What Is Emotion & How Is It Measured?

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CS 686/486
Chinese humanoid robot turns on the charm in Shanghai

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The humanoid robot ‘Jia Jia’ can hold a simple conversation and make specific facial expressions when asked.

"You are a handsome man," she complimented one, but when asked later if she has a boyfriend, replied, "I prefer to stay single."

What is Emotion?

Many definitions (Kleinginna and Kleinginna, 1981). Two agreed upon definitions:

1. Emotion is a reaction to events deemed relevant to the needs, goals, or concerns of an individual

and

2. Emotion encompasses physiological, affective, behavioral, and cognitive components.
What is Emotion?

E.g., fear is a reaction to a situation that threatens or is perceived to threaten an individual’s physical well-being

- strong negative affective state
- strong physiological and cognitive preparation for action.

Brave and Nass, 2002
Simple Neurophysiological Model

Thalamus:

Sensory input from external environment received by thalamus

-> like a signal processor.

This information is then sent simultaneously to both......
Simple Neurophysiological Model

Limbic System -> called the ‘seat of emotion’.

Evaluates need/goal relevance of input

-> if relevant input

Sends appropriate signals to body (physiological responses) and cortex.

Direct thalamic-limbic pathway

-> more ‘primitive’ emotions, e.g. startle-based fear, innate aversions, attractions.
Simple Neurophysiological Model

Cortex:

‘Higher-level’ processing. Biases attention and other cognitive processes.

‘Secondary’ emotions, e.g. frustration, pride, satisfaction
The discrete model of affect

Paul Ekman and colleagues, (see Ekman, Friesen, and Ellsworth, 1972 for review), evidence gathered over three decades identifying a small number of so-called ‘basic’ emotions:

- Fear: Upper eyelids raised
- Disgust: Nose wrinkled
- Anger: Jaw thrust forward
- Determination/Anger: Lips pressed
- Sadness: Eyebrows drawn up
- Sadness: Lip corners down

http://www.sentientdecisionscience.com/its-not-in-your-words-its-all-over-your
The discrete model of affect

Anger
Disgust
Fear
Happiness
Sadness
Surprise

Contempt added more recently

-- Paul Ekman
James Russell and colleagues strongly challenged this data. Multi-dimensional affect space rather discrete emotion categories.

Many researchers argue that two dimensions—arousal (activation) and valence (pleasant/unpleasant)—are nearly sufficient to describe the entire space of conscious emotional experience (Feldman, Barrett, & Russell, 1999).
Continuous – Circumplex model of affect
How can we measure emotion?
Self-assessment
### Worksheet 3.1 The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988)

**PANAS Questionnaire**

This scale consists of a number of words that describe different feelings and emotions. Read each item and then list the number from the scale below next to each word. Indicate to what extent you feel this way right now, that is, at the present moment. **OK** indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure).

<table>
<thead>
<tr>
<th></th>
<th>Very Slightly or Not at All</th>
<th>A Little</th>
<th>Moderately</th>
<th>Quite a Bit</th>
<th>Extremely</th>
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<tr>
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<td>5</td>
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</tbody>
</table>

**Scoring Instructions:**

Positive Affect Score: Add the scores on items 1, 3, 5, 9, 10, 12, 14, 16, 17, and 19. Scores can range from 10 – 50, with higher scores representing higher levels of positive affect. Mean Score: Momentary = 29.7 (SD = 7.9); Weekly = 33.3 (SD = 7.2)

Negative Affect Score: Add the scores on items 2, 4, 6, 7, 8, 11, 13, 15, 18, and 20. Scores can range from 10 – 50, with lower scores representing lower levels of negative affect. Mean Score: Momentary = 14.8 (SD = 5.4); Weekly = 17.4 (SD = 6.2)

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Self-assessment manikin (SAM)

Bradley and Lang, 1994
Let’s have a go at using SAM now to rate how you feel after watching 3 videos.

Video 1
https://www.youtube.com/watch?v=4U_xmfSwYSw

Video 2
https://www.youtube.com/watch?v=_u6Tt3PqIfQ

Video 3
https://www.youtube.com/watch?v=urturSNMgd0
SAM ratings of International Affective Picture Systems (IAPS) – Lang et al. 1998

Bradley and Lang, 1994
Self-assessment

Not good for continuous data – affected by when asked

Only measure conscious experience of emotion (much unconscious processes in limbic system)

 Interruption of experience

Emotions difficult to describe in words

Experimenter bias – participants want to look good and also please experimenter
(More) Objective Measures of Emotion

Distance
- Face, voice

Sensing:
- Posture
- Gestures, movement, behavior

Up-close
- Pupil dilation, Temperature, Respiration

Sensing:
- Skin conductance, ECG, EEG, Blood pressure volume, HR, HRV

Internal
- Hormones

Sensing:
- Neurotransmitters
Physiological Measures (Autonomic Activity)
Measures of Autonomic Nervous System (ANS)
- Cardiovascular Measures
- Peripheral Measures – electrodermal activity
- Neuroendocrine Measures
Physiological Computing

• Provides real-time, continuous data
• Reads unconscious responses
• No conscious assessment required
• Circumvents deliberate distortions in responses
Physiological Computing

Greatest challenge is mapping physiological measures to psychological states.
One-to-one – ideal but very rare
Many-to-one

Cortical activity in frontal lobes

↑ systolic blood pressure

Changes in HRV

↑ Mental workload
One-to-many

↑ HR

X

Y

Fear

Anger

Excitement
Many-to-many

↑ diastolic blood pressure
↑ HR
↑ skin conductance

Fear
Anger
Excitement
Heart Rate

HR is derived from blood volume pulse by measuring the interbeat interval and then transforming this in beats per minute (bpm).

E.g., interbeat interval of 0.80 s is 60/0.8 = 75 bpm.

Interbeat interval of 0.93 s is 60/0.93 = 64.5 bpm.
Heart Rate

Empatica E4 wristband - PPG (Photoplethysmography) is used to give the blood volume pulse (BVP)

Heart Rate

Heart rate is computed by detecting the peaks (beats) from the PPG and computing the lengths of the intervals between adjacent beats.

Empatica’s PPG is supposed to be more robust to motion artifact – uses both green and red light.

Green data contains main information about heart beats
Red data contains information on movements.

Heart Rate

Though the debate is far from resolved, certain measures have proven reliable at distinguishing among ‘basic emotions’.

HR increases most during fear, followed by anger, sadness, happiness, surprise, and finally disgust.

HR increases during excitement, mental concentration, and intense sensory stimuli.

HR decreases with relaxation, attentive visual and audio observation, and pleasant stimuli.

HR increase can be a function of sympathetic activation or parasympathetic withdrawal.
Heart Rate Variability

Variation in the beat-to-beat interval (time interval between heartbeats).
Heart Rate Variability

HRV changes have been linked to valence:
- Decreases during emotion inductions of sadness, anger, and fear.
- Increases during positive mood, happiness, and maybe compassion.

HRV decreases also linked to mental effort:
- Associated with improved decision making
- Associated with better performance during landings and emergency simulations for airline pilots.
Electrodermal Activity (EDA)

Formerly known as Galvanic Skin Response (GSR)

Skin conductance – measures the activity in the eccrine (sweat gland)

Skin resistance varies with the state of sweat glands in the skin. Sweating is increased by the activation of sympathetic nervous system -> increases skin conductance.
Electrodermal Activity (EDA)

Emotional activation
-> brain sends signals to the skin to increase level of sweating
-> electrical conductance increases (as pores below surface fill)
(you may not feel any difference)
How is EDA measured?

Several different ways such as skin potential, resistance, conductance, admittance, and impedance (see Electrodermal Activity by Wolfram Boucsein for more info).

The Empatica E4 measures electrical conductance across skin by passing a minuscule amount of current between two electrodes in contact with skin.
Skin conductance measurement can be characterized into two types:

1. **Tonic skin conductance response** = smooth, underlying slow changing levels.
2. **Phasic skin conductance response** = rapidly changing peaks
   - short-term events, discrete environmental stimuli

How is EDA measured?
How is EDA measured?

Circled – examples of phasic activations.

Tonic value is more smoothly-changing level, approximated by the straight white line.
Facial Expression Recognition
Facial Expression Recognition

Anger
Disgust
Fear
Happiness
Sadness
Surprise

Contempt added more recently

-- Paul Ekman
Facial Action Coding System (FACS) by Ekman et al. 1978, 2002

Categorizes facial behavior as *Action Units*, tied to muscle movement.

### Upper Face Action Units

<table>
<thead>
<tr>
<th>AU 1</th>
<th>AU 2</th>
<th>AU 4</th>
<th>AU 5</th>
<th>AU 6</th>
<th>AU 7</th>
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</thead>
<tbody>
<tr>
<td>Inner Brow Raiser</td>
<td>Outer Brow Raiser</td>
<td>Brow Lowerer</td>
<td>Upper Lid Raiser</td>
<td>Cheek Raiser</td>
<td>Lid Tightener</td>
</tr>
</tbody>
</table>

- *AU 41*  
- *AU 42*  
- *AU 43*  
- AU 44  
- AU 45  
- AU 46

### Lower Face Action Units

<table>
<thead>
<tr>
<th>AU 9</th>
<th>AU 10</th>
<th>AU 11</th>
<th>AU 12</th>
<th>AU 13</th>
<th>AU 14</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nose Wrinkler</td>
<td>Upper Lip Raiser</td>
<td>Nasolabial Deepener</td>
<td>Lip Corner Puller</td>
<td>Cheek Puffer</td>
<td>Dimpler</td>
</tr>
<tr>
<td>AU 15</td>
<td>AU 16</td>
<td>AU 17</td>
<td>AU 18</td>
<td>AU 20</td>
<td>AU 22</td>
</tr>
<tr>
<td>Lip Corner Depressor</td>
<td>Lower Lip Depressor</td>
<td>Chin Raiser</td>
<td>Lip Puckerer</td>
<td>Lip Stretcher</td>
<td>Lip Funneler</td>
</tr>
</tbody>
</table>

- AU 23  
- AU 24  
- *AU 25*  
- *AU 26*  
- *AU 27*  
- AU 28

### Lip Actions

- Lip Tightener  
- Lip Pressor  
- Lip Part  
- Jaw Drop  
- Mouth Stretch  
- Lip Suck
Duchenne Smile
Duchenne Smile

AU 12
Lip Corner Puller

AU 6
Cheek Raiser

AU 12

AU 6 + AU 12
Dynamics and Emotion Perception

– Genuine smiles have longer onset/offset times (Hess & Kleck 1990)
– Smiles with longer onset judged more trustworthy, more attractive, & less dominant (Krumhuber & Kappas, 2005)
– Smiles with long apex judged less authentic

Emotion Perception and decision making

– Job applicants with “inauthentic smiles” rated lower (Krumhuber & Manstead, 2006)
But do people really show what they feel?

Micro-expressions – leak emotions, unintentionally display emotions. Universal emotions. Process unconsciously. \( \sim 1/25^{th} \) sec

There is no evolutionary advantage to showing what you feel.

vs.

Expressions are like language – they help achieve social goals.
Do people really show what they feel?

Bowling alleys: Kraut & Johnston (1979)

Encoding Takeaway

Automatic methods need to be careful when interpreting facial expressions
Need to consider social context
People can voluntarily control their expressions of emotion to a degree.
Posture

Can you teach a chair to recognize behaviors indicating interest and boredom (Mota and Picard, 2003) – sensor chair can pick up on learner interest