A wee bit more
Cardiovascular Psychophysiology
…and then...

The Skeletomotor System

Measuring Vagal Influence
- Descending Vagal Influence slows HR
- Respiration interrupts this vagal influence
- The size of periodic oscillations due to respiration can therefore index the strength of the Vagal influence
- Note, however, that under some circumstances, there can be dissociation between RSA and presumed central cardiac vagal efferent activity (cf., Grossman & Taylor, 2007)
- Concerns over changes in rate, and to lesser extent depth
- See special issue of Biological Psychology, 2007 for more in depth treatment of these issues and more!

Impedance Cardiography
- Low energy high-frequency AC passed through thoracic region (1-4 mA, 100 KHz)
- Changes in impedance to signal created by mechanical events of cardiac cycle, especially changes in thoracic blood volume
- ΔZ is change in impedance
- dz/dt is 1st derivative of impedance signal Z
- R-Z is time from r-wave to peak ventricular contraction indicated in Z signal
- The “Heather” index – divide dz/dt by R-Z interval, putative measure of heart's ability to respond to stress

Cardiac Vagal Control and Modulation
  - Reptilian “Dumb”: Dorsal Motor Nucleus
    - Massive reduction in HR & conservation of oxygen.
    - Dive reflex – cold water on the face during breath hold
  - Phylogenetically newer “smart” Vagus
    - Originates from Nucleus Ambiguous
    - Modulates influence to:
      - Promote attentional engagement, emotional expression, and communication.
      - Mobilizes organism to respond to environmental demands
      - Phasically withdraws inhibitory influence, increasing HR
      - Upon removal of the environmental stressor, resumes its efferent signal
      - Slowing heart rate
      - Allows the organism to self-sooth
- This polyvagal theory is not without its critics (e.g., Grossman & Taylor, 2007).
Tonic Vs Phasic

- Tonic Level indexes capacity
- Phasic change indexes actualization of that capacity
- Attention:
  - higher vagal “tone” was associated with faster reaction time to a task requiring sustained attention
  - Hyperactive kids treated with Ritalin (Porges, Walter, Korb, & Sprague, 1975):
    - attentional skills improved
    - appropriate task-related suppression of heart rate variability was observed while performing the task requiring sustained attention
- Emotion:
  - Beauchaine (2001):
    - low baseline vagal “tone” is related to negative emotional traits
    - high vagal withdrawal is related to negative emotional states

Individual Differences in Cardiac Vagal Control (aka “Trait Vagal Tone”)

- Infants
  - Various sick infants have lower vagal tone (Respiratory Distress Syndrome, Hydrocephalic)
  - Infants with higher vagal tone (Porges, various years)
    - More emotionally reactive (both + & -)
    - More responsive to environmental stimuli (behaviorally and physiologically)
- Anxiety Disorders
  - Lower Vagal Tone in GAD (Thayer et al., 1996)
  - Lower Vagal Tone in Panic Disorder (Friedman & Thayer, 1998)
- Depression
  - Depression characterized by lower Vagal tone?
  - State dependent? (Chambers & Allen, 2002)
Can Vagal Control predict development of anxiety following stressors?

Table 1. Significant contrasts among patients, blood phobics, and controls.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Panic mean. (SD)</th>
<th>Blood phobia mean. (SD)</th>
<th>Control mean. (SD)</th>
<th>F ratio, df, p value</th>
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<tbody>
<tr>
<td>HRV (ms)</td>
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P. p-value; R. Blood phobia; C. Control.

Trait Vagal Tone as Moderator of Response following Bereavement

- Bereavement as a period of cardiovascular risk
- Disclosure as an intervention for Bereavement (O’Connor, Allen, Kaszniai, 2005)
- Overall, all folks get better, but no differential impact of intervention
- BUT... Vagal Tone as moderator

Fig. 5. Effect of the interaction between RSA adjusted for age and Time since initial assessment on TRA over a 1-year period. Although RSA is a continuous variable, for demonstrative purposes, its effect on TRA is plotted at ±1 SD from the mean. Error bars represent standard errors. RSA: respiratory sinus arrhythmia; SD: standard deviation; TRA: Theory of Mind Anxiety Scale.

Chambers and Allen (2002) *Psychophysiology*

Kogan, Allen, Weihs (2012) *Biological Psychology*
Fetal Vagal Control?

Do Maternal Behaviors Affect Fetal Cardiac Vagal Control?

Orienting, Attention, and Defense

SCR (by contrast)

OR Vs DR
Electromyography

Why Record EMG?
- Facial Musculature rich; emotional expressions; a “leaky channel of expression”
- Startle blink as a probe for affective valence
- Muscle tension in disorders and stress
- Record “pre-behavioral” motor output
  - Facial Expressions
  - Human Performance (e.g. incorrect channel EMG in forced-choice RT task)

The Expressive Face
- Clip 1
- Clip 2

Striated Muscle
- Large number of muscle fibers arranged in parallel
- “Striated” reflects that these fibers actually comprise smaller fibrils
  - Fibrils have repeating cross striations (Z-lines)
  - Fibrils plus tissue between = Sarcomeres

Striated Muscle
- During contraction:
  - Very small changes in length of filaments
  - But big changes in the distance between the Z-bands as the thick filaments slide between the thin
Innervation

- Muscle needs stimulation to contract
- The motor nerve
- Contains many motoneurons
- Each motoneuron branches into several axon fibrils
- At end of each axon fibril is a junction with the muscle fiber
- Known as the motor endplate

Innervation

- Each motoneuron innervates several to many muscles (innervation ratios 10:1 to 2000:1), but each muscle innervated by only one motoneuron
- Therefore, muscle fibers fire simultaneously or in concert with one another
- Stronger contractions due to either more motoneurons firing, or increases in rate of already firing motoneurons

Cartoon of how it works

What is EMG signal?

- Reflects electrical field generated by Muscle Action Potentials (MAPs)
- Small portion conveyed to surface via extracellular fluids to skin
- Can also record invasively with subcutaneous needle electrodes
Signal Recording

- MAPs summate in quasi-random fashion to produce resultant signal
- Range of ~10-500 Hz
- Amplitude of sub-microvolt to over 1000 microvolts
- Note overlap with 60 Hz range
  - Prepare ground site carefully; Differential amplifier will assist in removing 60 Hz
  - Prepare recording sites carefully to lower impedance
  - Shielded rooms and leads can help
  - Can also filter out this range, but may toss “baby with bathwater”

Signal Recording (cont’)

- Can use wide variety of electrodes
  - Ag-AgCl still preferred
  - Small size increases specificity of recording
- Skin Prep
  - Abrade to reduce impedance to < 5K Ω
  - Use Bipolar arrangements, in line with long direction of muscle of interest
  - Use common ground for all sites
  - Keep wires and such out of subject’s visual field
  - Describe placements precisely
    - Standard for location is Fridlund & Cacioppo (1986) for facial EMG placements

EMG Power

Signal Recording (cont’)

- Amplification
  - Differential amplifiers with common mode rejection
  - Actually double differential (ground)
  - Amplify voltages 1000-20000 times
  - May use on-line filter
  - Should pass 10-500 Hz
  - Digitization (more in next lecture)
    - Fast, very fast
    - Or, slower, following on-line signal processing

Signal Transformations

Corrugator “Frown”
A few Applications

- Startle Probe
- Subtle affect
  - Mere Exposure
  - Subliminal effects
  - Mortality Salience
  - Biofeedback of EEG -- outcome measure
  - Emotion Regulation -- outcome measure
  - Empathy -- individual difference measure

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From: Ruiz-Padilla, Sollers, Vila, & Thayer (2003) Psychophysiology

Figure 1. Mean startle amplitude as a function of baseline HRV and valence. Startle amplitudes are in microvolts.
The Phenomenon:

- People prefer stimuli to which they have been previously exposed to unfamiliar stimuli
- In absence of any reinforcement ("mere" exposure)
- Examples:
  - People we see incidentally in our routines
  - Songs
  - Scientific journal preferences
- Effect size $r=.26$ (Meta-analysis, Bornstein, 1989)

The logic:

- Evolutionary account Bornstein (1989)
  - It may be adaptive to prefer the familiar over the novel
  - Novel objects could present a potential threat
  - Organisms that had a fear of the strange and unfamiliar were more likely to survive, reproduce, and pass on genetic material
  - Preferring the familiar may thus be an adaptive trait that has evolved in humans and nonhumans
- Prediction:
  - Unfamiliar as compared with familiar stimuli may be associated with more negative attitudes because of the unfamiliar stimuli’s association with potential danger
  - Thus may see greater corrugator activity to novel than to familiar
  - No prediction for positive affect (Zygomaticus activity)

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Loosely translated from Harmon-Jones & Allen, 2001

Dimberg et al. Psychological Science 2000

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From Allen, Harmon-Jones, and Cavender (2001)
Allen, Cavender, Harmon-Jones. Psychophysiology, 2001

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Figure 1. Self-reported negative affect on a 7-point Likert scale, where 0 = “not negative at all” and 7 = “strongly negative.”

Ray, McRae, Ochsner, & Gross. Emotion, 2010

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Dimberg & Thunberg (2012) *Psych Journal*