What Is Emotion
&
How Is It Measured?
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CS 686/486
Announcements

What was missing from third research paper?

Unity Field Trip Dates!
Global Affective Computing Market to grow at a compound annual growth rate of 33%+ 2017-2022

What is Emotion?

Many theories (and thus definitions) of emotion.
Still no agreed upon definition.
Here are some theories...
James-Lange Theory

Event $\rightarrow$ Physiological Arousal $\rightarrow$ Interpretation of Emotion

If physiological arousal is not noticed, no emotion.
Cannon-Bard Theory

Event -> Physiological Arousal
AND
-> Emotion

Physiological arousal occurs at same time as emotion
Schachter-Singer Theory

Event -> Physiological Arousal
       -> Reasoning
       -> Emotion

Appraisal or reasoning of what the physiological arousal means leads to emotion. E.g., fear or exciting.
Cognitive Theory e.g., Lazarus

Event -> Reasoning -> Physiological Arousal -> Emotion

Cognition necessary for emotion to occur.
Components of Emotion

Valence: positive, negative, neutral

Eliciting or intentional object

Multi-component response

Enables pursuit of important goals
Multi-Component Response of Emotion

SUBJECTIVE

BEHAVIORAL

PHYSIOLOGICAL

https://www.youtube.com/watch?v=kgqep0h1tuo
https://www.youtube.com/watch?v=6buiTtvrft4
https://www.youtube.com/watch?v=fPxsVzR7Gqs
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
Classifications of Emotion

Discrete Model          Continuous Model
And the “One Hundred Year Emotion War”
Discrete model of affect

Discrete categorization based on facial expressions of basic emotions.

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.
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 than 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
PANAS

Discrete self-assessment measurement.

<table>
<thead>
<tr>
<th>Worksheet 3.1 The Positive and Negative Affect Schedule (PANAS; Watson et al., 1988)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PANAS Questionnaire</strong></td>
</tr>
<tr>
<td>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. <strong>Indicate to what extent you feel this way right now,</strong> that is, at the present moment <strong>OR</strong> indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure).</td>
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<td>19.</td>
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<td>20.</td>
</tr>
</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 Scores: 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)
Self-assessment manikin (SAM)
Continuous Self-Assessment Measurement

Bradley and Lang, 1994
SAM ratings of International Affective Picture Systems (IAPS) – Lang et al. 1998

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=_u6Tt3PqlfQ

Video 3
https://www.youtube.com/watch?v=urturSNMgd0
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

<table>
<thead>
<tr>
<th>Distance</th>
<th>Face, voice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensing:</td>
<td>Posture</td>
</tr>
<tr>
<td></td>
<td>Gestures, movement, behavior</td>
</tr>
<tr>
<td>Up-close</td>
<td>Pupil dilation, Temperature, Respiration</td>
</tr>
<tr>
<td>Sensing:</td>
<td>Skin conductance, ECG, EEG, Blood pressure volume, HR, HRV</td>
</tr>
<tr>
<td>Internal</td>
<td>Hormones</td>
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<tr>
<td>Sensing:</td>
<td>Neurotransmitters</td>
</tr>
</tbody>
</table>
Physiological Measures (Autonomic Activity)
Physiological Computing

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

X

Cortical activity in frontal lobes

↑ systolic blood pressure

Changes in HRV

Y

↑ Mental workload
One-to-many

X

↑ HR

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.
ECG workflow

- **Hardware:**
  - Biopac MP160, ECG Transmitter

- **Software:**
  - AcqKnowledge, Network Data Transfer system
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.

How is EDA measured?

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?

Circled – examples of phasic activations.

Tonic value is more smoothly-changing level, approximated by the straight white line.
Detecting Affect

Horror Movie

Calm Movie

Empatica E4 Wristband

Results from Yi Yang and Bingkun Yang’s work in Human-Computer Interaction Lab.
Posture and Gesture Detection
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.
Posture Detection

Move/No Move: The absolute sum of frame-to-frame acceleration was accumulated in a rolling one second window at each frame.

Pos Near/ Far:
- Get Standard Position
- Get Standard Near Position
- Get Standard Far Position
- Compare current position with standard Near/Far Position

Lean Left/ Right:
- Get Standard X Position
- Detect changes per frame
Gesture Detection

Hand-to-face gesture detection using breadth-first surface propagation.
Gesture Detection

Breadth-First Surface Propagation:

• Start from headPixel (headCenter, headRow);
• Add pixels to the ArrayList of surface pixels through a comparison between headPixel and currentPixel -> gradient has to be less than a certain threshold;

Surface propagation carried out each frame, Length of the ArrayList is checked after each frame.
Facial Expression Recognition
Facial Expression Recognition

Anger
Disgust
Fear
Happiness
Sadness
Surprise

Contempt added more recently

-- Paul Ekman
Categorizes facial behavior as *Action Units (AUs)*. Unique upper and lower facial AUs that correspond to different movements of muscles in the face.

**Facial Action Coding System (FACS) Ekman et al. 1978, 2002**

### 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>
</tr>
</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

- Lid Droop
- Slit
- Eyes Closed
- Squint
- Blink
- Wink

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

AU 12
Lip Corner Puller

A

AU 6 + AU 12
Cheek Raiser

B
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. ~1/25\textsuperscript{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)

Facial Expression 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.
Overall Conclusions

Emotions have varying definitions but essentially are made up of:
• Subjective experience
• Behavioral response
• Physiological response

There is no one certain way to measure emotion. It is best to have multi-modal methods to combine different techniques.
Affectiva’s AFFDEX SDK

https://www.affectiva.com/product/emotion-sdk/
https://developer.affectiva.com/

Software Pipeline:  
1. Face and facial landmark detection

Face detection is performed using the Viola-Jones face detection algorithm.


Landmark detection is then applied to each facial bounding box and 34 landmarks identified using a supervised descent based landmark detector similar to Xiong and De la Torre.


If the confidence of the landmark detection is below a threshold then the bounding box is ignored.

Software Pipeline:
2. Extraction of facial textual features

An image of the region of interest (ROI) includes eyes, eyebrows, nose, and mouth. The ROI is normalized using rotation and scaling to 96x96 pixels.

To capture the textual changes, histograms of oriented gradients (HOG) features are extracted from the ROI. The HOG features are extracted from 32 x 32 pixel blocks with a histogram of 6 bins for each block.


3. Facial Action Classification

Support Vector Machine (SVM) classifiers, trained on 10,000s of manually coded facial images, are used to provide scores from 0 to 100 for each facial action.


Software Pipeline: 4. Emotion State Classification

The emotion expressions Anger, Disgust, Fear, Joy, Sadness, Surprise, and Contempt are based on combinations of facial actions. (This encoding is built on the Emotional facial action coding system (EMFACS)).
