont'd)

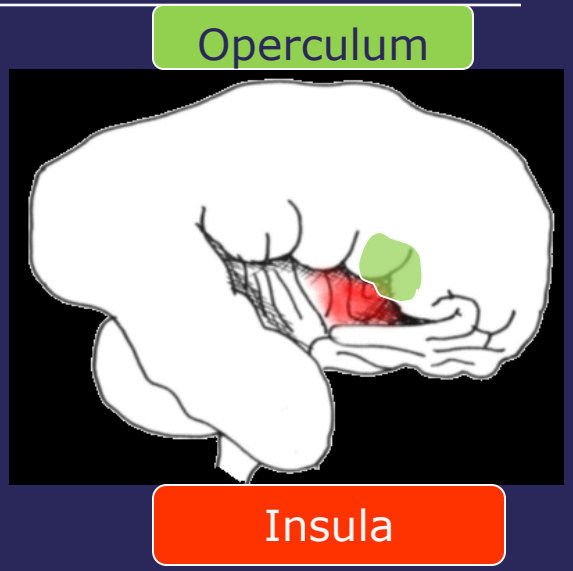
- Emotional (feeling) awareness
  - Includes the ability to
    - Feel
    - Understand
    - Discuss
  - Dissociable from interoceptive awareness

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

Neuroanatomic Substrates: Interoceptive awareness (cont'd)

- 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 mindfullness 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)

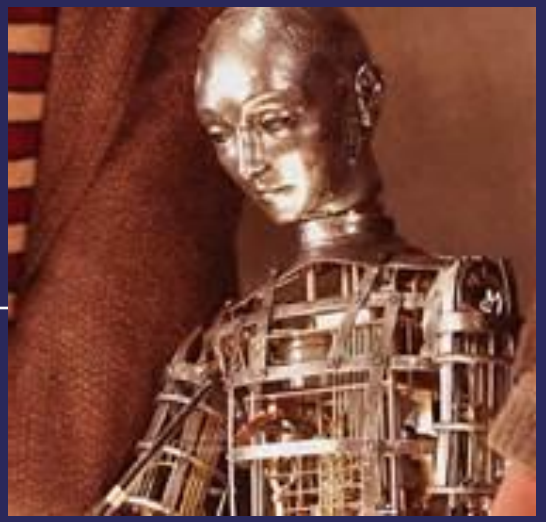
- Emotional Awareness (cont'd)
  - Functional imaging in alexithymics
    - Greater activation in the anterior insula (bilateral)
    - Decreased activation in
      - Posterior and anterior cingulate gyrus
      - DLPFC
      - Pons and cerebellum
  - Slower inter-hemispheric transfer

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

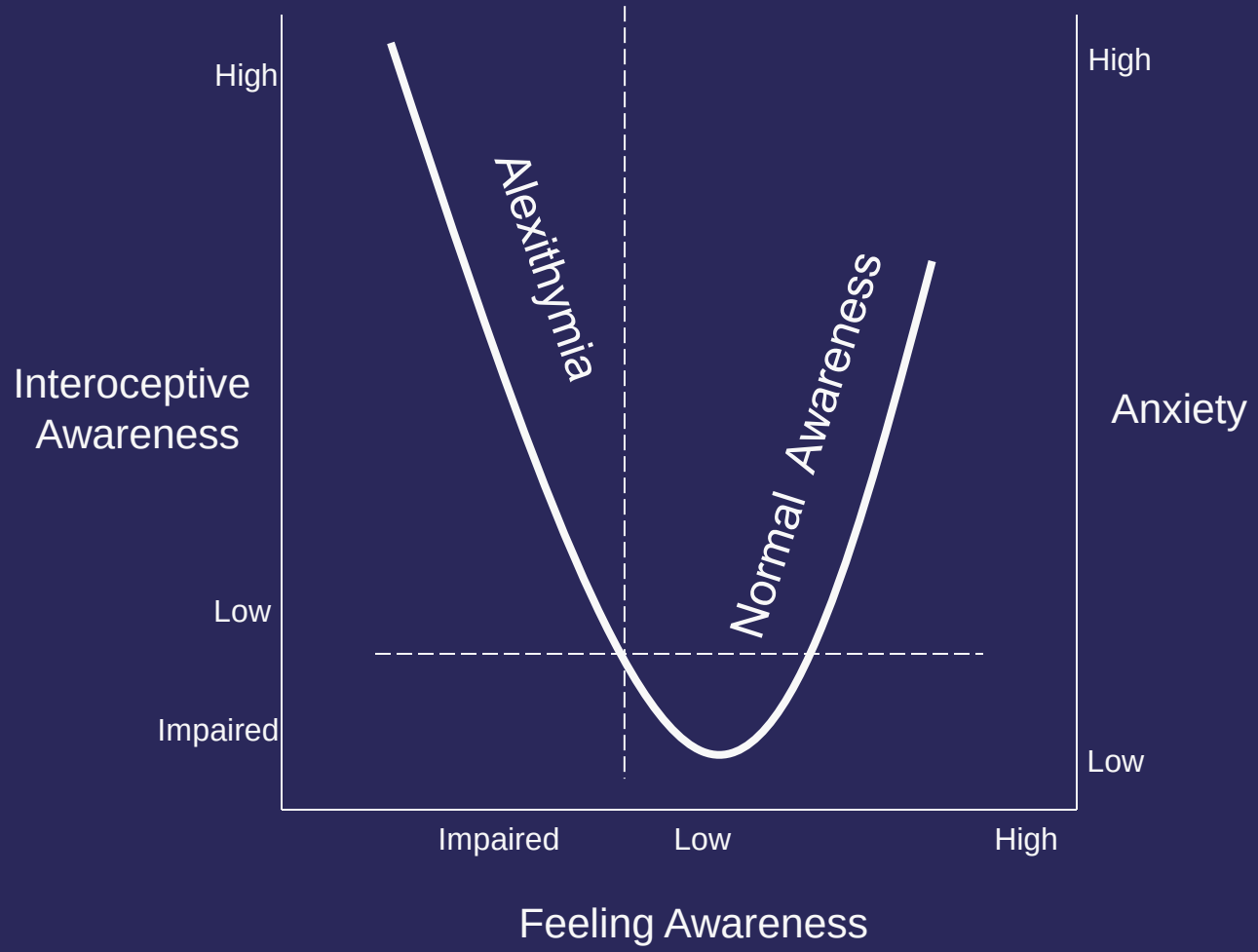
emotions

- Normal ability to
  - Exhibit
  - Be aware of

physiologic response to emotional stimuli

Taylor, 1984; Warnes, 1986

Alexithymia:
Interoceptive awareness



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

Guttman & 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 *hyper*active arousal
      - Explaining physiologic symptoms in physical terms

Infrasca, 1997; Luminet et al., 2004; Stone & Nielson, 2001; Vanman et al., 1998

Alexithymia: Comorbid characteristics

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

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

Fukunishi & Tsurata, 2001; Kauhanen, Kaplan, Cohen, & Julkunen, 1996; Kauhanen et al., 1991; van Heck, den Oudsten, Vingerhoets, Nyklicek, & Denollet, 2008

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

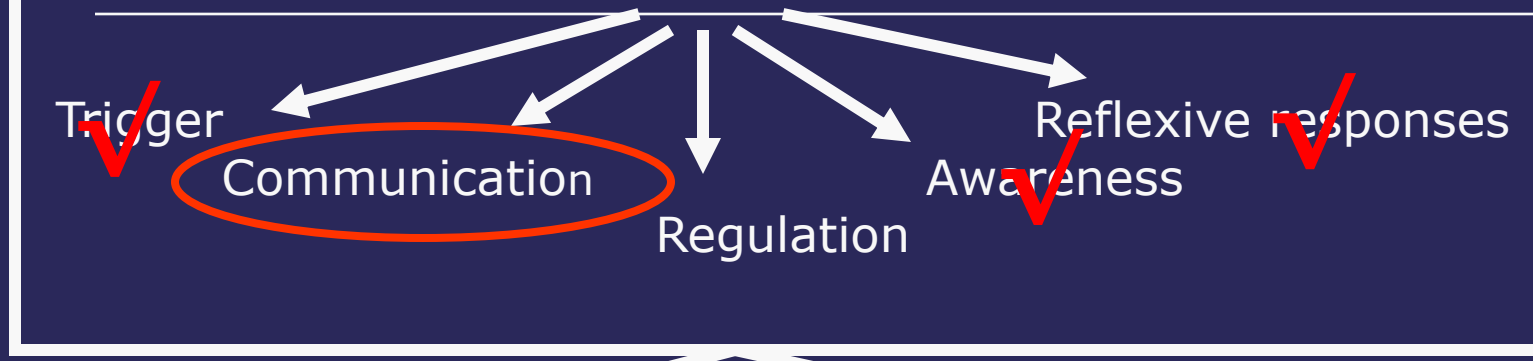
- Toronto Alexithymia Scale (TAS-20)
  - Factors
    - Difficulty identifying emotions
    - Difficulty describing emotions
      - More susceptible to cultural and familial norms
    - Externally oriented thinking
  - Scores stable across five years
  - Available for purchase
    - http://www.gtaylorpsychiatry.org/tas.htm

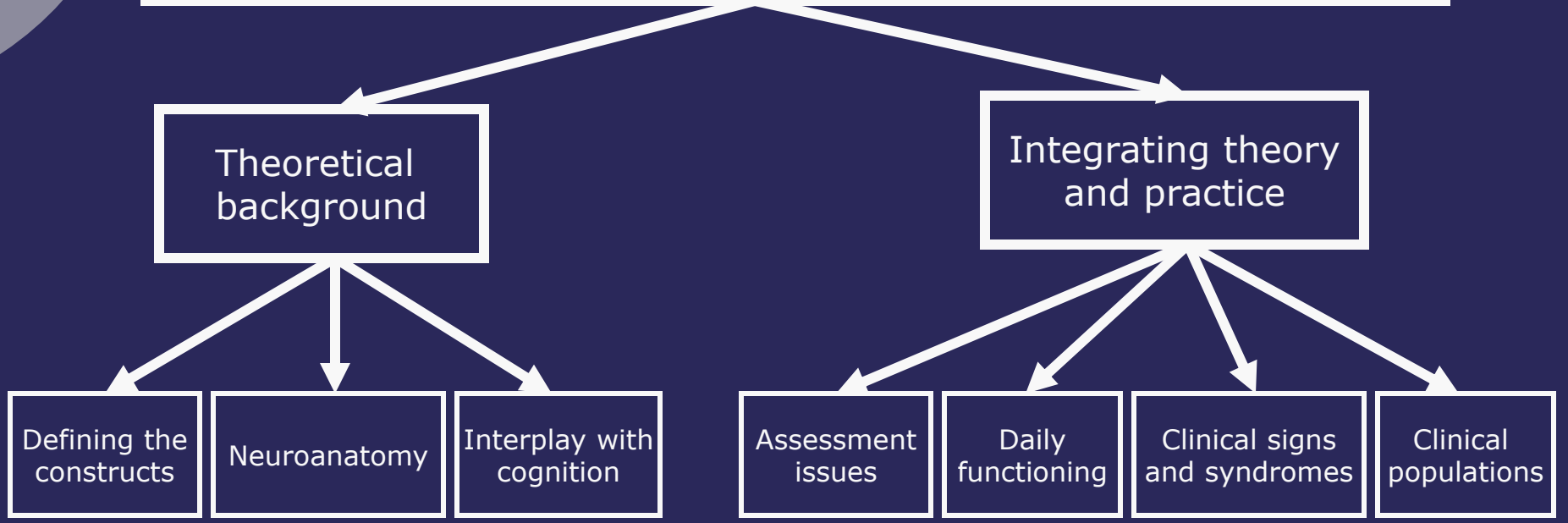
Bagby, Parker et al., 1994; Fukunishi, Kawamura, Ishikawa, & Ago, 1997; Le, Berenbaum, & Raghavan, 2002; Parker, Taylor, & Bagby, 2003; Saarijarvi, Salminen, & Toikka, 2006; Taylor, Bagby, & Parker, 2003

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





THEORETICAL BACKGROUND: Defining affective communication

- Direction
  - Expressive
  - Receptive
- Mode
  - Linguistic
  - Paralinguistic
  - Situational
- Volitional control
  - Nonvolitional
  - Posed

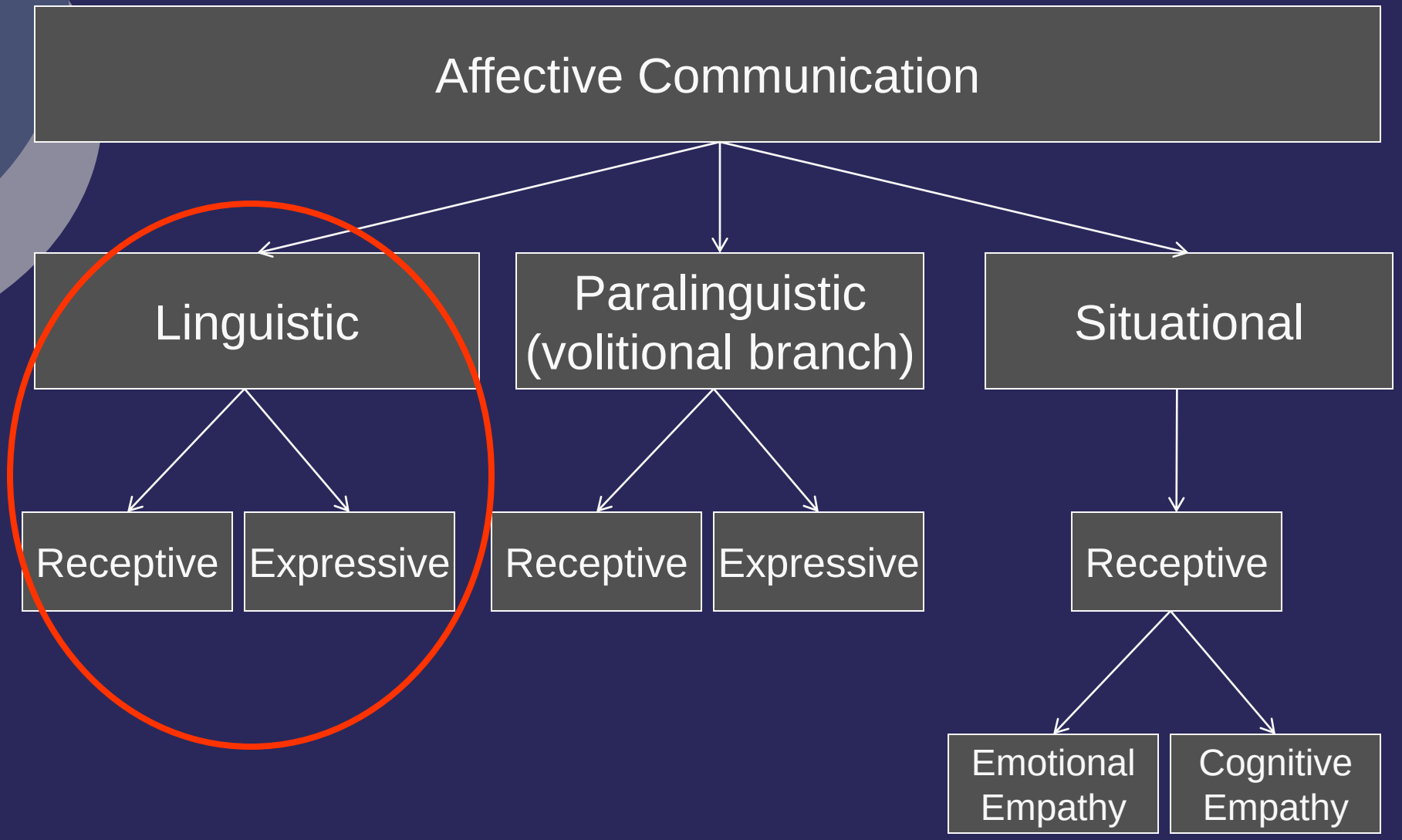
Specific emotions

- Happiness
- Sadness
- Fear
- Anger
- Disgust
- Surprise

THEORETICAL BACKGROUND: Volitional vs. non-volitional comm.

Dependant variables	Type of communication		References
	Volitional	Non-volitional	
Physiologic arousal	Absent or minimal	Present	Boiten et al., 1996
Emotional experience	Absent or minimal	Present	Boiten et al., 1996
Facial symmetry	Less symmetric	More symmetric	Ekman et al, 1981
Ease of recognition	Easier	More difficult	Gosselin & Kirouac, 1995
Facial muscles	Somewhat different muscle groups used in each		Boiten et al., 1996

THEORETICAL BACKGROUND: Neuroanatomy

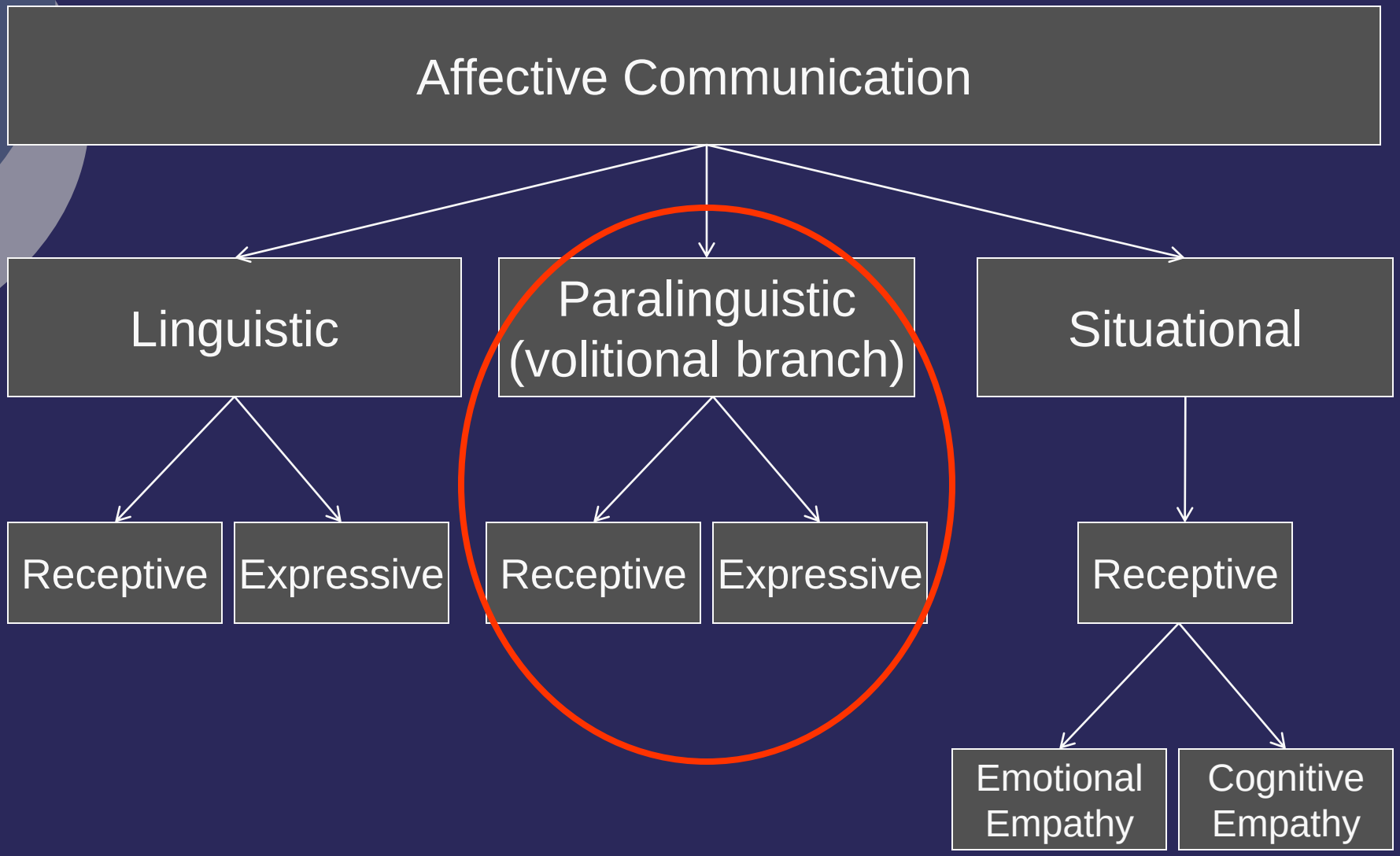


Neuroanatomy: Linguistic communication

- Construct not well defined
- Expressive and Receptive neuroanatomy
  - Both hemispheres
    - Basal ganglia
    - Inferior frontal
    - Posterior superior temporal

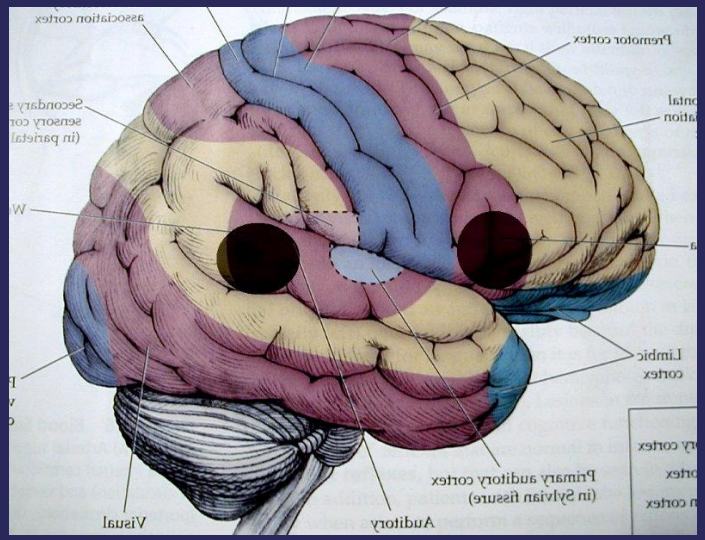
Beaucousin et al., 2007; Blonder et al., 2005; Borod et al., 2002; Karow et al., 2001; Pick, 2002; Sherratt, 2007

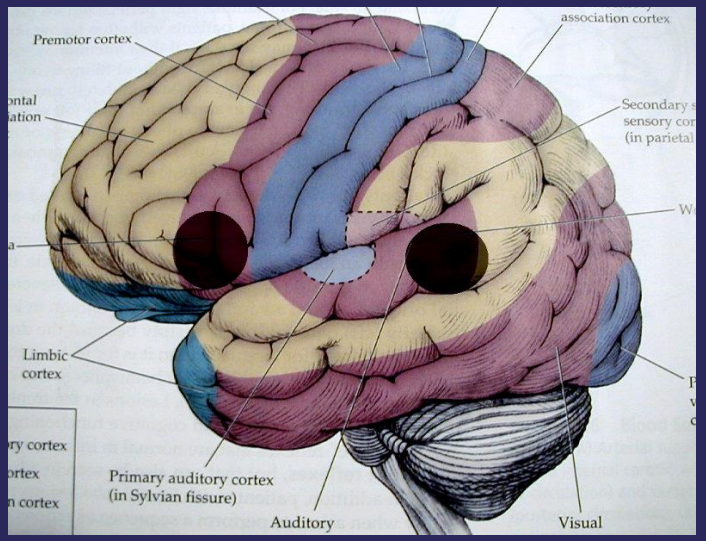
THEORETICAL BACKGROUND: Neuroanatomy



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

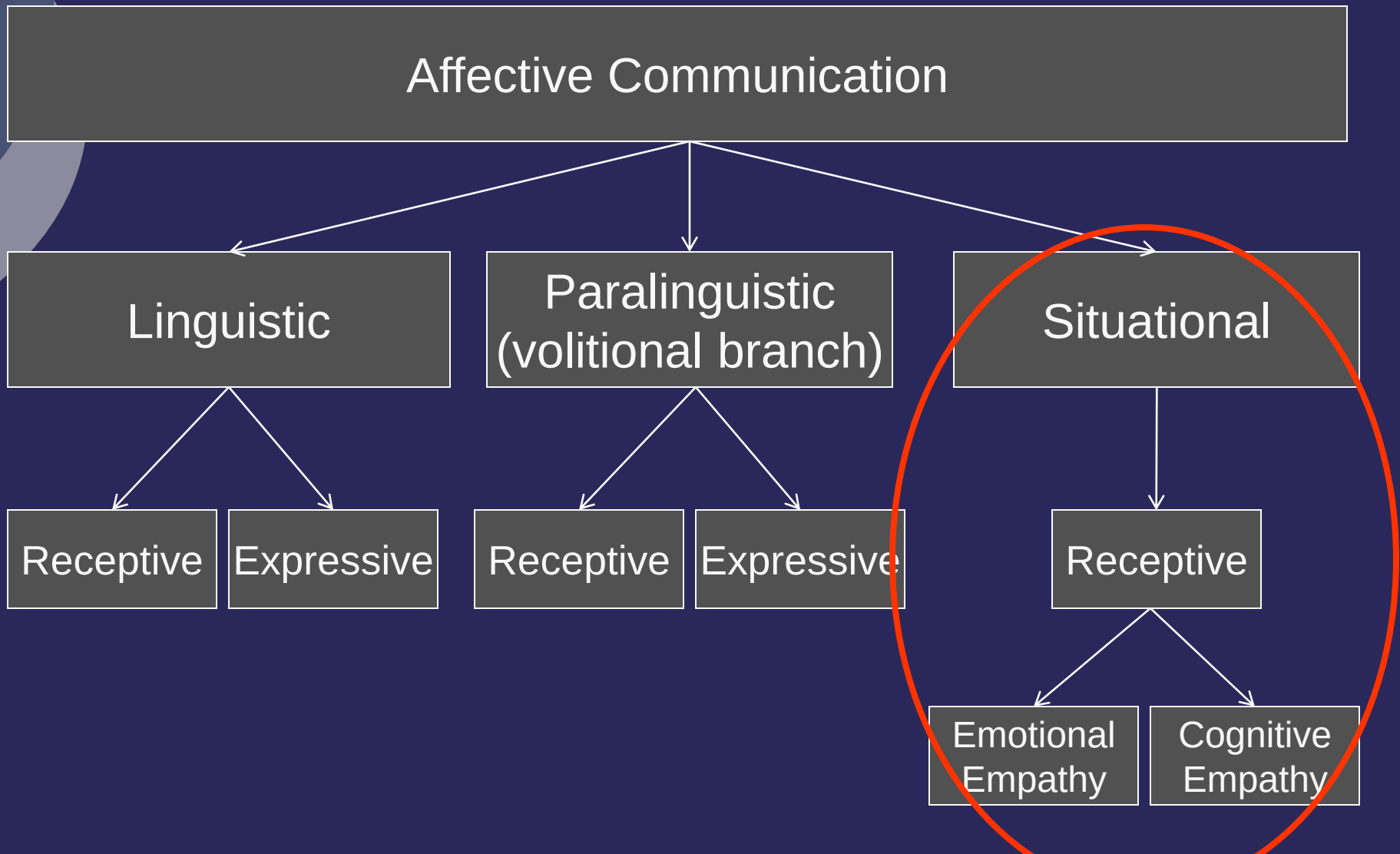
Baum & Pell, 1999; Bradvik, Dravins, Holtas, & Rosen, 1991; Cancelliere & Kertesz, 1990; Heilman, Leon, & Rosenbek, 2004; Karow et al., 2001; Lee et al., 2006

Testing Ross' Paralinguistic Theory (cont'd)

	Receptive	Expressive
Anterior	Right	Right and left
Posterior	~~Right~~	

- 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

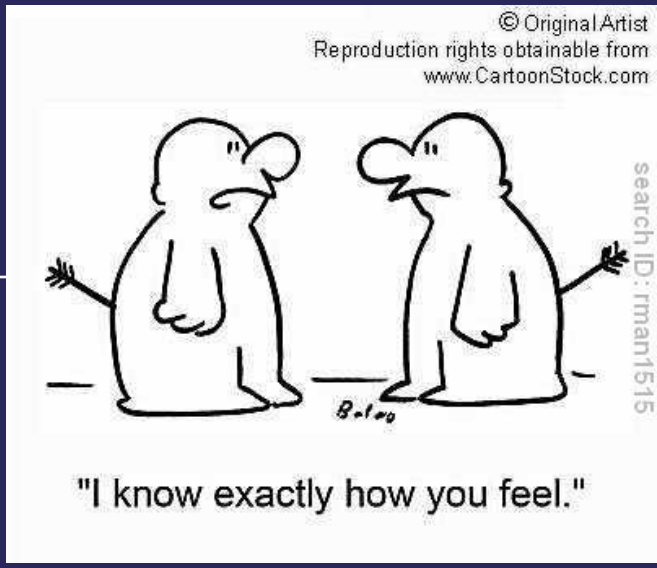


Neuroanatomic Substrates: Situational Communication

- 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)

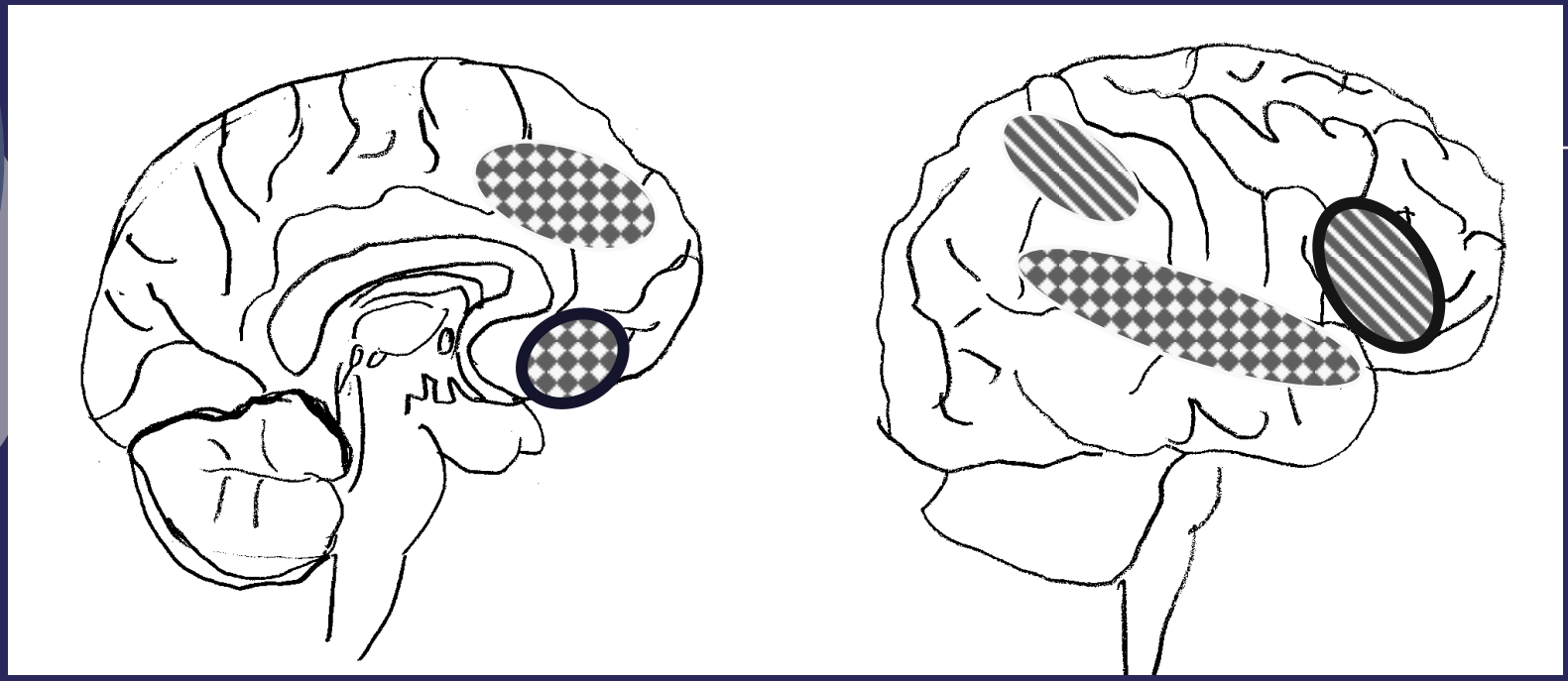


- Empathy Networks
  - Cognitive Empathy
    - *Know* what others feel
    - Relies on the Theory of Mind networks(MNS)
      - Perspective taking
    - Medial prefrontal, temporal poles
      - Activated during cognitive empathy tasks

Premack & Woodruff, 1978; Schulte-Ruether et al., 2007

Medial view

Lateral view



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

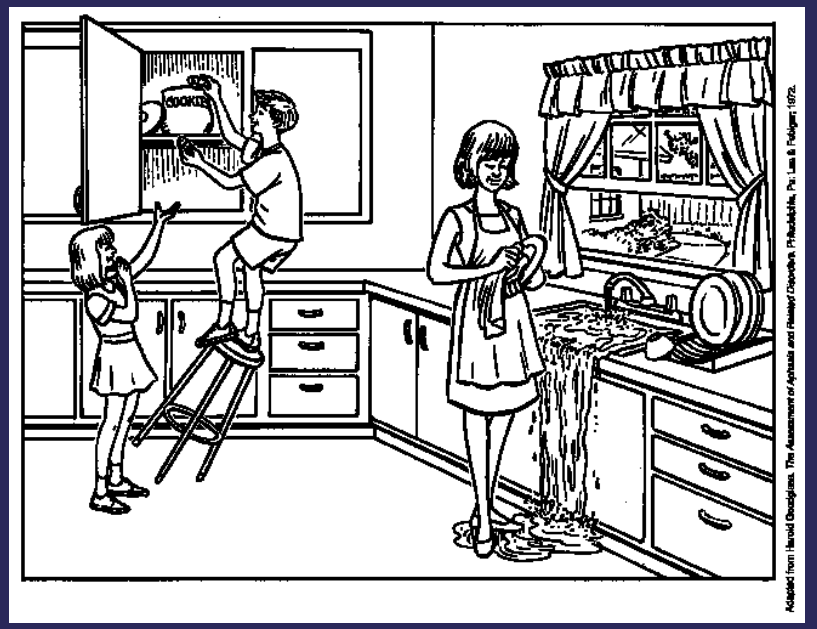
- Affect recognition associated with
  - Visual-spatial memory and learning
  - Visual recognition memory
  - Visual-spatial scanning

- 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

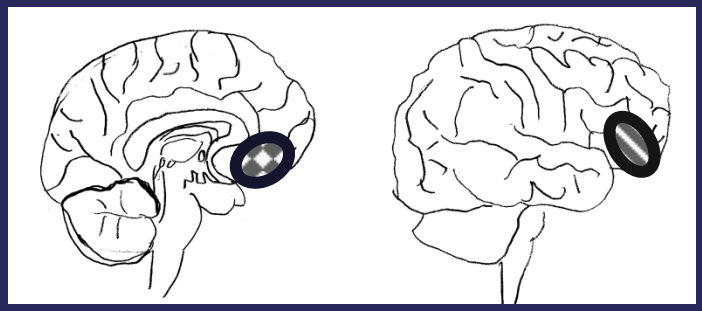
Shamay-Tsoory, Tomer, Goldsher, Berger, & Aharon-Peretz, 2004

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

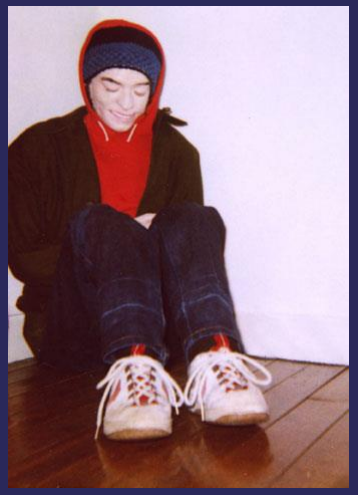


- TBI
  - Affect recognition
  - Cognitive and emotional empathy

Radice-Neumann, Zupan, Babbage, & Willer, 2007; Shamay-Tsoory et al., 2004

Clinical populations: Neurodevelopmental disorders

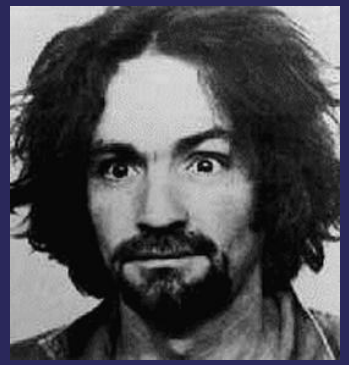
- Autism
- Down syndrome/Intellectual dis.
- Williams syndrome
  - Poorer than autism
- FAS
- ADHD



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

Clinical populations: Neuropsychiaric 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, Lovallo, & Ross, 2001; Monnot, Lovallo, 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

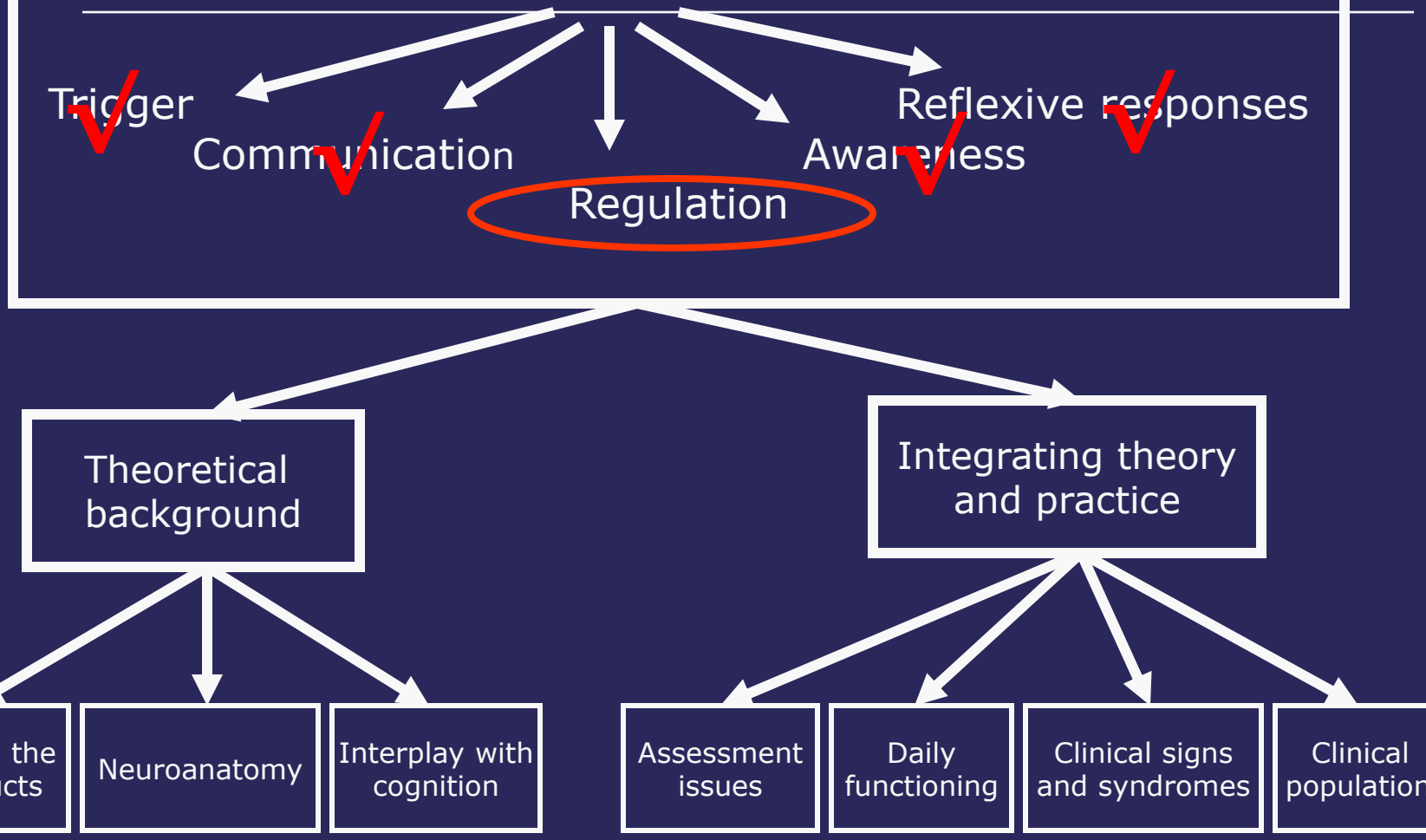
- WAIS-IV: Advanced Clinical Solutions
  - Social Cognition Test
    - Facial Expressions
    - Social Interactions
    - Prosody
- The Awareness of Social Inference Test (TASIT)
    - Emotion Evaluation
    - Social Inference

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, visualspatial, and executive deficits
- Impairments may mimic other deficits due to affectively loaded content of test materials

Components of an emotional event



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)

	Primary	Secondary
Treatment	Non-responsive	Responsive
Anxiety	Low	High
Emotions	Callousness	Lability
Aggression	Instrumental	Reactive

Blair, 2001; Falkenbach, Poythress, & Creevy, 2008;
Newman, MacCoon, Vaughn, & Sadeh, 2005; Skeem, Johansson, Andershed, Kerr, & Louden, 2007

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

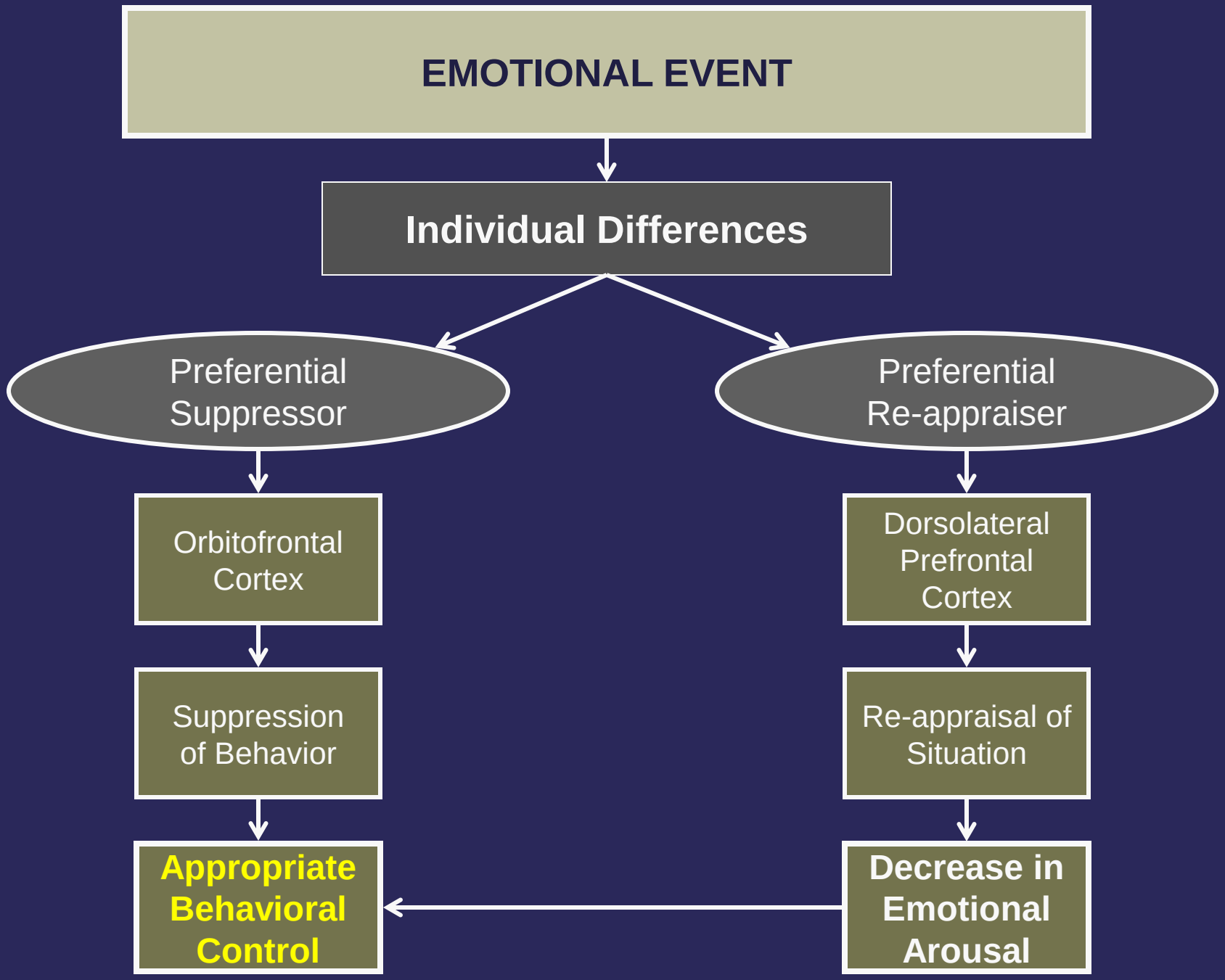
Populations: TBI (cont'd)

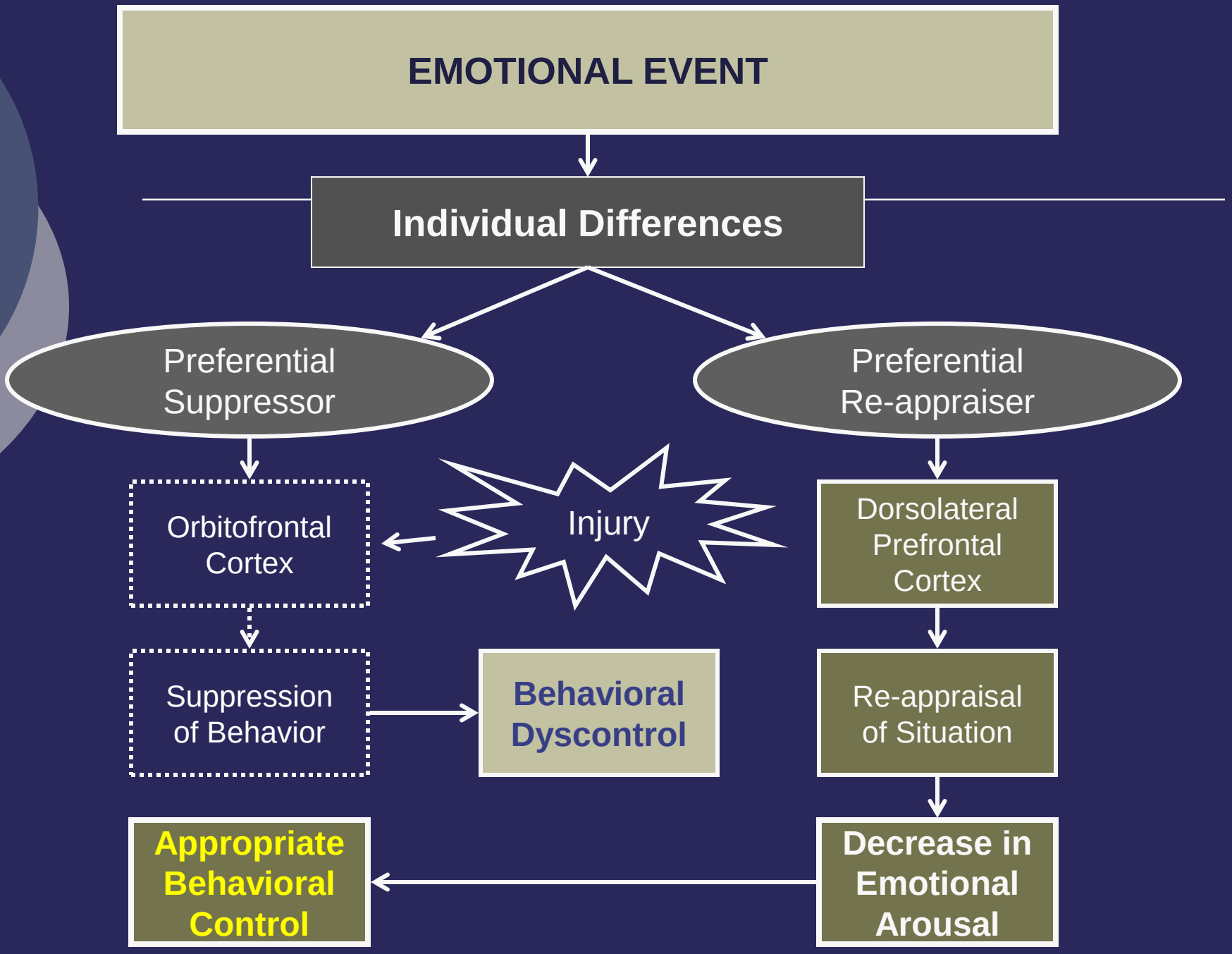
- Evidence of *psychogenic* ER deficits
  - Greater rate of premorbid psychopathology and life stress among the "miserable minority"

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
Preferential Re-appraiser
Orbitofrontal Cortex
Dorsolateral Prefrontal Cortex
Suppression of Behavior
Re-appraisal of Situation
Appropriate Behavioral Control
Decrease in Emotional Arousal


EMOTIONAL EVENT
Individual Differences
Preferential Suppressor
Preferential Re-appraiser
Orbitofrontal Cortex
Injury
Dorsolateral Prefrontal Cortex
Suppression of Behavior
Behavioral Dyscontrol
Re-appraisal of Situation
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

CVA: Post-stroke Depression (cont'd)

- 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
    - Stereoptype 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