Emotion
&
How It Is Measured

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CHANGE THE WORLD FROM HERE

Global Affective Computing Market to grow at a compound annual growth rate of 33%+ 2017-2022

JANUARY 26, 2018 BY QYREPORTS

Global Affective Computing Market to grow at a CAGR of +33% during forecast period 2017-2022 with top key players like Google Inc, IBM Corporation, Microsoft Corporation and others

The research report of global Affective Computing market examines the current and futuristic development estimate of the market. This report offers a complete detail about the Affective Computing market which is extremely thrusting in the present market situation. The driving key factors and restraint are given which are capable for its progress and slow down of the market too. The research study is an accumulation of primary and secondary research, which enables the players to have a robust understanding of the overall market.

http://www.satprnews.com/2018/01/26/global-affective-computing-market-to-grow-at-a-cagr-of-33-during-forecast-period-2017-2022-with-top-key-players-like-google-inc-ibm-corporation-microsoft-corporation-and-others/

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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

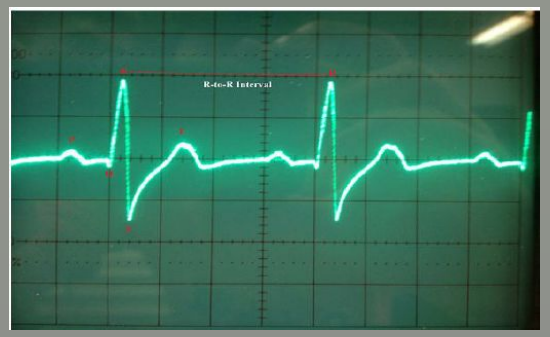
and

2. Emotion encompasses physiological, affective, behavioral, and cognitive components.

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

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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

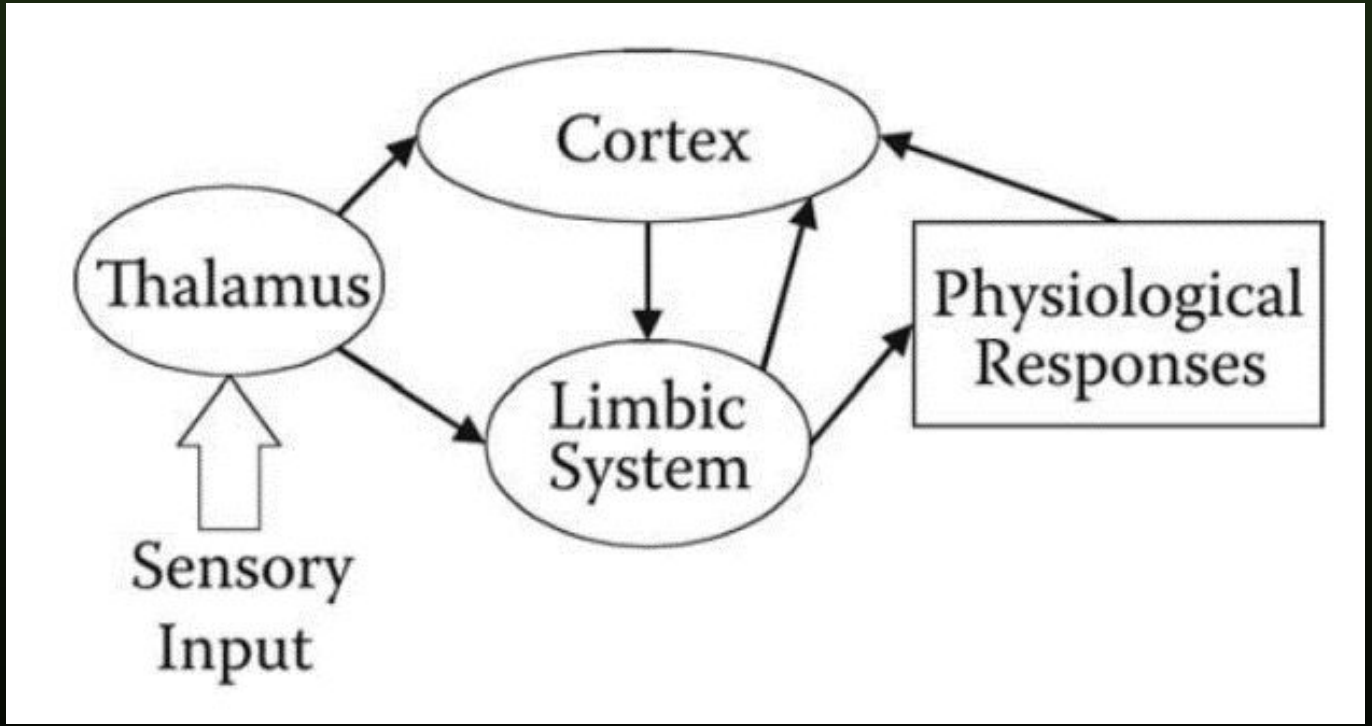
Simple Neurophysiological Model

Thalamus:

Sensory input from external environment received by thalamus

-> like a signal processor.

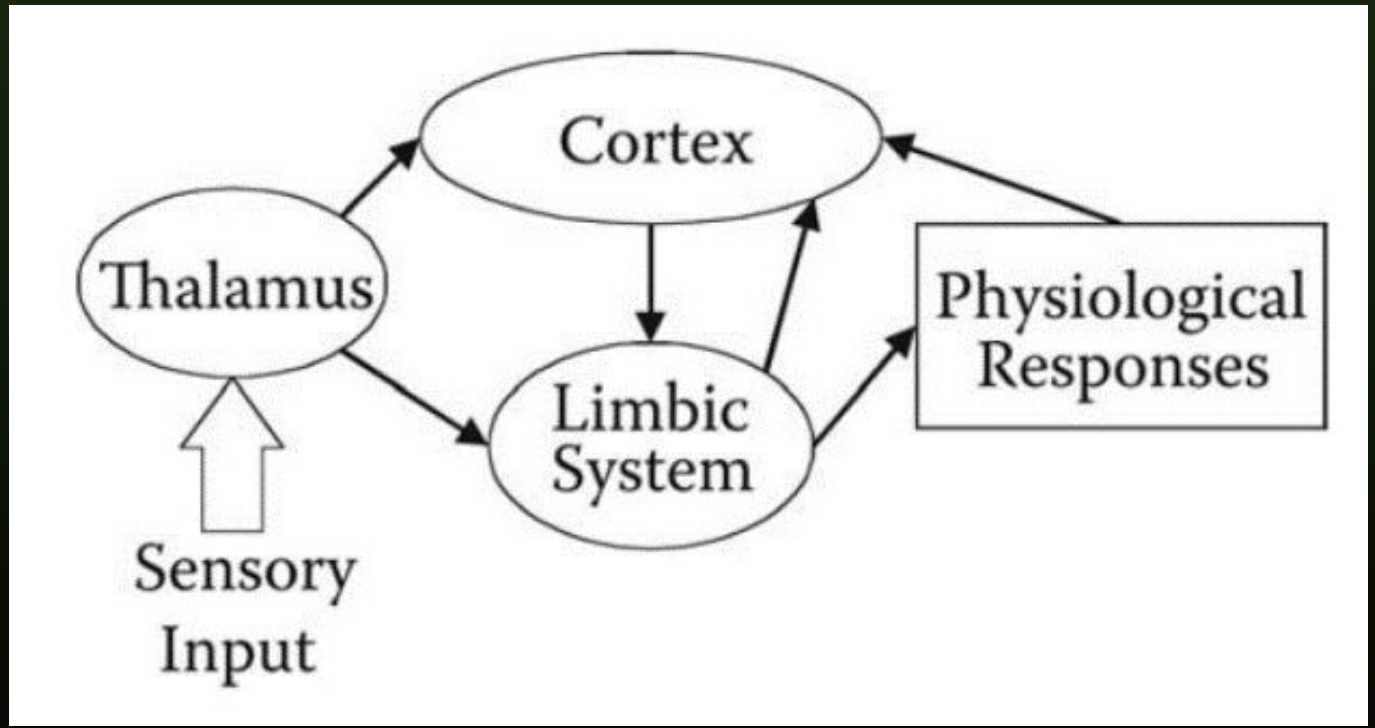
This information is then sent simultaneously to both……



Simple Neurophysiological Model

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

Direct thalamic-limbic pathway -> more ‘primitive’ emotions, e.g. startle-based fear, innate aversions, attractions.

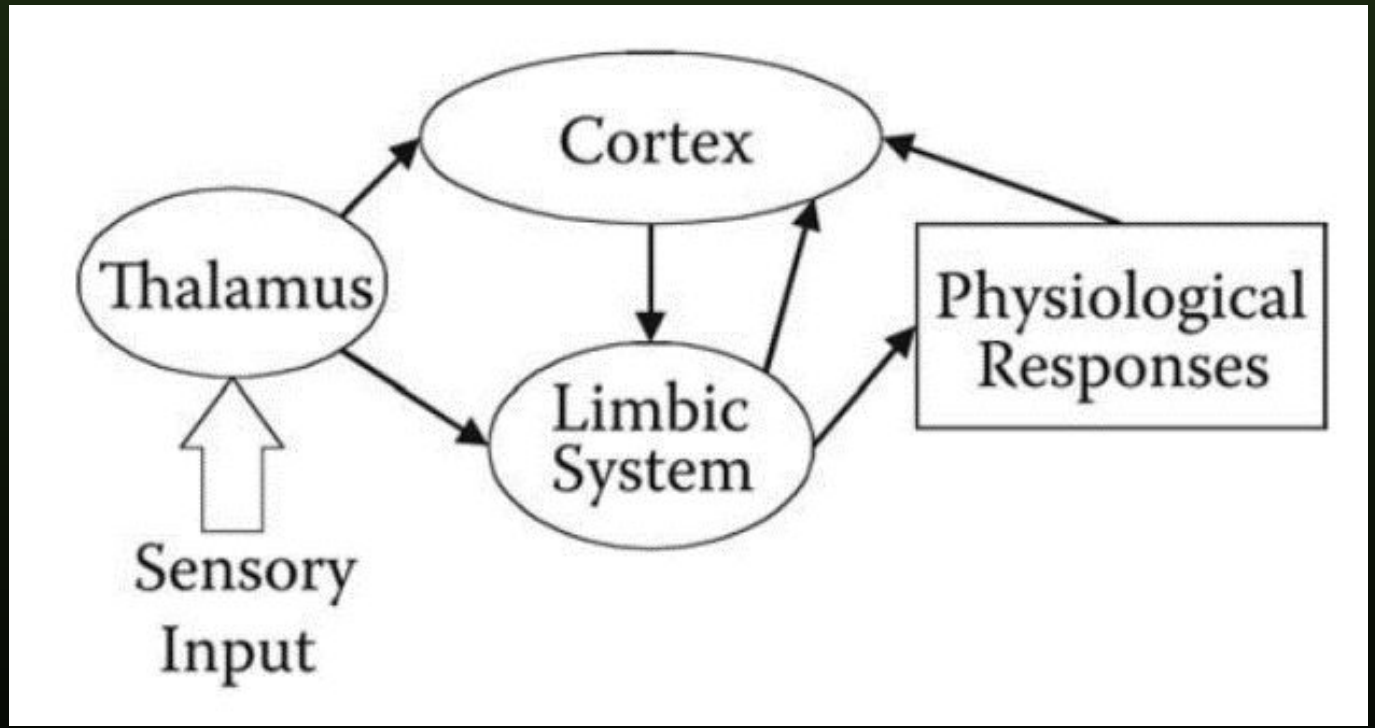


Simple Neurophysiological Model

Cortex:

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

‘Secondary’ emotions, e.g. frustration, pride, satisfaction



Classifications of Emotion

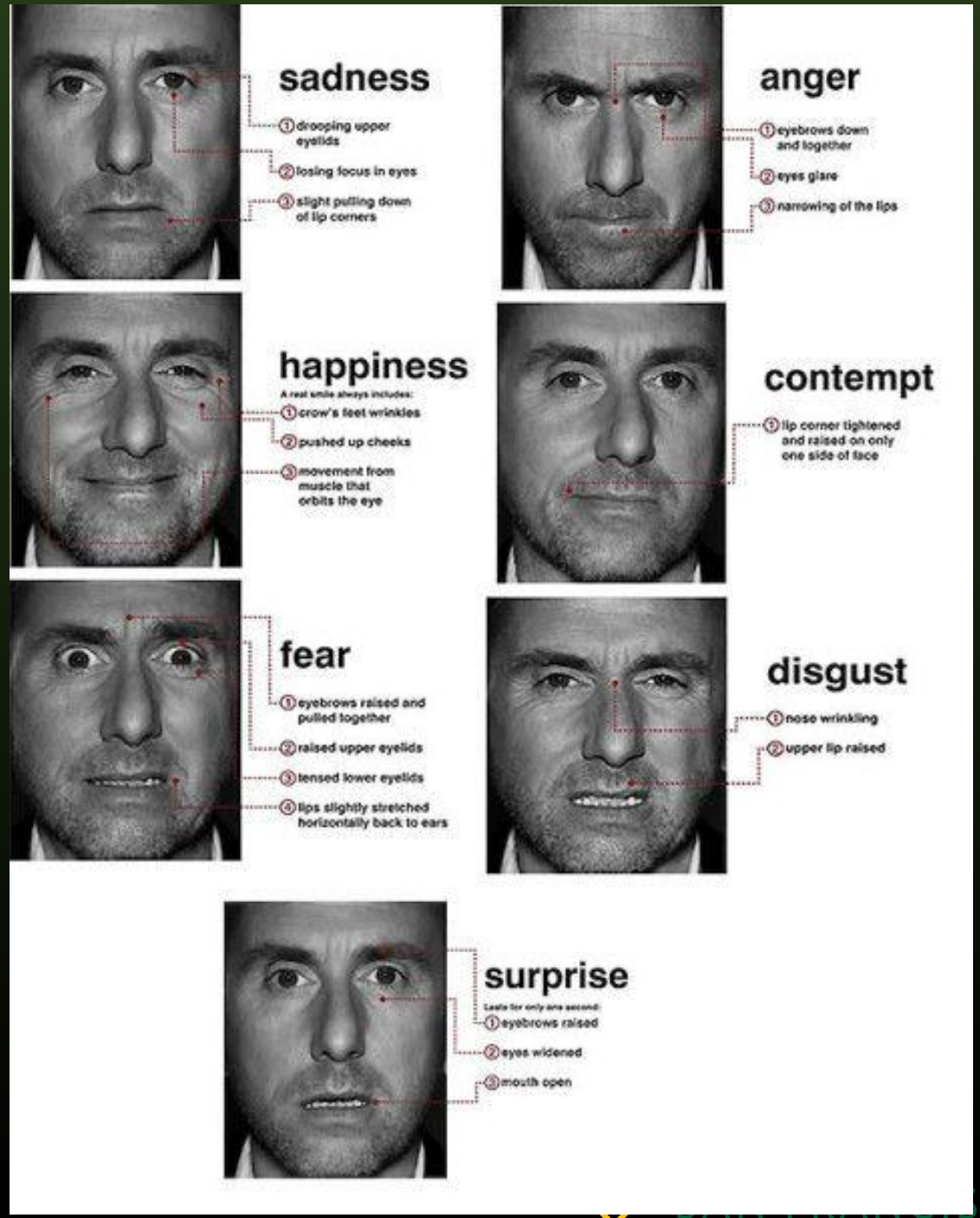
Discrete Model Continuous Model

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.

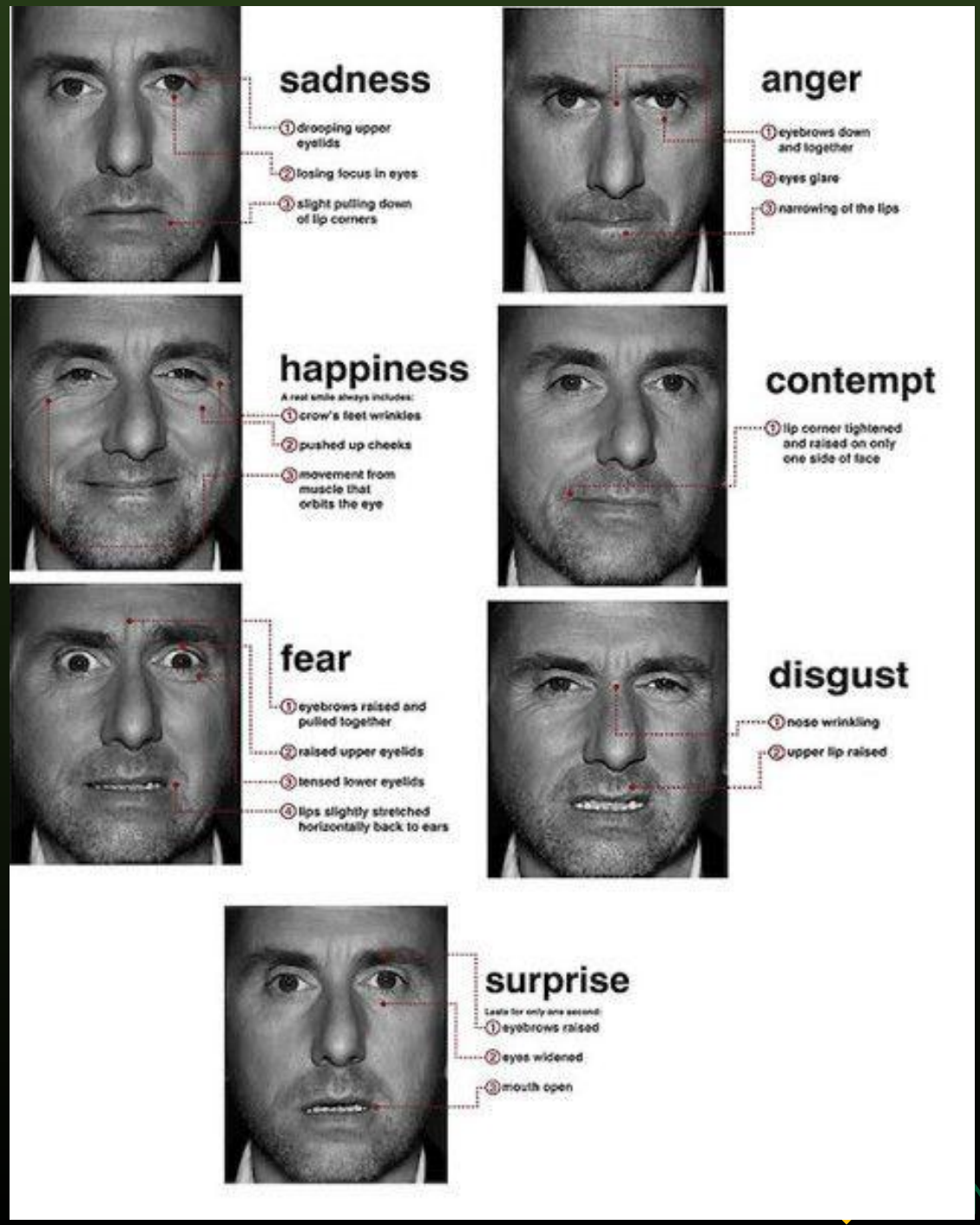


Discrete model of affect

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

Contempt added more recently

-- Paul Ekman

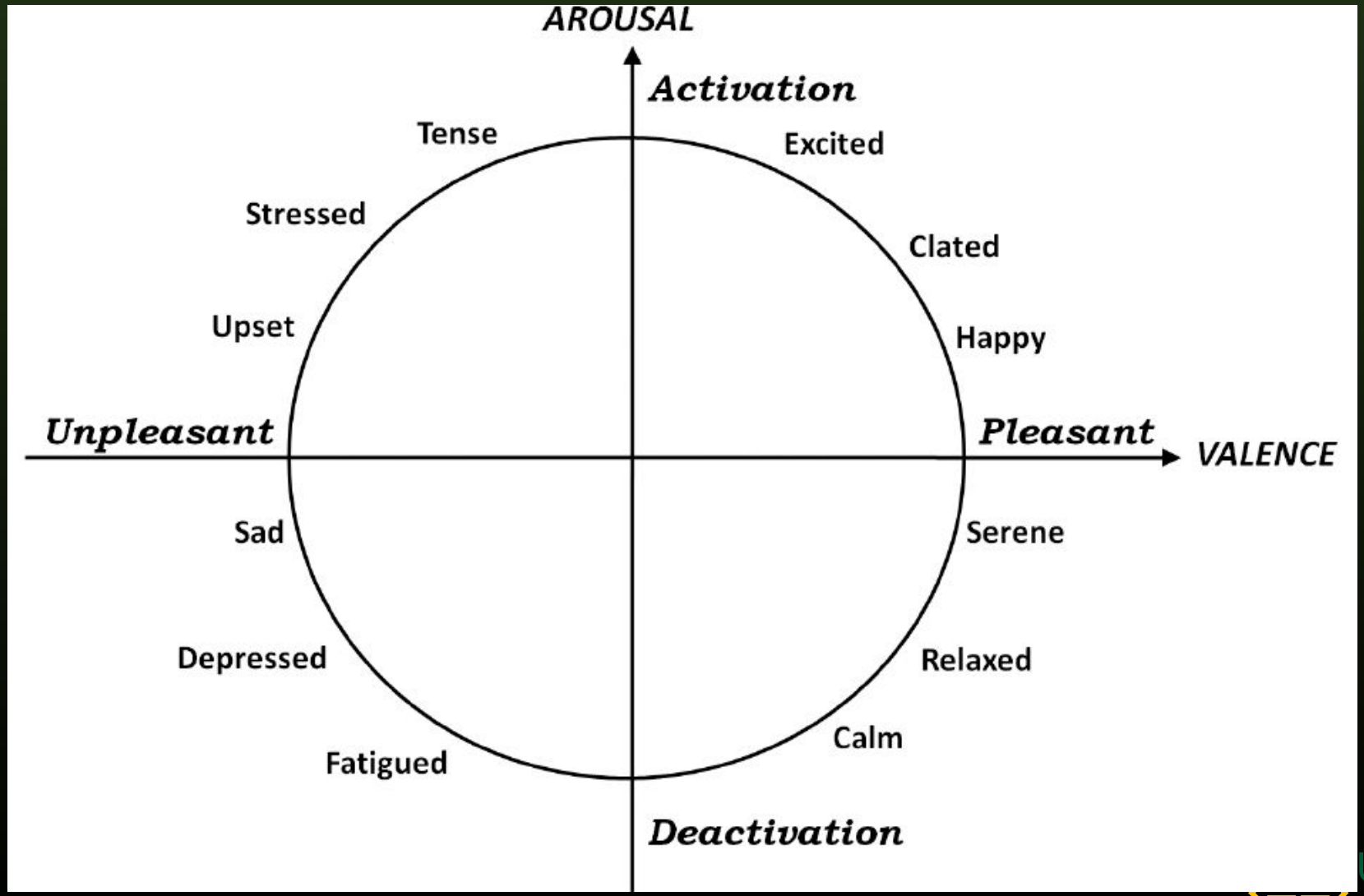


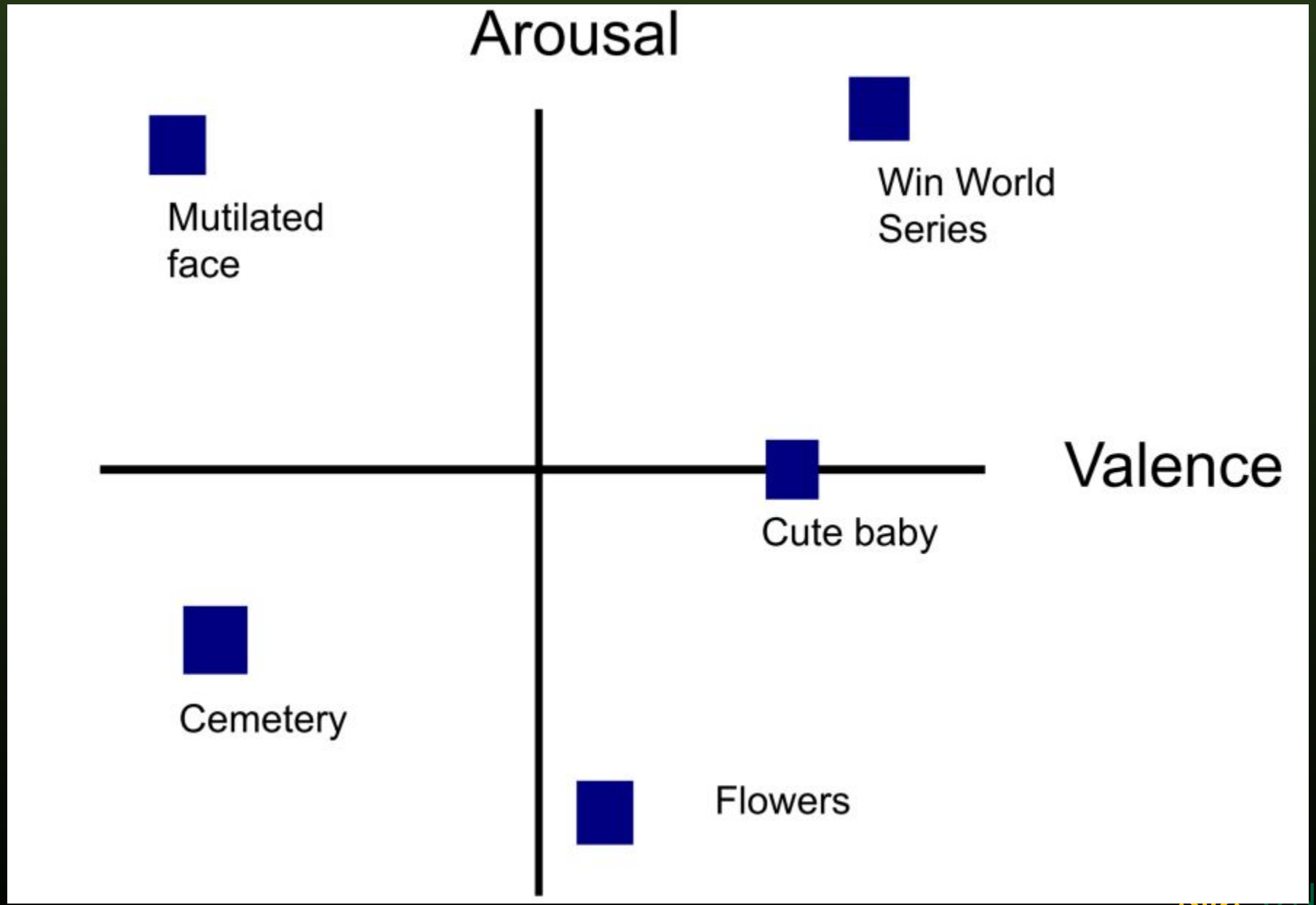
Continuous – Circumplex model of affect (Russell, 1980)

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



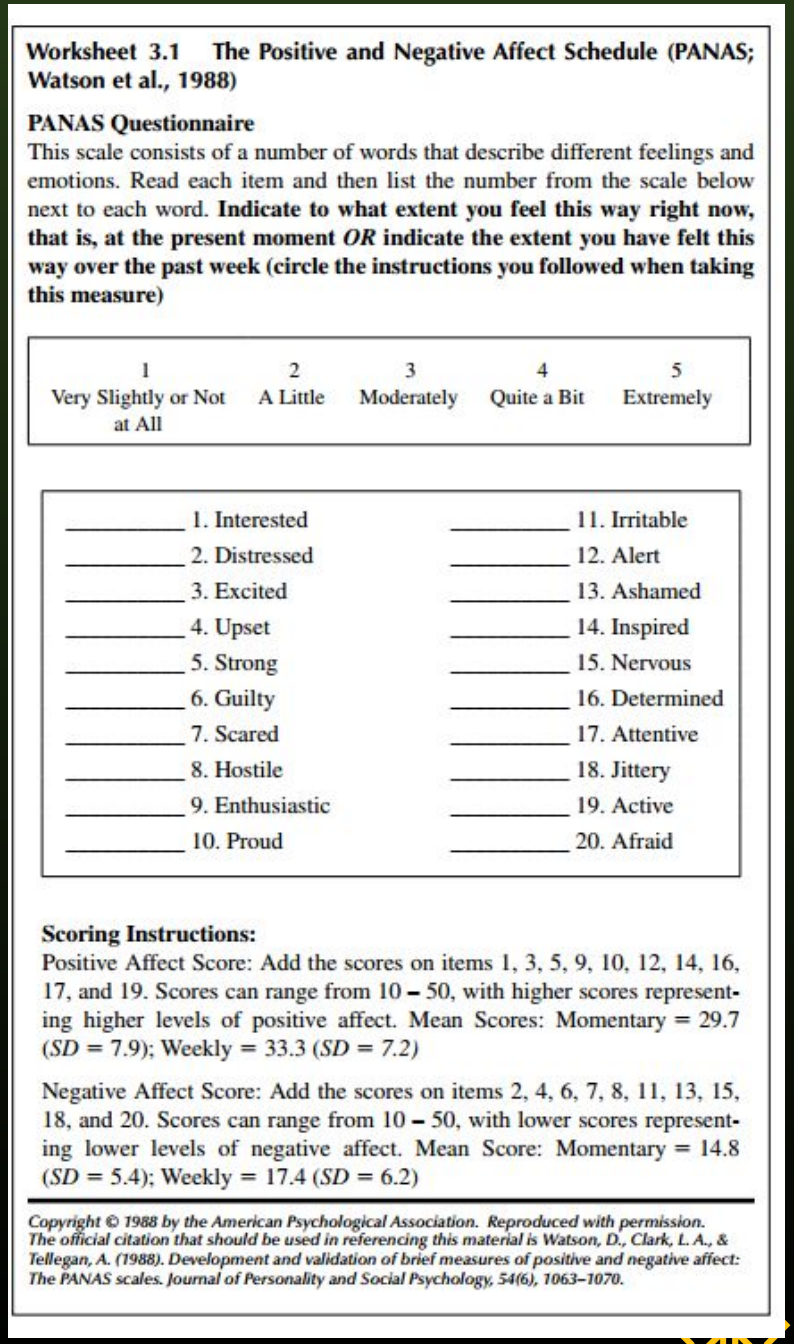


How can we measure emotion?

Self-assessment

PANAS

Discrete self-assessment measurement.



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 *OR* indicate the extent you have felt this way over the past week (circle the instructions you followed when taking this measure)**

1	2	3	4	5
Very Slightly or Not at All	A Little	Moderately	Quite a Bit	Extremely

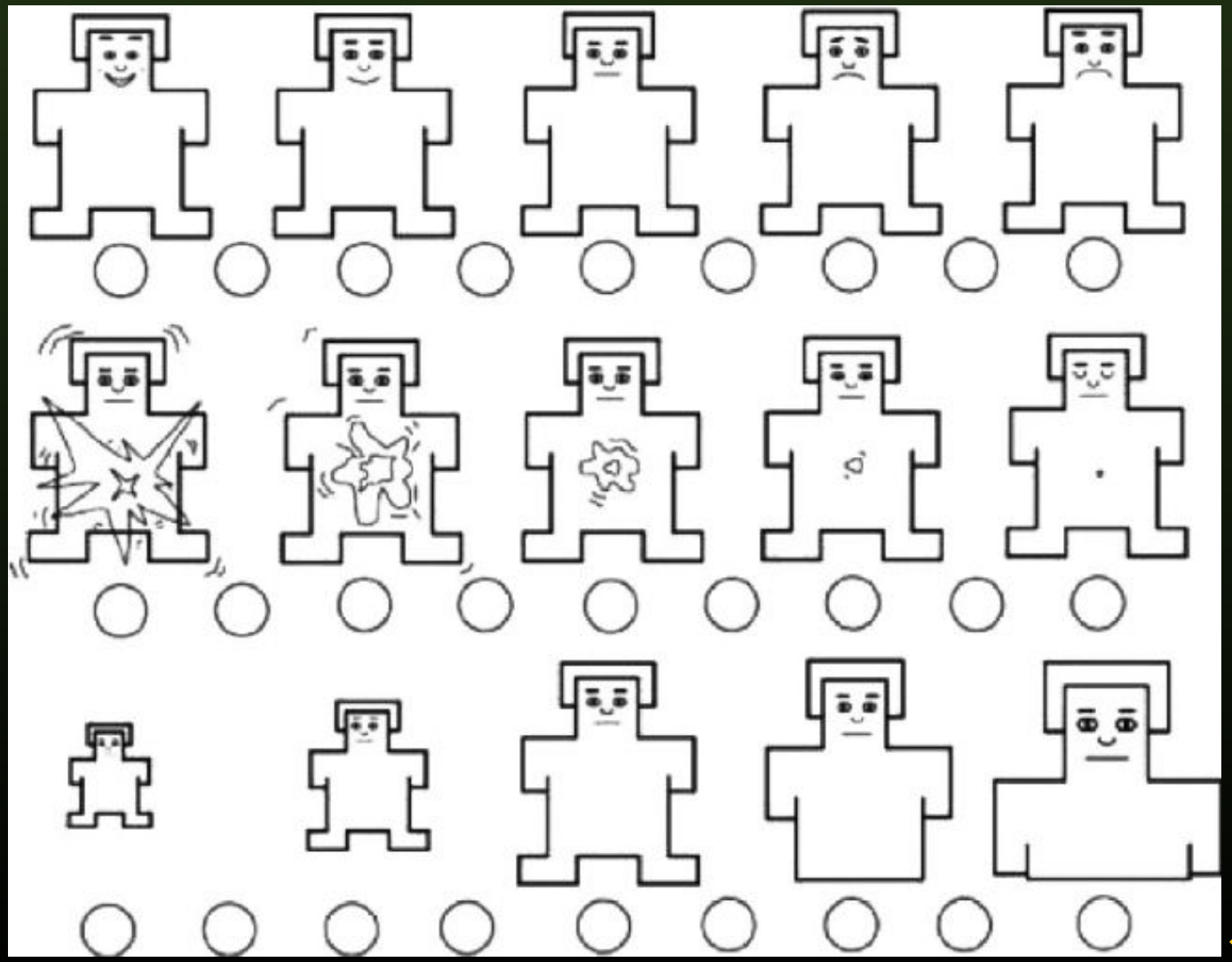
_____ 1. Interested	_____ 11. Irritable
_____ 2. Distressed	_____ 12. Alert
_____ 3. Excited	_____ 13. Ashamed
_____ 4. Upset	_____ 14. Inspired
_____ 5. Strong	_____ 15. Nervous
_____ 6. Guilty	_____ 16. Determined
_____ 7. Scared	_____ 17. Attentive
_____ 8. Hostile	_____ 18. Jittery
_____ 9. Enthusiastic	_____ 19. Active
_____ 10. Proud	_____ 20. Afraid

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

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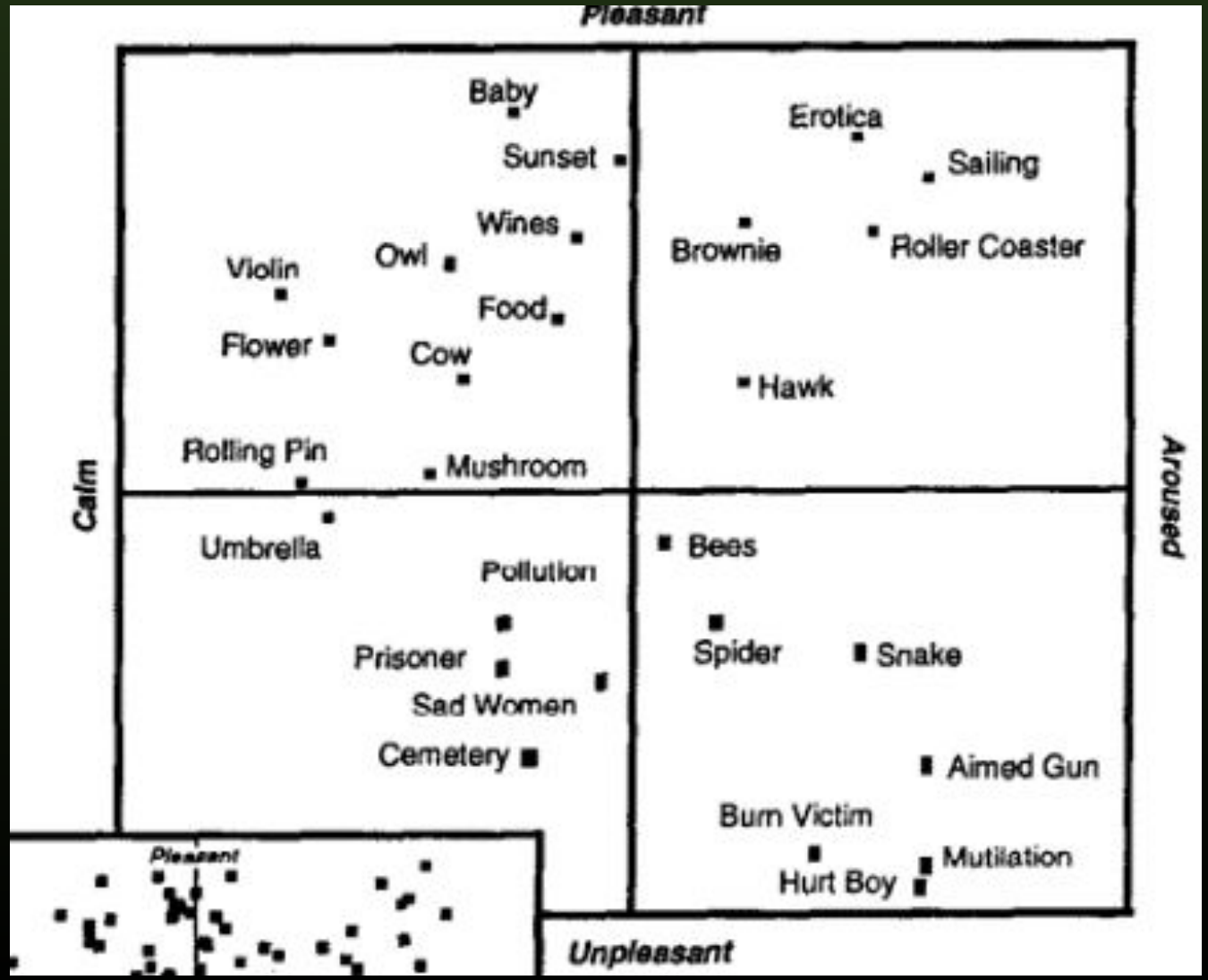
SAM ratings of International Affective Picture Systems (IAPS) – Lang et al. 1998)



Bradley and Lang, 1994

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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

Video 1

Video 2

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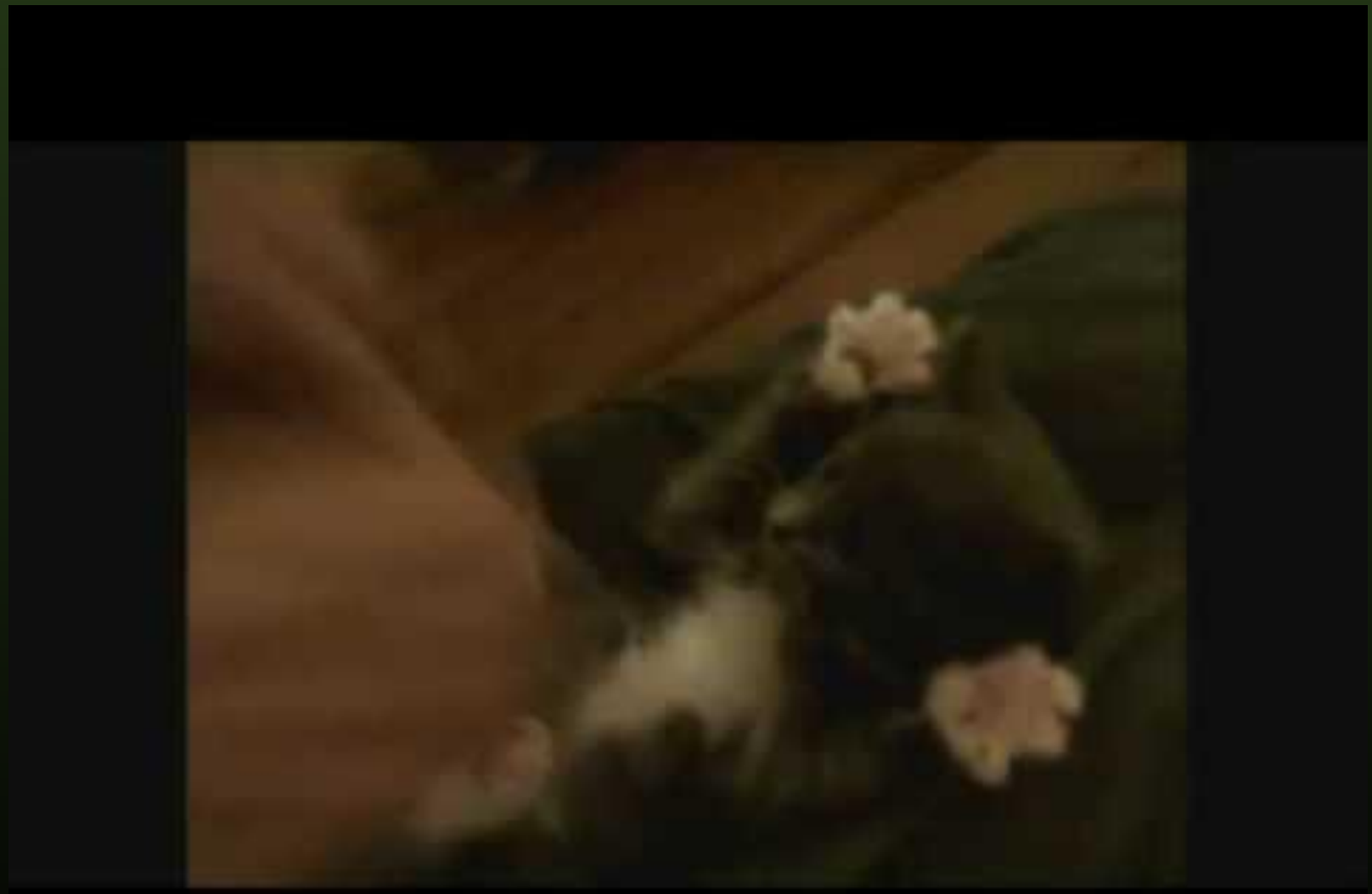
Video 3



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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

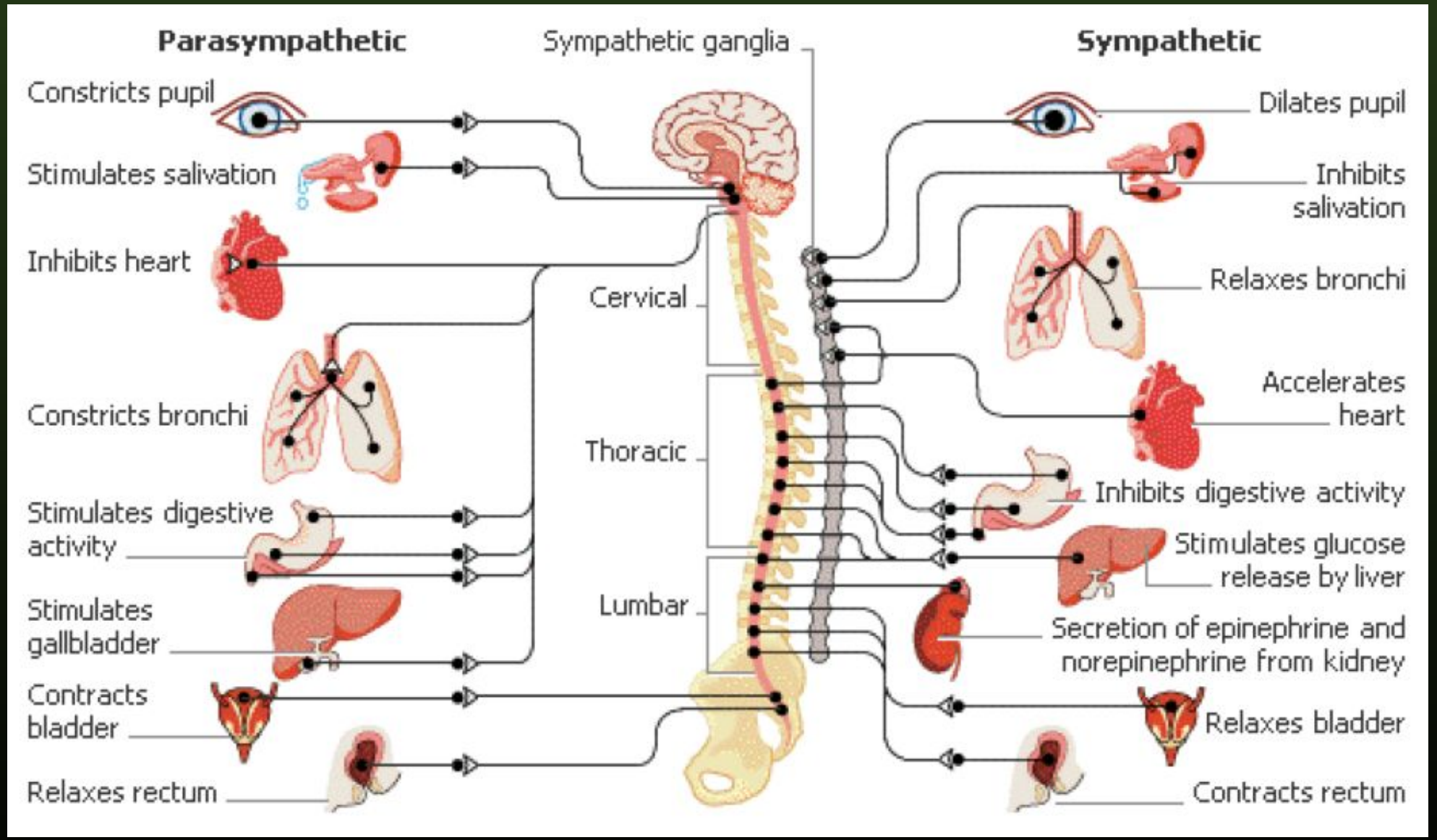
Emotions difficult to describe in words

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)



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

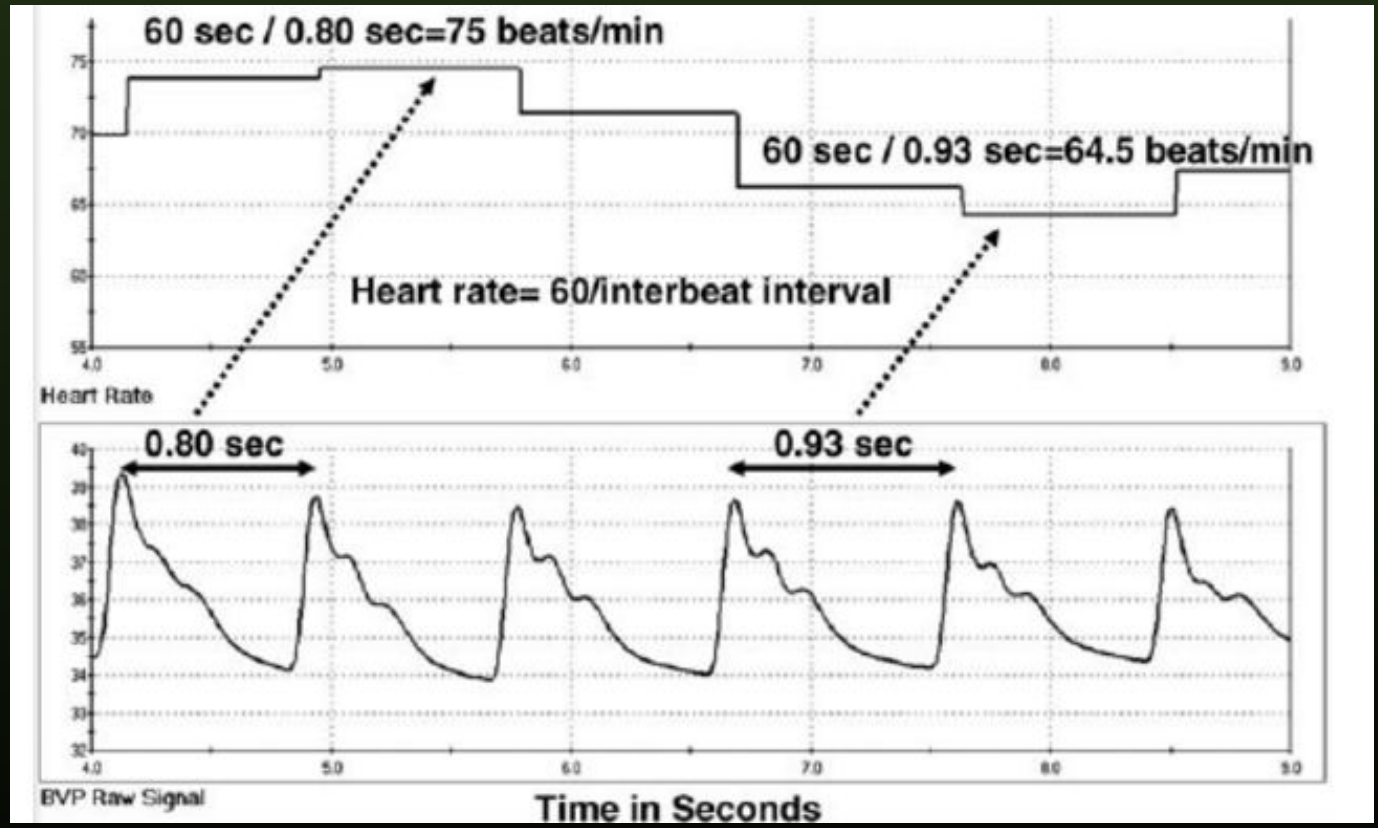
Heart Rate

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

E.g.

0.6 s interbeat interval is 60/0.6 = 100 bpm.

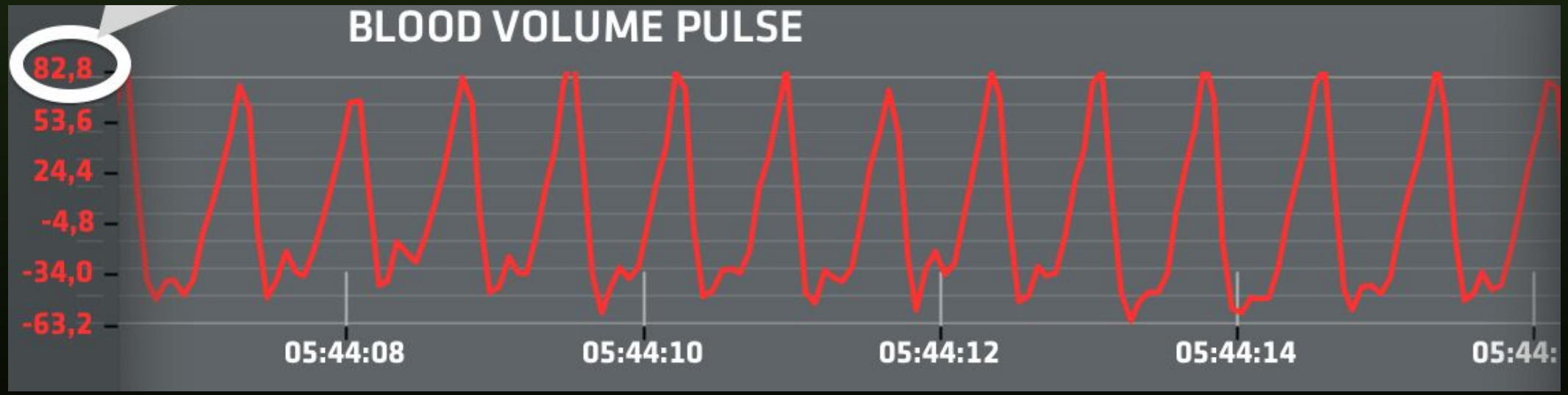
0.3 s interbeat interval is 60/0.3 = 200 bpm.



https://www.researchgate.net/figure/281574849_fig3_Figure-3-Heart-rate-is-derived-from-measures-of-blood-volume-pulse-by-measuring-the

Heart Rate

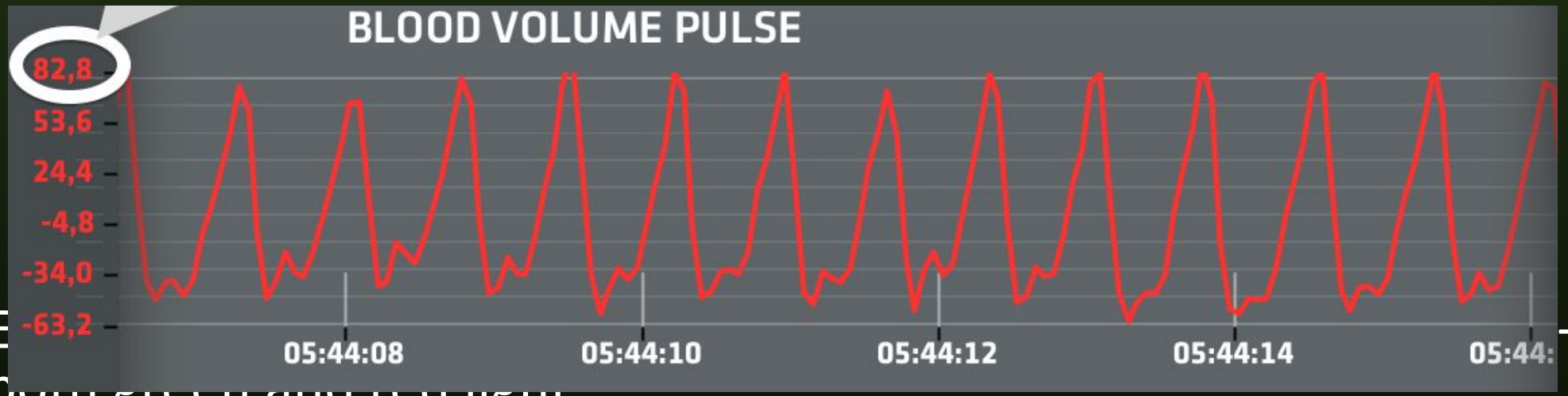
Empatica E4 wristband - PPG (Photoplethysmography) is used to give the blood volume pulse (BVP)



https://support.empatica.com/hc/en-us/articles/203621335-What-should-I-know-to-use-the-PPG-IBI-data-in-my-experiment-

Heart Rate

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



E – uses both green and red light.

Green data contains main information about heart beats

Red data contains information on movements.

https://support.empatica.com/hc/en-us/articles/203621335-What-should-I-know-to-use-the-PPG-IBI-data-in-my-experiment-

Heart Rate

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

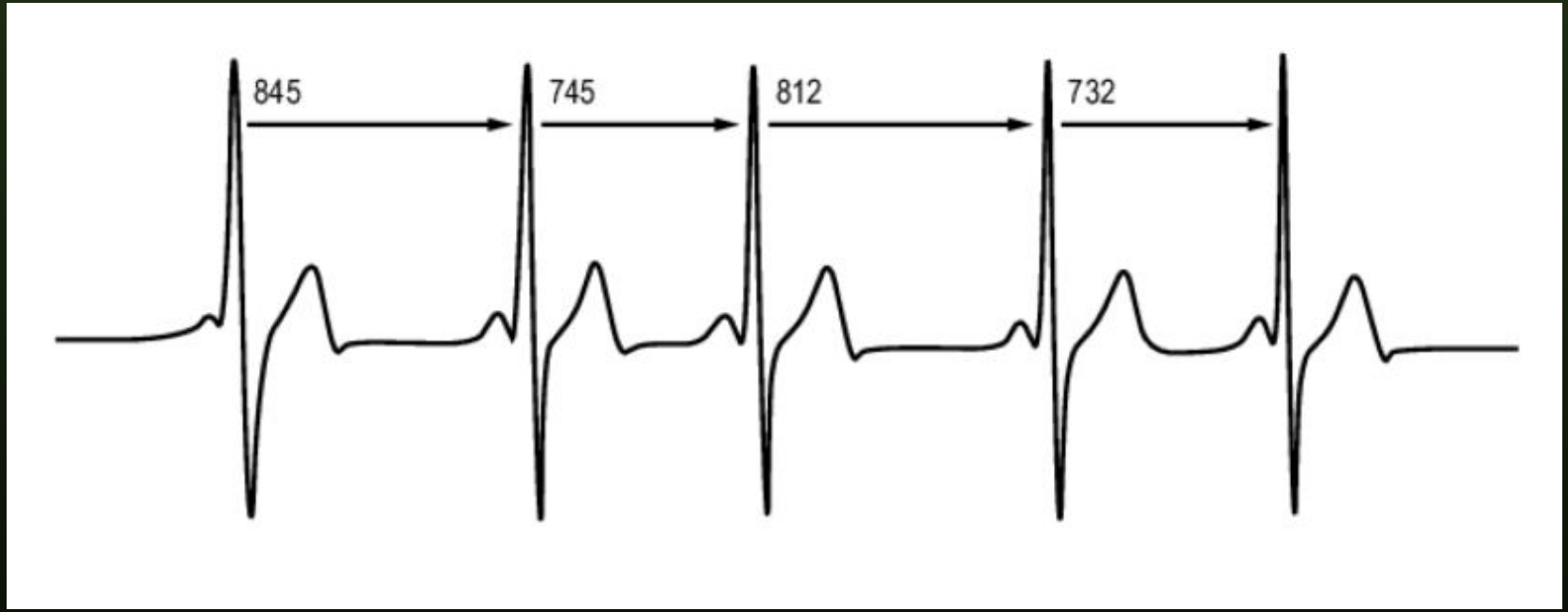
HR increases most during fear, followed by anger, sadness, happiness, surprise, and finally disgust.

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).

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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)

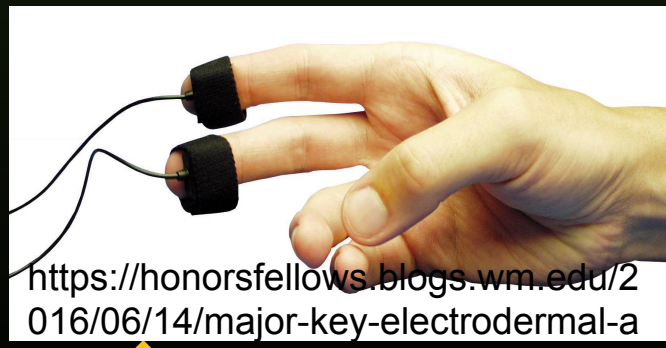
Formerly known as Galvanic Skin Response (GSR)

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.



https://honorsfellows.blogs.wm.edu/2016/06/14/major-key-electrodermal-activity/

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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. The units of measurement for conductance are microSiemens (μS).

If sweat increases -> conductance increases -> can infer arousal has increased.

https://support.empatica.com/hc/en-us/articles/203621955-What-should-I-know-to-use-EDA-data-in-my-experiment-

How is EDA measured?

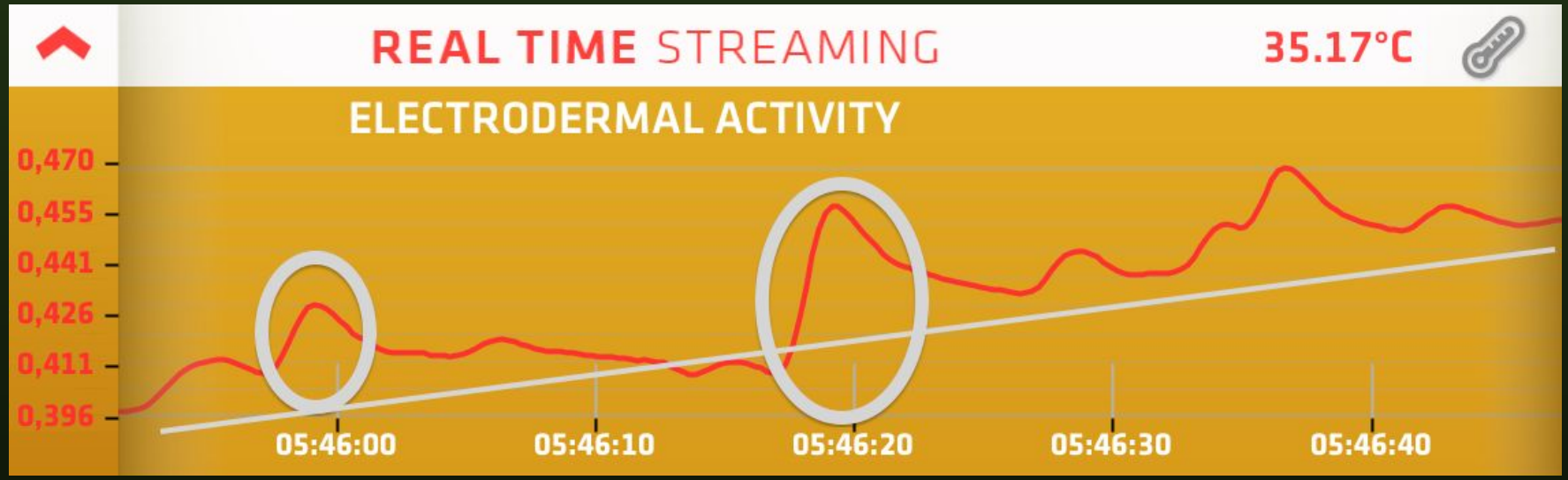
Skin conductance measurement can be characterized into two types:

1. *Tonic skin conductance response* = smooth, underlying slow changing levels.
2. *Phasic skin conductance response* = rapidly changing peaks

   - short-term events, discrete environmental stimuli

https://support.empatica.com/hc/en-us/articles/203621955-What-should-I-know-to-use-EDA-data-in-my-experiment-

How is EDA measured?



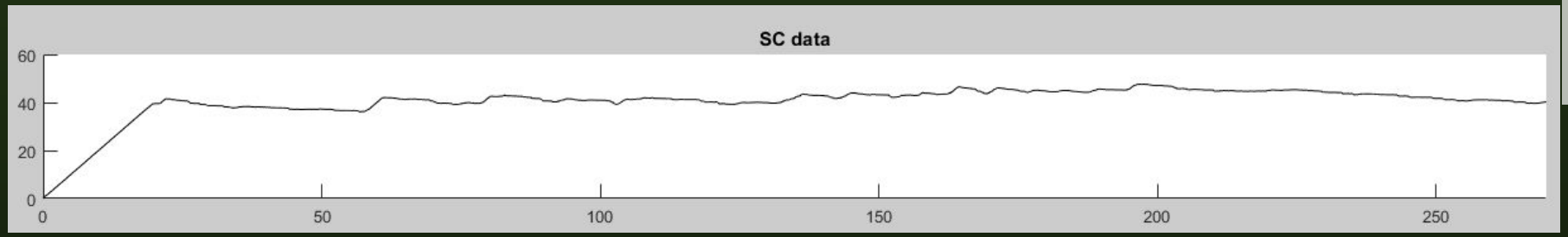
Circled – examples of phasic activations.

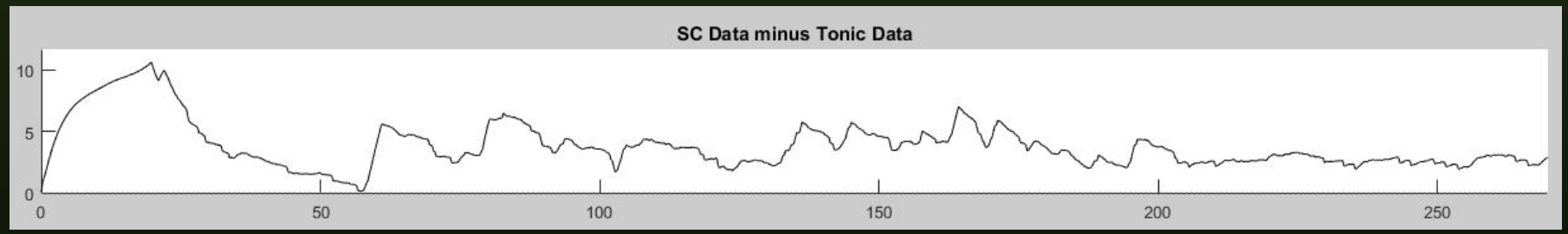
Tonic value is more smoothly-changing level, approximated by the straight white line.

https://support.empatica.com/hc/en-us/articles/203621955-What-should-I-know-to-use-EDA-data-in-my-experiment-

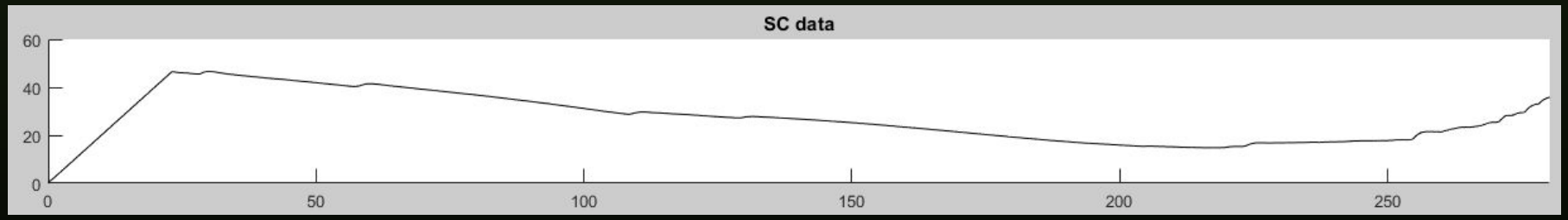
Detecting Affect

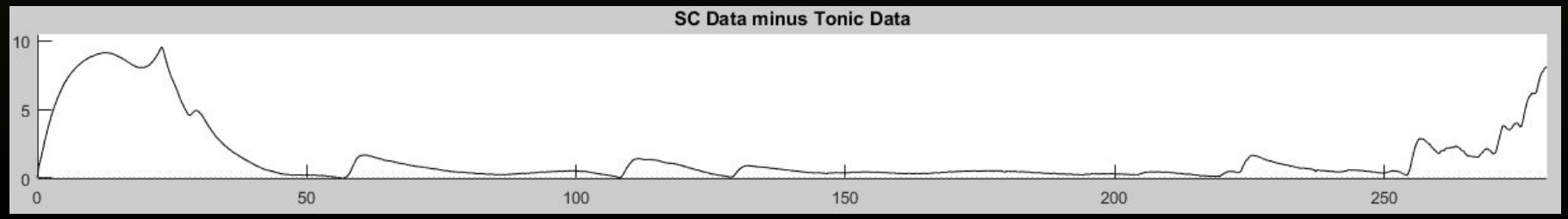
Horror Movie





Calm Movie





Empatica E4 Wristband

Results from Yi Yang and Bingkun Yang's work in Human-Computer Interaction Lab.

Notice how phasic activations are highlighted once the tonic data is subtracted.

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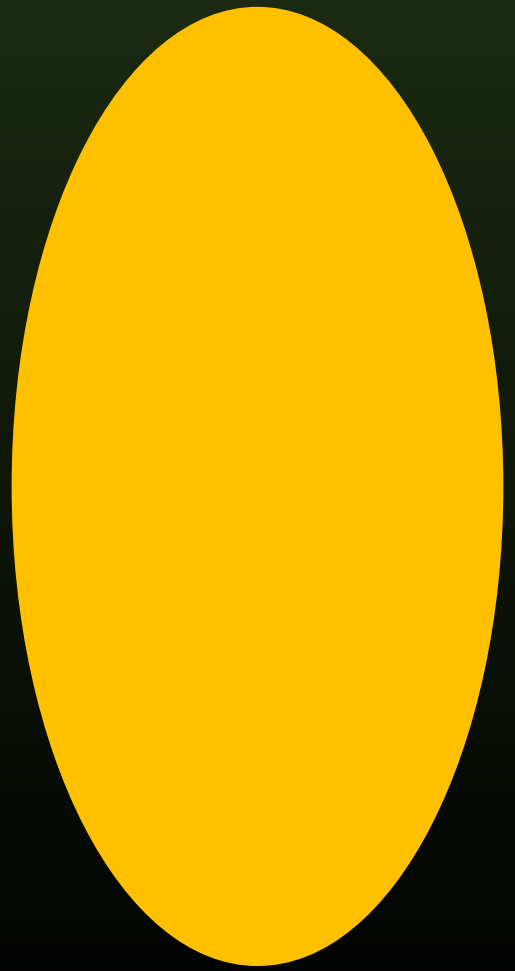
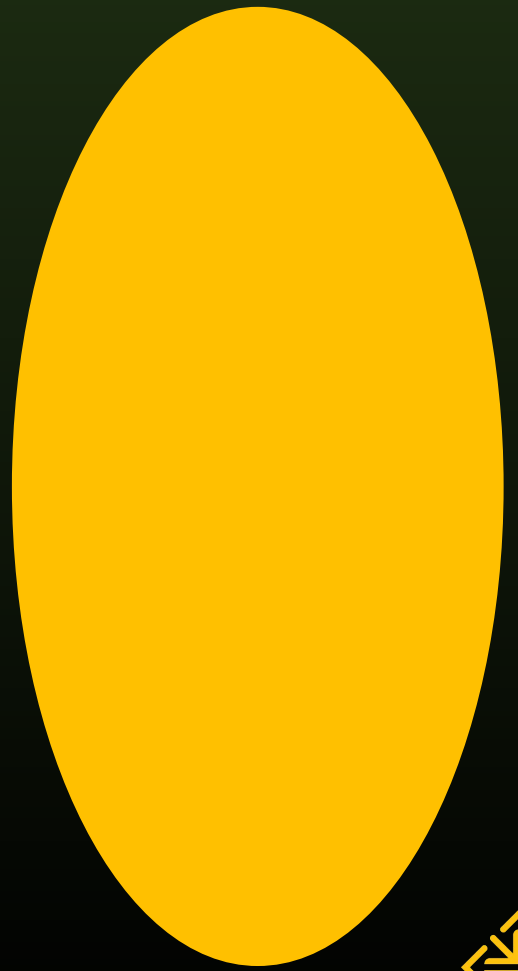
Physiological Computing

*Greatest challenge is **mapping** physiological measures to psychological states.*

Physiological measure

Psychological state





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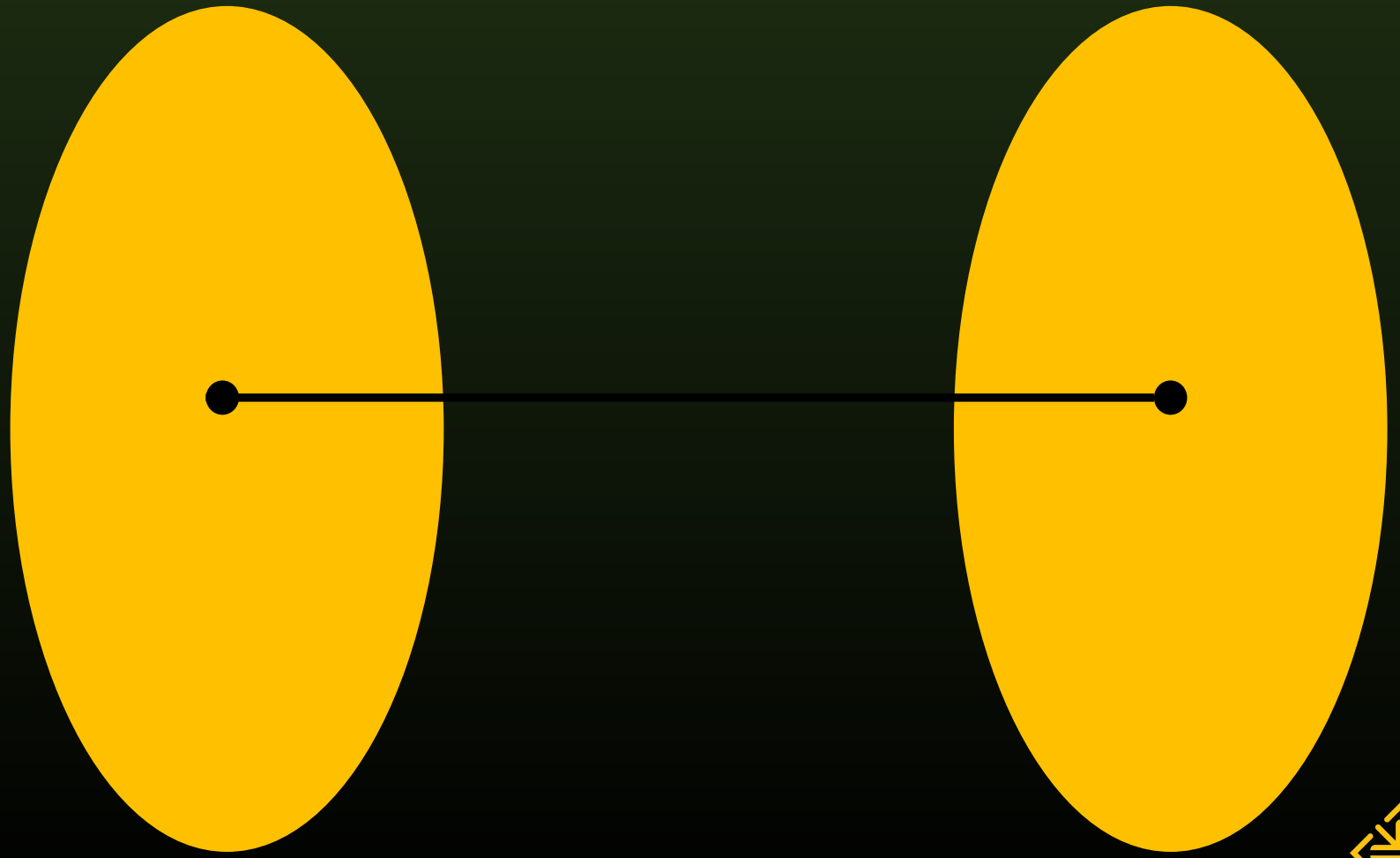
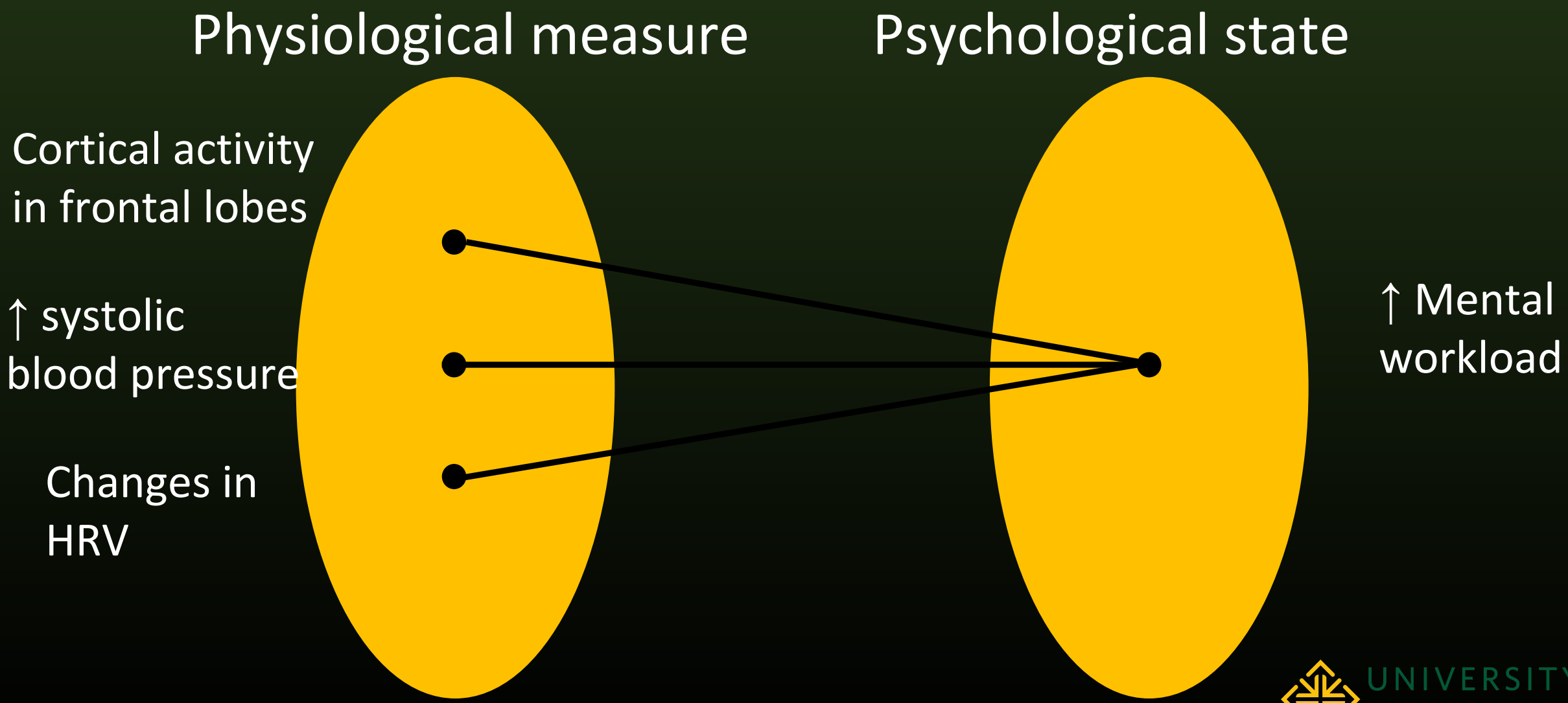
One-to-one – ideal but very rare

Physiological measure

Psychological state



Many-to-one



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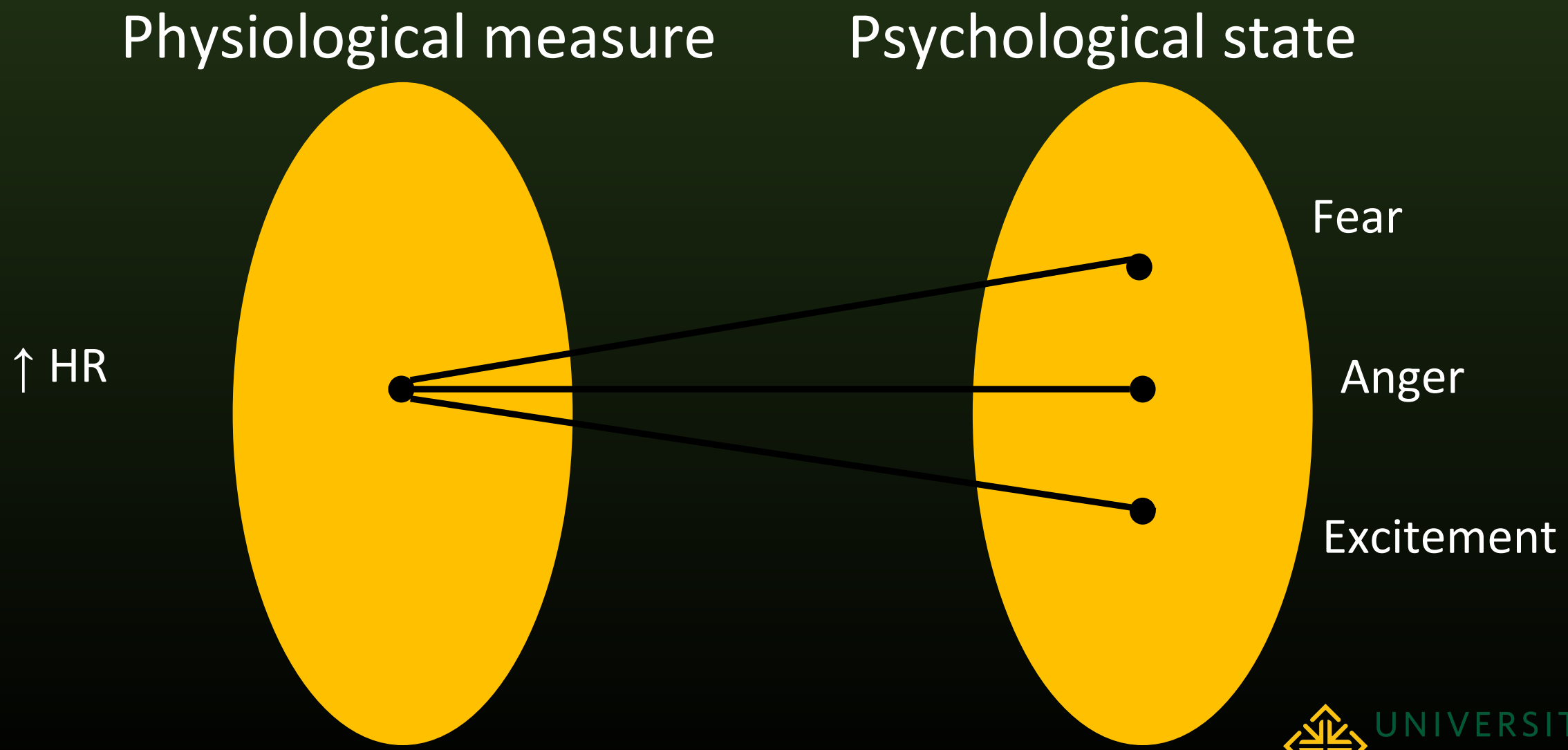
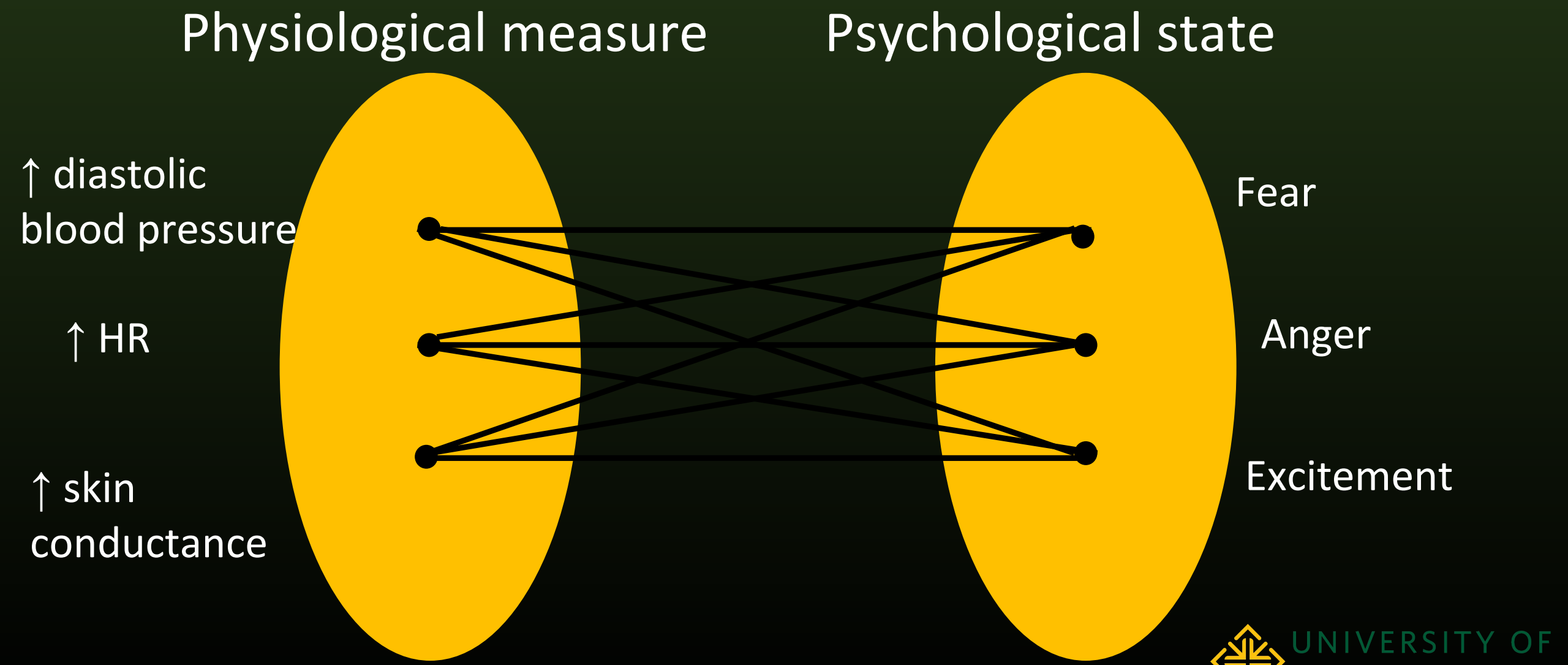
One-to-many



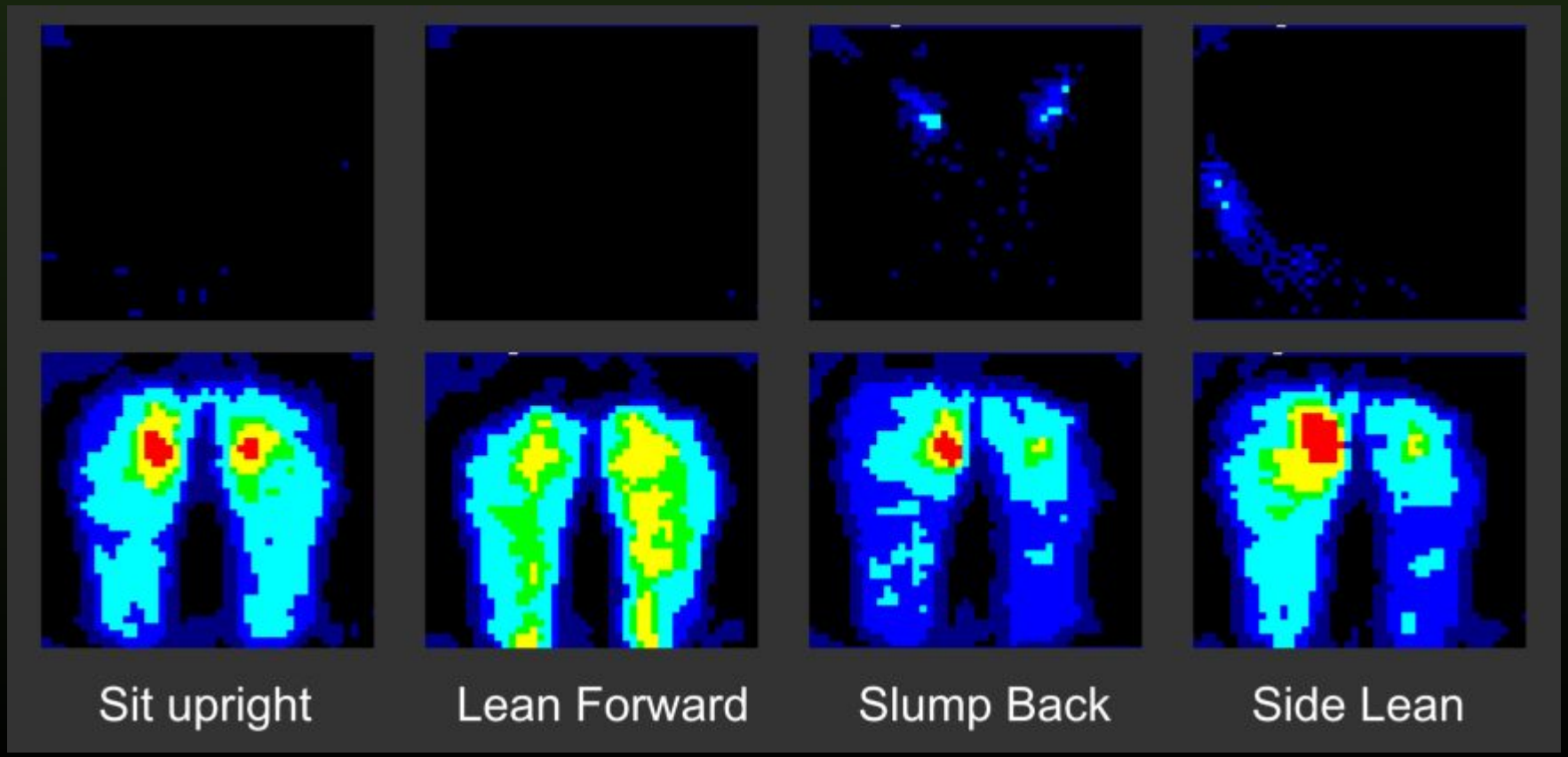
Many-to-many



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



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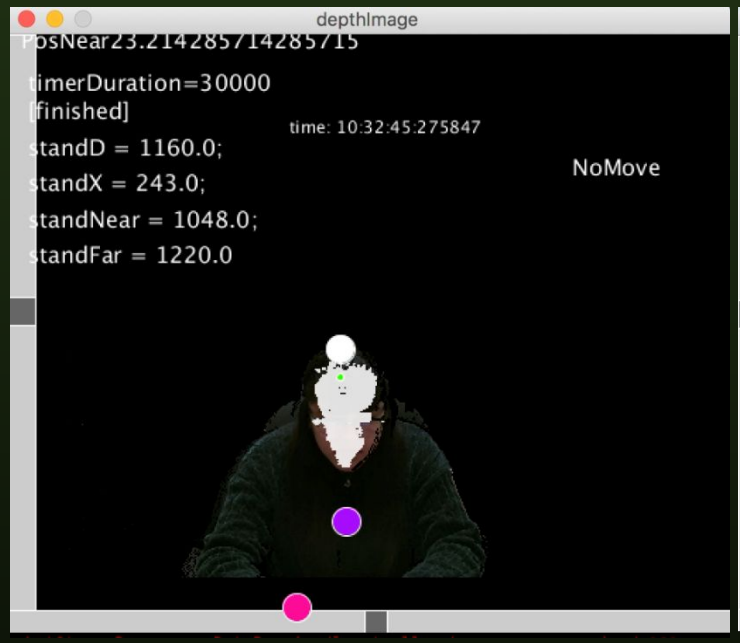
Posture Detection



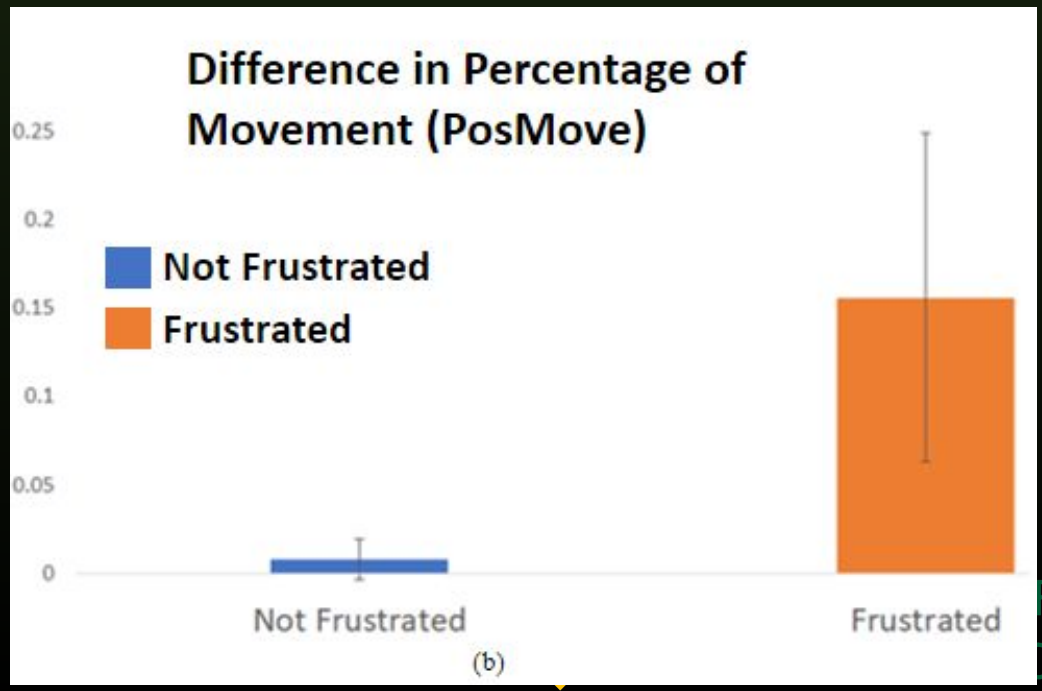
Move/No Move: The absolute sum of frame-to-frame acceleration was accumulated in a rolling one second window at each frame.

Pos Near/ Far:

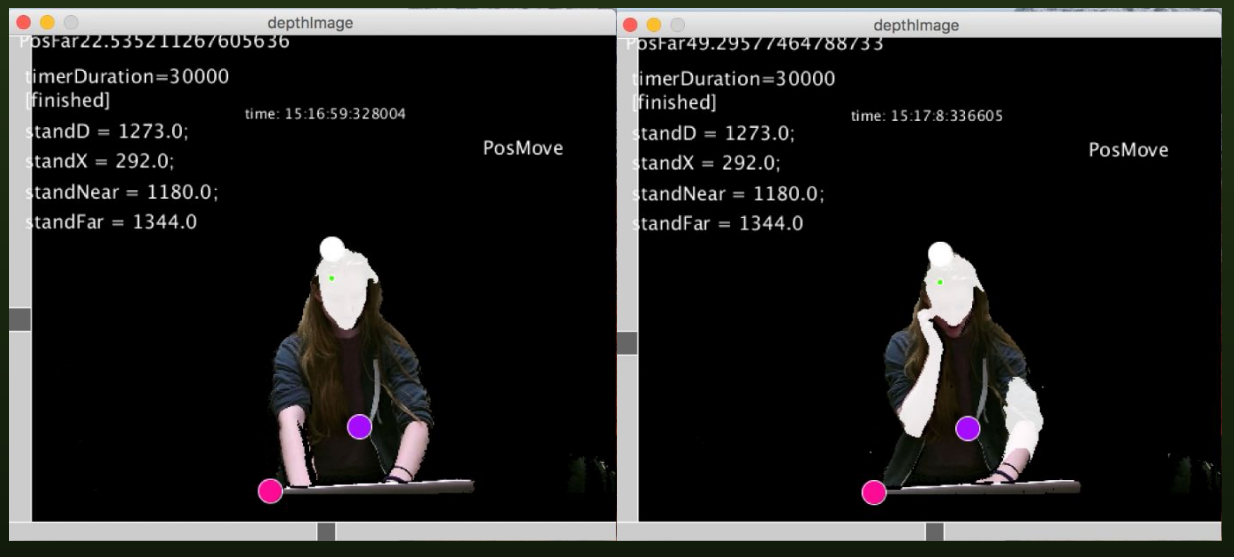
- Get Standard Position
- Get Standard Near Position
- Get Standard Far Position
- Compare current position with standard Near/Far Position

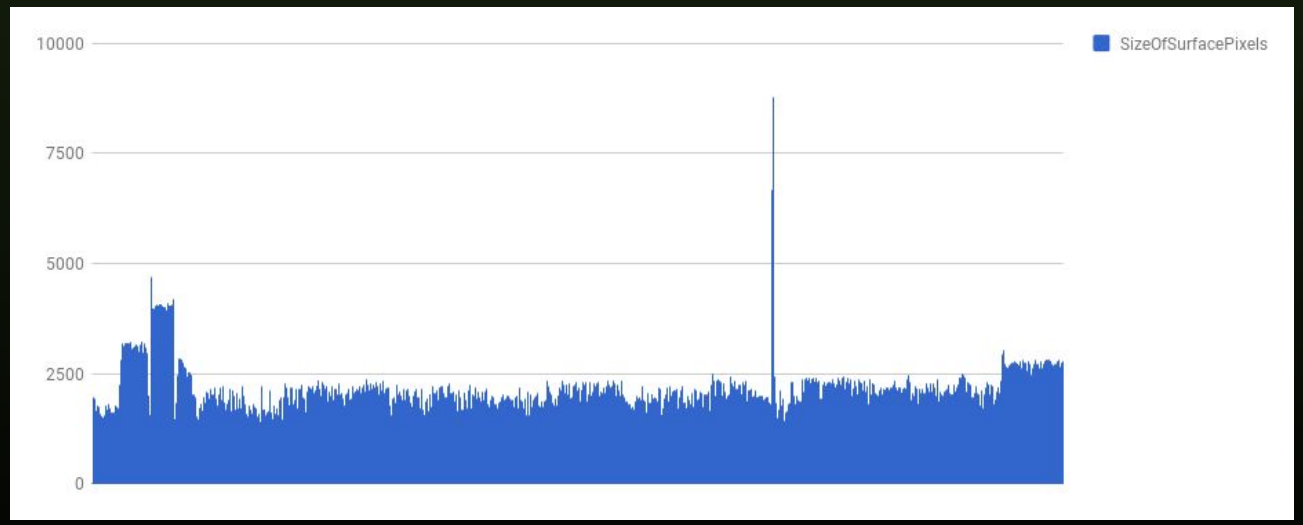
Lean Left/ Right:

- Get Standard X Position
- Detect changes per frame



Gesture Detection





Hand-to face gesture detection using breadth-first surface propagation

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Gesture Detection

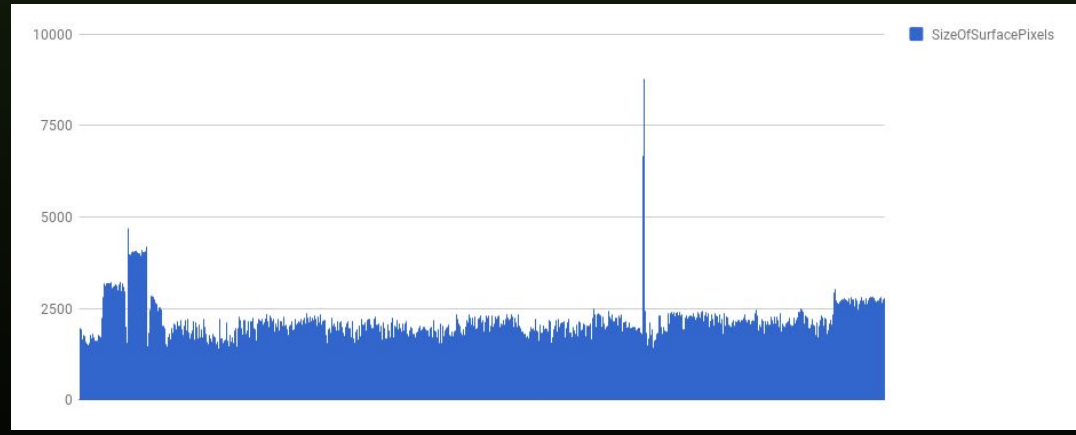
Breadth-First Surface Propagation:

- 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.



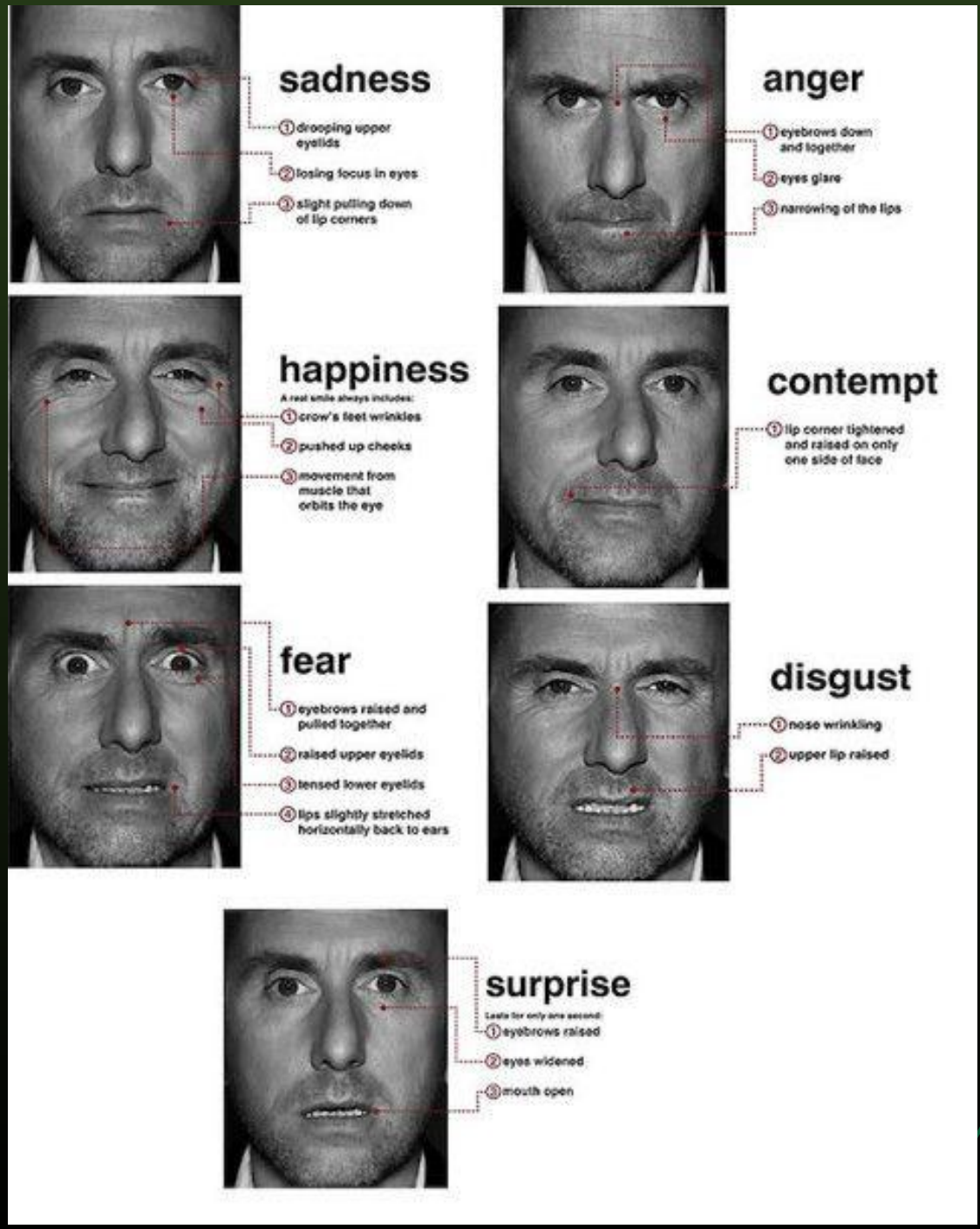
Facial Expression Recognition

Facial Expression Recognition

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

Contempt added more recently

-- Paul Ekman

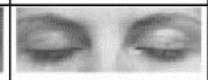


Facial Action Coding System (FACS) Ekman et al. 1978, 2002

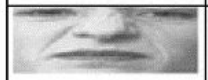
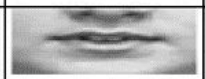
Categorizes facial behavior as Facial *Action Units (AUs)*. Unique upper and lower facial AUs that correspond to different movements of muscles in the face.

Great Visual Resource: https://imotions.com/blog/facial-action-coding-system/

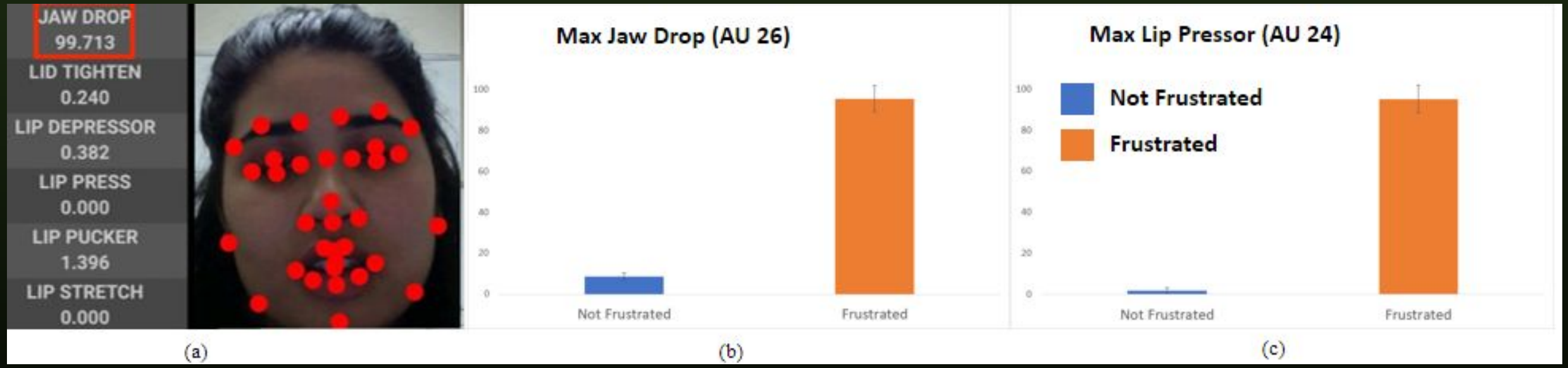
Upper Face Action Units

AU 1	AU 2	AU 4	AU 5	AU 6	AU 7
					
Inner Brow Raiser	Outer Brow Raiser	Brow Lowerer	Upper Lid Raiser	Cheek Raiser	Lid Tightener
*AU 41	*AU 42	*AU 43	AU 44	AU 45	AU 46
					
Lid Droop	Slit	Eyes Closed	Squint	Blink	Wink

Lower Face Action Units

AU 9	AU 10	AU 11	AU 12	AU 13	AU 14
					
Nose Wrinkler	Upper Lip Raiser	Nasolabial Deepener	Lip Corner Puller	Cheek Puffer	Dimpler
AU 15	AU 16	AU 17	AU 18	AU 20	AU 22
					
Lip Corner Depressor	Lower Lip Depressor	Chin Raiser	Lip Puckerer	Lip Stretcher	Lip Funneler
AU 23	AU 24	*AU 25	*AU 26	*AU 27	AU 28
					
Lip Tightener	Lip Pressor	Lips Part	Jaw Drop	Mouth Stretch	Lip Suck

Facial Action Units while learning



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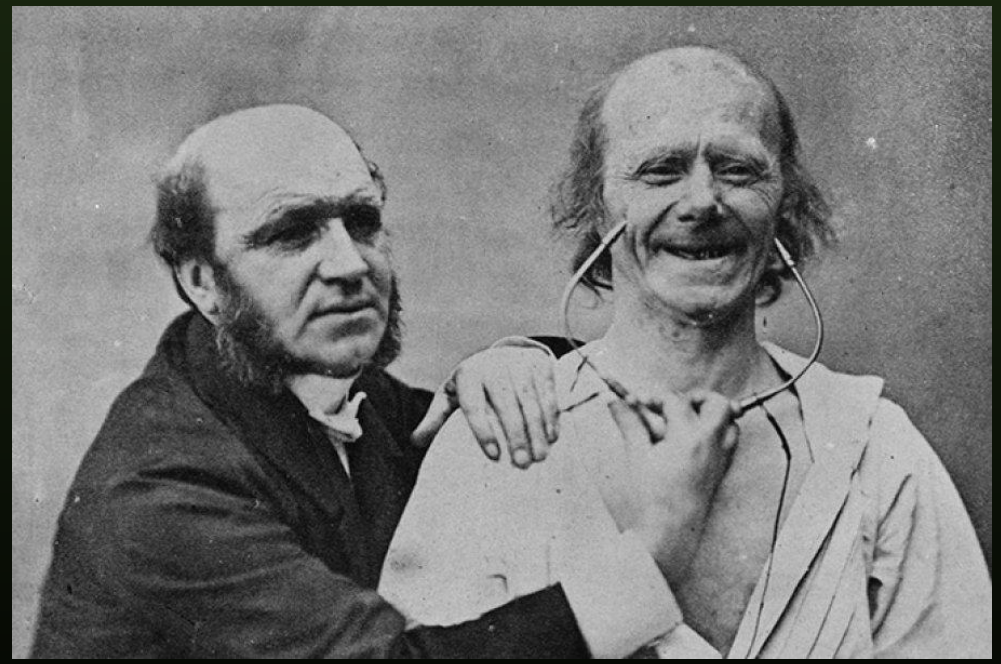
Duchenne Smile



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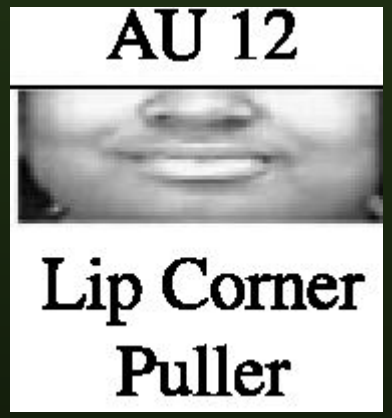
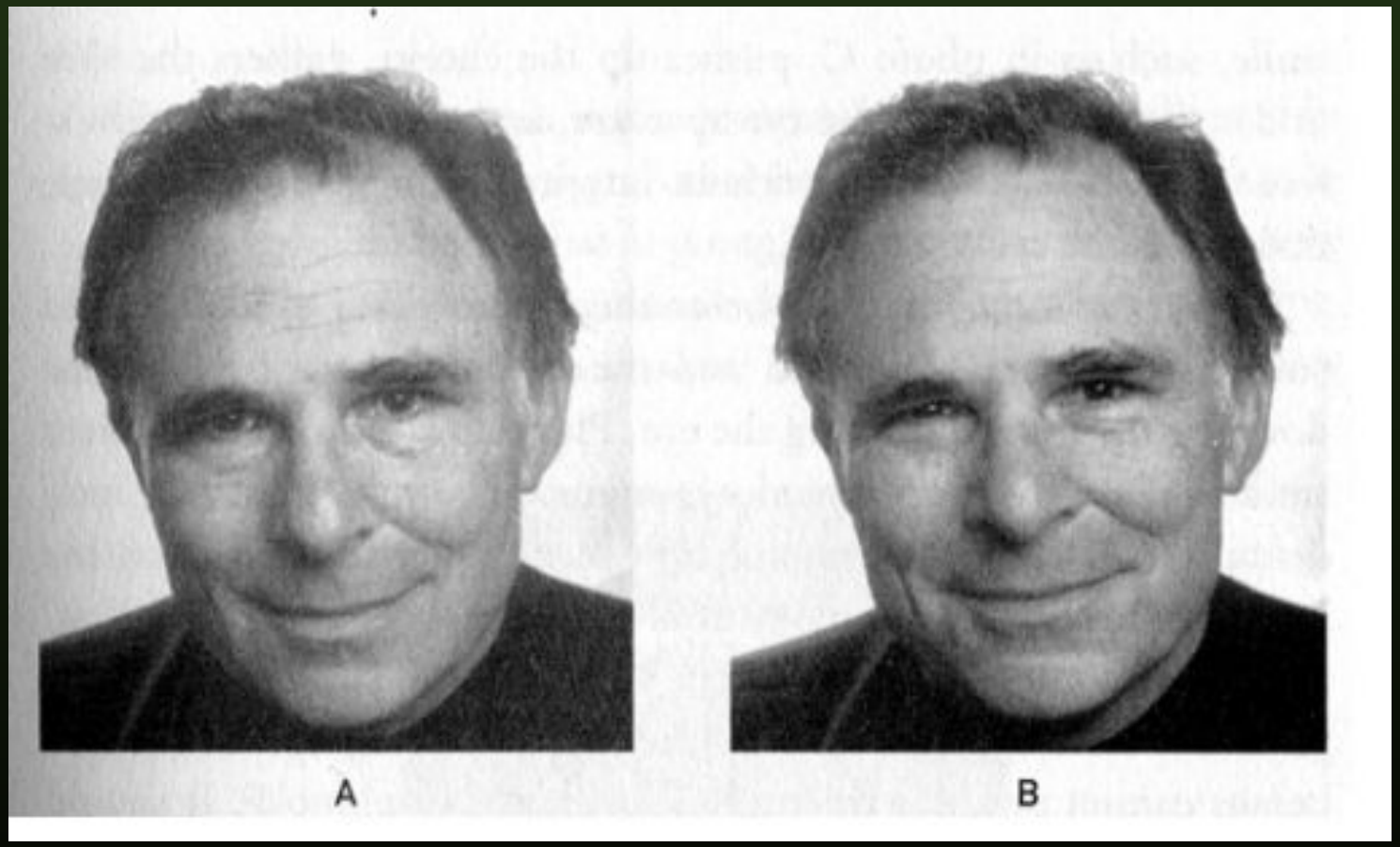
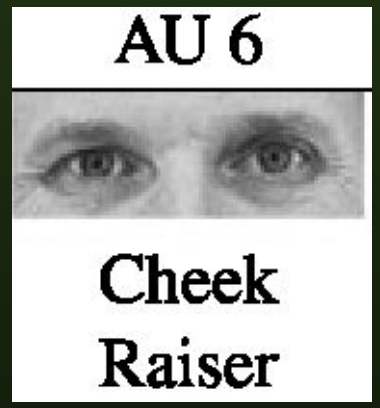
Duchenne Smile







AU 12

AU 6 + AU 12

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Dynamics and Emotion Perception

– Genuine smiles have longer onset/offset times (Hess&Kleck90)

– 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. Typically lasts less than 0.5 s.

There is no evolutionary advantage to showing what you feel.

vs.

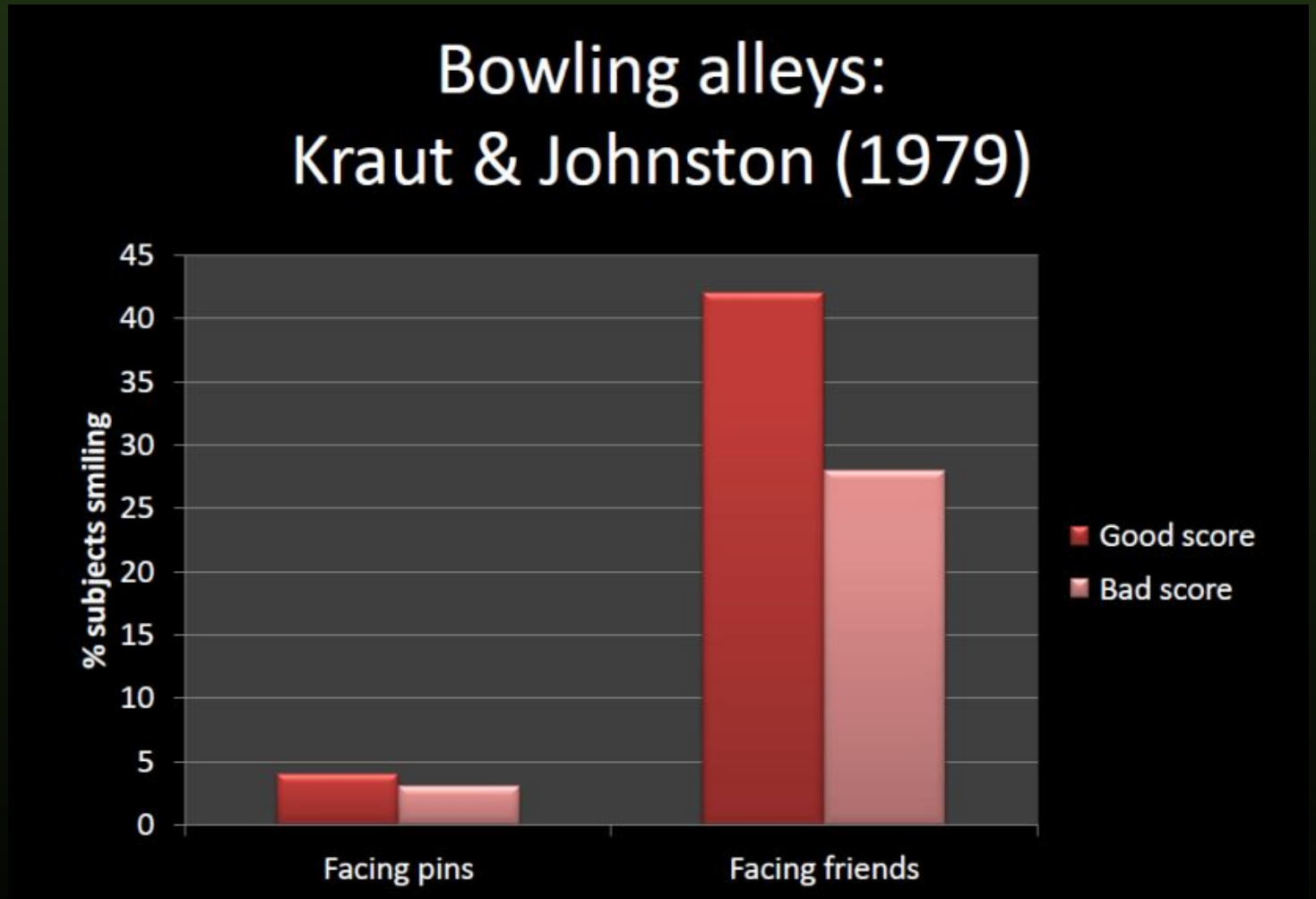
Expressions are like language – they help achieve social goals.

Microexpressions

https://www.youtube.com/watch?v=gAIg4baVhDk

https://www.youtube.com/watch?v=rGhOuA3rr1k

Do people really show what they feel?



Kraut, R. E. & Johnston, E. E. (1979). Social and emotional messages of smiling: An ethological approach. *Journal of Personality and Social Psychology*, *37*, 1539-1553.

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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

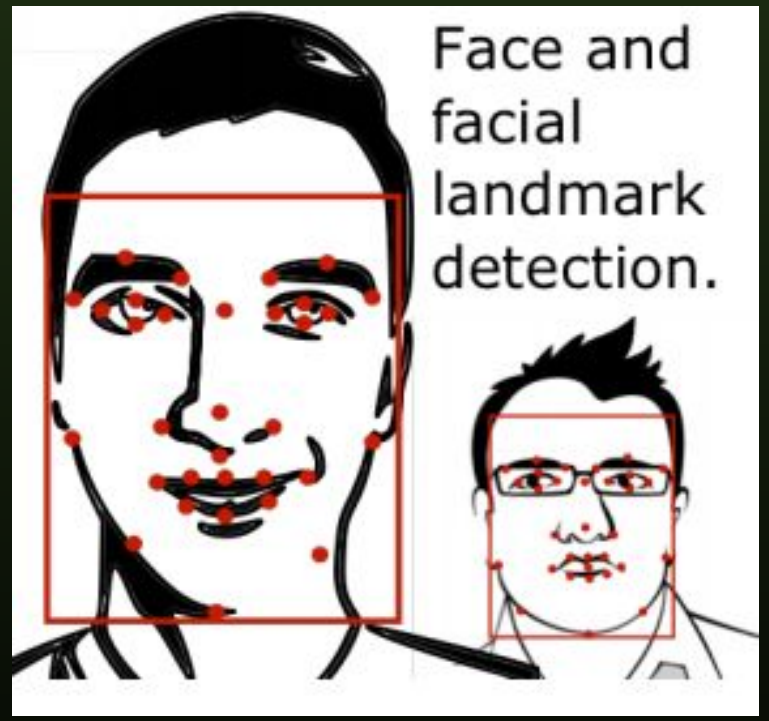
https://www.affectiva.com/product/emotion-sdk/
https://developer.affectiva.com/
https://www.youtube.com/watch?v=4A6m8-V40Z4
https://www.youtube.com/watch?v=mFrSFMnskI4&t=106s

McDuff, Daniel, Abdelrahman Mahmoud, Mohammad Mavadati, May Amr, Jay Turcot, and Rana el Kaliouby. "AFFDEX SDK: a cross-platform real-time multi-face expression recognition toolkit." In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 3723-3726. ACM, 2016.

Software Pipeline:
1. Face and facial landmark detection

Face detection is performed

Viola, P. and Jones, M. 2001. "Rapid object detection using a boosted cascade of simple features." PROC CVPR IEEE '01.



Landmark detection is then applied to each facial bounding box and 34 landmarks identified.

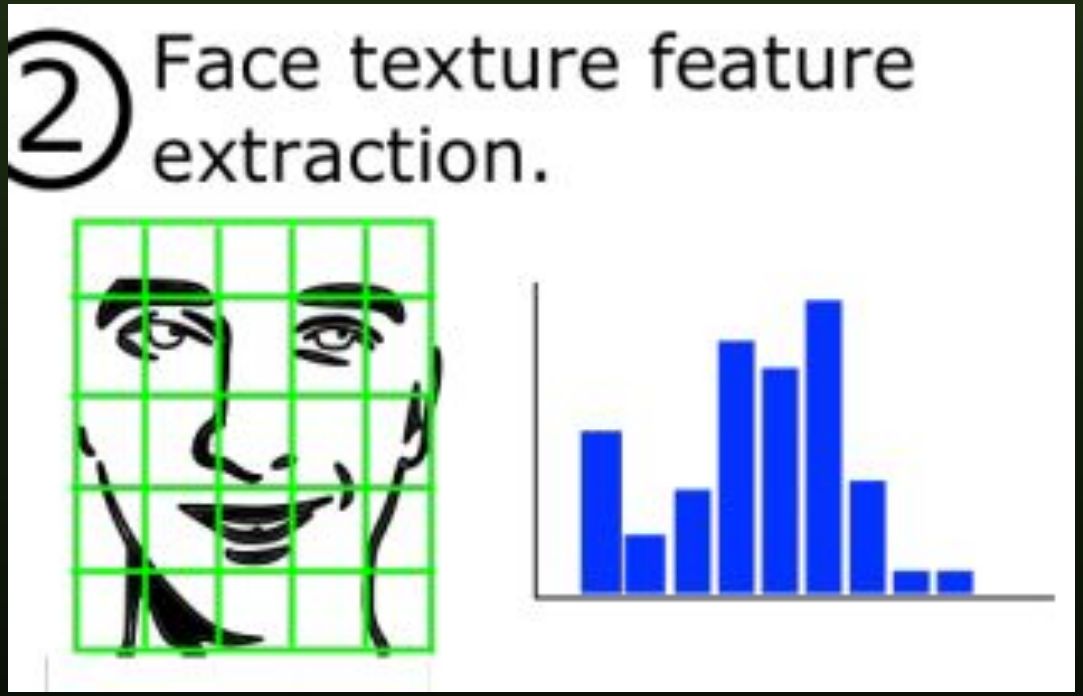
Xiong, X. and De la Torre, F., 2013, June. Supervised descent method and its applications to face alignment. In *Computer Vision and Pattern Recognition (CVPR), 2013 IEEE Conference on* (pp. 532-539). IEEE.

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

McDuff, Daniel, Abdelrahman Mahmoud, Mohammad Mavadati, May Amr, Jay Turcot, and Rana el Kaliouby. "AFFDEX SDK: a cross-platform real-time multi-face expression recognition toolkit." In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 3723-3726. ACM, 2016.

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.

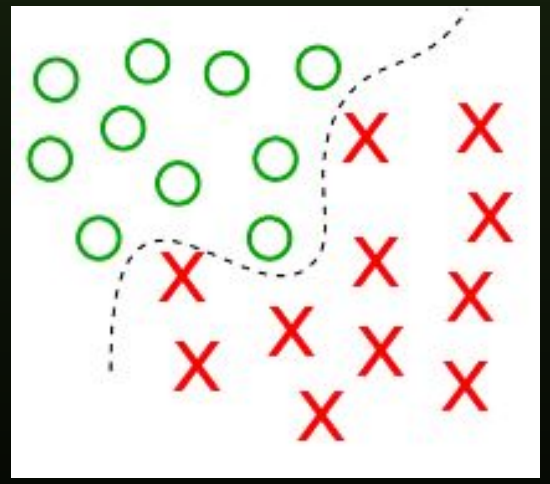


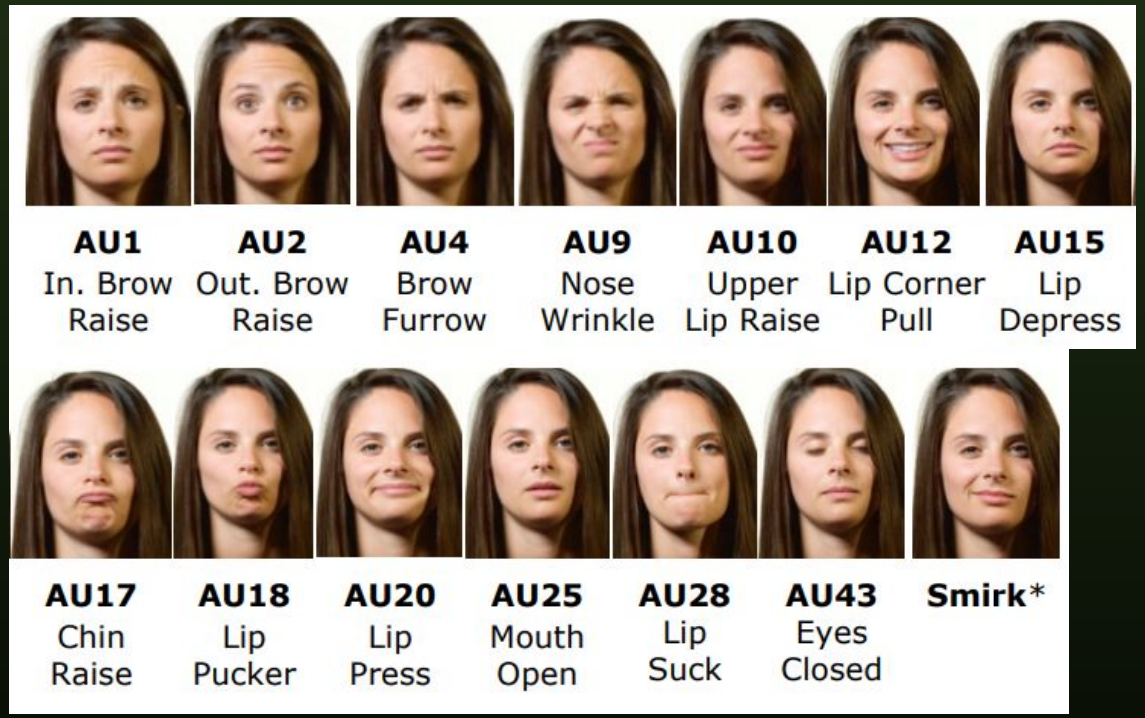
Dalal, N. and Triggs, B., 2005, June. Histograms of oriented gradients for human detection. In *Computer Vision and Pattern Recognition, 2005. CVPR 2005. IEEE Computer Society Conference on* (Vol. 1, pp. 886-893). IEEE.

McDuff, Daniel, Abdelrahman Mahmoud, Mohammad Mavadati, May Amr, Jay Turcot, and Rana el Kaliouby. "AFFDEX SDK: a cross-platform real-time multi-face expression recognition toolkit." In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 3723-3726. ACM, 2016.

Software Pipeline:
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.



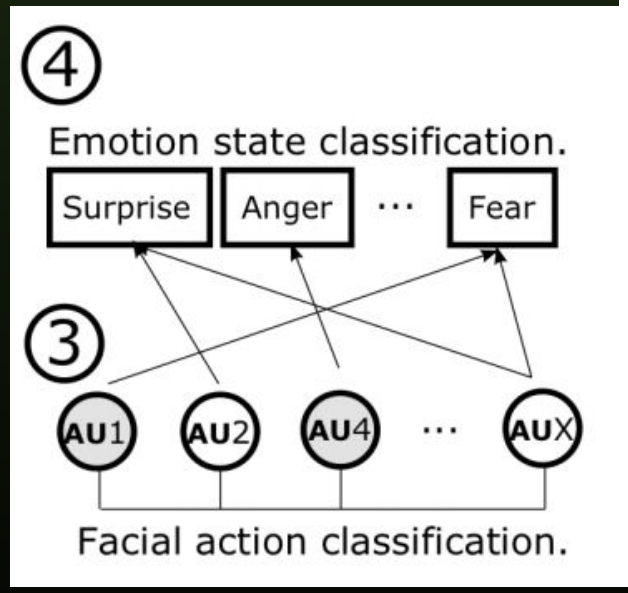


Senechal, T., McDuff, D. and Kaliouby, R., 2015. Facial action unit detection using active learning and an efficient non-linear kernel approximation. In *Proceedings of the IEEE International Conference on Computer Vision Workshops* (pp. 10-18).

McDuff, Daniel, Abdelrahman Mahmoud, Mohammad Mavadati, May Amr, Jay Turcot, and Rana el Kaliouby. "AFFDEX SDK: a cross-platform real-time multi-face expression recognition toolkit." In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 3723-3726. ACM, 2016.

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)).



Ekman, P., W. Irwin, and E. L. Rosenberg. "The emotional facial action coding system (EMFACS)." *London, UK* (1994).

McDuff, Daniel, Abdelrahman Mahmoud, Mohammad Mavadati, May Amr, Jay Turcot, and Rana el Kaliouby. "AFFDEX SDK: a cross-platform real-time multi-face expression recognition toolkit." In *Proceedings of the 2016 CHI Conference Extended Abstracts on Human Factors in Computing Systems*, pp. 3723-3726. ACM, 2016.