A wee bit more Cardiovascular Psychophysiology …and then…

The Skeletomotor System

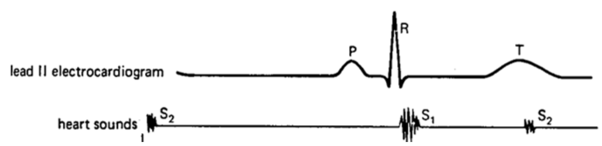
Announcements 2/25/13

- Electricity test – See me about retake if needed
- Lab meets Tuesday (2/26/13) Room 409
- Papers: 1 or 2 paragraph prospectus due no later than Monday March 25
- 3x5 time

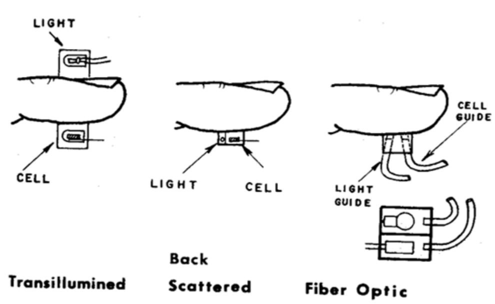
Returning to last time

Phonocardiography

- Position microphone over heart
- Lub-Dub is transduced to electrical signal

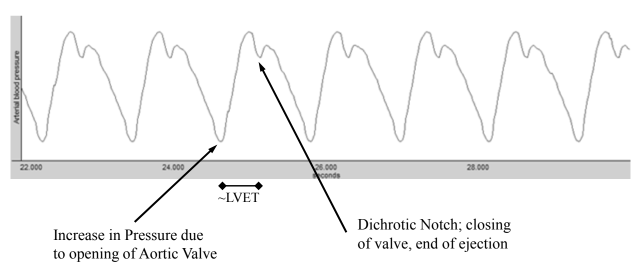


Photoplethysmography

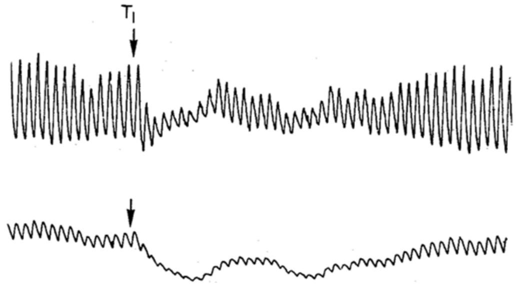


Three methods, all involve measuring light absorbed by peripheral vasulature

The Photoplethysmographic Output



Photoplethysmograph: Peripheral Vasoconstriction

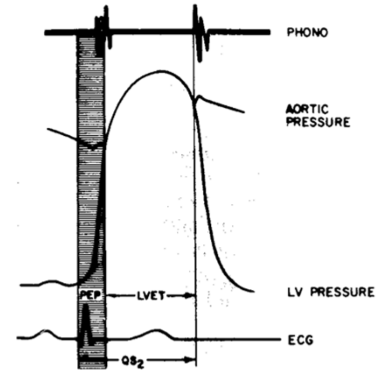


T1 is onset of constriction
Top Panel: Pulse Volume (recorded with 1 sec time constant)
Lower Panel: Blood Volume (no filter)

Measuring contractility with EKG, PCG, and Photoplethysmography

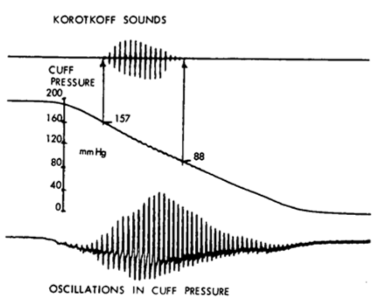
PEP = Pre-ejection period
LVET = Left Ventricular Ejection Time
= Upswing of pressure wave to S2
Electromechanical Systole = Q to S2
PEP = EMS – LVET

PEP reflects sympathetic influence on cardiac contractility



After Newlin & Levenson (1979) *Psychophysiology, 16*, 546-553

Measuring Blood Pressure



Auscultatory Technique
- Not good for instantaneous readings
- Not good for repeated readings

BP and Stress?

Psychophysiology, 45 (2008), 327–332. Blackwell Publishing Inc. Printed in the USA.
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DOI: 10.1111/j.1469-8986.2007.00622.x

Cardiovascular effects in adolescents while they are playing video games: A potential health risk factor?

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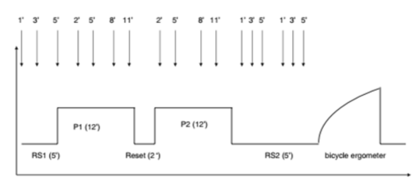


Fig 1. Study design (RS1, RS2 = resting phase 1 and 2; P1, P2 = video game phase 1 and 2; arrows indicating blood pressure measuring)

BP and Stress?

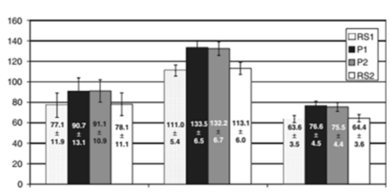


Fig 2. Mean values and SD of cardiovascular parameters during resting state and video game

Differences were significant for heart rate (HR), systolic (SBP) and diastolic blood pressure (DBP) comparing resting phases and game phases. No significant differences could be found comparing RS1 vs. RS2 and P1 vs. P2 (RS1, RS2 = resting phase 1 and 2; P1, P2 = video game phase 1 and 2).

- Significantly elevate BP during Video Game (VG)
- Energy consumption during Video Game unaltered compared to Rest, and significantly lower compared to Exercise!
- "Comparing all measured parameters it can be said that the relation of blood pressure and energy consumption during VG might not be favorable."

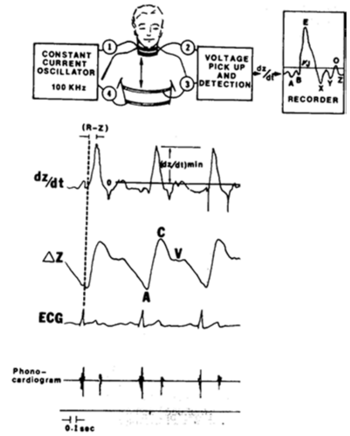
Ballistocardiography

- Imagine
  - On a chair on a platform on an air hockey table
  - Cardiac events cause movement of platform
- New applications:
  - Finding individuals hiding in vehicles
  - Finding individuals stuck in rubble

Ballistocardiography

Impedance Cardiography

- Low energy high-frequency AC passed through thoracic region
- 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



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!
- Demo with QRSTool

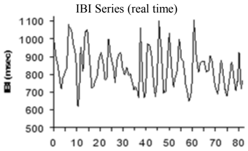
Abbreviated History of HR Variability

(with thanks to Porges, 2007)

- Physiology treated HR as DV, similar to behavior
- Dominance of behaviorism emphasized control over the DV (behavior)
- Changes in HR unrelated to the manipulation considered noise
  - Lacey (1967) and Obrist (1981) had models related to attention, and metabolic demand, but HR *variability* did not fit in either model
  - Via appropriate experimental design, HR should be entirely under the control of experimental or environmental demands
- Nonetheless, history of quantifying HR variability dates to the 1950's with case report long before that:
  - 1958: Lacey and Lacey, greater HRV associated with greater impulsivity
  - 1915: Eppinger and Hess, described a vagotonic syndrome with clinical features that included an exaggerated RSA
  - Interest in HRV as an *individual difference* variable, however, really starts with the work of Steve Porges

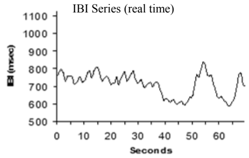
High Variability Subject

IBI Series (real time)

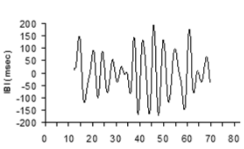


Low Variability Subject

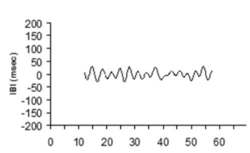
IBI Series (real time)



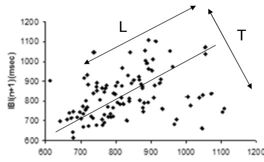
.12-.40 Hz filtered IBI Time Series



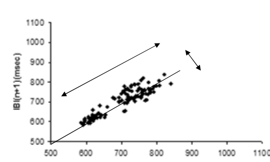
.12-.40 Hz filtered IBI Time Series



High Variability Subject



Low Variability Subject



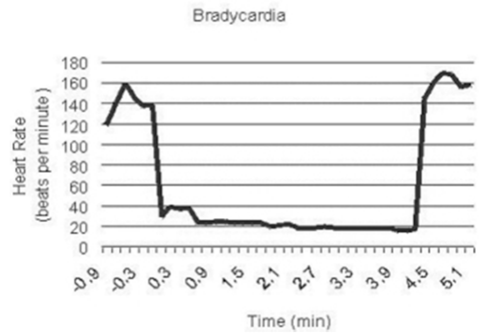
	Rate	
73.3	HR	85.7
832.3	IBI	707.7
	Total Variability	
9.2	HRV	8.3
112.4	SDNN	66.3
132.8	RMSSD	27.7
	"Sympathetic"	
1.4	CSI	4.7
	"Parasympathetic"	
57.1	PNN50	10.8
97.6	MCD	22.0
5.3	CVI	4.5
8.8	RSA	5.3

Metrics output by CMetX, with notes concerning computation

Metrics of rate, which are influenced by both parasympathetic (PNS) and sympathetic (SNS) influences
Mean interbeat interval (IBI), calculated as simple average of IBIs
Mean heart rate (HR), calculated as the average of the rate-transformed IBIs, not as the rate-transformation of the average IBI
Metrics summarizing total heart rate variability, which are influenced by both SNS and PNS
Heart rate variability (HRV), operationalized as the natural log of the variance of the IBI time series
Standard deviation of IBI series (SDNN); NN in the acronym SDNN is the abbreviation for "normal-to-normal intervals," which is the artifact-free IBI series
Root mean square of successive differences between IBIs (RMSSD)
Putative sympathetic metric
A cardiac sympathetic index (CSI; Toichi et al. (1997), see Fig. 1)[a]
Putative parasympathetic metrics
Mean absolute successive IBI difference (MSD)
Proportion of consecutive IBI differences >50 ms (pnn50)
Respiratory sinus arrhythmia (RSA), defined as natural log of band-limited (.12–.40 Hz) variance of IBI time series
A cardiac vagal index (CVI; Toichi et al. (1997), see Fig. 1)[a]

Cardiac Vagal Control and Modulation

- Two Vagal Efferent Branches which terminate on SA Node (Porges 1995, 2003, 2007)
  - Reptilian "Dumb": Dorsal Motor Nucleus
    - Massive reduction in HR & conservation of oxygen.
    - Dive reflex -- cold water on the face during breath hold
  - Phylogentically newer "smart" Vagus
    - Orginates from Nucleus Ambiguous
    - Modualtes influence to:
      - Promote attentional engagement, emotional expression, and communication.
    - Mobilizes organism to respond to environmental demands
      - Phasicly 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).



Bradycardia observed in a diving seal. **Data adapted from R.S. Elsner (1998), courtesy of http://www.deeperblue.net/article.php/225**

	ANS Component	Behavioral Function	Lower motor neurons
III	Myelinated vagus *(ventral vagal complex)*	Social communication, self-soothing and calming, inhibit "arousal"	Nucleus ambiguus
II	Sympathetic-adrenal system	Mobilization (active avoidance)	Spinal cord
I	Unmeyelinated vagus *(dorsal vagal complex)*	Immobilization (death feigning, passive avoidance)	Dorsal motor nucleus of the vagus

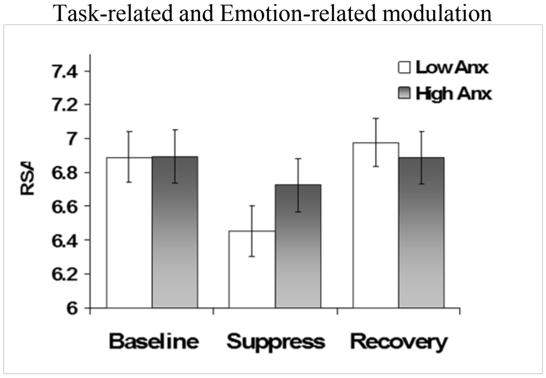
Fig. 1. Phylogenetic stages of the polyvagal theory.

Porges, 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

Task-related and Emotion-related modulation



Movius & Allen, 2005

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)

BIOL PSYCHIATRY 259
1996;39:255–266

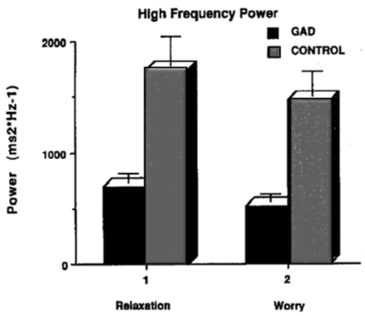
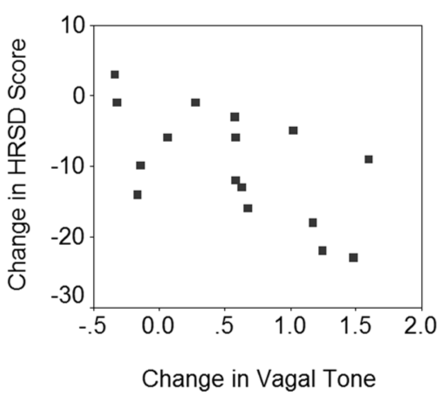


Figure 1. Power in the high frequency (respiratory) component of heart period variability in GAD patients and controls during relaxation and worry.

Table 1
Significant contrasts among panickers, blood phobics, and controls

Variable	Panic (mean, S.D.)	Blood phobic (mean, S.D.)	Control (mean, S.D.)	*T* ratio, df, *p* value
IBI (ms)	761.8 (141.0)	837.1 (92.4)	905.2 (132.5)	P<B 4.59 (215) $p<0.001$ P<C 7.65 (214) $p<0.001$ B<C 4.30 (207) $p<0.001$
VAR (ms^2)	3942 (4009)	4334 (2663)	6112 (4563)	P<C 3.70 (214) $p<0.001$ B<C 3.44 (207) $p<0.001$ P=B N.S.
MSD (ms)	44.4 (31.2)	55.6 (22.7)	71.4 (32.1)	P<B 3.05 (215) $p<0.001$ P<C 6.34 (214) $p<0.001$ B<C 4.11 (207) $p<0.001$
HF power (ms^2 Hz^{-1})	991 (1225)	1385 (1073)	2239 (1911)	P<B 2.49 (212) $p<0.01$ P<C 5.67 (212) $p<0.001$ B<C 3.90 (203) $p<0.001$
LF/HF	2.1(2.5)	1.3 (1.8)	1.0 (1.5)	P<B 2.41 (209) $p<0.005$ P<C 3.64 (203) $p<0.001$ B=C N.S.

P, panic; B, blood phobic; C, control.



Chambers and Allen (2002) *Psychophysiology*

Can Vagal Control predict development of anxiety following stressors?

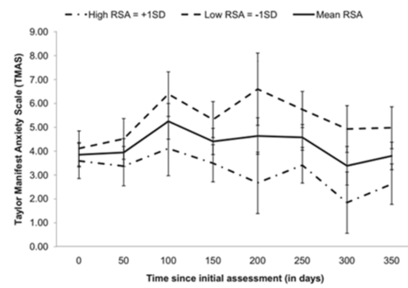
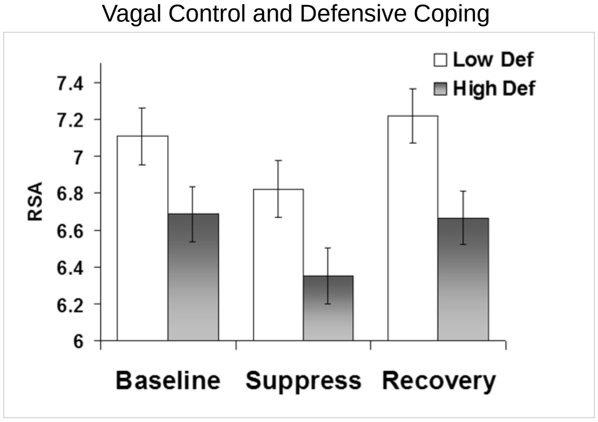


Fig. 1. Effect of the interaction between RSA adjusted for age and Time since initial assessment on TMAS over a 1-year period. Although RSA is a continuous variable, for illustrative purposes, its effect on TMAS is plotted at ±1 SD from the mean. Error bars represent standard errors. RSA: respiratory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

Kogan, Allen, Weihs (2012)
Biological Psychology

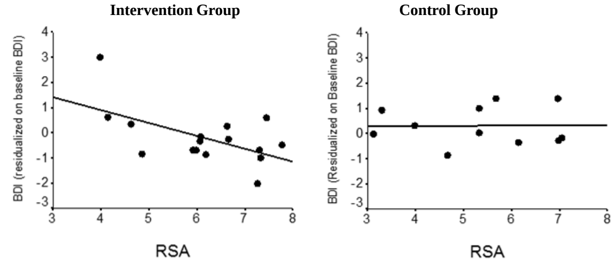
Vagal Control and Defensive Coping



Movius & Allen, 2005

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, Kaszniak, 2005)
- Overall, all folks get better, but no differential impact of intervention
- BUT… Vagal Tone as moderator



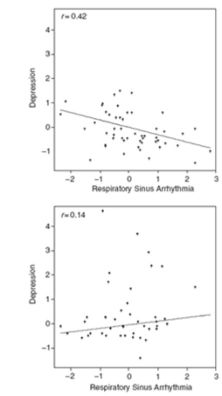


Figure 1. Scatterplot, prediction line, and prediction equation for the relationship between respiratory sinus arrhythmia (log of the variance of the band-limited [.12–.40 Hz] IBI series) and depression score (residualized on baseline depression score), for the disclosure group (top panel) and the control group (bottom panel). Negative depression score represents improvement from baseline to follow-up.

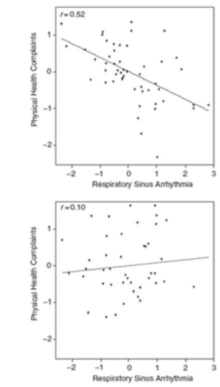
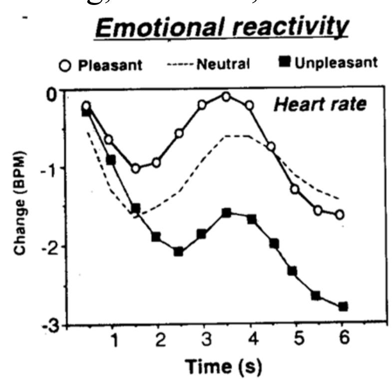
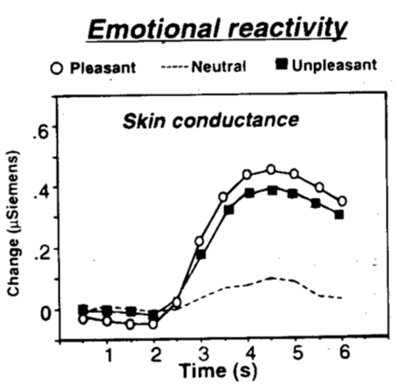


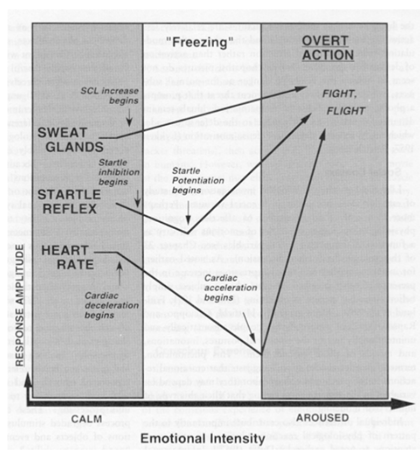
Figure 2. Scatterplot, prediction line, and prediction equation for the relationship between respiratory sinus arrhythmia (log of the variance of the band-limited [.12–.40 Hz] IBI series) and physical health complaint score (residualized on baseline physical health complaints score) for the disclosure group (top panel) and the control group (bottom panel). Negative physical health complaint score represents improvement from baseline to follow-up.

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
- 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

The Muscle

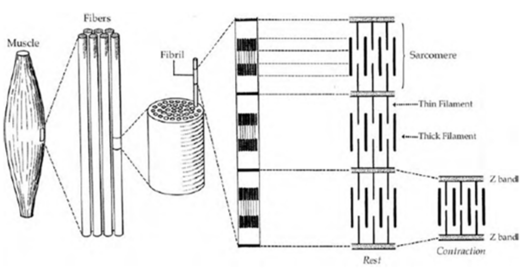


Figure 12.2. Diagram of the structure of the muscle with increasing magnification going from left to right. The bottom right corner of the figure illustrates the microgeometric changes that occur with contraction. (Modified from Figure 10.7 of Schmidt-Nielsen, 1997).

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
- 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

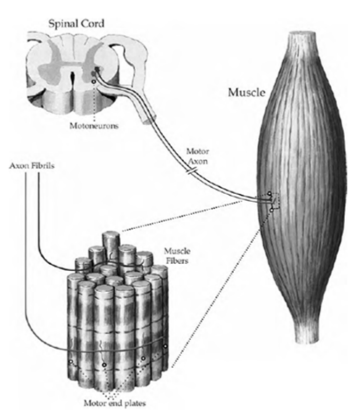
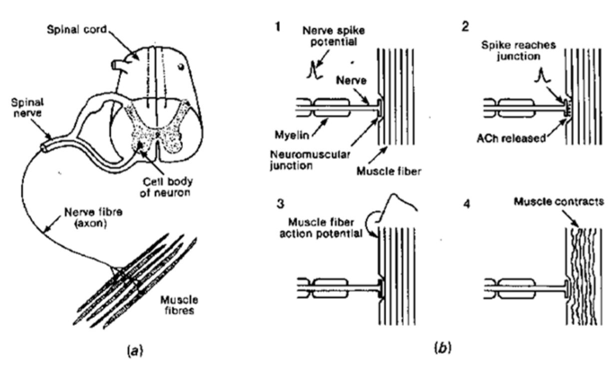


Figure 12.3. Diagram of two motor units. (Modified from slide 3705 of Netter, 1991).

Cartoon of how it works




Botox rumours put spite into White House race
By Tim Shipman in Washington, Sunday Telegraph
Last Updated: 12:56am BST 10/06/2007

Hillary Clinton's enemies have long criticised her political -makeover, from the liberal firebrand First Lady to the moderate senator and White House candidate that she is today.

Now, the frontrunner for the Democratic presidential nomination is the subject of a whispering campaign suggesting that she has also undergone a physical makeover - with Botox injections to enhance her appearance.

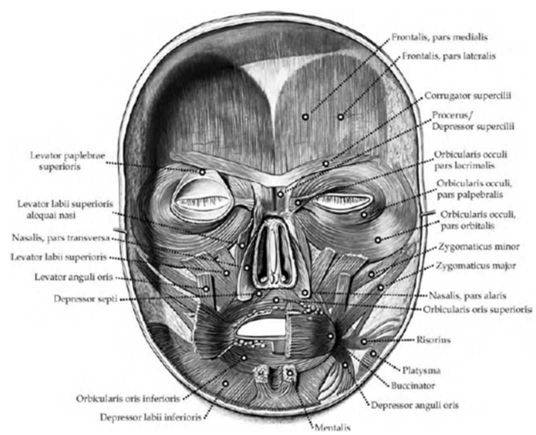
Sen Clinton's fresh-faced demeanour at last weekend's New Hampshire presidential

Botox and Prozac Gets a Thumbs Up

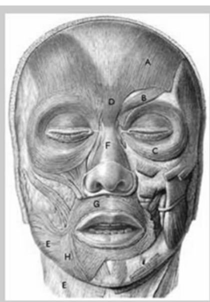
VP nominee Paul Ryan may only be 42, but Dr. Spiegel thinks he could use some Botox, stat. Although the doc commends his great head of hair, his very "expressive" face makes his forehead look like "corduroy pants up there."

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



The Facial Muscles



The primary muscles of facial expression treated with BOTOX:
(A) Frontalis
(B) Corrugator and Depressor supercilli complex
(C) Orbicularis oculi
(D) Procerus
(E) Platysma
(F) Nasalis
(G) Orbicularis oris
(H) Depressor anguli oris

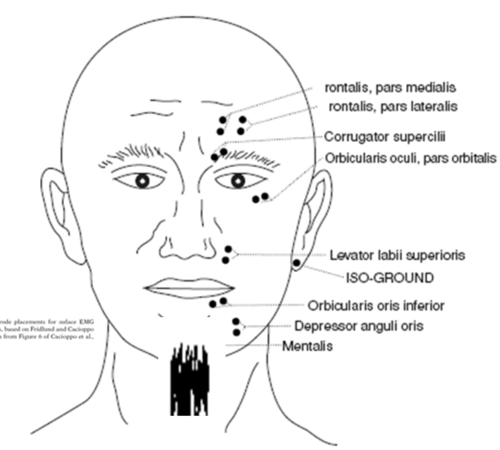
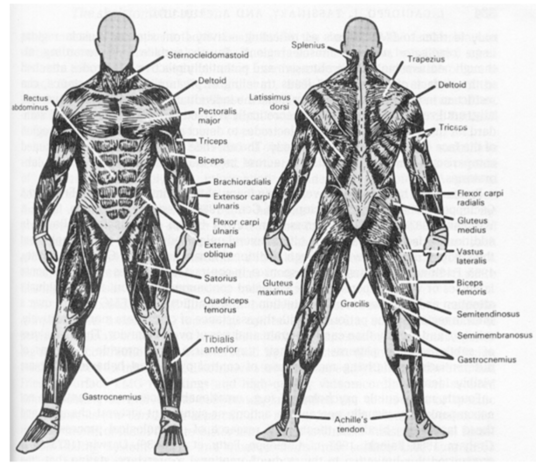
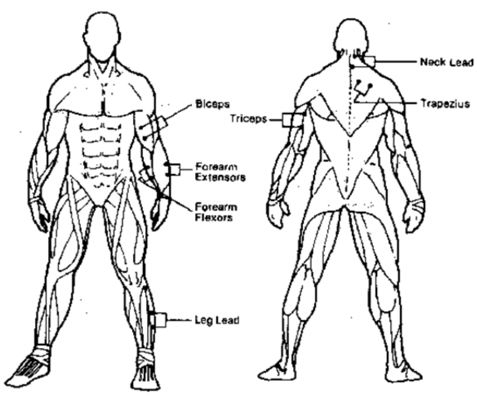


Figure 12.4. Suggested electrode placements for suface EMG recording of the facial muscles, based on Fridlund and Cacioppo (1986). (Modified and redrawn from Figure 6 of Cacioppo et al., 1990c).

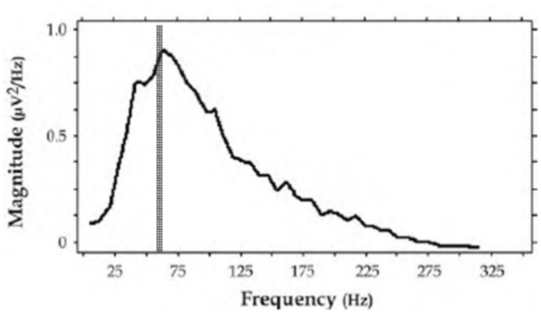




Signal Recording

- 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”

EMG Power

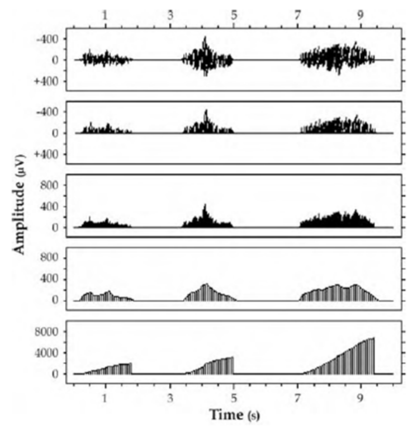


Signal Recording (cont’)

- 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

Signal Recording (cont')

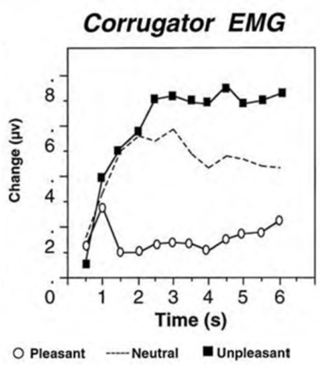
- Amplification
  - Differential amplifiers with common mode rejection
  - Actually double differential (ground)
- Amplify voltages 1000-20000 times
- May use on-line filter
  - Should pass 10-500 Hz
- Digitization (more in next lecture)
  - Fast, very fast
  - Or, slower, following on-line signal processing



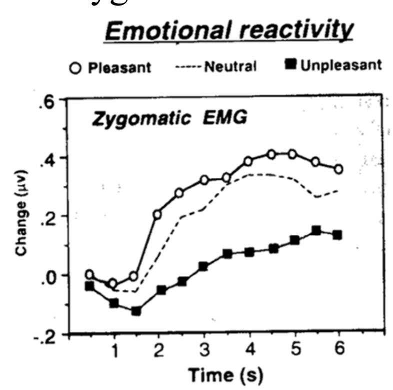
Signal Transformations

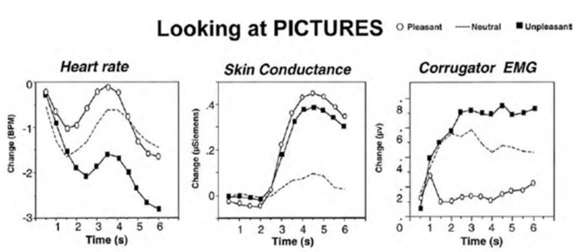
Demos

Corrugator "Frown"



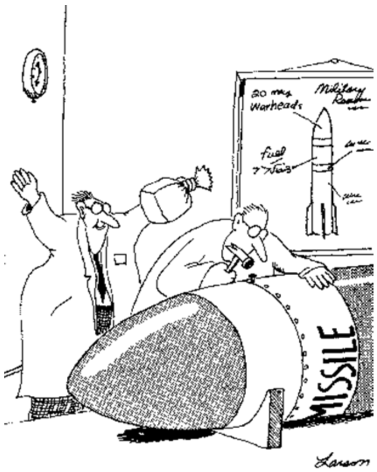
Zygomatic "Smile"



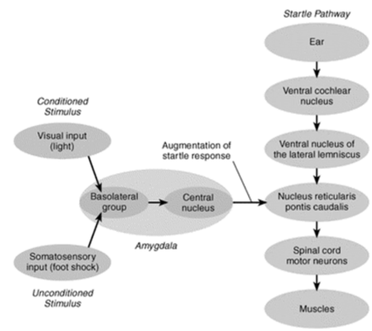


A few Applications

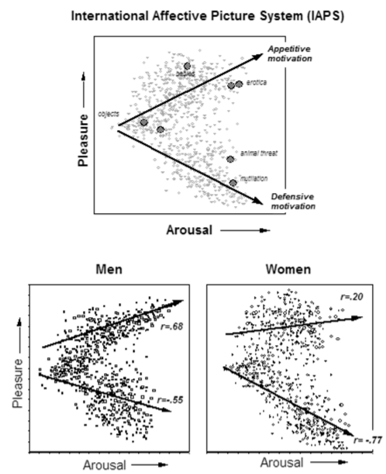
- Startle Probe
- Subtle affect
  - Mere Exposure
  - Subliminal effects
  - Mortality Salience
  - Biofeedback of EEG -- outcome measure
  - Emotion Regulation – outcome measure
  - Empathy – individual difference measure

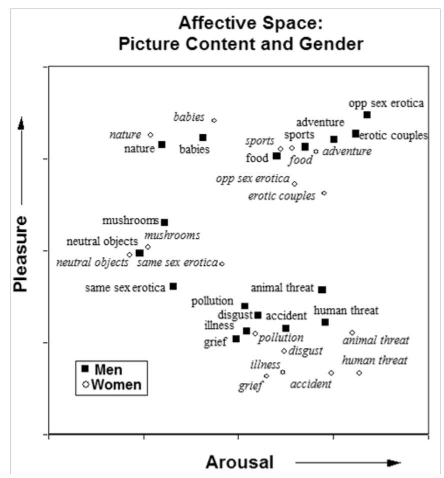


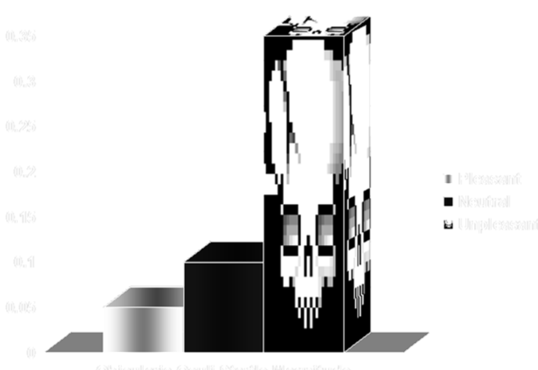
► **Neural Circuits Responsible for an Auditory Startle Response and for Its Augmentation by Conditioned Aversive Stimuli**

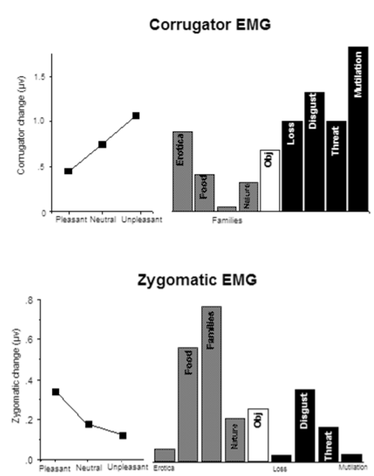


Source: Adapted from Davis, M., *Trends in Pharmacological Sciences*, 1992, *13*, 35–41.









Resting HRV as moderator of Startle Potentiation

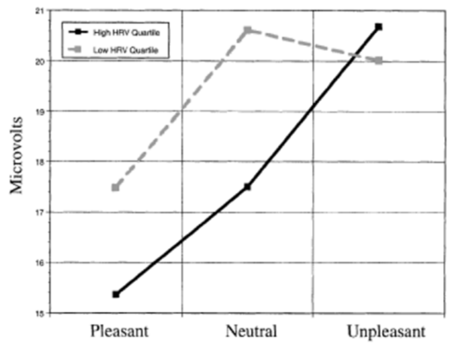


Figure 1. Mean startle amplitude as a function of baseline HRV and valence. Startle amplitudes are in microvolts.

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

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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)

Loosely translated from Harmon-Jones & Allen, 2001

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D… ., & Elmehed, K. (2000). Unconscious facial reactions to emotional facial ex… *…al Science, 11*

Dimberg et al *Psychological Science* 2000

PSYCHOLOGICAL SCIENCE

Unconscious Facial Reactions

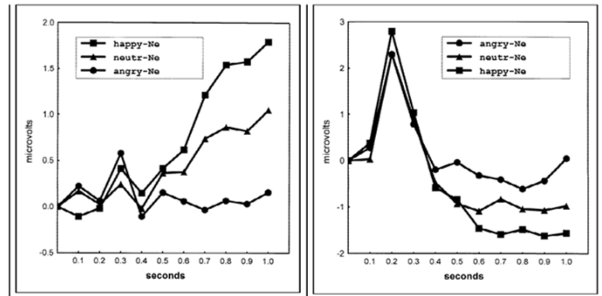

Fig. 1. Mean facial electromyographic response for the *zygomatic major* muscle, plotted in intervals of 100 ms during the first second of exposure. Three different groups of participants were exposed to identical neutral faces ("Ne"), preceded by unconscious exposure of happy, neutral ("neutr"), or angry target faces, respectively.

Fig. 2. Mean facial electromyographic response for the *corrugator supercilii* muscle, plotted in intervals of 100 ms during the first second of exposure. Three different groups of participants were exposed to identical neutral faces ("Ne"), preceded by unconscious exposure of angry, neutral ("neutr"), or happy target faces, respectively.

Dimberg et al *Psychological Science* 2000

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Another loose translation: Arndt, J., Allen, J.J.B., & Greenberg, J. (2001). Traces of terror: Subliminal death primes and facial electromyographic indices of affect. *Motivation and Emotion, 25*, 253-277.

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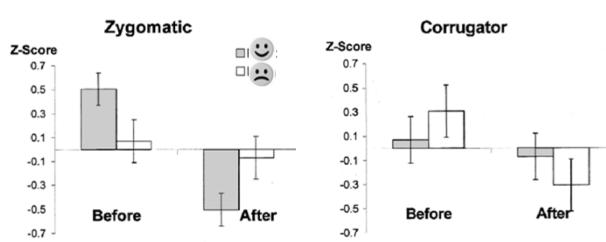

From Allen, Harmon-Jones, and Cavender (2001)

Allen, Cavender, Harmon-Jones, *Psychophysiology* 2001

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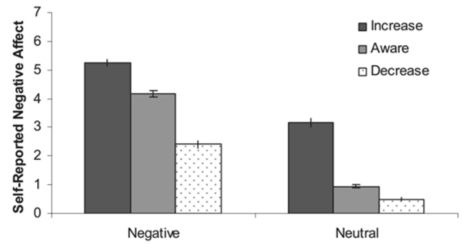

Figure 1. Self-reported negative affect on a 7-point Likert scale, where 0 = "not negative at all" and "7" = "strongly negative."

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

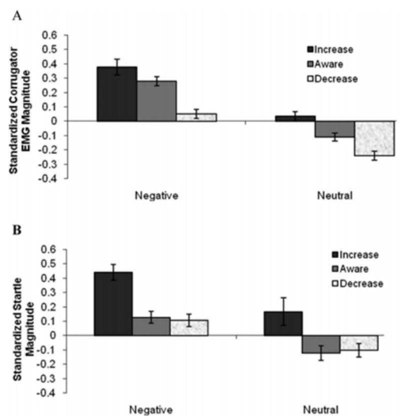

Figure 2. Standardized (A) corrugator EMG and (B) startle magnitude (averaged over Times 1 and 2).

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

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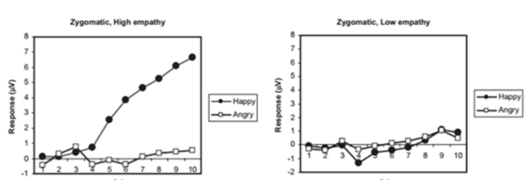

Figure 1. The *zygomaticus major* muscle response to pictures of happy and angry facial expressions for the High and Low empathy groups, plotted as a function of 100-ms intervals during the first second after stimulus onset.

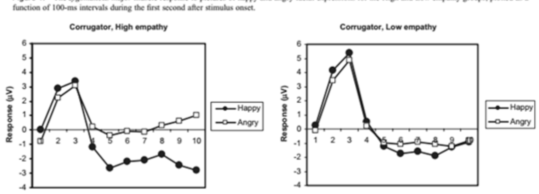

Figure 2. The *corrugator supercilii* muscle response to pictures of happy and angry facial expressions for the High and Low empathy groups, plotted as a function of 100-ms intervals during the first second after stimulus onset.

Dimberg & Thunberg (2012) *PsyCh Journal*