Emotions & Physiological Monitoring

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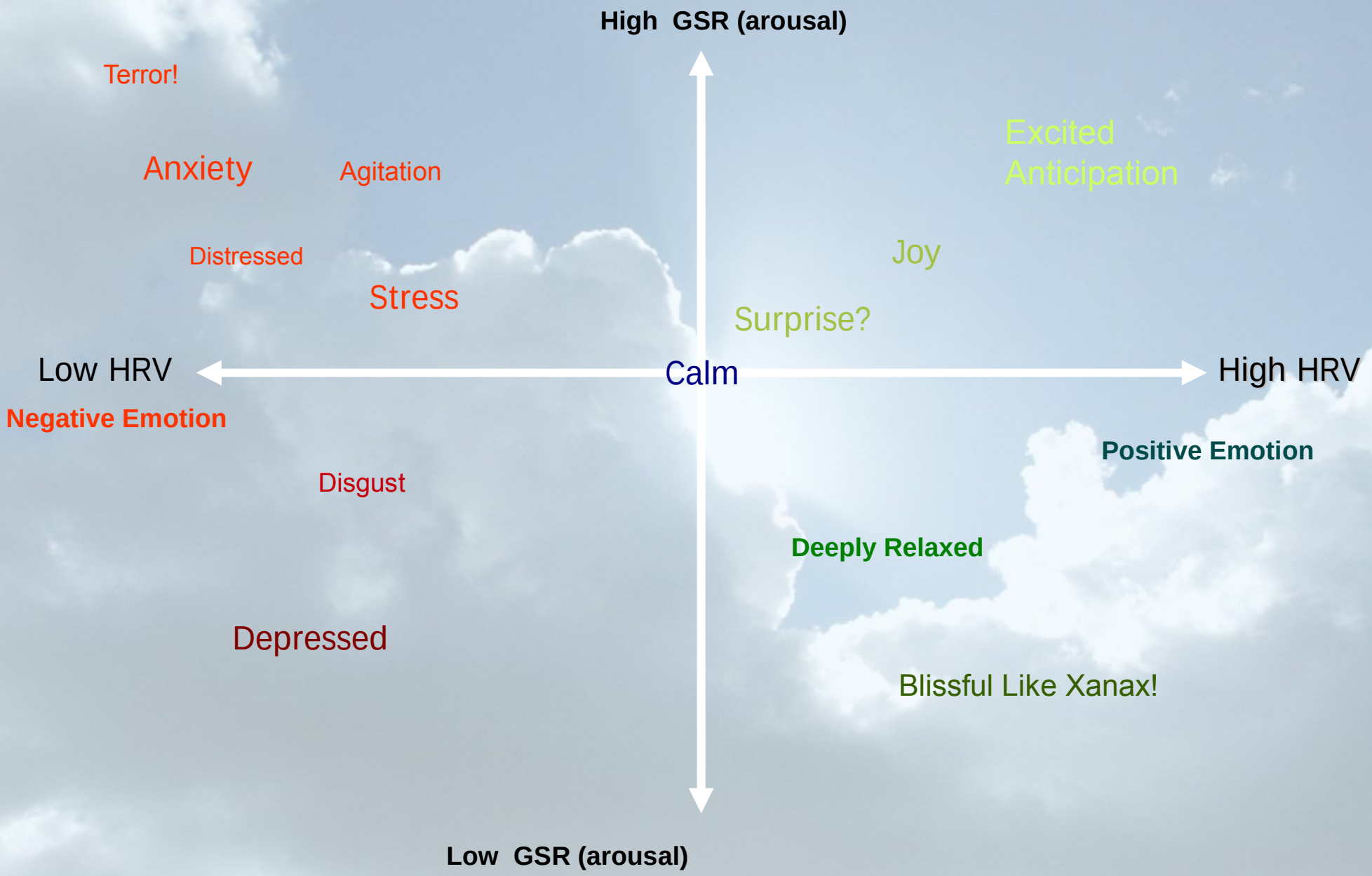
Emotions Model

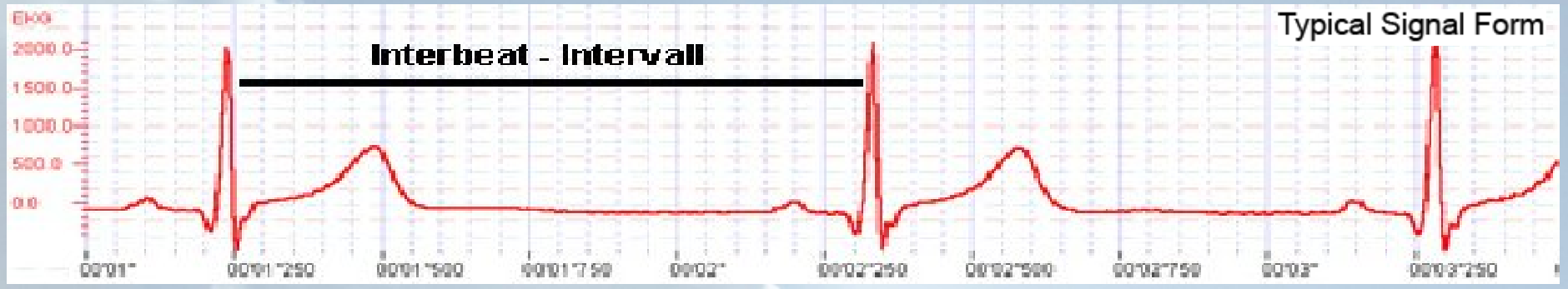


Physiological Monitoring

Various emotional expressions produce different changes in autonomic activity:

- Anger: increased heart rate
- Fear: increased heart rate
- Happiness: decreased heart rate

ECG (Electrokardiogram)



- Measures contractile activity of the heart
- On surface of chest or limbs
- Heart rate (HR), inter-beat intervals (IBI) and heart rate variability (HRV), respiratory sinus arrhythmia
- Emotional cues:
  - Decreasing HR: relaxation, happy
  - Decreasing HRV: stress, frustration, anger, etc.

ECG, HR, HRV

- The normal variability in heart rate, which can be determined from the electrocardiogram (ECG), or from the pulse wave, is due to the synergistic action of the two branches of the ANS.

- The ANS strives toward balance via neural, mechanical, hormonal and other physiological mechanisms in order to maintain cardiovascular (and other bodily system) parameters in their most favorable ranges to facilitate optimal reaction to changing external or internal conditions.

- Low HRV has been linked to psychological problems. A number of studies have demonstrated that patients with anxiety and phobias exhibit low HRV (Middleton, 1990; Kawachi, Sparrow, Vokonas & Weiss, 1995; Freidman & Thayer, 1998a; Freidman & Thayer, 1998b; Watkins, Grossman, Krishnan & Blumenthal, 1999).

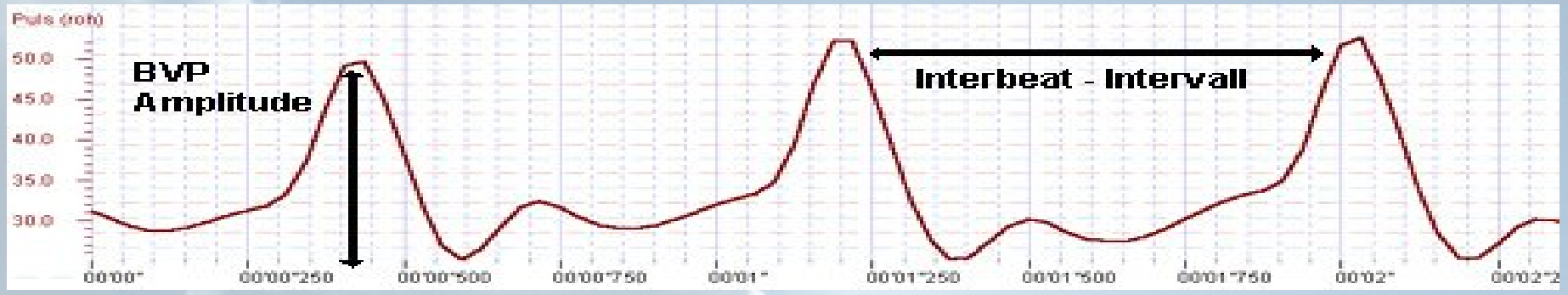
Heart Rate Variability

- Similarly, subjects with post traumatic stress disorder (PTSD) consistently show lower HRV, even when not exposed to a trauma related prompt, than those who did not have PTSD (Cohen, et al., 1998).

- Furthermore, data also suggests a connection between low HRV and depression (Carney, et al., 1995; Krittayaphong, et al, 1997), although not all studies found this association (Watkins, et al., 1999; Yeragani, et al., 1991) thus, some controversy still exists in this realm (Carney, Freedland & Stein, 2000).

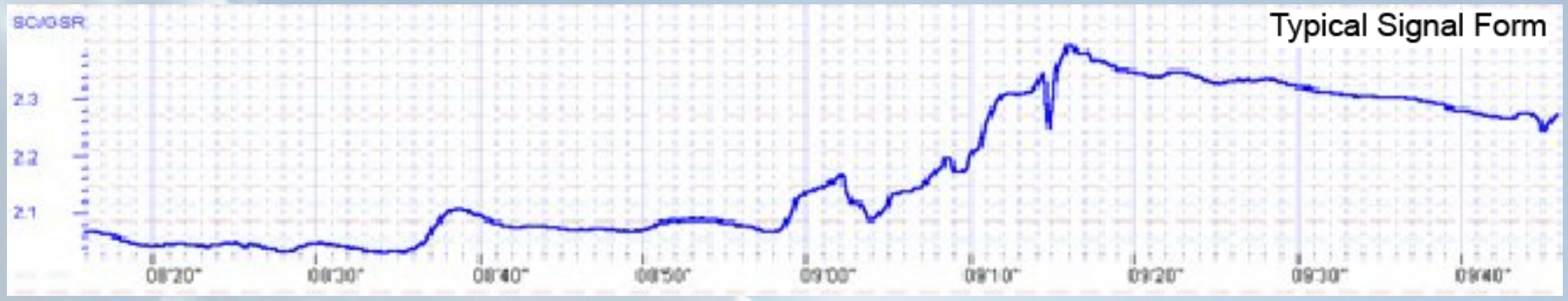
- Additionally, a more recent study (Dishman, et al., 2000), illustrated the relationship between low HRV and anxiety, and showed a statistically significant correlation between subjects' self-rated anxiety and emotional stress and low HRV. Importantly, this relationship existed independent of age, gender, trait anxiety, cardiorespiratory fitness, heart rate, blood pressure and respiration rate.

BVP (Blood Volume Pulse)



- Photoplethysmography, bounces infra-red light against a skin surface and measures the amount of reflected light.
- Palmar surface of fingertip
- Features: heart rate, vascular dilation (pinch), vasoconstriction
- Cues: Increasing BV- angry, stress
  - Decreasing BV- sadness, relaxation

SC (Skin Conductivity)



- Measure of skin's ability to conduct electricity
- Linear correlated with arousal
- Represents changes in sympathetic nervous system and reflects emotional responses and cognitive activity
- Cues: symathetic arousal

Galvanic Skin Response

- There is a relationship between sympathetic activity and emotional arousal, although one cannot identify the specific emotion being elicited.

- The GSR is highly sensitive to emotions in some people.
- Fear, anger, startle response, orienting response and sexual feelings are all among the emotions which may produce similar GSR responces.

Other Research

Ekman et al. (1983)

- Manual analysis of physiological signals (finger temperature, heart rate) anger, fear, sadness, happiness, disgust, and surprise
- Relative emotional cues
  - HR: anger, fear, sadness > happiness, surprise > disgust
  - HR Acceleration: anger > happiness

Cacioppo et al. (1993, 2000)

- Provide a wide range of links between physiological features and emotional states
- Anger increases diastolic blood pressure to the greatest degree, followed by fear, sadness, and happiness
- Anger is further distinguished from fear by larger increases in blood pulse volume
- “anger appears to act more on the vasculature and less on the heart than does fear”

Gross & Levenson (1995, 1997)

- Study to find most effective films to elicit discrete emotions, amusement, anger, contentment, disgust, fear, neutrality
- Amusement, neutrality, and sadness were elicited by showing films
- Skin conductance, inter-beat interval, pulse transit times and respiratory activation were measured
- Inter-beat interval increased for all three states, the least for neutrality
- Skin conductance increased after the amusement film, decreased after the neutral film and stayed the same after the sadness film.

Vyzas, Picard et al. (MIT Media Lab, 2000)

- Discriminating self-induced emotional states in a single subject (actress)
- Dataset: 20 days x 8 emotions x 4 sensors x 1 actress
- Emotion model: happiness, sadness, anger, fear, disgust, surprise, neutrality, platonic love, and romantic love
- Sensors: GSR (SC), BVP, RESP, EMG
- 11 features for each emotion
- Algorithms: SFFS (sequential forward floating search), Fisher projection, hybrid of these
- Overall accuracy 81.25% by hybrid method

Kim et al. (Univ. Augsburg, 2004)

- "Emote to Win": emotive game interfacing based on affective interactions between player and computer pet *("Tiffany")*
- Combined analysis of two channels, speech + biosignal in online
- Features
  - Speech: pitch, harmonics, energy
  - Biosignal: mean energy (SC/EMG), StdDeviation (SC, EMG), heart rate (ECG), subband spectra (ECG/RESP)
- Simple threshold-based online classification
- Hard to acquire reliable emotive information of users in online condition

Challenges

- Need to develop strong correlations between sensor data and emotion (robust signal processing and pattern matching algorithms)
- Too many dependency variables
- Skin-sensing requires physical contact, compared with camera and microphone
- Need to improve physiological sensor technology
  - Accuracy, robustness to motion artifacts, vulnerable to distortion
  - Wireless ambulant sensor system
- Most research measures artificially elicited emotions in a lab setting and from single subject
- Different individuals show emotion with different response in autonomic channels (hard for multi-subjects)
- Rarely studied physiological emotion recognition, literature offers ideas rather than well-defined solutions