IMPLICIT AND EXPLICIT EMOTION

Ryan Smith
Outline

- Foundational Neuroscientific Concepts
  - Large-scale neural network perspective
  - Bayesian brain perspective
  - Global Broadcasting and Conscious Access

- An emotion process model
  - Affective response *generation*
  - Affective response *representation*
  - Conscious *accessibility*

- Implications
LARGE-SCALE NETWORK PERSPECTIVE

Foundational Neuroscientific Concepts
Functional Brain Organization

1. Executive Control Network
2. Salience Network
3. Dorsal Attention Network
4. Visual Network
5. Default Mode Network
6. Somatomotor Network
7. Limbic Network

7-Network Parcellation (N=1000)

(Yeo et al., 2011)
Functional Brain Organization

- Working Memory & Cognitive Control
- 7-Network Parcellation (N=1000)
- Interoception-Guided Attention
- Somatic/Proprioceptive Representation
- External Attention
- Conceptualization
- Visual Representations
- Visceral Regulation
Body State Representation & Regulation

- Working Memory & Cognitive Control
- 7-Network Parcellation (N=1000)
- Somatic/Proprioceptive Representation
- Interoception-Guided Attention
- External Attention
- Conceptualization
- Visceral Regulation
- Visual Representations
Conceptualization and Cognitive Control

- Working Memory & Cognitive Control
- 7-Network Parcellation (N=1000)
- Somatic/Proprioceptive Representation
- Interoception-Guided Attention
- External Attention
- Conceptualization
- Visceral Regulation
- Visual Representations
• **Psychological processes**
  - Involve context-specific and/or goal-directed interactions between networks
    - Patterns of *functional* or *effective connectivity*
    - Driven by mechanisms involving modulation of *postsynaptic gain*, *oscillatory coherence*, and others

(Anderson, 2014)
BAYESIAN BRAIN PERSPECTIVE

Foundational Neuroscientific Concepts
According to this perspective, what neural populations are actually doing is **estimating probability distributions**
According to this perspective, what neural populations are actually doing is estimating probability distributions.
\[ P(H|E) = \frac{P(H) \times P(E|H)}{P(E)} \]

- **Prior Probability**: \( P(H) \)
- **Likelihood of the evidence ‘E’ if the Hypothesis ‘H’ is true**: \( P(E|H) \)
- **Prior probability that the evidence itself is true**: \( P(E) \)
- **Posterior Probability of ‘H’ given the evidence**: \( P(H|E) \)
Perceptual/Memory Systems

- Concept-level Representations
  - Predictions
  - Prediction-Errors
  - Retina, Cochlea, etc.

- Percept-level Representations
  - Predictions
  - Prediction-Errors

Patterns at larger spatial and temporal scales (often multimodal)

Patterns at smaller spatial and temporal scales (often unimodal)

(e.g., Friston, 2005)
Perceptual/Memory Systems

Concept-level Representations

Percept-level Representations

Predictions → Prediction-Errors

Retina

Sensory Input

Possible Interpretations

Represented Probability

ANCHOR DOG TREE ... Possible Interpretations

Represented Probability

Possible Interpretations
Implicit Associative Learning

- Implicit learning can occur via adjusting the strength of synapses conveying predictions
  - Serves to minimize prediction-error across repeated experience

- This can lead to associations within levels as well as between levels

- Many human and animal studies have suggested that associative learning (both classical/operant conditioning) can occur without conscious awareness of stimuli or of pleasant/unpleasant feelings
SELECTIVE CONSCIOUS ACCESS

Foundational Neuroscientific Concepts
Global Workspace Models of Consciousness

- Many things are represented in parallel and processed locally

- Global distributed processing is a limited resource
  - can only be allocated to a few representations at a time

- The executive control network selectively amplifies, broadcasts, and maintains some representations
  - Suppresses others

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Intense activation, yet confined to sensori-motor processors
- Occipito-temporal loops and local synchrony
- Priming at multiple levels
- No reportability while attention is occupied elsewhere

Orientation of top-down attention
- Amplification of sensori-motor activity
- Intense activation spreading to parieto-frontal network
- Long-distance loops and global synchrony
- Durable activation, maintained at will
- Conscious reportability

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(Dehaene, 2014)
Global Workspace Models of Consciousness

- conscious access vs. representation

<table>
<thead>
<tr>
<th>Represented</th>
<th>Unconscious</th>
<th>Conscious</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effects on behavior and physiology (e.g., priming)</td>
<td>Reportable Content</td>
<td></td>
</tr>
<tr>
<td>No Effect</td>
<td></td>
<td></td>
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</tbody>
</table>
Perceptual/Memory Systems

- Concept-level Representations
- Percept-level Representations
- Low-level Feature Representations

Hierarchical Control System

- Global Workspace Network
- Top-Down Control Signals
- Amplification, Maintenance, and Manipulation
- Global Broadcasting
- Unconscious Influences On Behavior
- Motor Cortex
- Subcortical Nuclei

Motor Output to Body
AN EMOTION PROCESS MODEL
And different types of unconscious emotion
Emotion-Related Processes

- Several interacting processes contribute to an emotion episode

Global Neuronal Workspace
(Conscious Access, Working Memory, Cognitive Control)

Modulation of
cognitive systems
(attention, interpretation, motivation)

Multi-level situation representation

Multi-level evaluative appraisal

Involuntary Bodily Response
(skeletomotor, visceral)

Event
(real, remembered, or imagined)

Multi-level internal state representation
Emotion-Related Processes

- Affective *response generation* processes

Event (real, remembered, or imagined)

Multi-level situation representation

Multi-level evaluative appraisal

Global Neuronal Workspace
(Conscious Access, Working Memory, Cognitive Control)

Modulation of cognitive systems
(attention, interpretation, motivation)

Involuntary Bodily Response
(skeletomotor, visceral)

Multi-level internal state representation
Emotion-Related Processes

• Affective response representation processes

Global Neuronal Workspace
(Conscious Access, Working Memory, Cognitive Control)

- Multi-level situation representation
- Event (real, remembered, or imagined)
- Multi-level evaluative appraisal
- Modulation of cognitive systems (attention, interpretation, motivation)
- Involuntary Bodily Response (skeletomotor, visceral)
- Multi-level internal state representation
Emotion-Related Processes

- Selective *conscious access* to representational content

**Global Neuronal Workspace**
(Conscious Access, Working Memory, Cognitive Control)

1. **Event**
   (real, remembered, or imagined)

2. **Multi-level situation representation**

3. **Multi-level evaluative appraisal**

4. **Modulation of cognitive systems**
   (attention, interpretation, motivation)

5. **Involuntary Bodily Response**
   (skeletomotor, visceral)

6. **Multi-level internal state representation**
Emotion-Related Processes

- Affective response generation processes
Affective Response Generation

Situation

“Unhappy Audience”

Concern-Relevant
Goal-Incongruent
Low Controllability
Self-Responsibility

Appraisals

Information Processing Biases

Attention to scowls in the audience
Biased negative Interpretation of facial cues
Strong desire to get out here

Body State Changes

Increased Heart Rate
Increased Bodily Inflammation
Increased Muscle Tension

(Siemer, Mauss, Gross, 2007) (Scherer, 2009)

Correlations Among Appraisal- and Emotion-Ratings

<table>
<thead>
<tr>
<th>Appraisal</th>
<th>Anger</th>
<th>Guilt</th>
<th>Shame</th>
<th>Sadness</th>
<th>Amusement</th>
<th>Pleasure</th>
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</thead>
<tbody>
<tr>
<td>Unexpectedness</td>
<td>.228*</td>
<td>.307**</td>
<td>.343**</td>
<td>.280**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>-.276**</td>
<td>-.309*</td>
<td>-.265**</td>
<td></td>
<td>.276**</td>
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<tr>
<td>Other-responsibility</td>
<td>.295**</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-responsibility</td>
<td>.284**</td>
<td>.275**</td>
<td></td>
<td>.305**</td>
<td></td>
<td>-.245*</td>
</tr>
</tbody>
</table>

*p (two-tailed) < .05. **p (two-tailed) < .01.
Examples of Unconsciously Generated Emotions

- Several studies have shown that unconscious/subliminal presentations of emotional stimuli can lead to affective reactions.

  - For Example:
    - **Blindsight patients** still show autonomic and skeletomotor responses to unexperienced visual stimuli.
    - Similar results with **subliminal affective stimuli** in neurologically healthy participants.

  - In such cases, the person might be conscious of the emotional feeling.

  - But they are not consciously aware of the stimulus that triggered it or why.

  (e.g., Monahan, Murphy, & Zajonc, 2000; Tamietto & de Gelder, 2010)
Mapping Psychological Processes to Network Interactions

Percept Representations

Input
Mapping Psychological Processes to Network Interactions

Percept Representations

Situation Conceptualization

Affect Generation
Mapping Psychological Processes to Network Interactions

- Percept Representations
- Affect Generation
- Situation Conceptualization
- Body State

Legend:
- Purple (Visual)
- Blue (Somatomotor)
- Green (Dorsal Attention)
- Violet (Ventral Attention)
- Cream (Limbic)
- Orange (Frontoparietal)
- Red (Default)

Modulatory Effects on Cognition not shown
Correspond (in part) to adjustments in the influence of diffuse neuromodulatory systems: 
Dopamine, serotonin, norepinephrine, acetylcholine, others...
Mapping Psychological Processes to Network Interactions

Percept Representations

Situation Conceptualization

Affect Generation

Body State

Modulatory Effects on Cognition not shown
Emotion-Related Processes

- Affective response representation processes
Affective response representation processes

Represented Aspects of Emotional Experience

Situation/Appraisal Representations → Emotion Concept Representations

Valenced Body State Representations

Information Processing Biases

Afferent Feedback from the Body
“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)
Affective response representation processes

Represented Aspects of Emotional Experience

Pessimistic Biases

Afferent Feedback from the Body
Mapping Psychological Processes to Network Interactions

- Percept Representations
- Affect Generation
- Body State
- Situation Conceptualization
- Modulatory Effects on Cognition (not shown)

Colors:
- Purple (Visual)
- Blue (Somatomotor)
- Green (Dorsal Attention)
- Violet (Ventral Attention)
- Cream (Limbic)
- Orange (Frontoparietal)
- Red (Default)
Mapping Psychological Processes to Network Interactions

Percept Representations

Body State Representations

Situation Conceptualization

Affect Generation

Body State

Modulatory Effects on Cognition not shown
Mapping Psychological Processes to Network Interactions

- Percept Representations
- Body State Representations
- Situation Conceptualization + Emotion Conceptualization
- Affect Generation
- Body State

Legend:
- Purple (Visual)
- Blue (Somatomotor)
- Green (Dorsal Attention)
- Violet (Ventral Attention)
- Cream (Limbic)
- Orange (Frontoparietal)
- Red (Default)

Modulatory Effects on Cognition not shown
Low emotional awareness

• Some individuals have trouble recognizing their own emotions

• This may involve a problem mapping bodily percepts to emotion concepts

• An “affective agnosia” similar to associative visual agnosia
Affective response representation processes

Represented Aspects of Emotional Experience

“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)

Pessimistic Biases

SAD

Afferent Feedback from the Body
Analogy to visual representation processes

Represented Aspects of Visual Experience

“I am looking around in my tool shed.”
(Familiar, concern-irrelevant, etc.)
Associative visual agnosia

Represented Aspects of Visual Experience

- Individual could draw a picture of what they see
- Could not link this percept to the concept SHOVEL

Retinal Input
Affective agnosia

Represented Aspects of Emotional Experience

- Individual could describe bodily percepts
  - (e.g., pain, fatigue, arousal, etc.)
- Could not link these percepts to the concept SADNESS

(Lane et al., 2015)
Emotion Episodes

- Selective *conscious access* to representational content

**Global Neuronal Workspace**
(Conscious Access, Working Memory, Cognitive Control)

- Multi-level situation representation
- Multi-level evaluative appraisal
- Modulation of cognitive systems
  (attention, interpretation, motivation)
- Multi-level internal state representation
- Involuntary Bodily Response
  (skeletomotor, visceral)
- Event
  (real, remembered, or imagined)
Represented Aspects of Emotional Experience

- Situation/Appraisal Representations
- Emotion Concept Representations
- Valenced Body State Representations

Conscious Access and Decision-Making

- Global Workspace
- Action Selection Mechanisms

Afferent Feedback from the Body
Efferent Motor Commands to Skeletal Muscle

B
Represented Aspects of Emotional Experience

“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)

SAD

Conscious Access and Decision-Making

Global Workspace

Action Selection Mechanisms

Afferent Feedback from the Body

Efferent Motor Commands to Skeletal Muscle
Represented Aspects of Emotional Experience

“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)

SAD

Consciously available information

Action Selection Mechanisms

Conscious Access and Decision-Making

Afferent Feedback from the Body

Efferent Motor Commands to Skeletal Muscle
Represented Aspects of Emotional Experience

“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)

SAD

Conscious Access and Decision-Making

“I am sad because I just lost a friend and so I don’t have much energy right now.”

Action Selection Mechanisms

Afferent Feedback from the Body

Efferent Motor Commands to Skeletal Muscle
SAD

“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)

Consciously available information

Action Selection Mechanisms

Conscious Access and Decision-Making

Efferent Motor Commands to Skeletal Muscle
Represented Aspects of Emotional Experience

“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)

SAD

Conscious Access and Decision-Making

“I feel really sad and low energy, but I don’t know why.”

Action Selection Mechanisms

Efferent Motor Commands to Skeletal Muscle

Afferent Feedback from the Body
Represented Aspects of Emotional Experience

“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)

SAD

Conscious Access and Decision-Making

Consciously available information

?

Action Selection Mechanisms

Afferent Feedback from the Body

Efferent Motor Commands to Skeletal Muscle
Represented Aspects of Emotional Experience

“I just lost someone I love unexpectedly and there is nothing I can do to get them back.”

(Novel, goal-incongruent, low control, etc.)

SAD

Action Selection Mechanisms

“I feel really low energy, but I don’t know why. Maybe I’m sick.”

Conscious Access and Decision-Making

Efferent Motor Commands to Skeletal Muscle

Afferent Feedback from the Body
Examples of Unconsciously Represented Emotions

- Subliminally presented smiles vs. frowns have been shown to cause **valence-specific** behavioral effects
  - No self-reported changes in emotion/mood

- Subliminal presentation of **guilty** vs. **sad** emotion adjectives has been shown to cause concept-specific behavioral effects
  - Only guilt-priming led to **increased helping behavior** and **reduced indulgence behavior**
  - No self-reported changes in emotion/mood

- **Suggests that both valence and emotion concepts can be represented unconsciously**

(Berridge & Winkielman, 2003; Winkielman, Berridge, & Wilbarger, 2005; Winkielman, Zajonc, & Schwarz, 1997; Zemack-Rugar, Bettman, & Fitzsimons, 2007)
Mapping Psychological Processes to Network Interactions

- Percept Representations
- Body State Representations
- Situation Conceptualization + Emotion Conceptualization
- Goal Representations + selection for conscious access
Mapping Psychological Processes to Network Interactions

- Percept Representations
- Body State Representations
- Situation Conceptualization + Emotion Conceptualization
- Goal Representations + selection for conscious access
- Action Selection
Global Neuronal Workspace
(Conscious Access, Working Memory, Cognitive Control)

Multi-level situation representation

Multi-level evaluative appraisal

Modulation of cognitive systems
(attention, interpretation, motivation)

Involuntary Bodily Response
(skeletomotor, visceral)

Multi-level internal state representation

Event
(real, remembered, or imagined)
IMPLICATIONS
Implications

- Can account for multiple types of “implicit” emotion

  - **Unconsciously Caused Emotions** – Conscious access to the emotional experience (body percepts and emotion concepts), but **no access to the appraisals** that elicited that experience
    - “I feel sad and I don’t know why.”

  - **Unconsciously Represented Emotions** – Conscious access to body percepts, but **no access to the appraisals or emotion concepts**
    - “I feel tired all the time, and my best friend recently died, but these things don’t feel connected.”

  - **Implicit Affective Learning** – Associative/statistical learning processes **operate on representations whether or not they are selected for conscious access**
The model

Global Neuronal Workspace
(Conscious Access, Working Memory, Cognitive Control)

Multi-level situation representation

Multi-level evaluative appraisal

Modulation of cognitive systems
(attention, interpretation, motivation)

Multi-level internal state representation

Event
(real, remembered, or imagined)

Involuntary Bodily Response
(skeletomotor, visceral)
Implications

- Can also account for **new emotions generated in therapy**

- Example: adult individual who suffered parental abuse/neglect as a child
  - They report feeling fear as a child
  - They do not report feeling anger as a child

- During therapy, they retrieve the memory of these events
  - But they **appraise the meaning of these events differently** from their current perspective as an adult (current beliefs, norms, values, etc.)

- **Now they report feeling angry in response to the events in this memory** – based on this new appraisal
Implications

- All of the following are **strongly influenced by prior experience and prior expectations**:
  - *Situation Perception*
  - *Situational Appraisal*
  - *Body State Perception*
  - *Emotion Recognition*
  - *Selection for Conscious Access*

- **Suggests that changing prior expectations will also change affective responding and emotional experience.**
  - Could occur through new implicit learning in therapy (repeated prediction-error)
  - Could occur explicitly as well (e.g., CBT, correcting cognitive distortions)
Implications

• What does conscious access allow?

  • **Maintenance** and **manipulation** of **emotion concepts** in **working memory**
    • Basis of **reflection** about how one feels and how one should respond

  • **Maintenance** and **manipulation** of **situational information** in **working memory**
    • Basis of cognitive **reappraisal**

  • If consciousness amplifies/maintains representations, one might expect it to **amplify implicit learning processes as well**
    • Emotion-Focused Therapy

• Sources of individual (trait) differences in self-reported emotional experience?

  • Differences in **affective response generation** processes
    • Appraisal Biases (e.g., strong priors for particular appraisals)
    • Tendency to generate an **insufficient number** of distinct, context-specific responses

  • Differences in **affective response representation** processes
    • Poor emotion concept acquisition during development

  • Differences in **conscious access** processes
    • Reinforced cognitive habits to avoid attending to emotion
    • Insufficient (learned) value assigned to emotional information
Further directions

• How might we understand the chronic negative affect in conditions like depression and anxiety?

  • Lack of conscious access to situation/appraisal representations
    • could interfere with finding ways to resolve the factors maintaining negative emotion

  • An inability to recognize one’s own emotions
    • could further prevent understanding and problem solving

  • Implicit state-action associations and implicit reinforcement
    • may promote both cognitive and behavioral habits that promote avoidance of conscious access to emotion

• The role of state arousal level
  • Yerkes-Dodson law
  • High levels of arousal may limit conscious access, working memory, etc.
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  • Richard Lane
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  • Sahib Khalsa
  • Anna Alkozei

• UA Departments of Psychology & Psychiatry

• Undoubtedly many others
More information

The Structure of Emotional Experience and its relation to Trait Emotional Awareness

Ryan Smith, William D.S. Killgore, Richard D. Lane

The hierarchical basis of neurovisceral integration

Ryan Smith\textsuperscript{a,*}, Julian F. Thayer\textsuperscript{b}, Sahib S. Khalsa\textsuperscript{c,d}, Richard D. Lane\textsuperscript{a}

The neural basis of one’s own conscious and unconscious emotional states

Ryan Smith\textsuperscript{a,b,*}, Richard D. Lane\textsuperscript{a,b}

Reconciling cognitive and affective neuroscience perspectives on the brain basis of emotional experience

Jaak Panksepp (PhD)\textsuperscript{a}, Richard D. Lane (MD, PhD)\textsuperscript{b}, Mark Solms (PhD)\textsuperscript{c}, Ryan Smith (PhD)\textsuperscript{b,*}

Unconscious emotion: A cognitive neuroscientific perspective

Ryan Smith (Ph.D.)\textsuperscript{a,*}, Richard D. Lane\textsuperscript{a,b,c}