A wee bit more Cardiovascular Psychophysiology

…and then…

The Skeletomotor System

Announcements 2/29/16

- Happy Leap Day!
- Electricity test – See me about retake if needed
- Lab: Get your scored data done by tomorrow!
- 3x5 time

Last session's 3-by-5's (and other inquiries)

Could you speak a little more about conditions under which RSA might be a problematic measure?

- Rate and volume of respiration are possible confounds
- Must examine to be sure differences in RSA cannot be accounted for by differences in rate (easy) or volume (difficult)

cf. Grossman et al. (1991) *Psychophysiology, 28,* 201-16.

- Baroreceptors adapt to <u>sustained</u> changes in arterial pressure.

RS is defined as the change in terbeat interval (IBI) in illiseconds per unit change in P. Change = Δ Systolic BP (ISI) or example, when the BP rises 10 mmHg and IBI increases by 00 ms, BRS would be 00/10 = 10 ms/mmHg.
P can be manipulated (pharmacologically, challenges) or can take advantage of normal fluctuations

- BRS accounts for large proportion of RSA (r~=.8), suggesting some other mechanisms as well

Returning to last time

BP and Stress?

Psychophysiology, *45* (2008), 327–332. Blackwell Publishing Inc. Printed in the USA.

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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[b]Zentrum für Kinder- und Jugendmedizin, Evangelisches Krankenhaus Oberhausen, Oberhausen, Germany

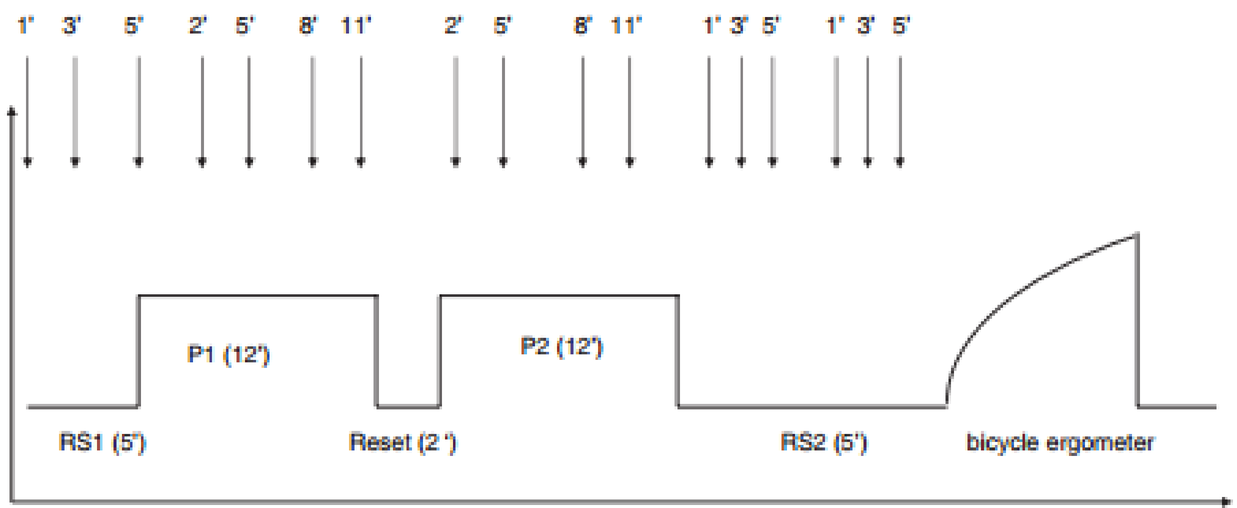


Fig 1. Study design (RS1, RS2 = resting phase 1 and 2; P1, P2 = video game phase 1 and 2; arrows indicating blood pressure measuring)

BP and Stress?

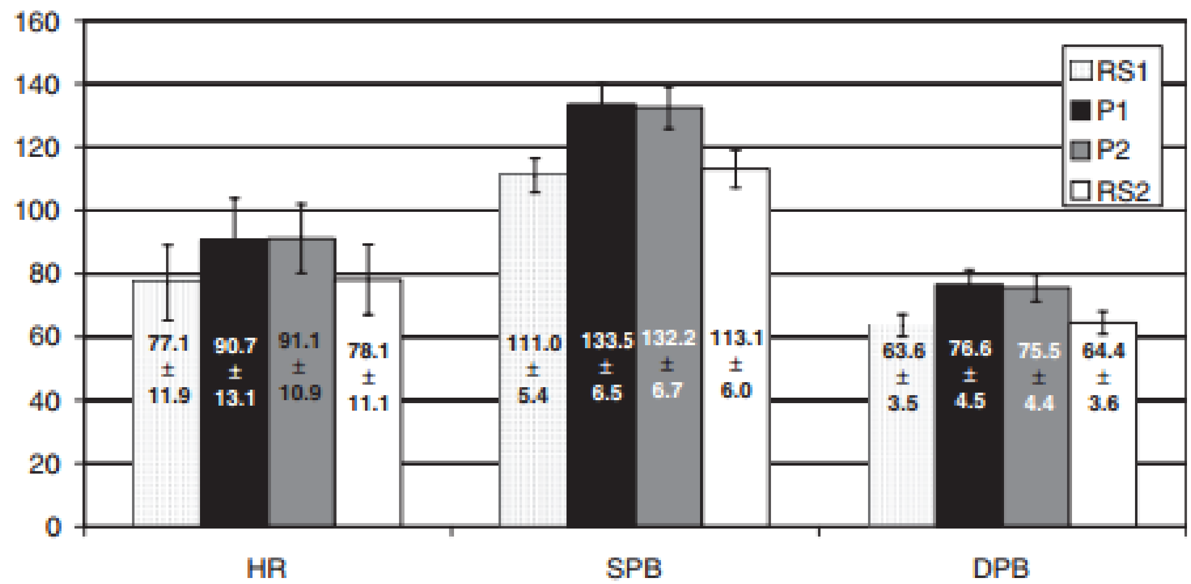
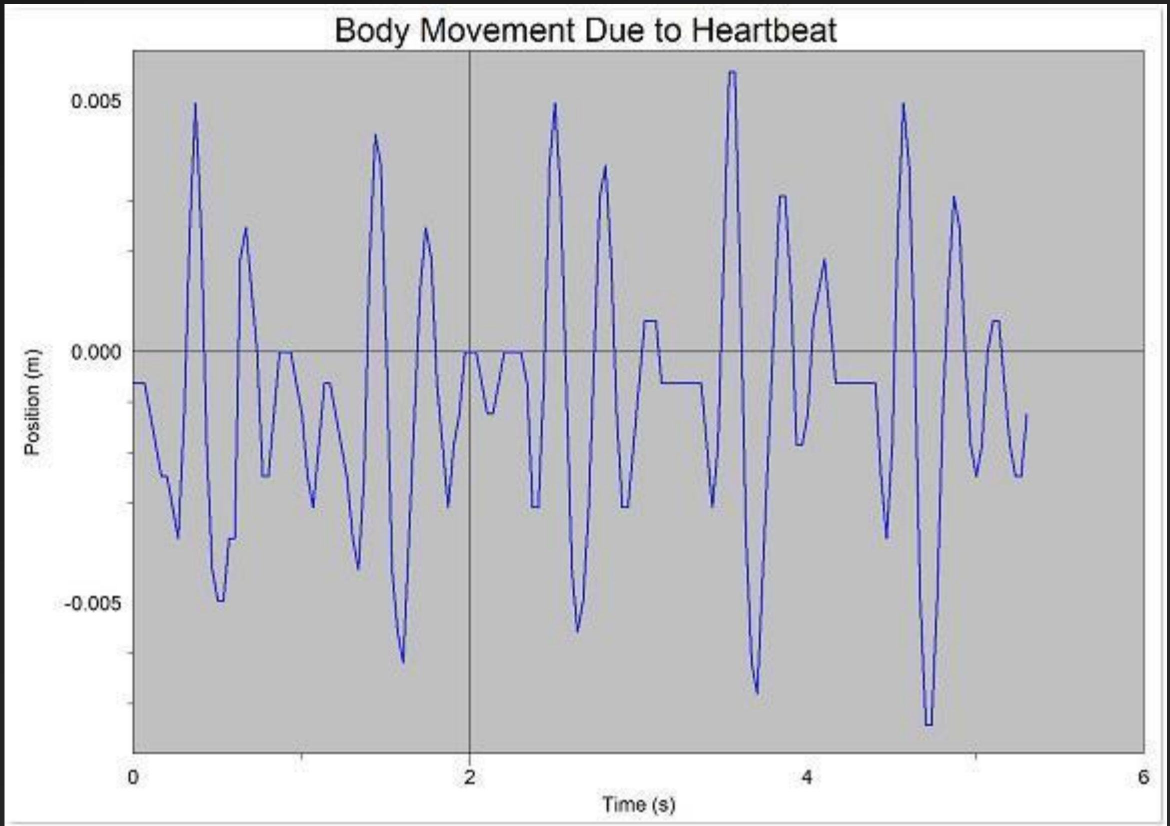


Fig 2. Mean values and SD of cardiovascular parameters during resting state and video game

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).

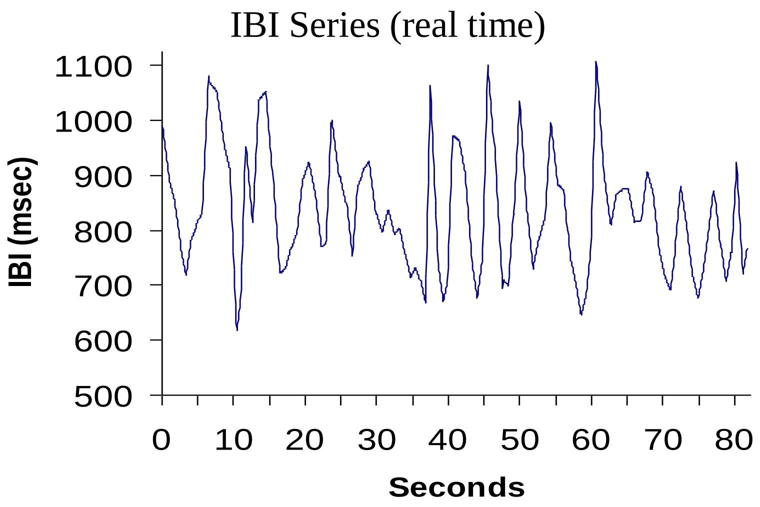
- Significantly elevate BP during Video Game (VG)
- Energy consumption during Video Game unaltered compared to Rest, and significantly lower compared to Exercise!
- “Comparing all measured parameters it can be said that the relation of blood pressure and energy consumption during VG might not be favorable.”

Ballistocardiography



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!


IBI Series (real time)
IBI (msec)
1100
1000
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700
600
500
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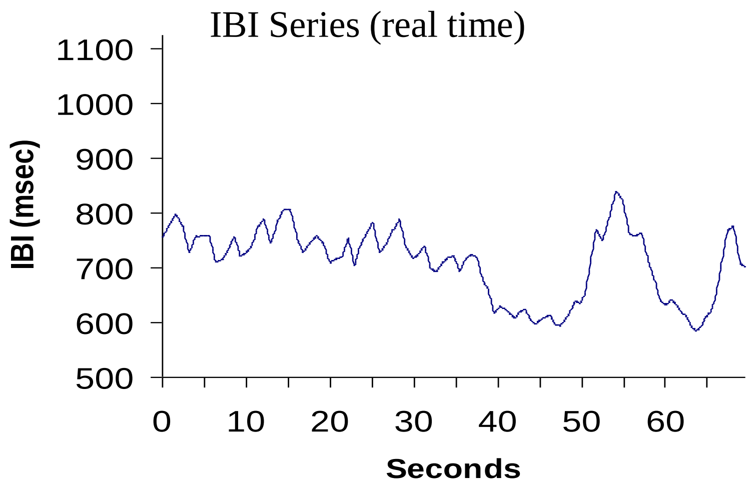
10
20
30
40
50
60
70
80
Seconds


IBI Series (real time)
IBI (msec)
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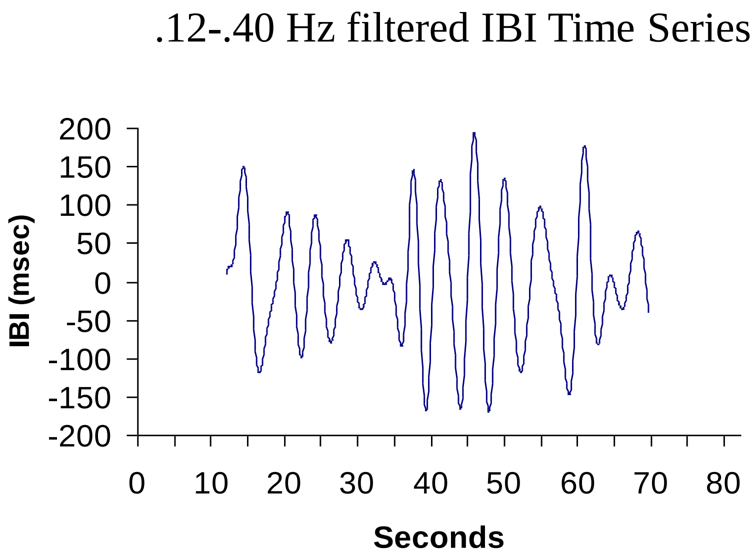
.12-.40 Hz filtered IBI Time Series
IBI (msec)
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-50
-100
-150
-200
0
10
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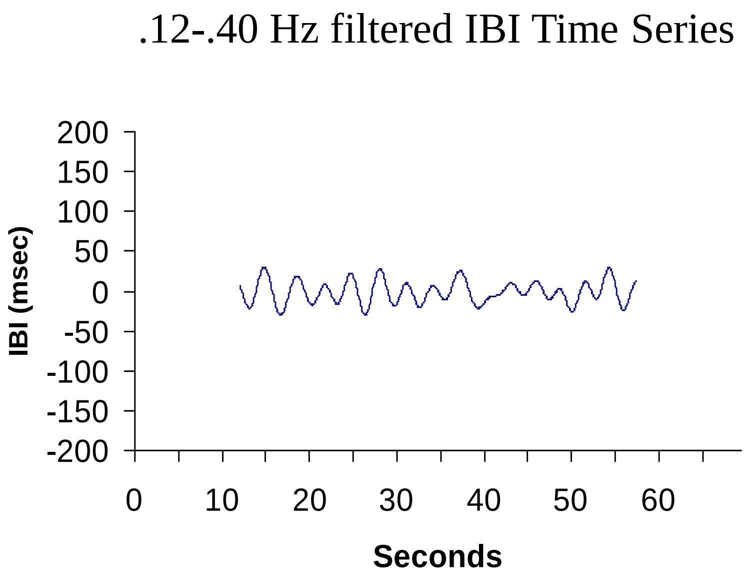
60
70
80
Seconds


.12-.40 Hz filtered IBI Time Series
IBI (msec)
200
150
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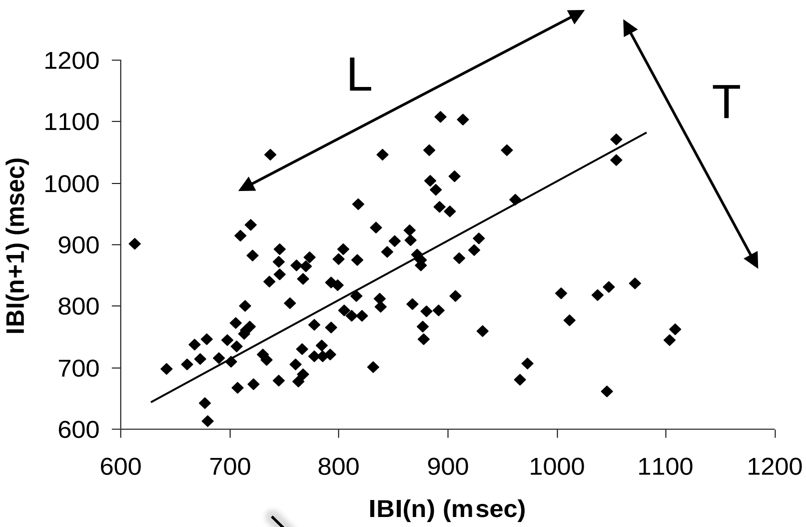
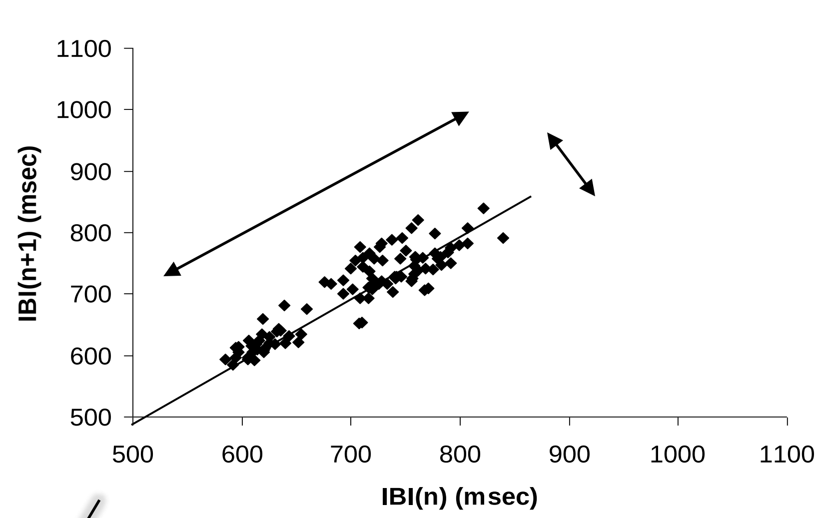
Seconds

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)

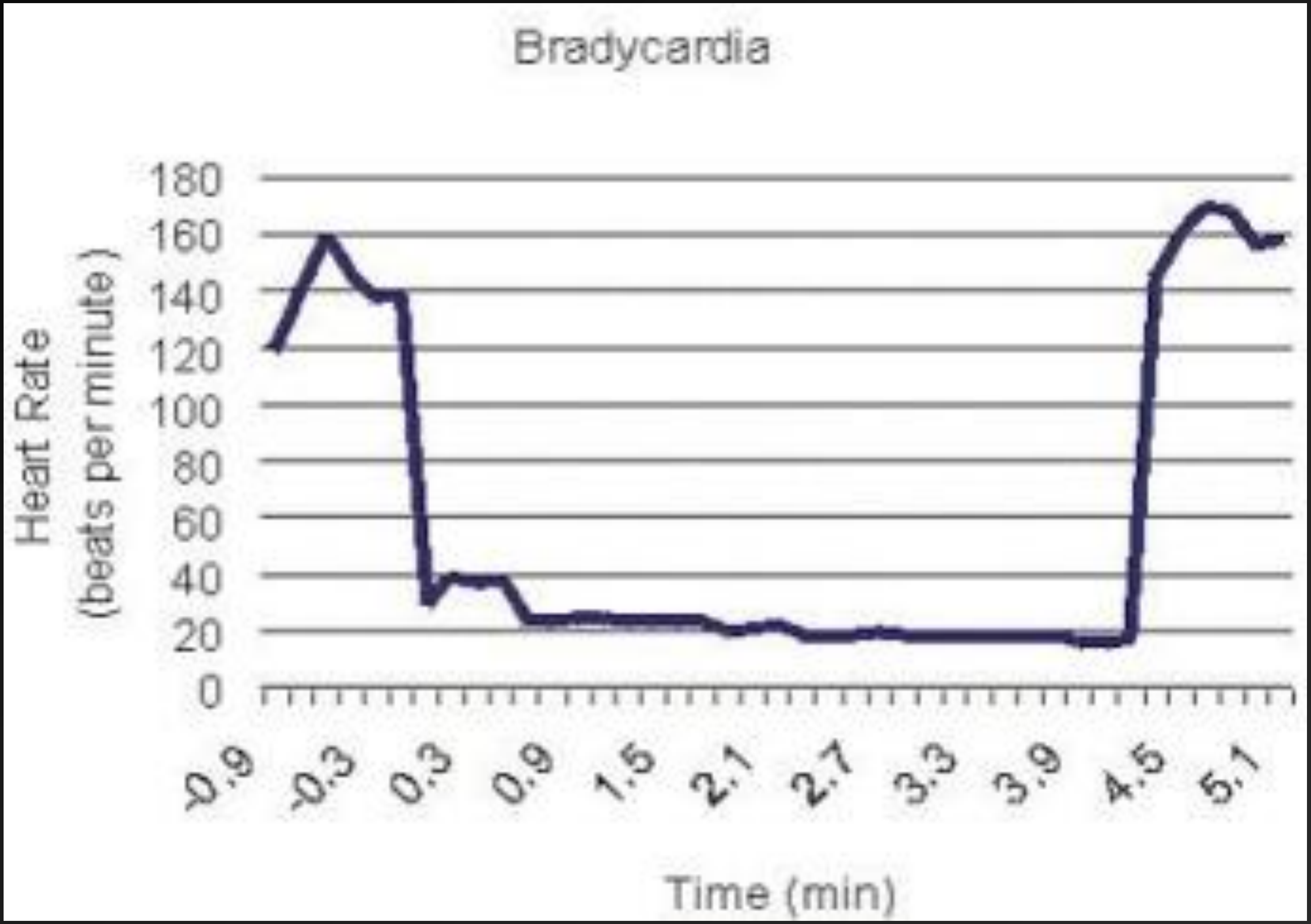
Proportion of consecutive IBI differences >50 ms (pnn50)

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

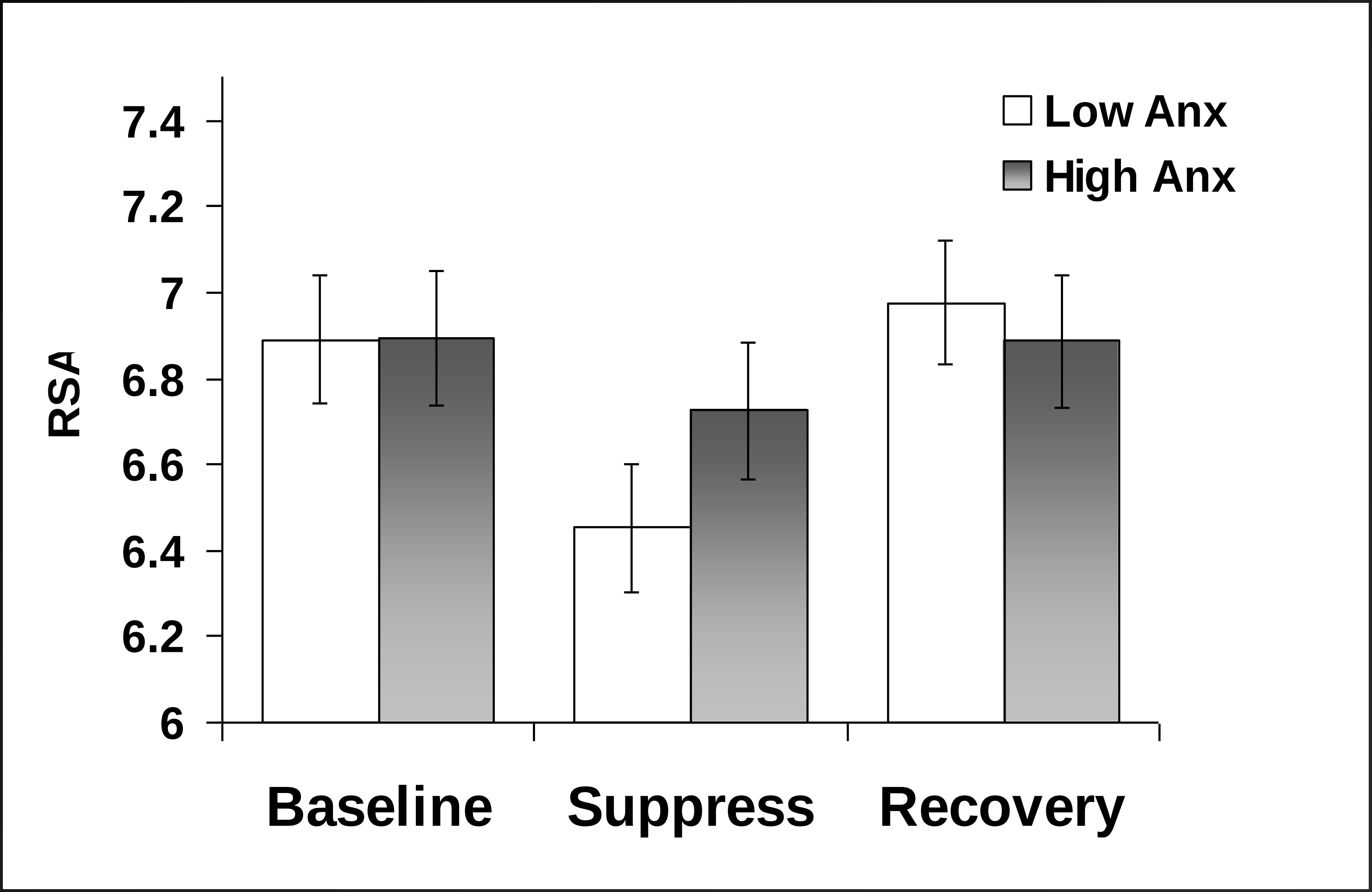
Fig. 1. Phylogenetic stages of the polyvagal theory.

Porges, 2007

Tonic Vs Phasic

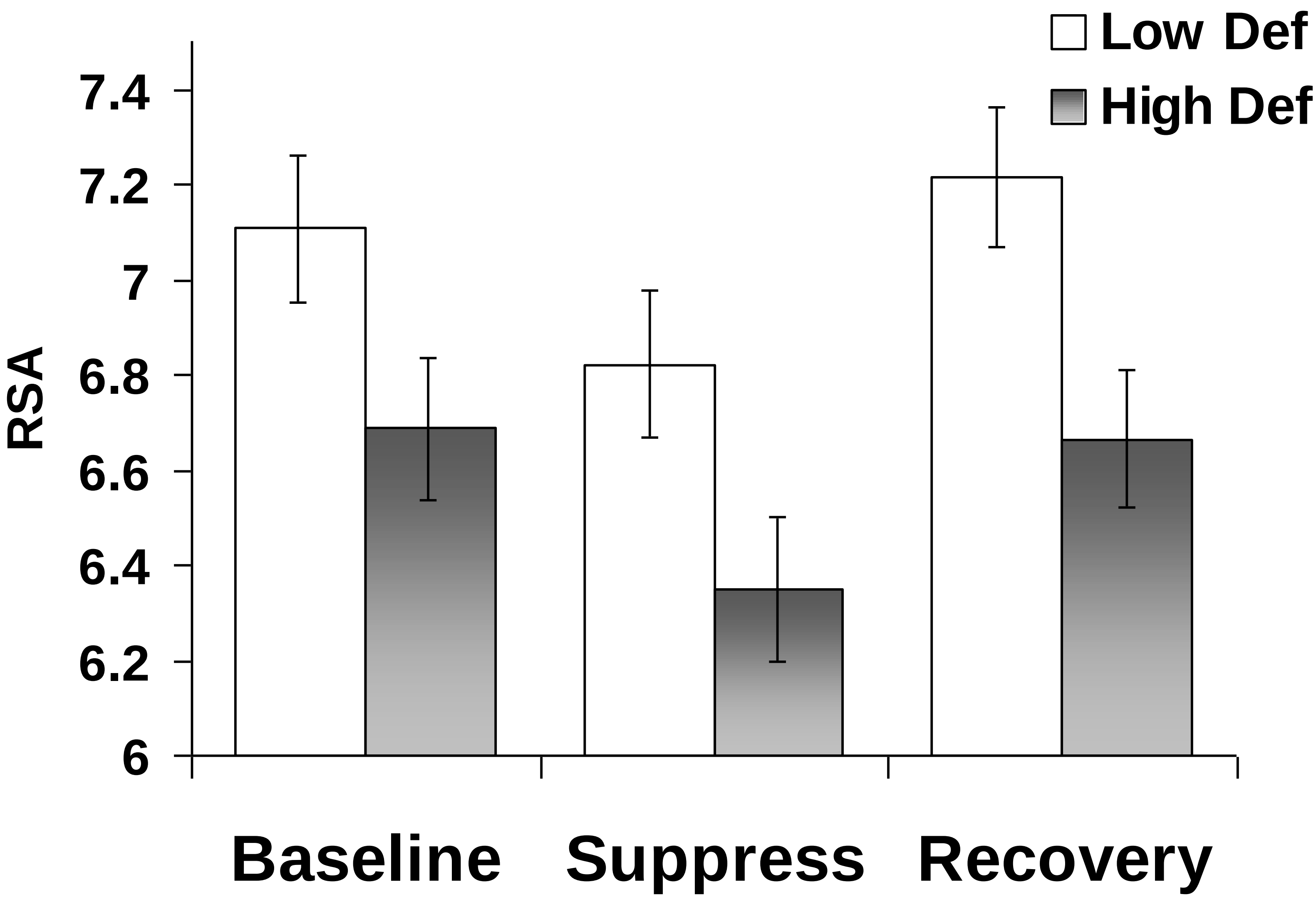
- Tonic Level indexes capacity
- Phasic change indexes actualization of that capacity
- Attention
  - higher vagal "tone" was associated with faster reaction time to a task requiring sustained attention
  - Hyperactive kids treated with Ritalin (Porges, Walter, Korb, & Sprague, 1975).
    - attentional 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

Vagal Control and Defensive Coping



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)

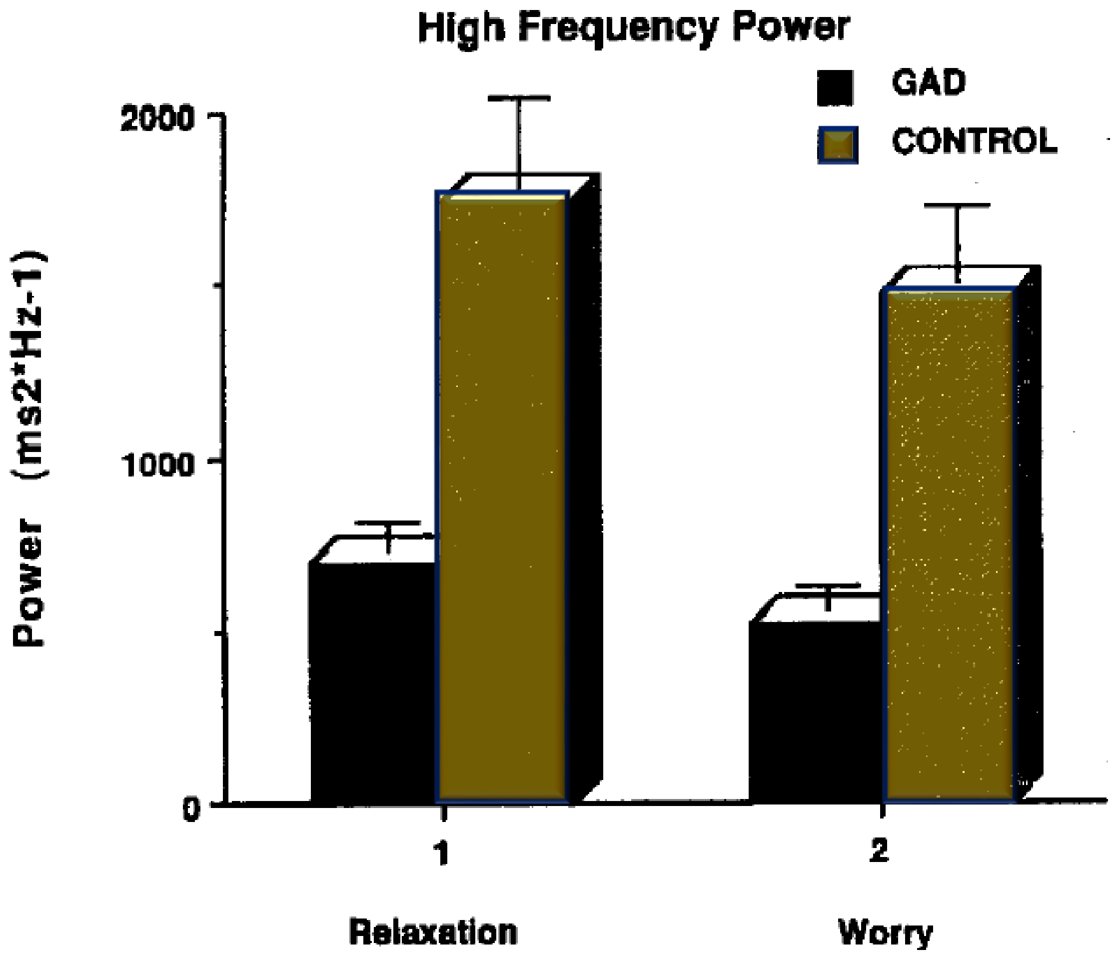
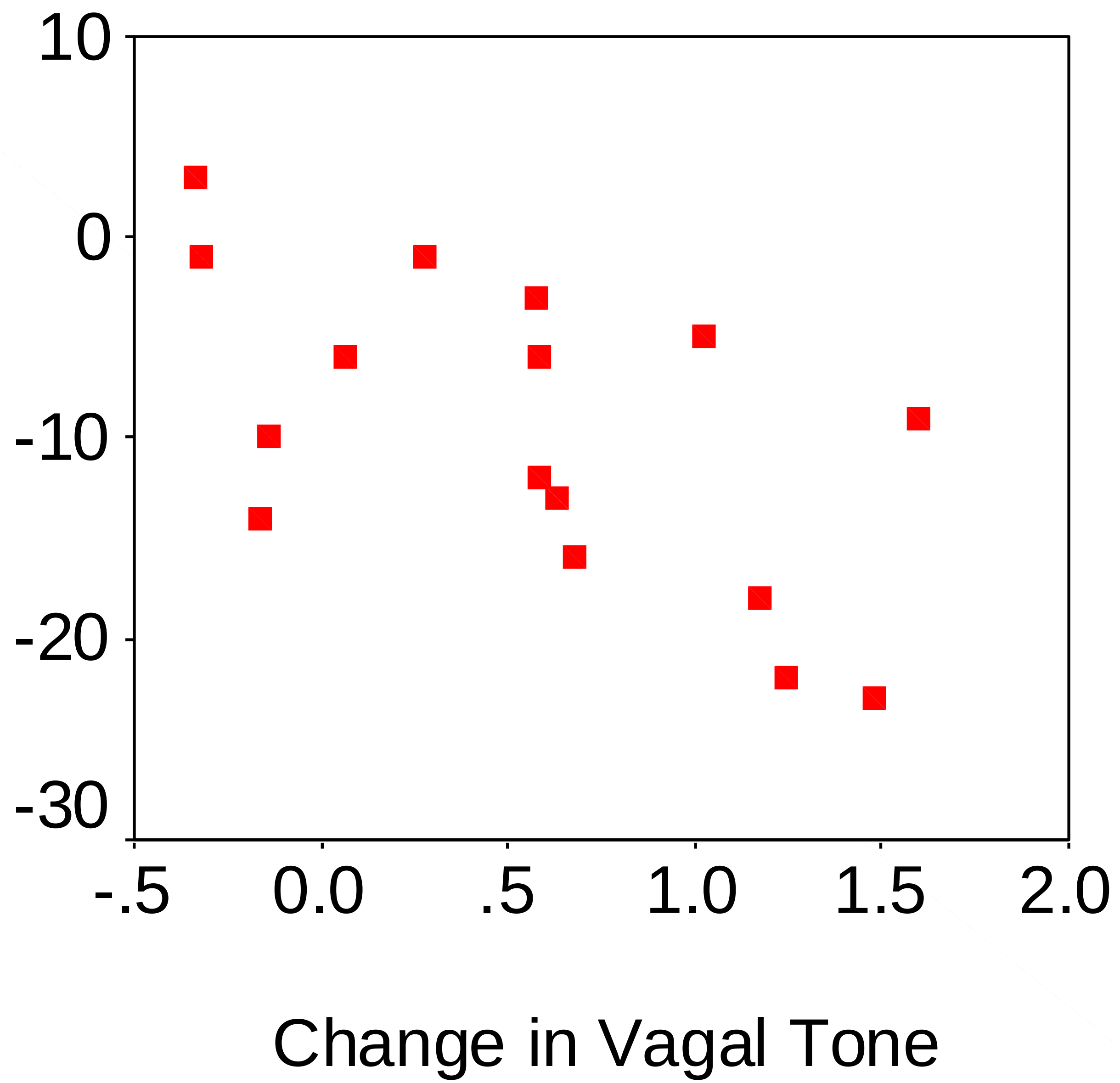


Figure 1. Power in the high frequency (respiratory) component of heart period variability in GAD patients and controls during relaxation and worry.

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?

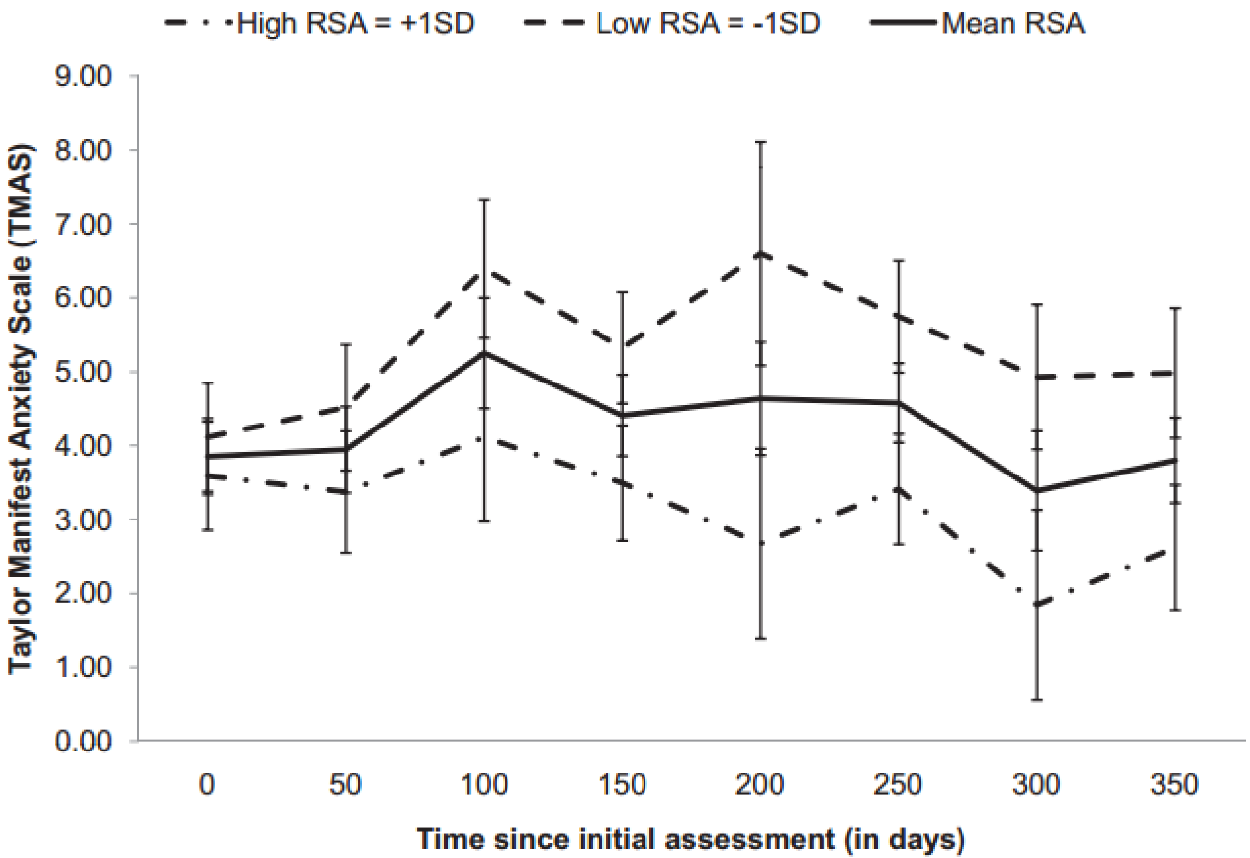


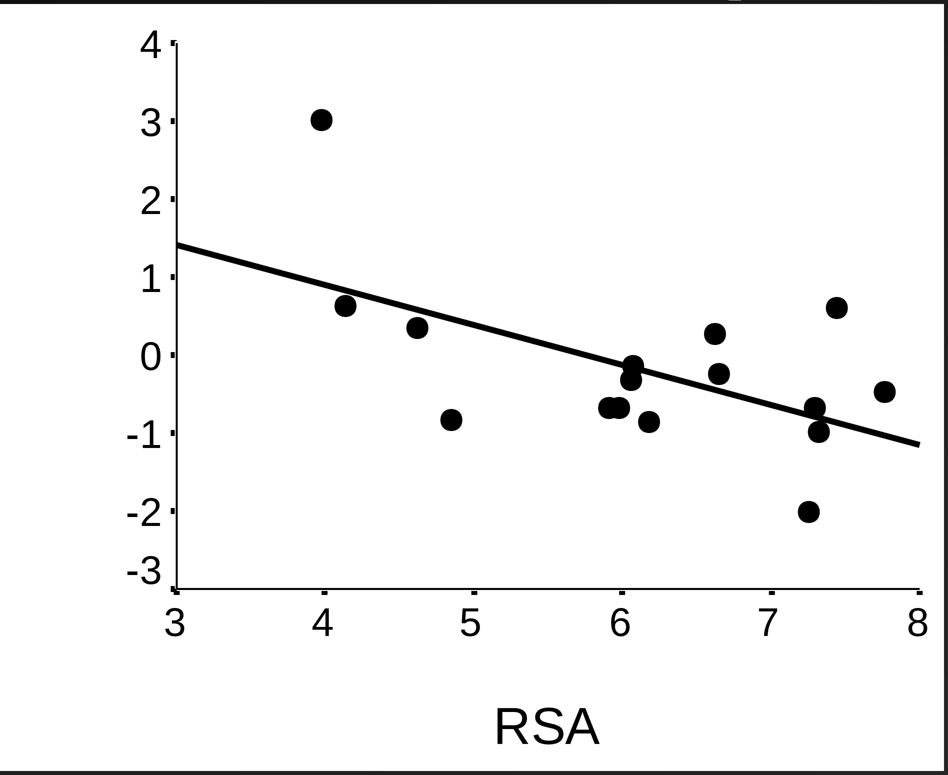
Fig. 1. Effect of the interaction between RSA adjusted for age and Time since initial assessment on TMAS over a 1-year period. Although RSA is a continuous variable, for illustrative purposes, its effect on TMAS is plotted at ±1 SD from the mean. Error bars represent standard errors. RSA: respiratory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

Kogan, Allen, Weihs (2012)
Biological Psychology

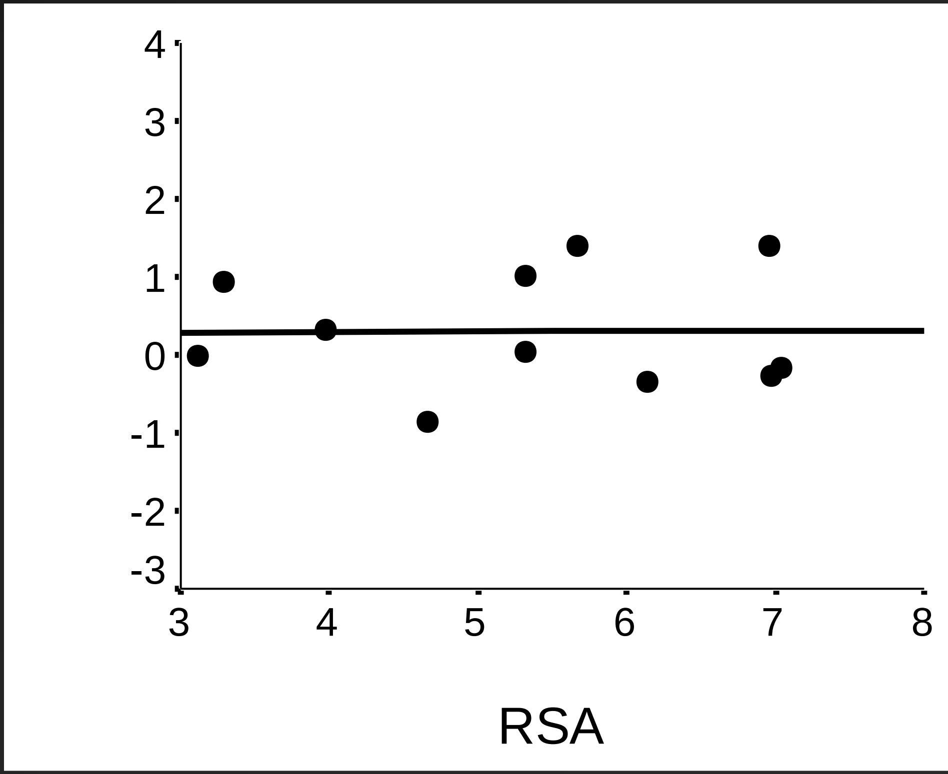
Trait Vagal Tone as Moderator of Response following Bereavement

- 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

Intervention Group



Control Group



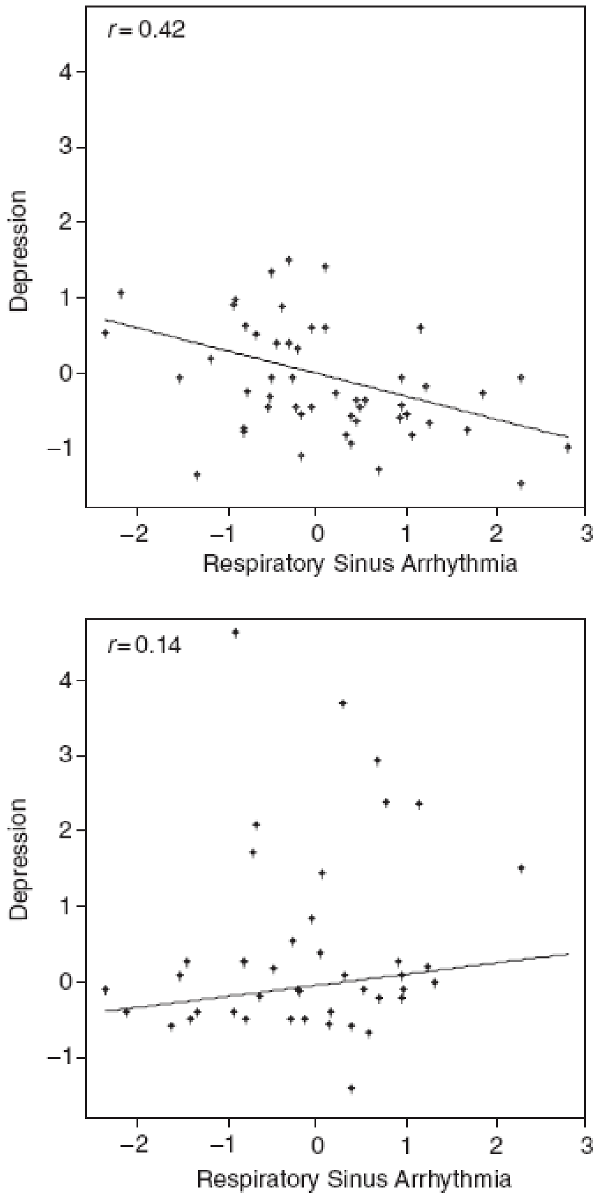


Figure 1. Scatterplot, prediction line, and prediction equation for the relationship between respiratory sinus arrhythmia (log of the variance of the band-limited [.12–.40 Hz] IBI series) and depression score (residualized on baseline depression score), for the disclosure group (top panel) and the control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

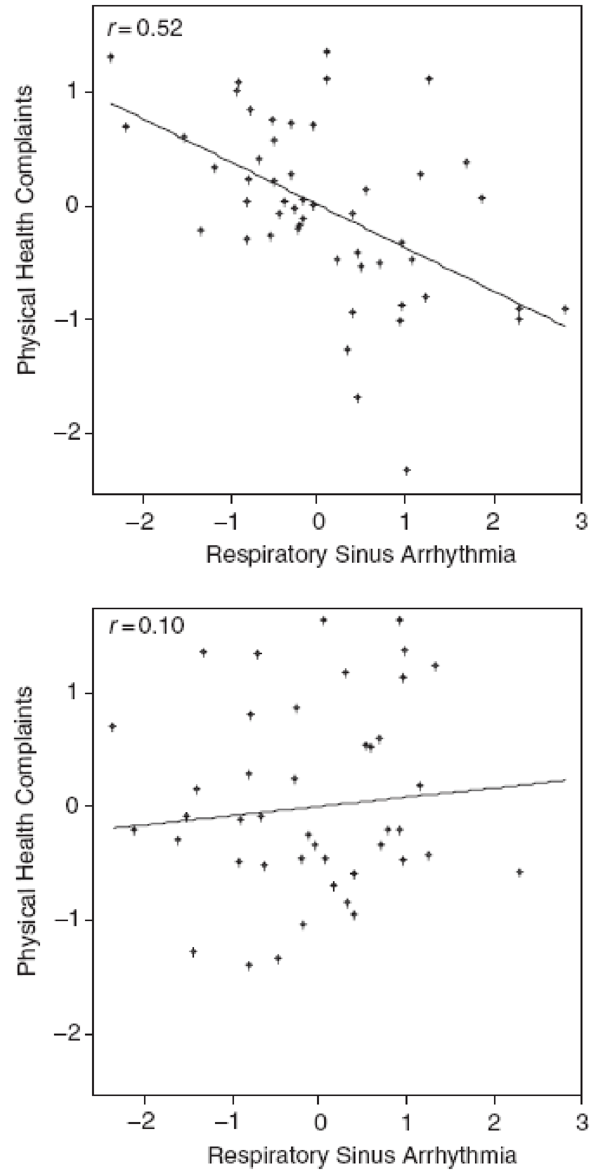
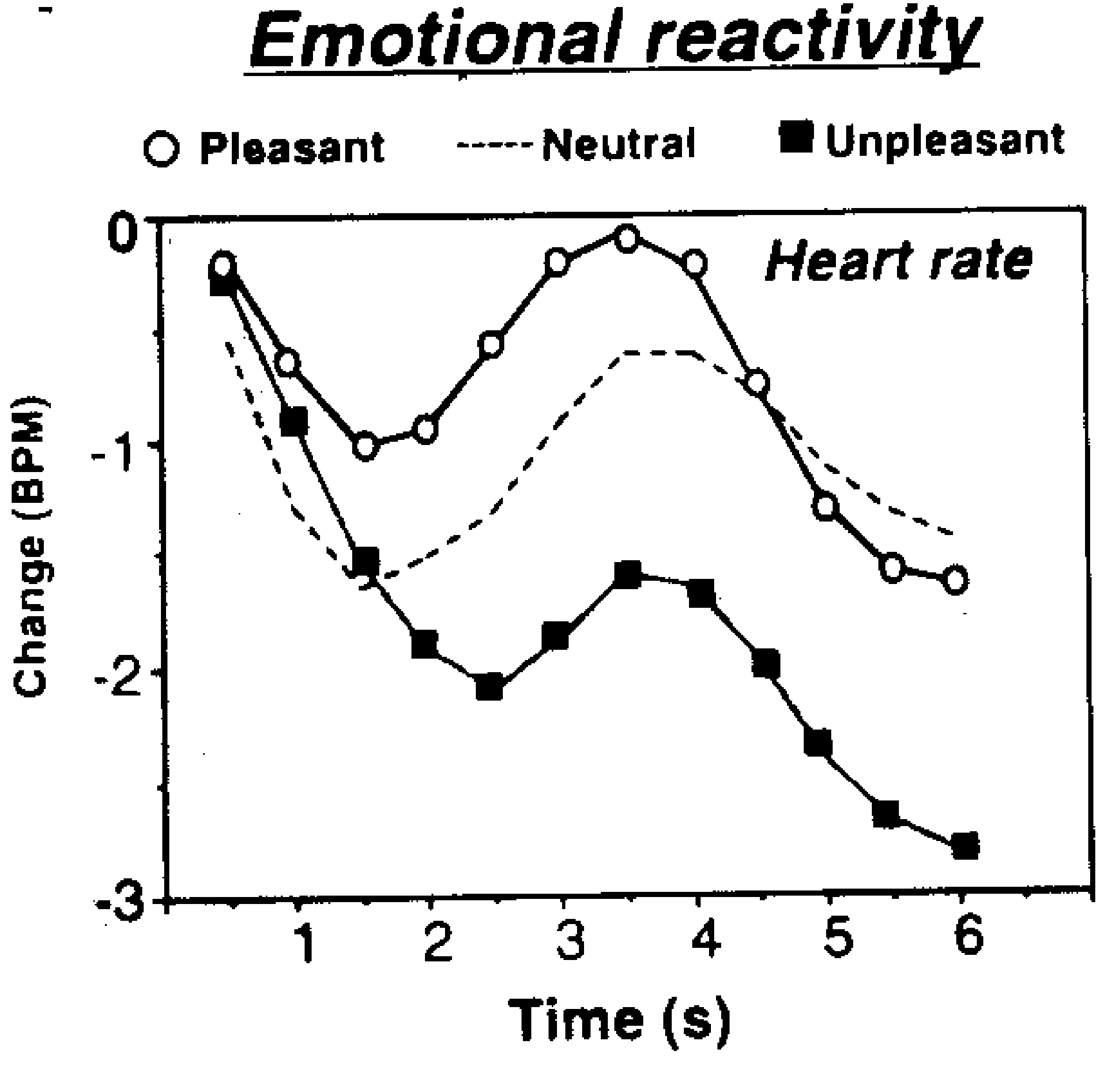
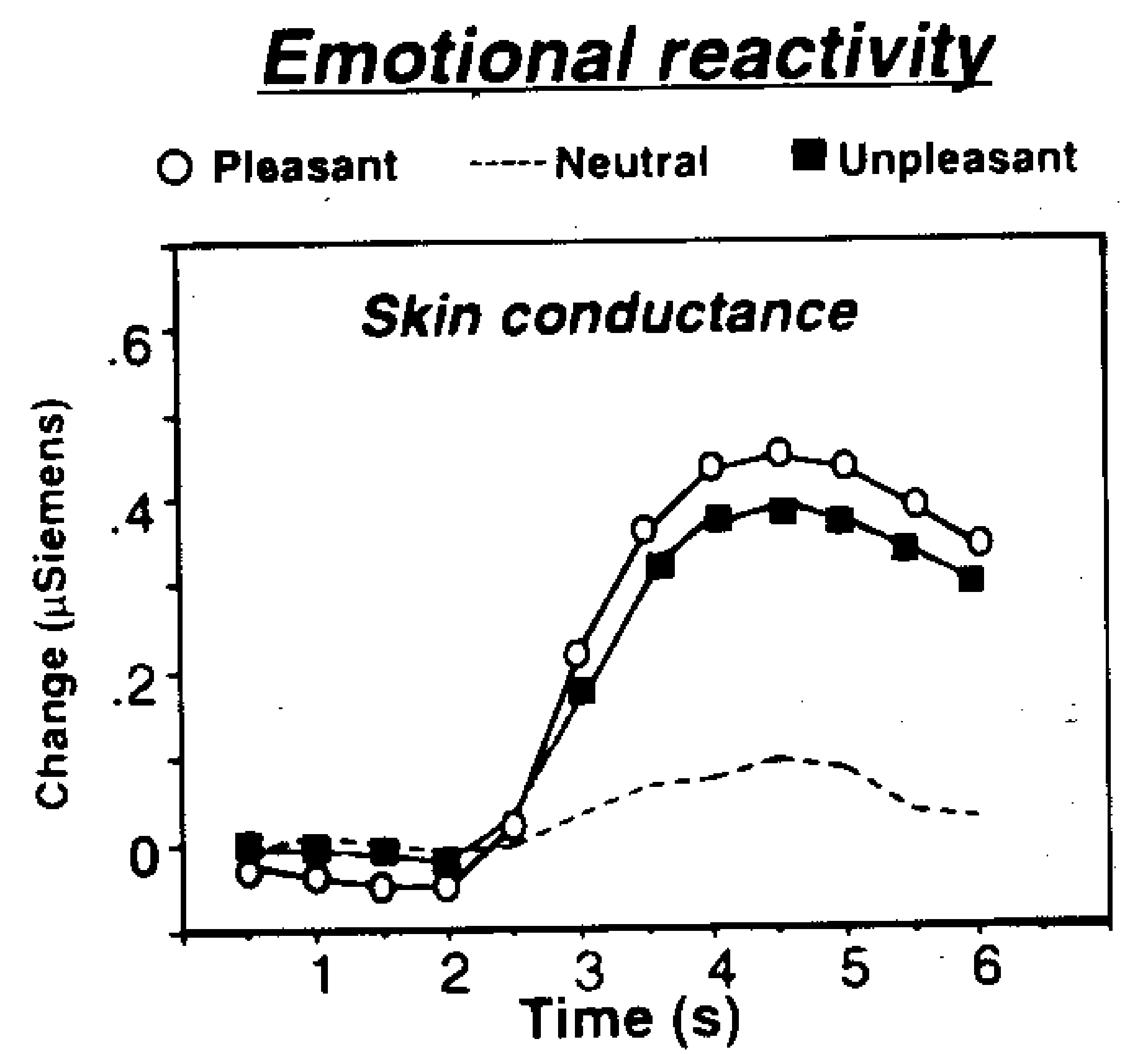


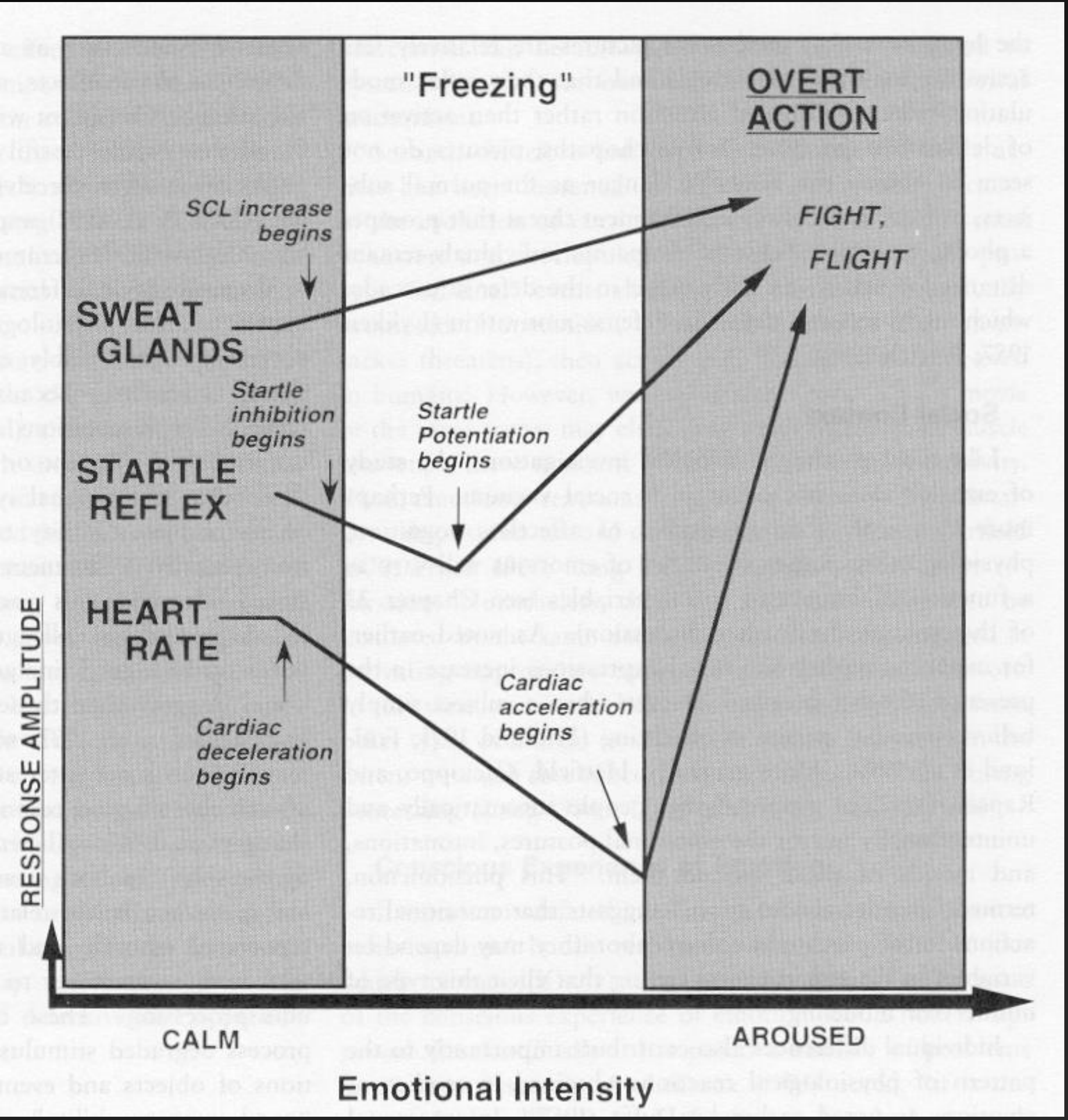
Figure 2. Scatterplot, prediction line, and prediction equation for the relationship between respiratory sinus arrhythmia (log of the variance of the band-limited [.12–.40 Hz] IBI series) and physical health complaint score (residualized on baseline physical health complaints score) for the disclosure 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)




"Freezing"
OVERT ACTION
SCL increase begins
FIGHT, FLIGHT
SWEAT GLANDS
Startle inhibition begins
Startle Potentiation begins
STARTLE REFLEX
HEART RATE
Cardiac acceleration begins
Cardiac deceleration begins
RESPONSE AMPLITUDE
CALM
AROUSED
Emotional Intensity

OR Vs DR

Electromygraphy

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

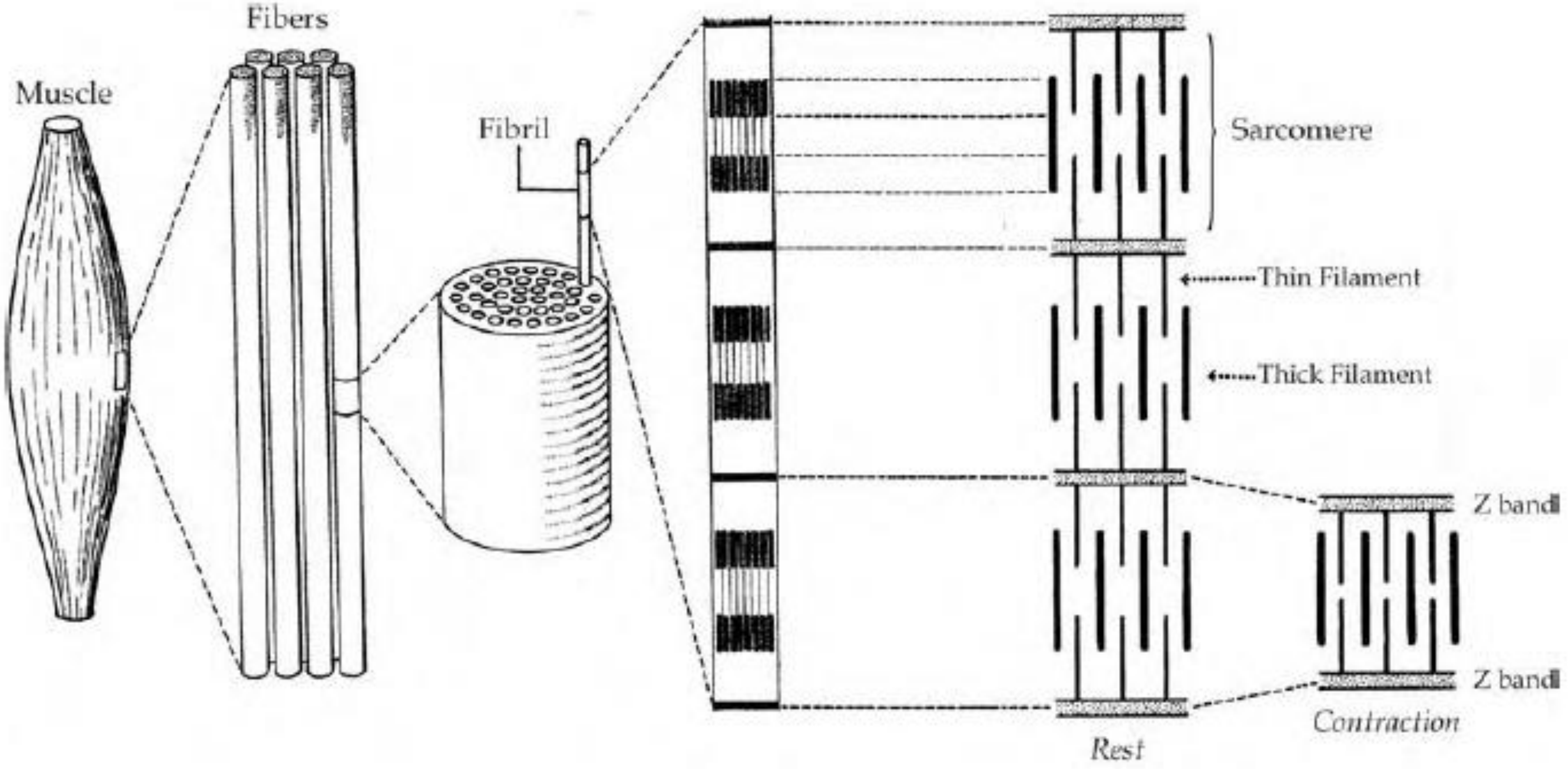


Figure 12.2. Diagram of the structure of the muscle with increasing magnification going from left to right. The bottom right corner of the figure illustrates the microgeometric changes that occur with contraction. (Modified from Figure 10.7 of Schmidt-Nielsen, 1997).

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

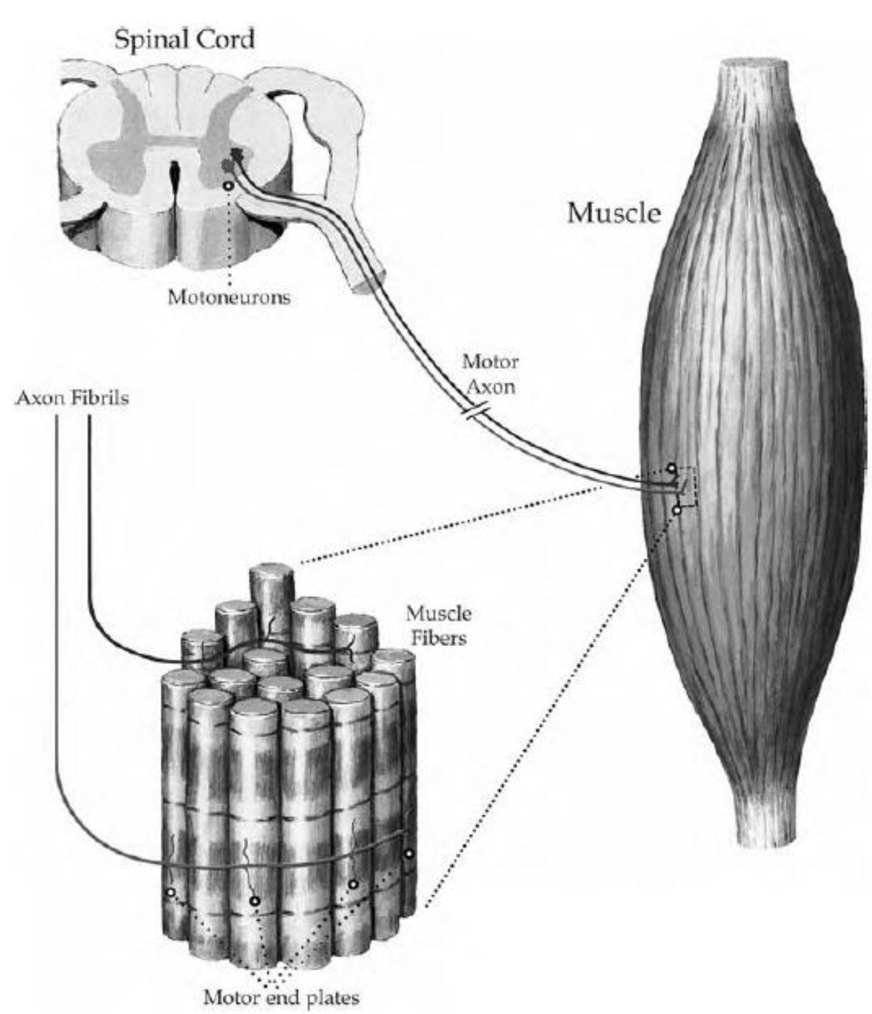


Figure 12.3. Diagram of two motor units. (Modified from slide 3705 of Netter, 1991).

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

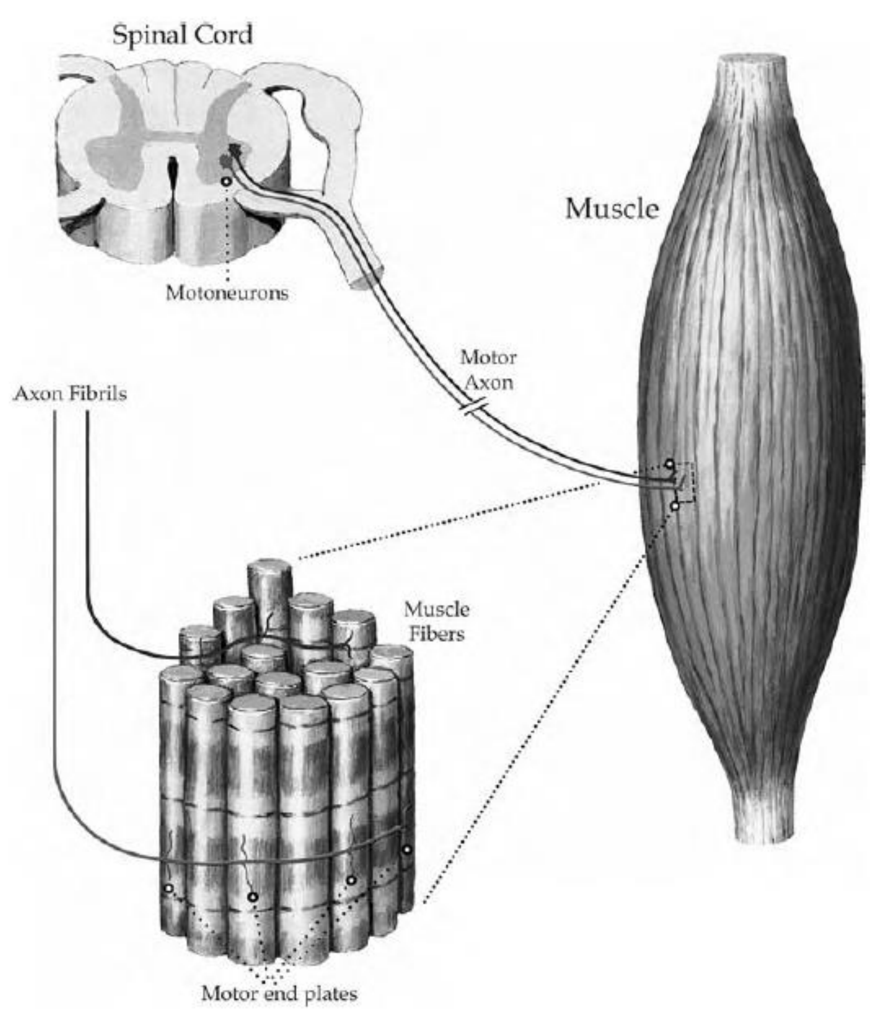
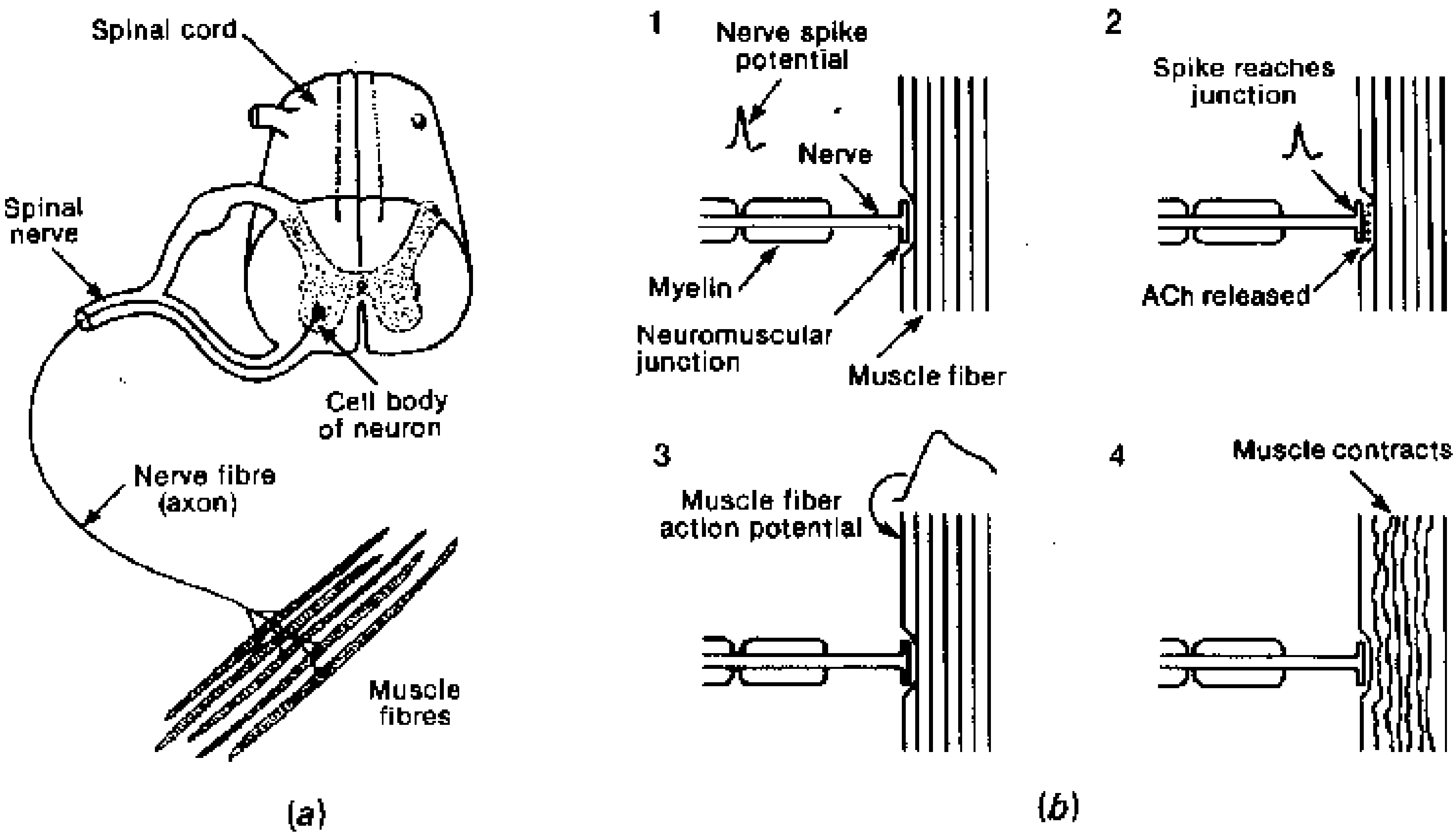


Figure 12.3. Diagram of two motor units. (Modified from slide 3705 of Netter, 1991).

Cartoon of how it works



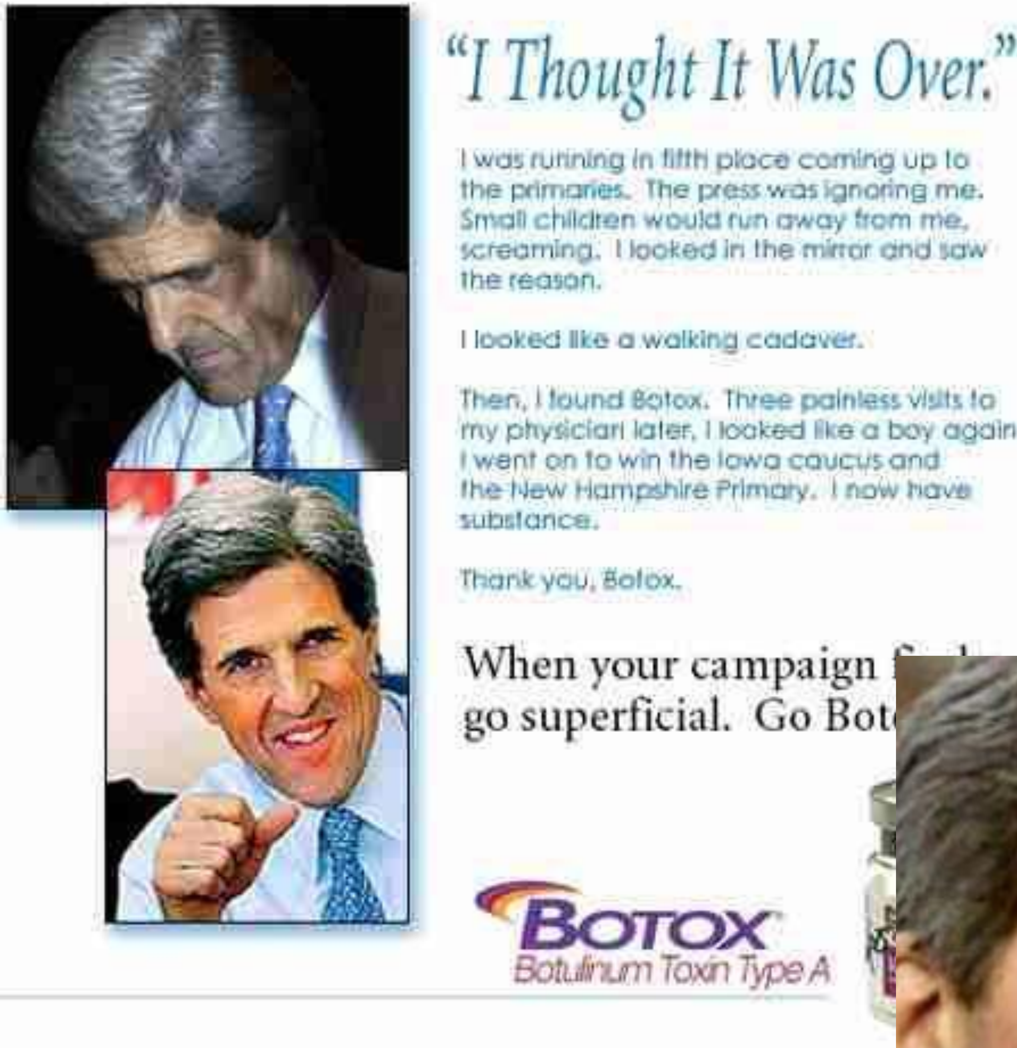
Before

After

BOTOX® Cosmetic

Before

After

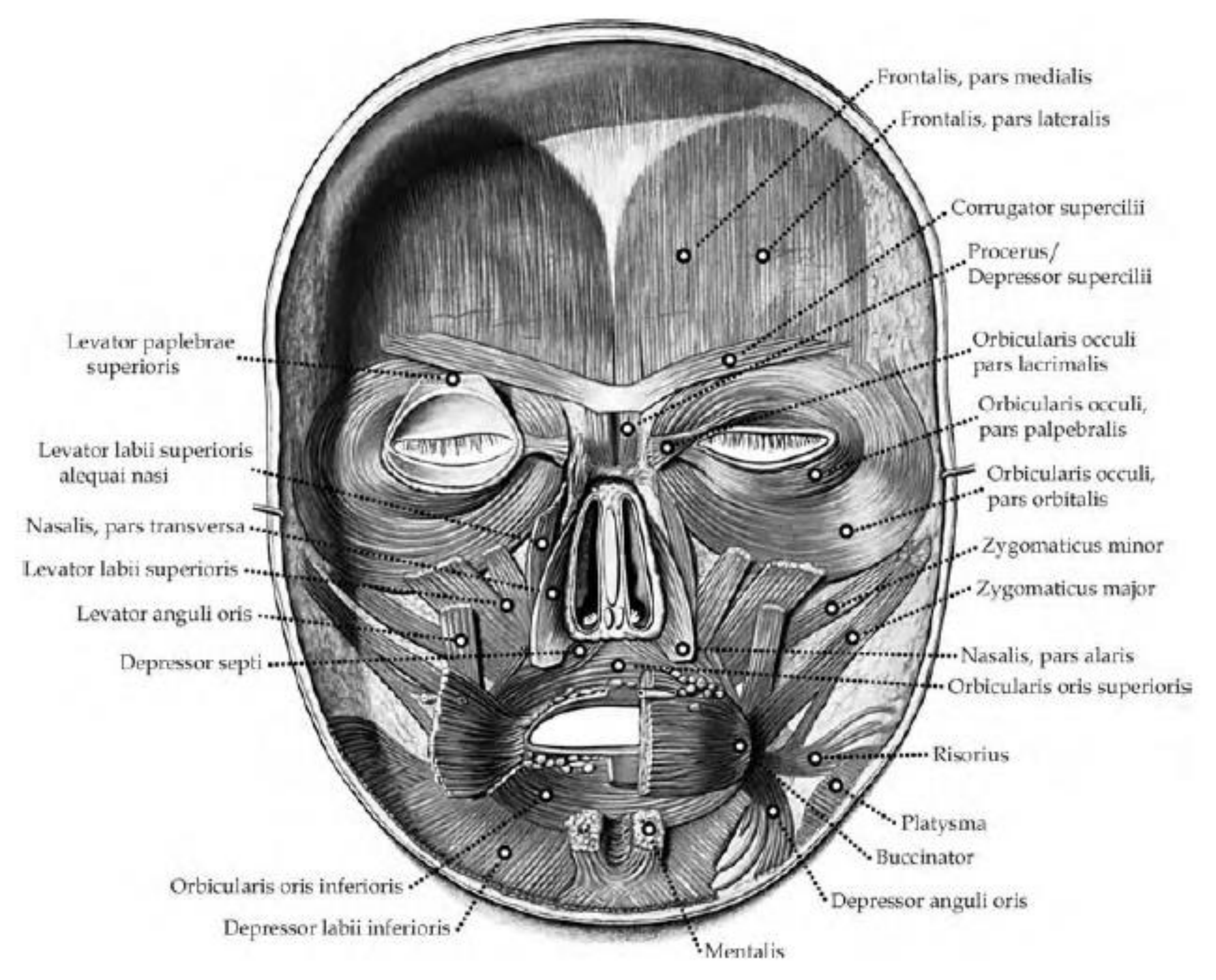

"I Thought It Was Over."
I was running in fifth place coming up to the primaries. The press was ignoring me. Small children would run away from me, screaming. I looked in the mirror and saw the reason.
I looked like a walking cadaver.
Then, I found Botox. Three painless visits to my physician later, I looked like a boy again. I went on to win the Iowa caucus and the New Hampshire Primary. I now have substance.
Thank you, Botox.
When your campaign
go superficial. Go Bot
BOTOX
Botulinum Toxin Type A

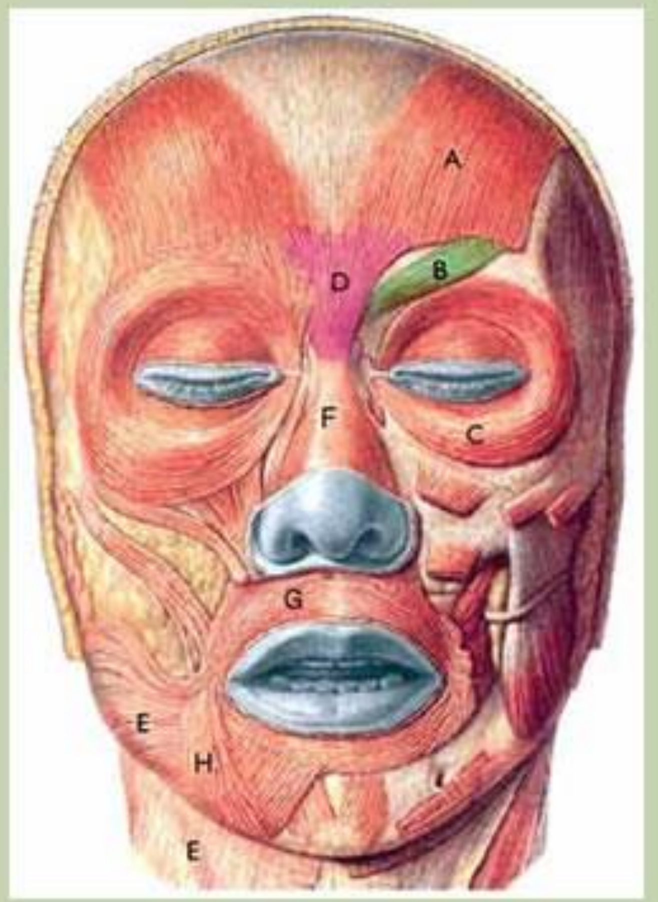

BEFORE
AFTER

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

From the educational website of
S. Sean Younai, MD,
Board Certified Plastic, Cosmetic,
and Reconstructive Surgeon

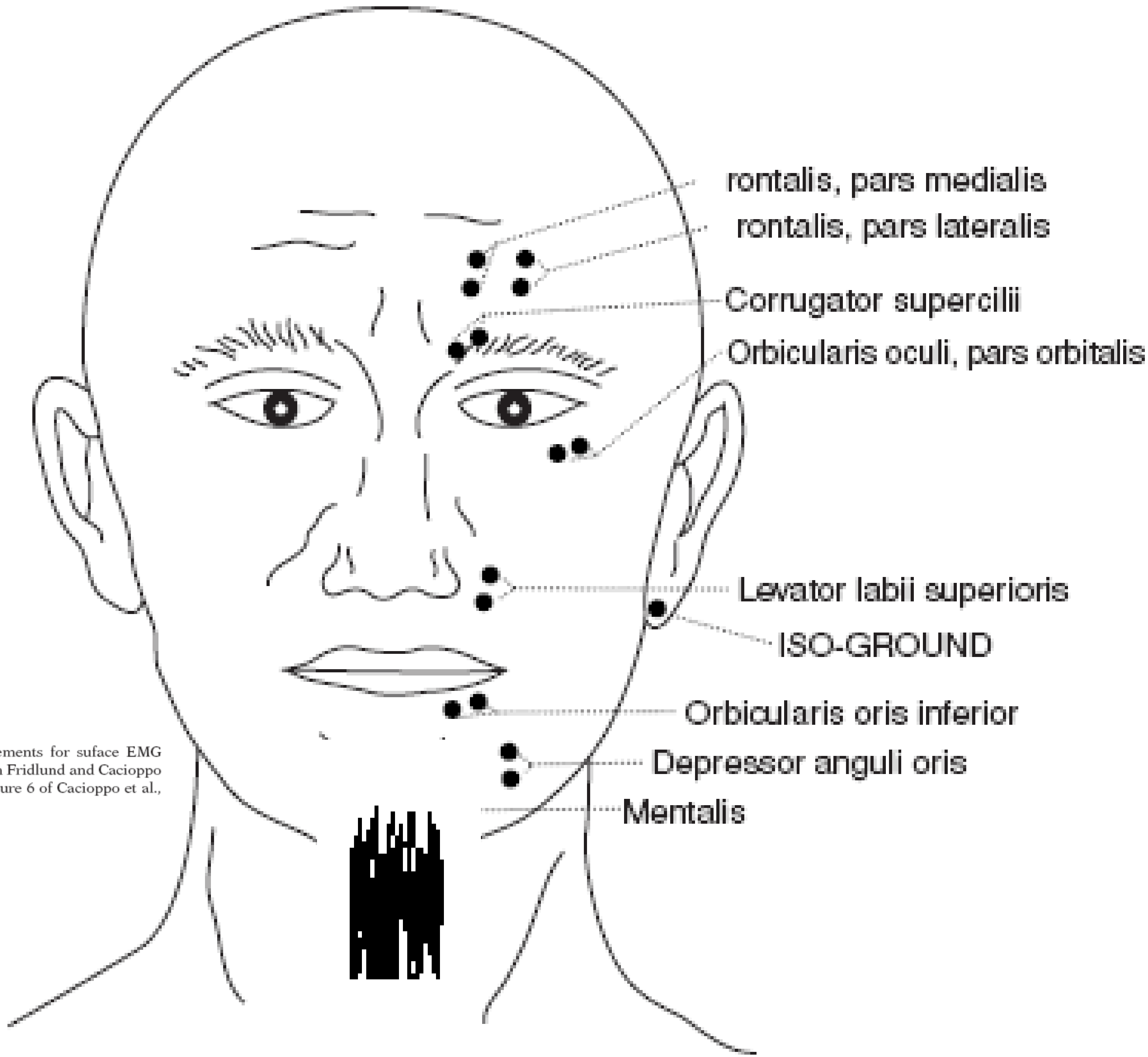
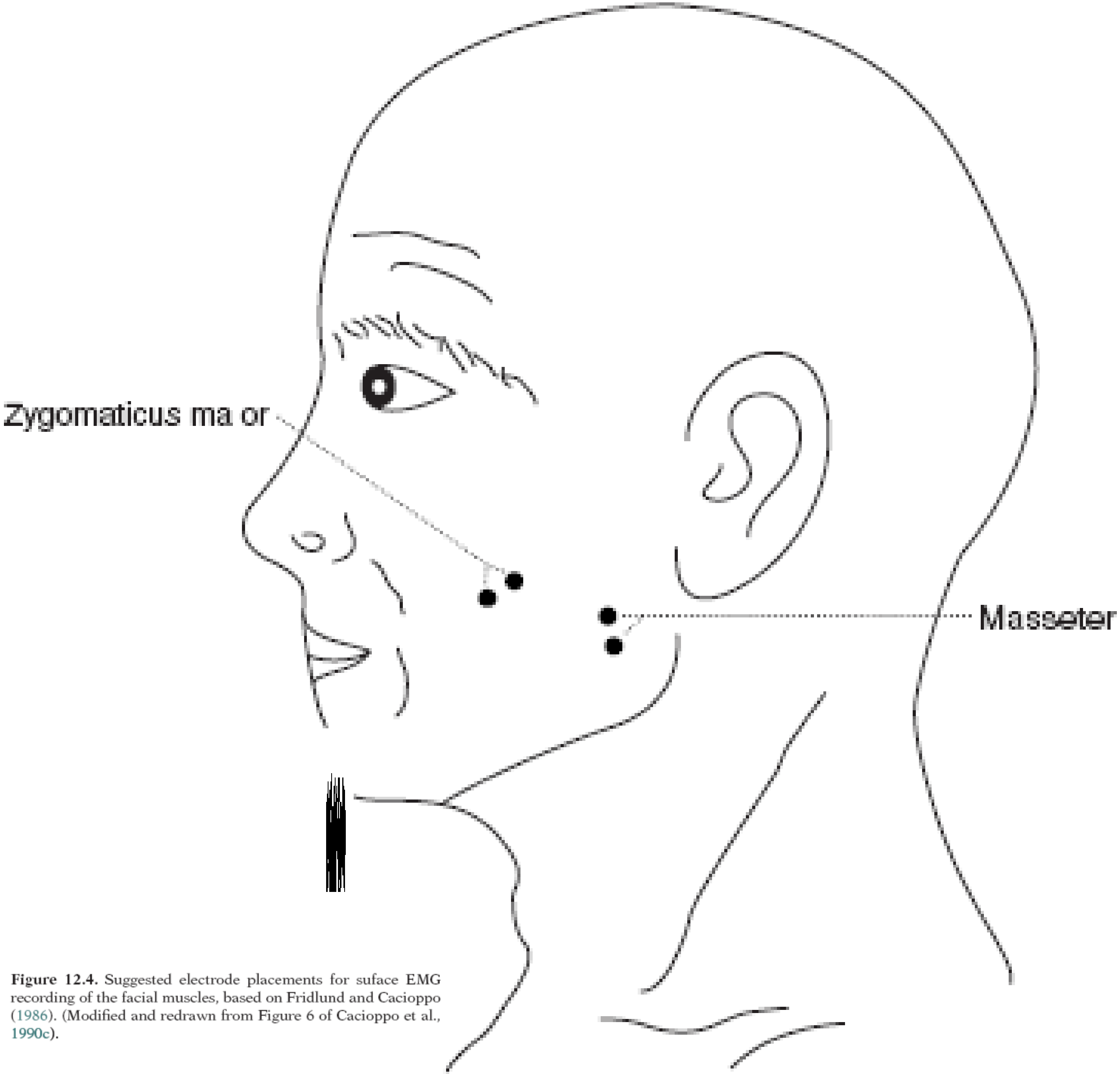


Figure 12.4. Suggested electrode placements for suface EMG recording of the facial muscles, based on Fridlund and Cacioppo (1986). (Modified and redrawn from Figure 6 of Cacioppo et al., 1990c).



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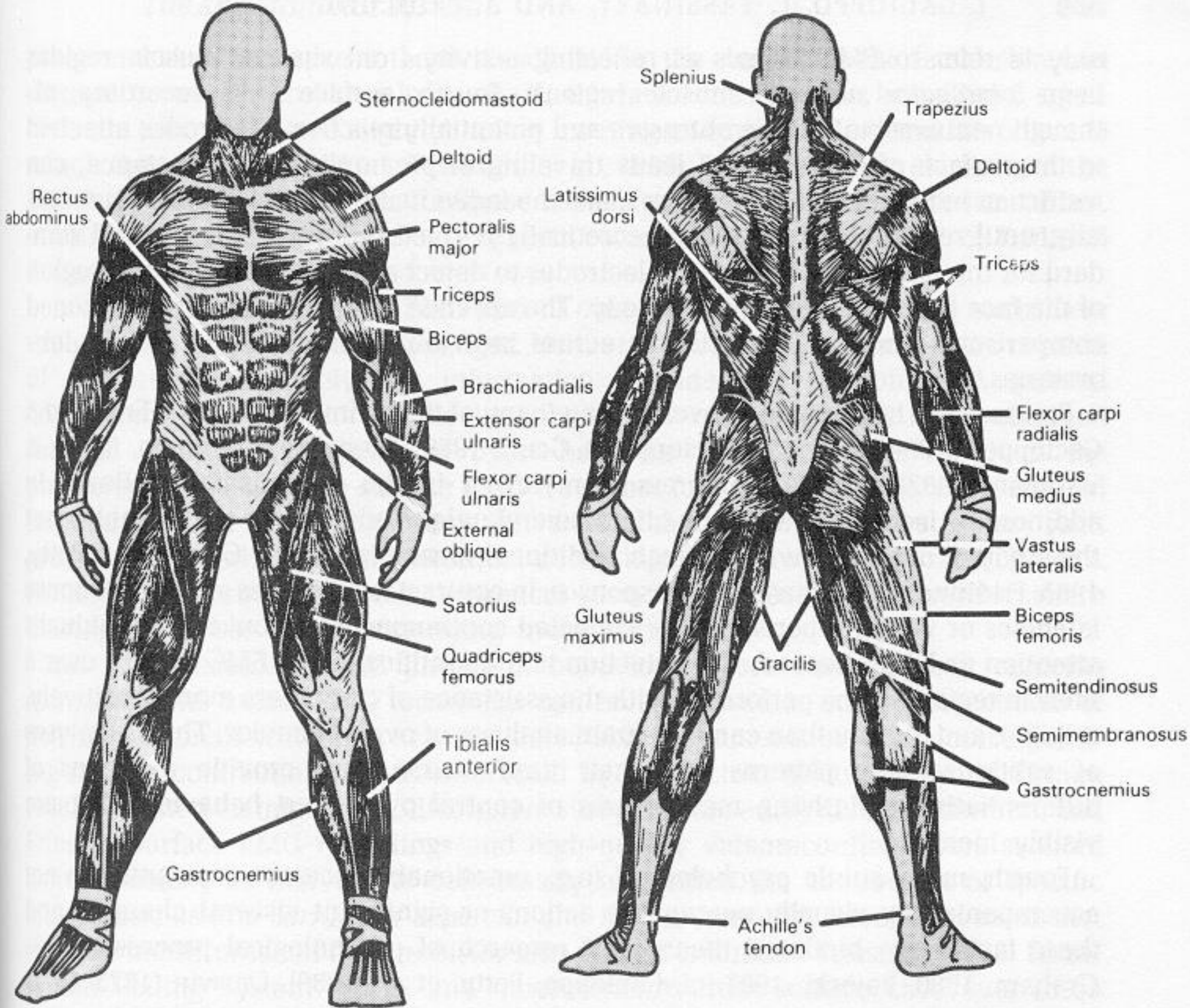
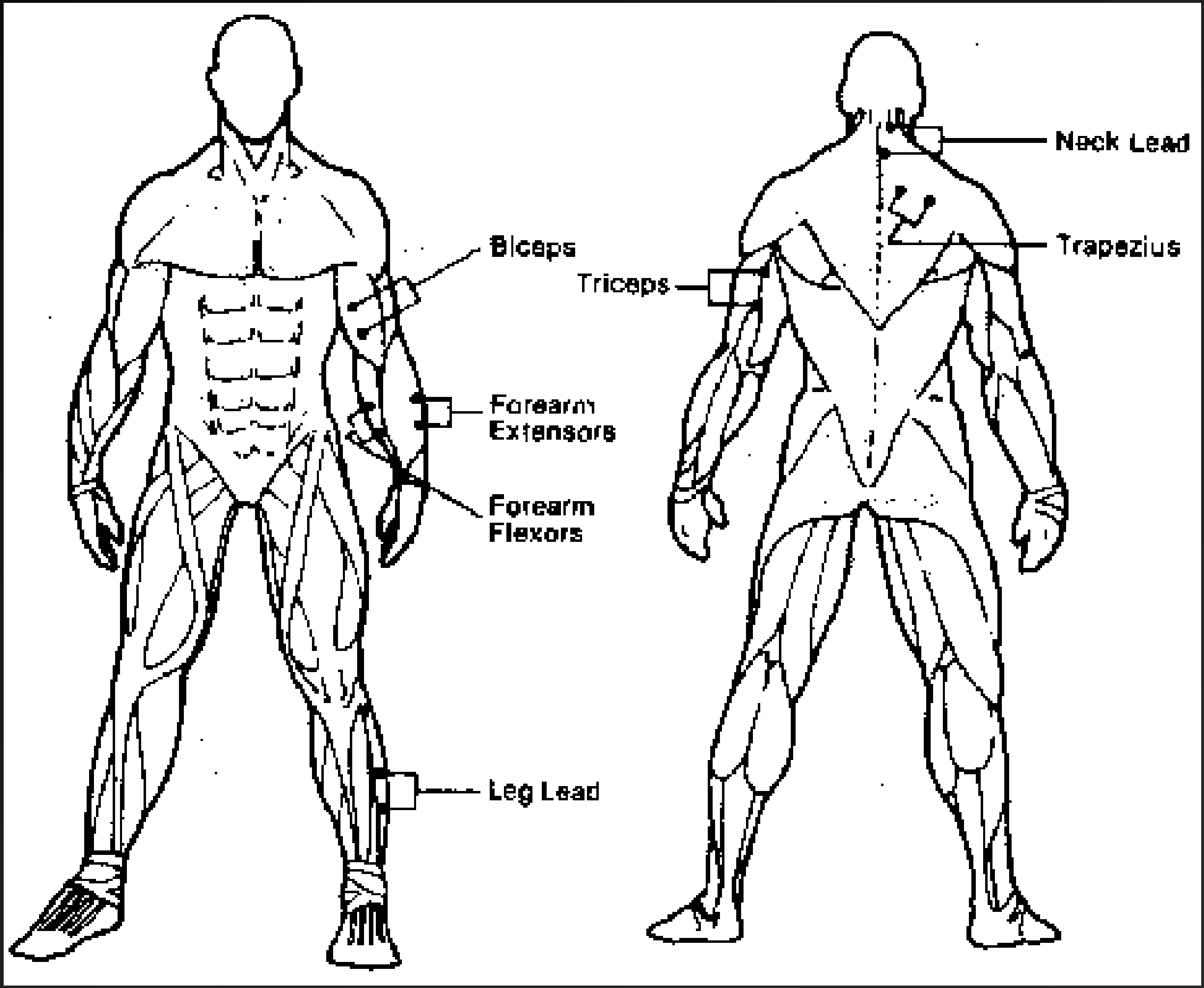
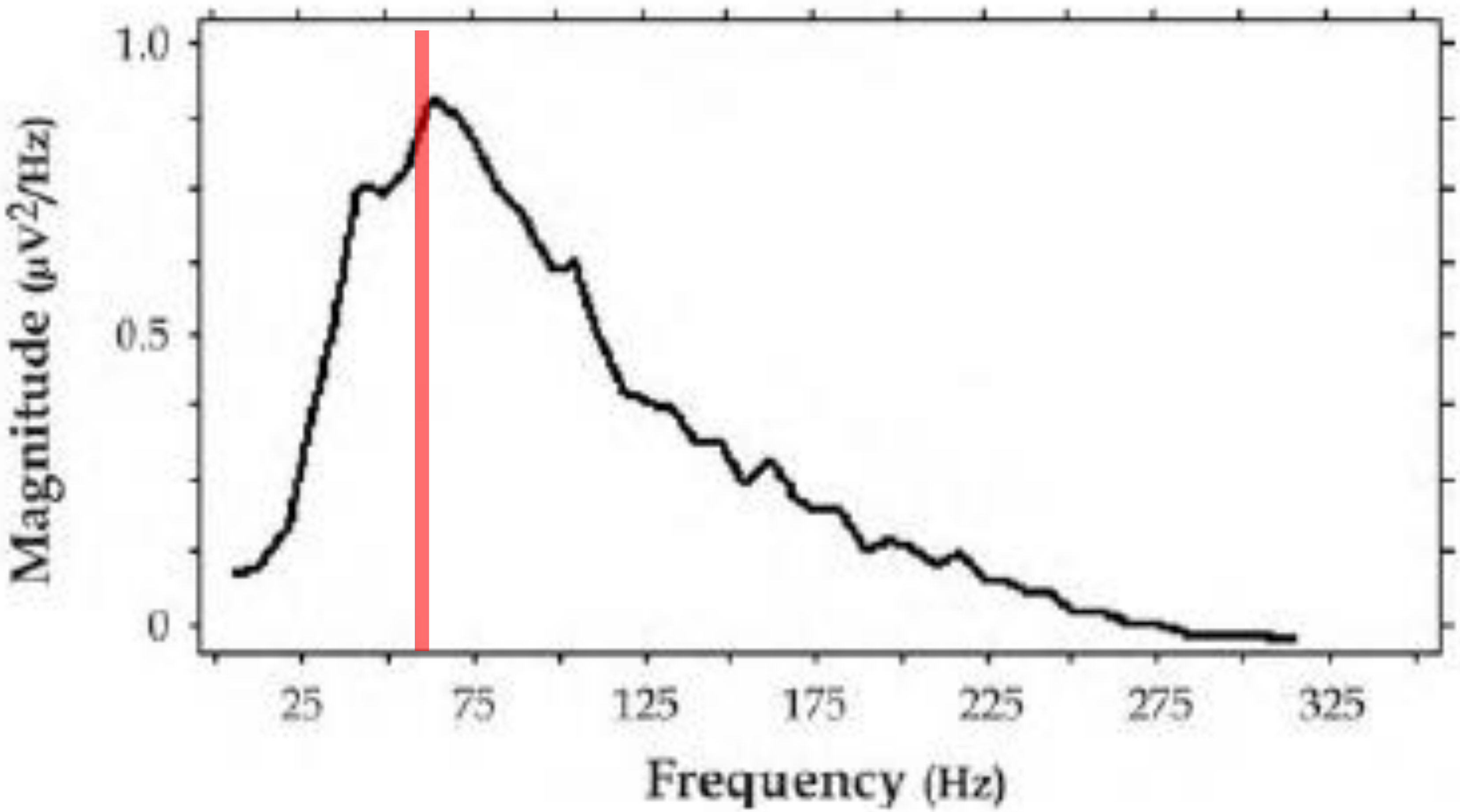

Sternocleidomastoid
Deltoid
Rectus abdominus
Pectoralis major
Triceps
Biceps
Brachioradialis
Extensor carpi ulnaris
Flexor carpi ulnaris
External oblique
Satorius
Quadriceps femorus
Tibialis anterior
Gastrocnemius
Splenius
Trapezius
Deltoid
Latissimus dorsi
Triceps
Flexor carpi radialis
Gluteus medius
Vastus lateralis
Gluteus maximus
Biceps femoris
Gracilis
Semitendinosus
Semimembranosus
Gastrocnemius
Achille's tendon


Biceps
Forearm Extensors
Forearm Flexors
Leg Lead
Neck Lead
Trapezius
Triceps

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

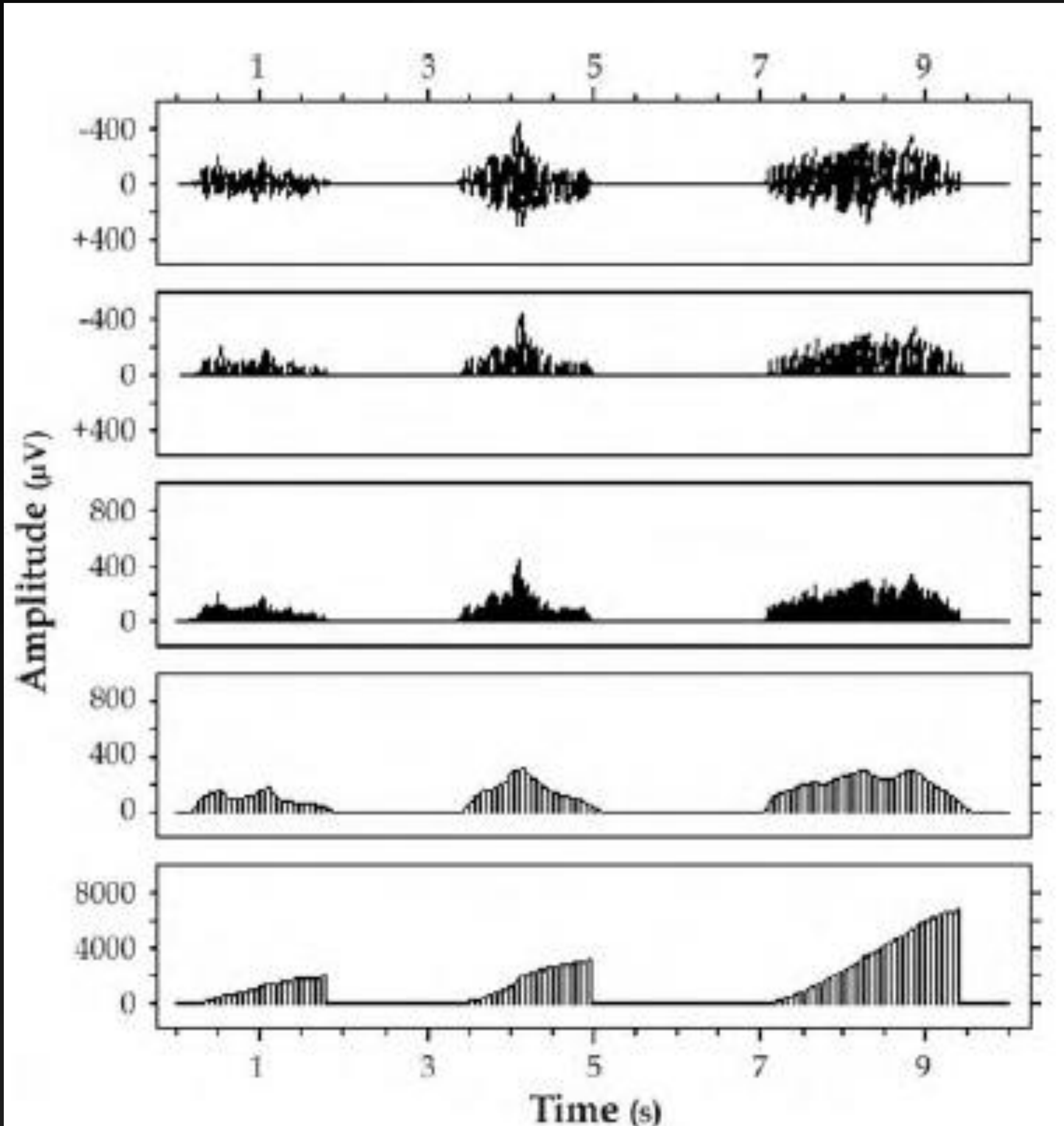
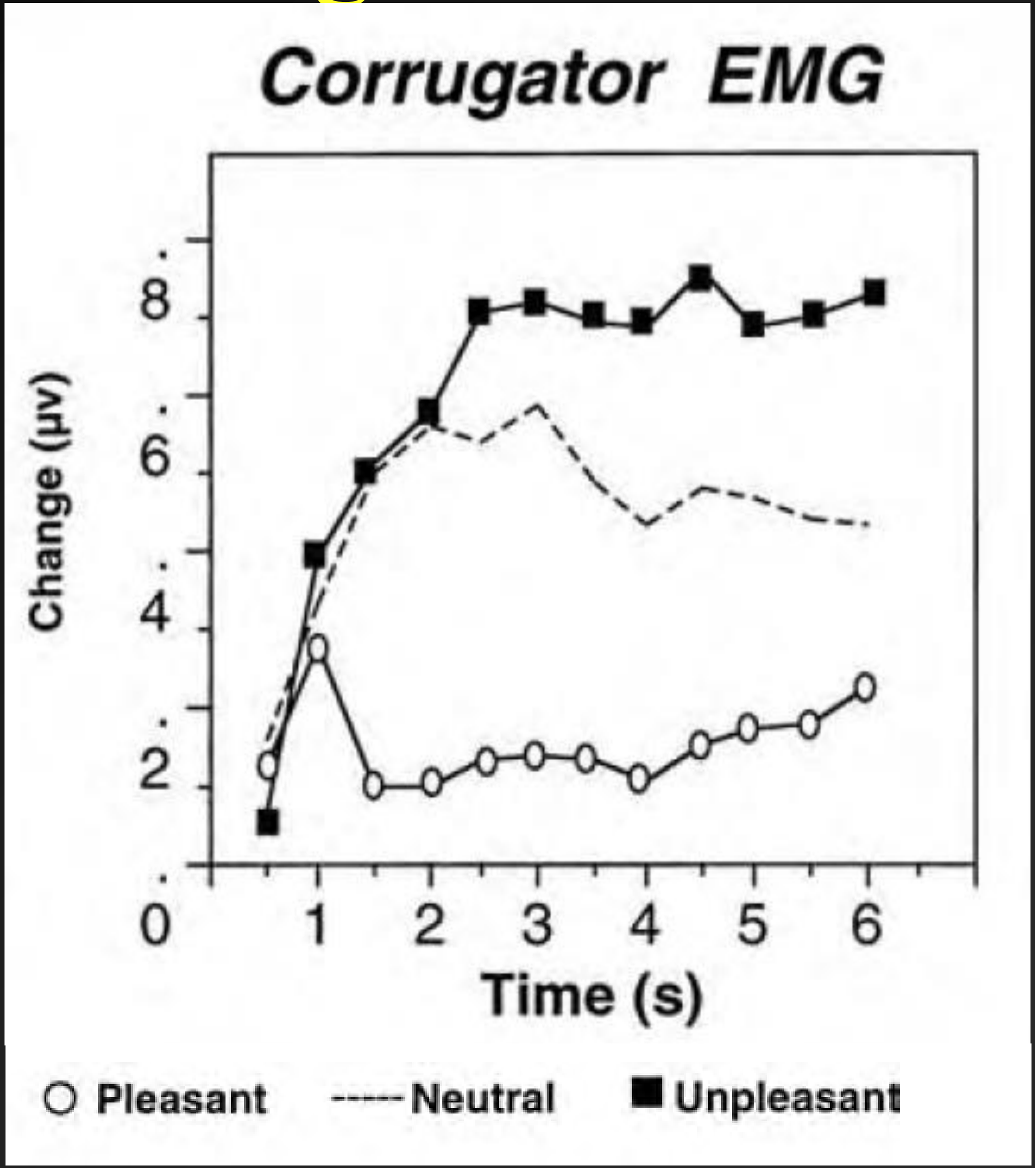
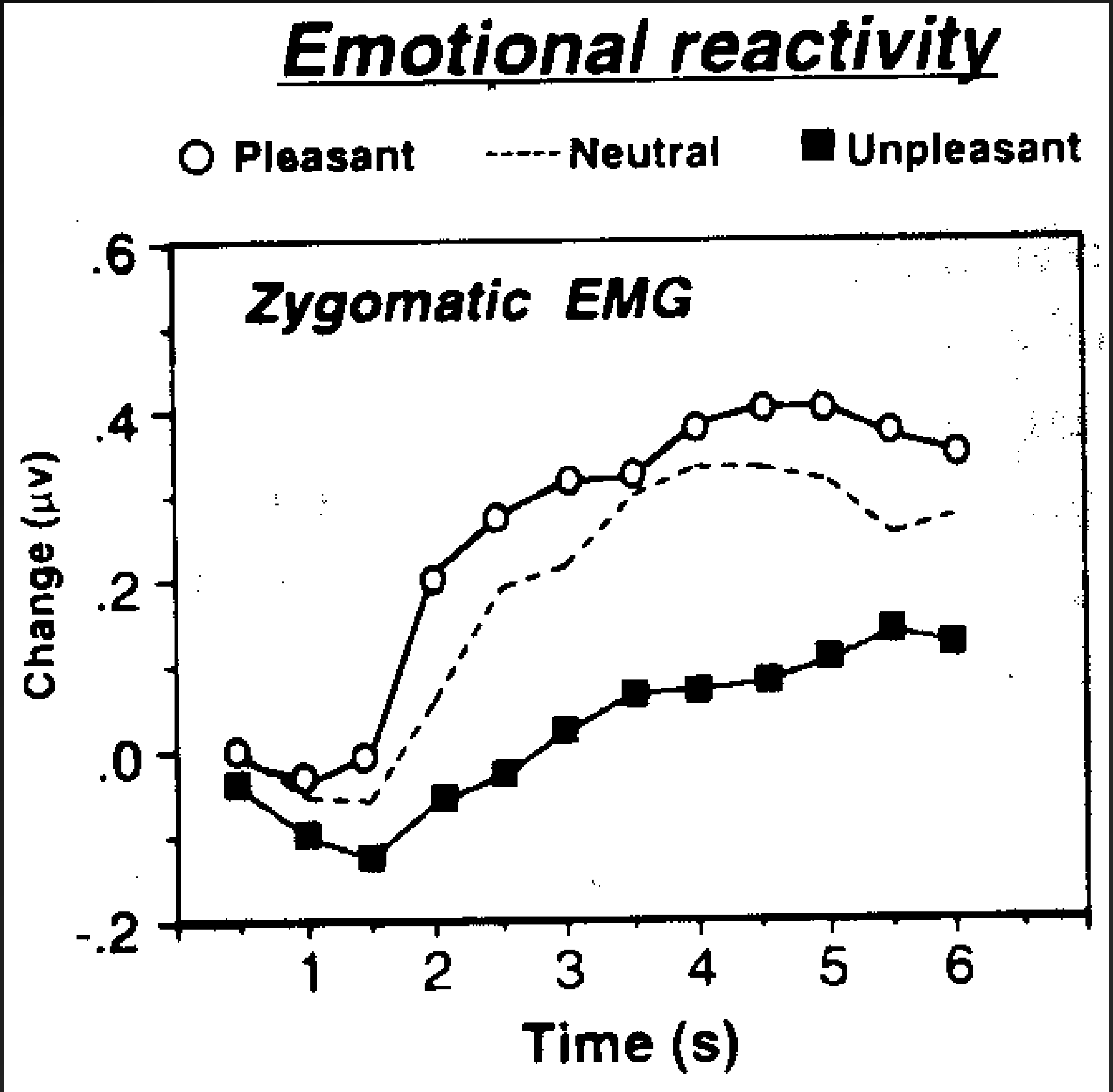


Figure 12.5. Common alternative representations of the surface EMG signal. The top five smaller panels depict three distinct non-fatigued responses. Going from top to bottom: the first represents "raw" (amplified and band-pass filtered only) waveforms; the second, half-wave rectified waveforms; the third, full-wave rectified waveforms; the fourth, "smoothed" waveforms; and the fifth, true integrated waveforms. The larger bottom panel depicts what one of these responses might look like if represented in the frequency domain. (Modified from Figure 7 of Cacioppo et al., 1990c).

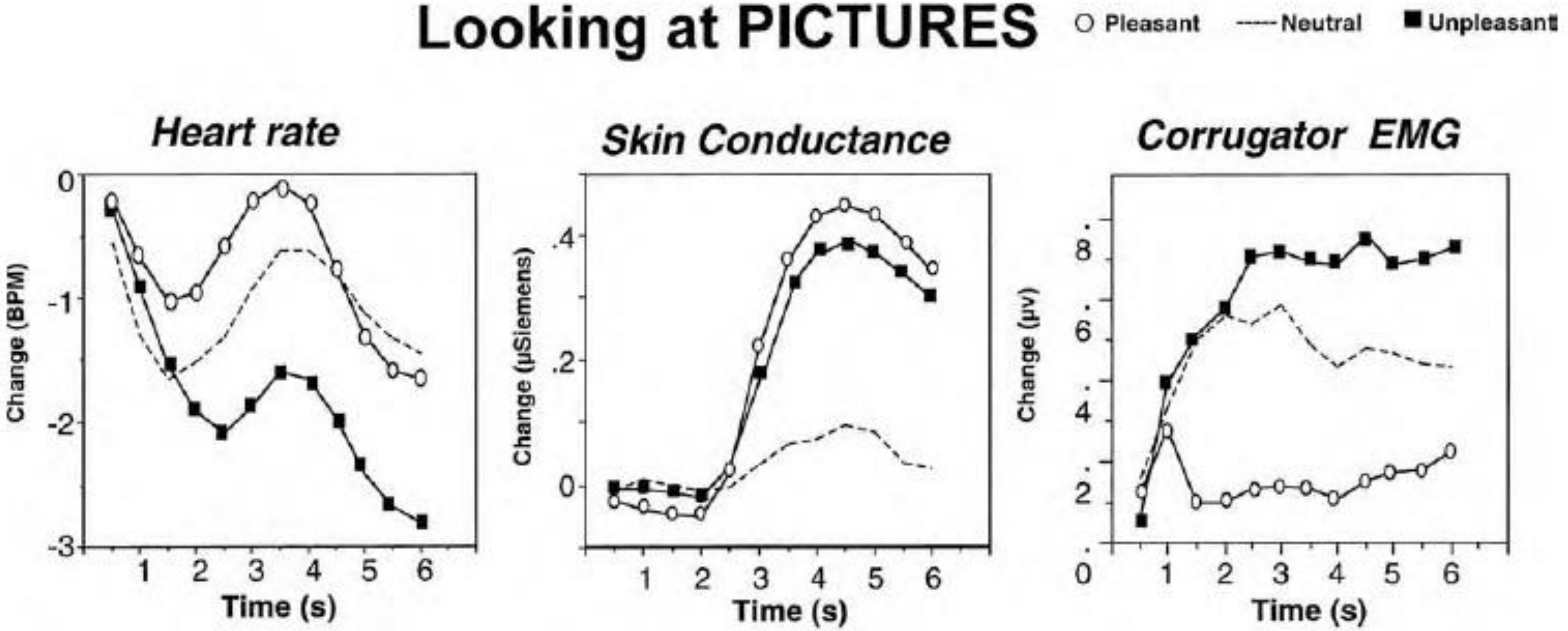
Corrugator “Frown”



Zygomatic "Smile"

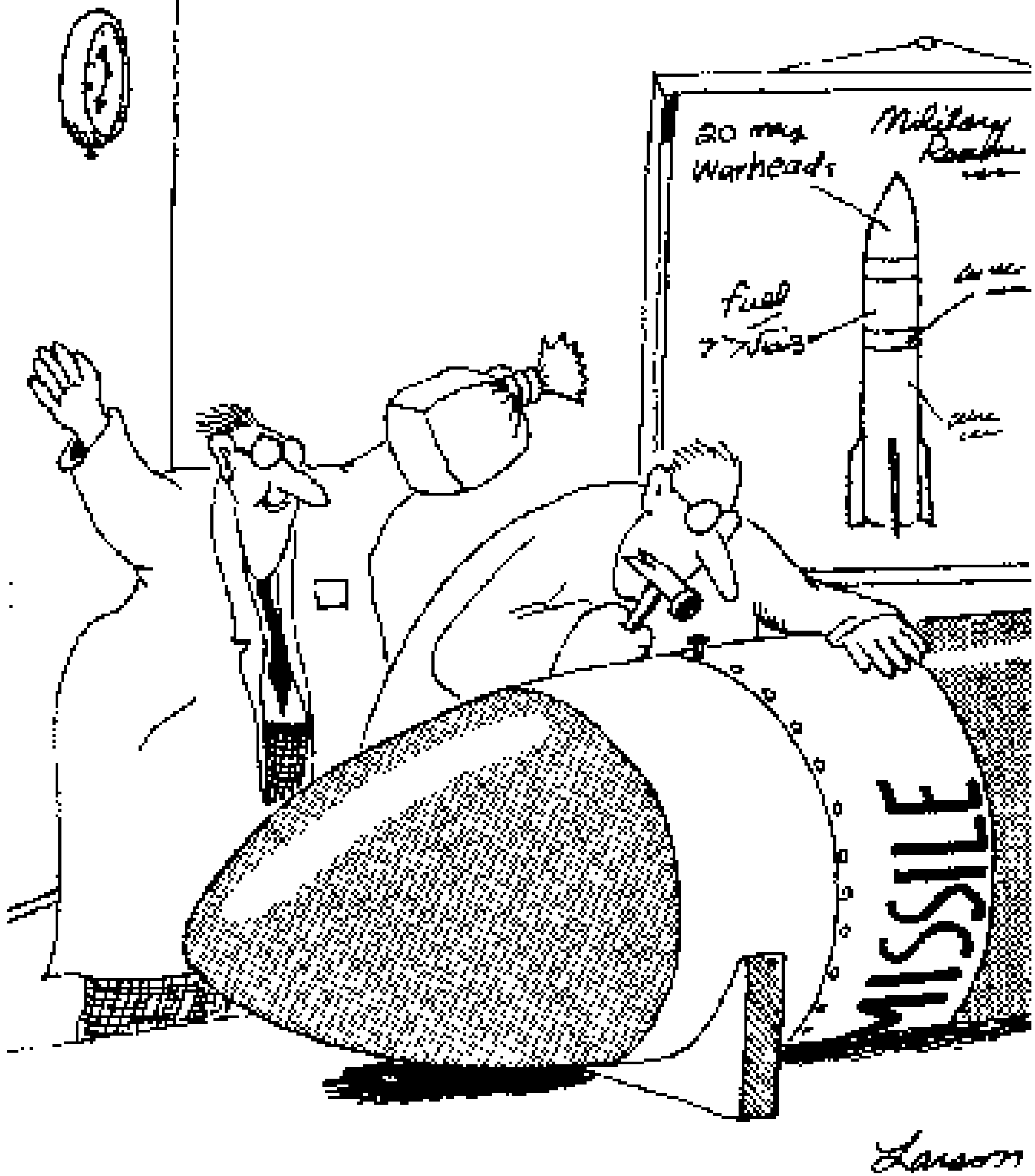


Looking at PICTURES

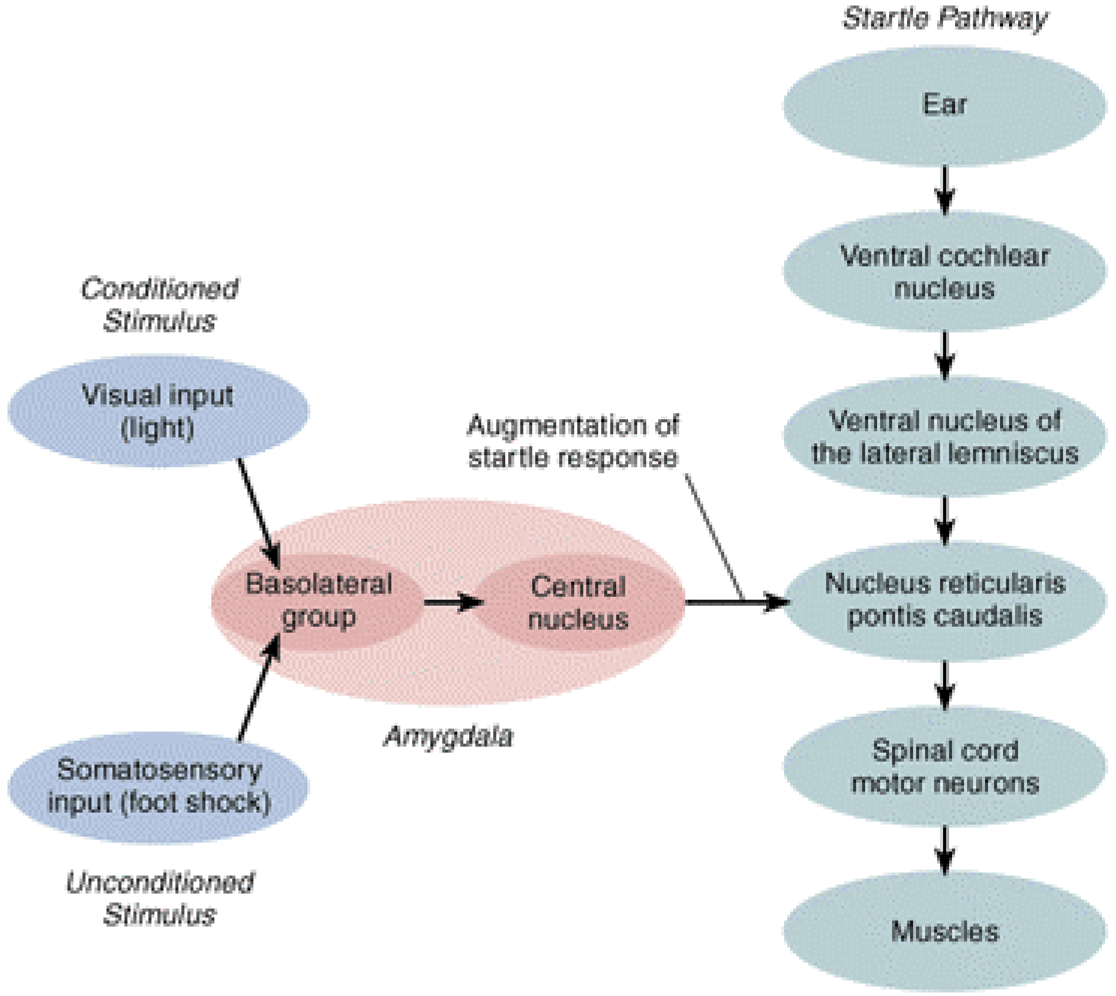


A few Applications

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

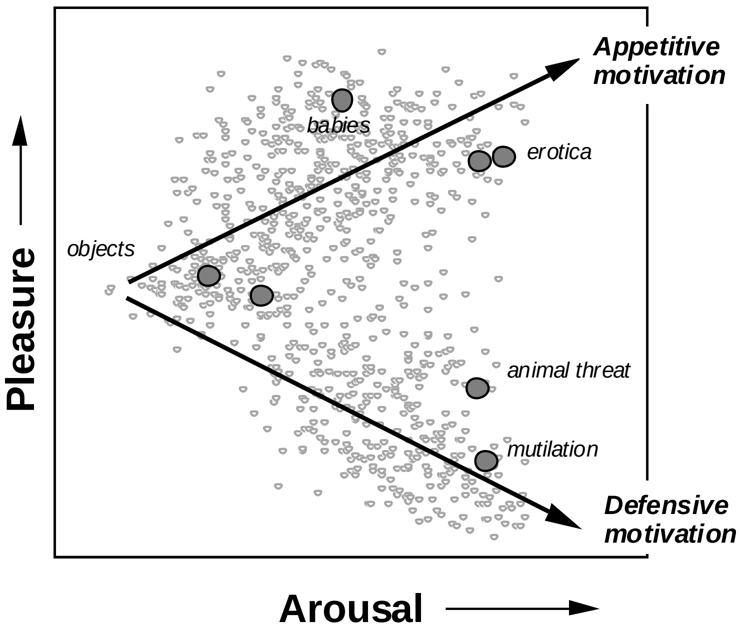

Warheads
fuel
MISSILE
Larson

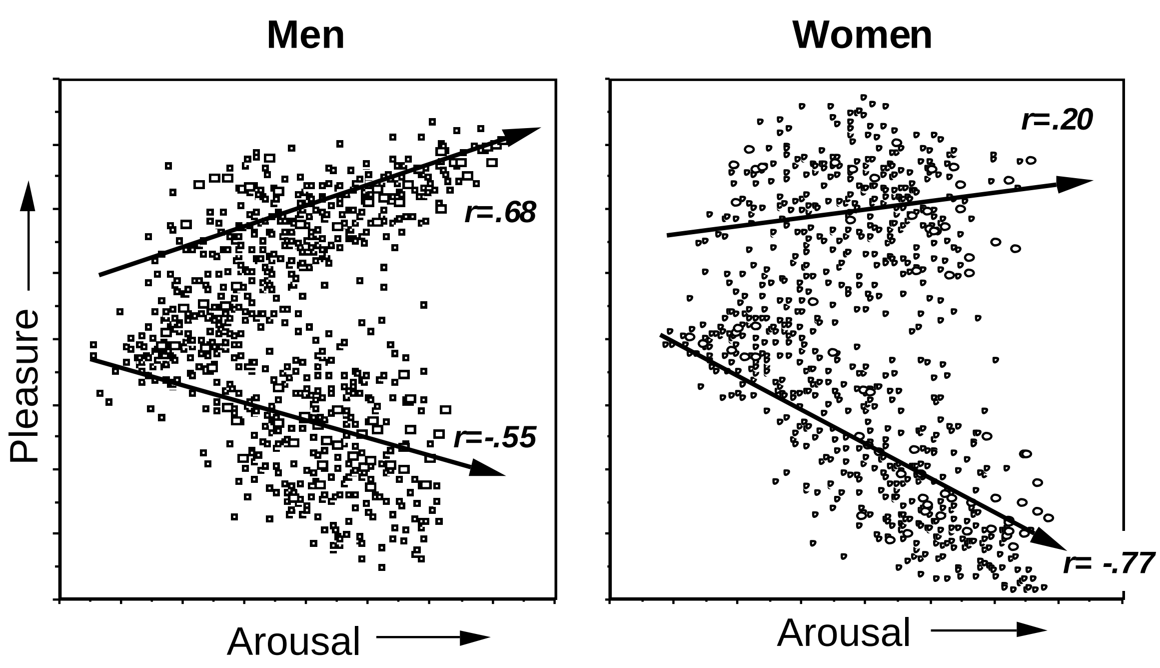
► Neural Circuits Responsible for an Auditory Startle Response and for Its Augmentation by Conditioned Aversive Stimuli



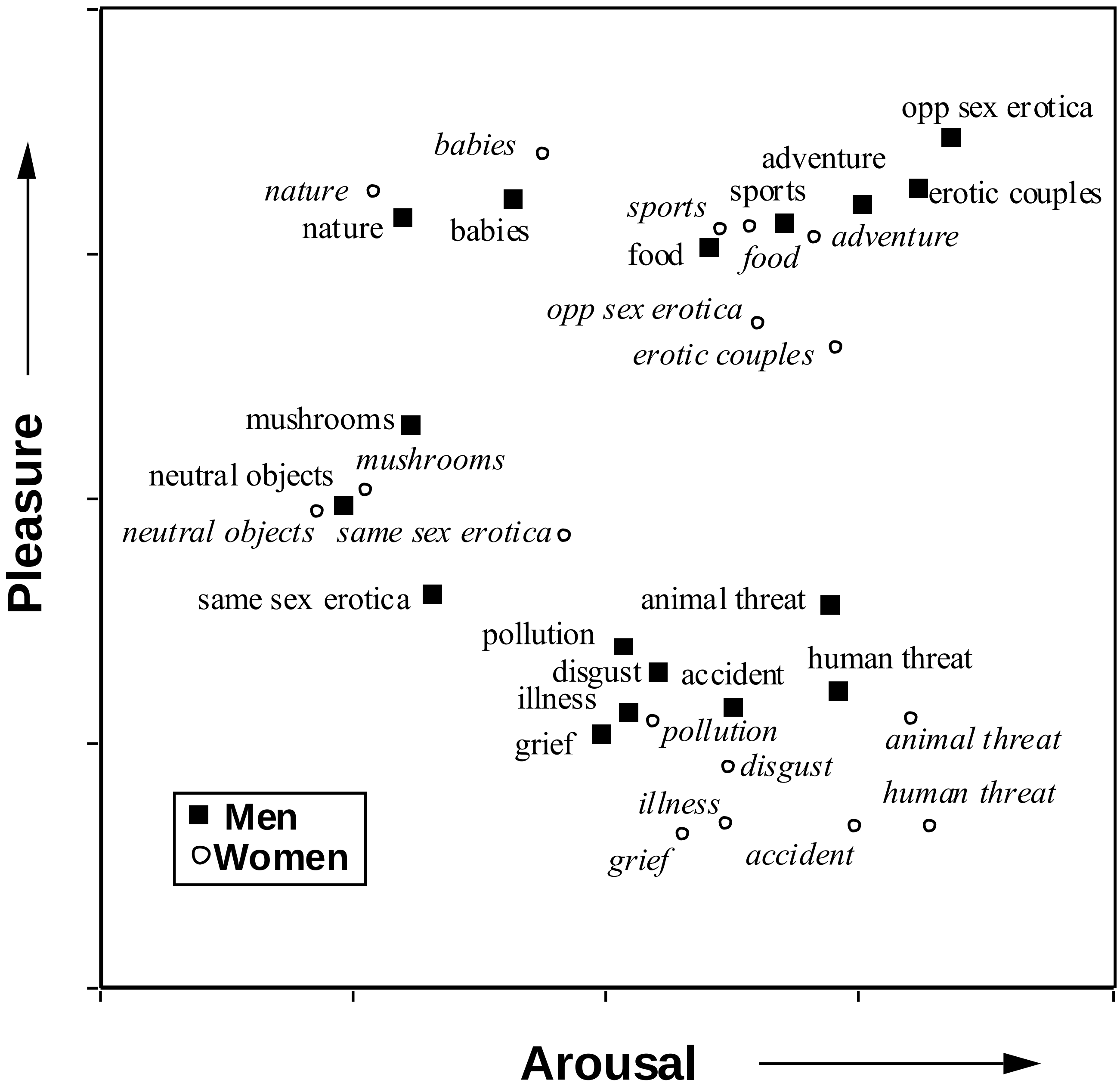
Source: Adapted from Davis, M., *Trends in Pharmacological Sciences*, 1992, *13*, 35–41.

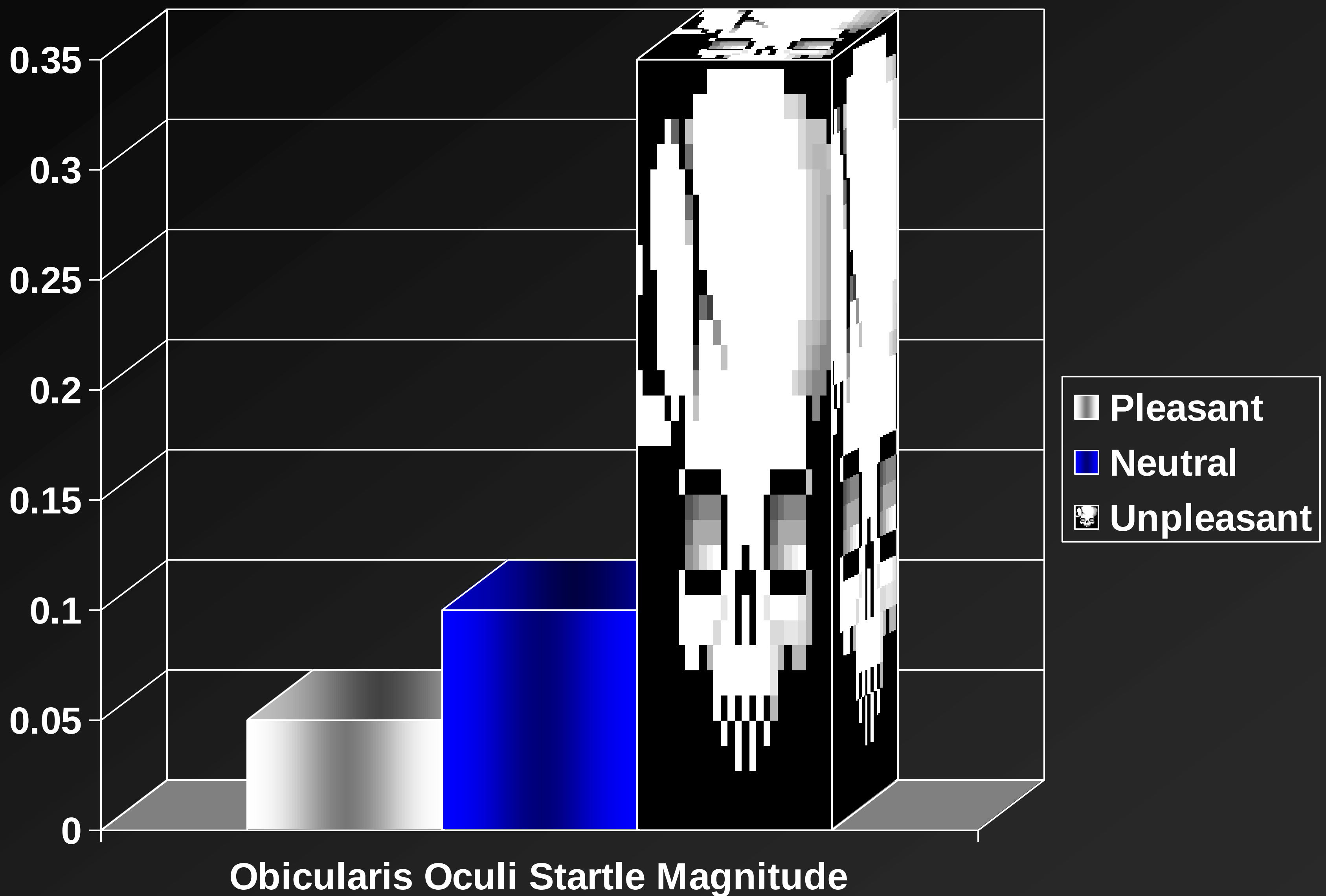
International Affective Picture System (IAPS)



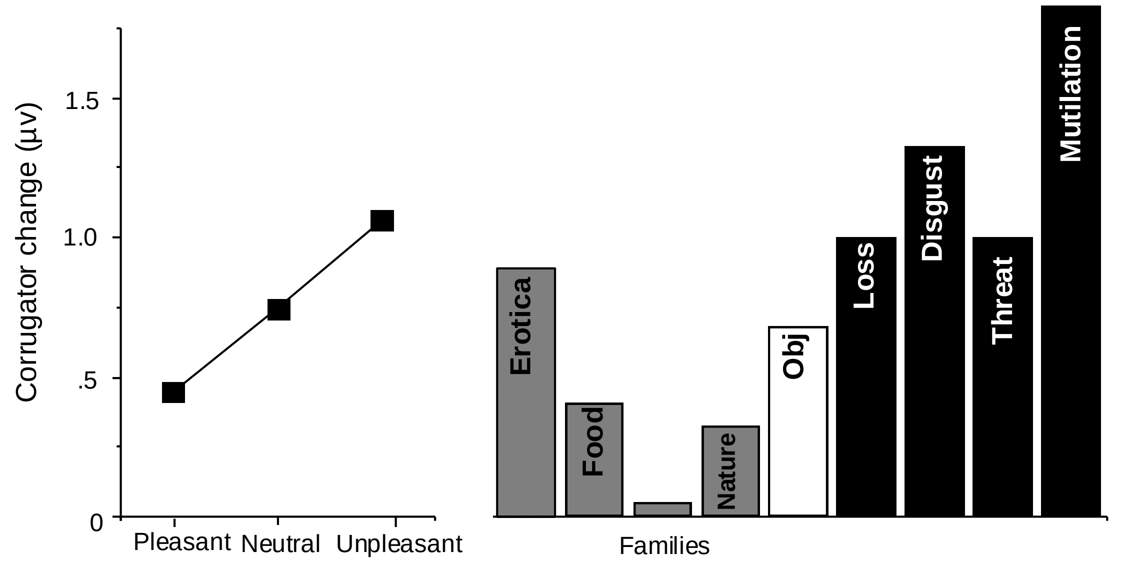


Affective Space:
Picture Content and Gender

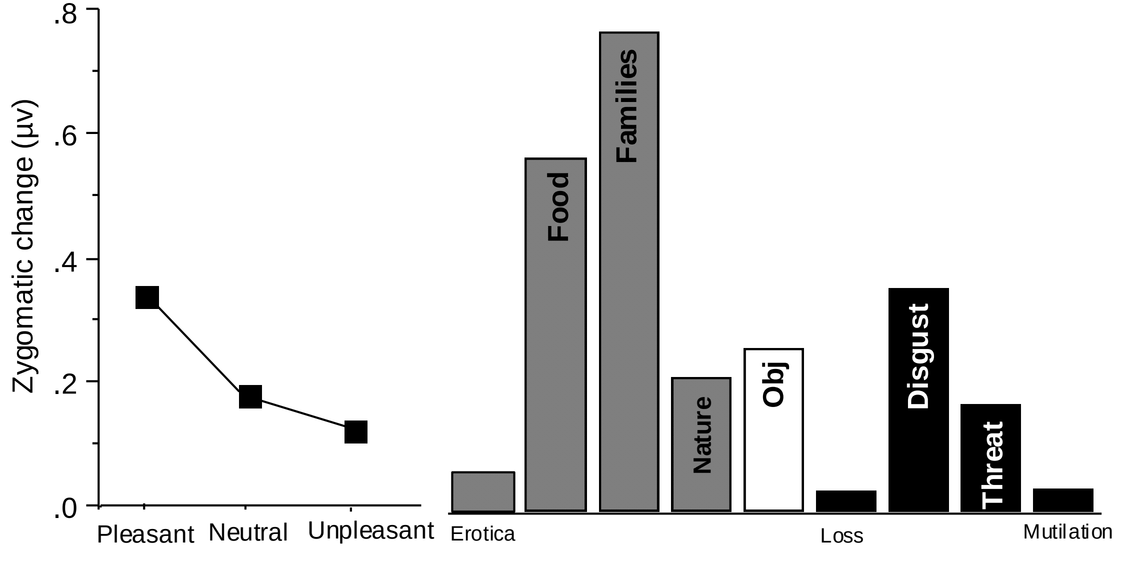



0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Obicularis Oculi Startle Magnitude
Pleasant
Neutral
Unpleasant

Corrugator EMG



Zygomatic EMG



Resting HRV as moderator of Startle Potentiation

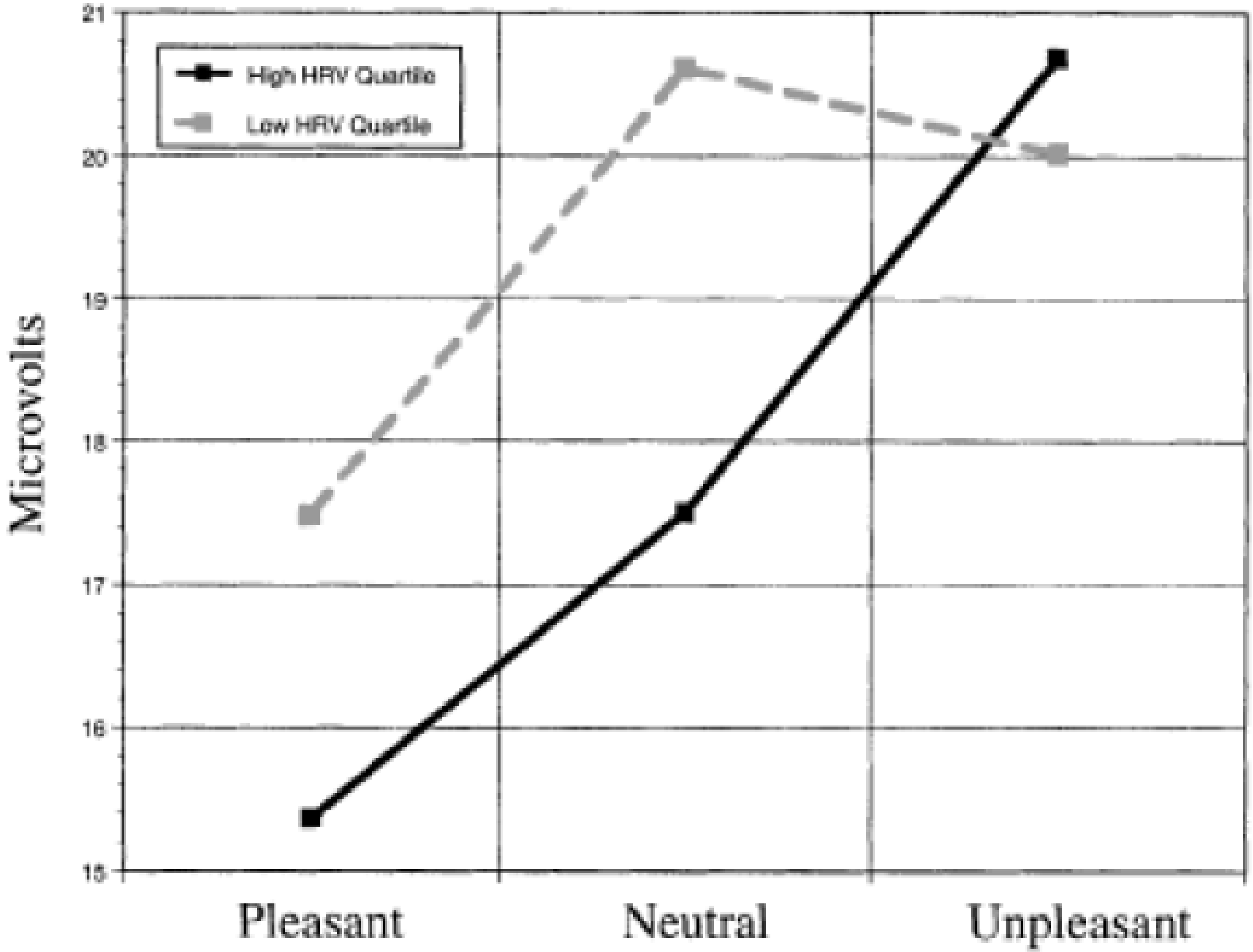


Figure 1. Mean startle amplitude as a function of baseline HRV and valence. Startle amplitudes are in microvolts.

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

A few Applications

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  - Subliminal effects
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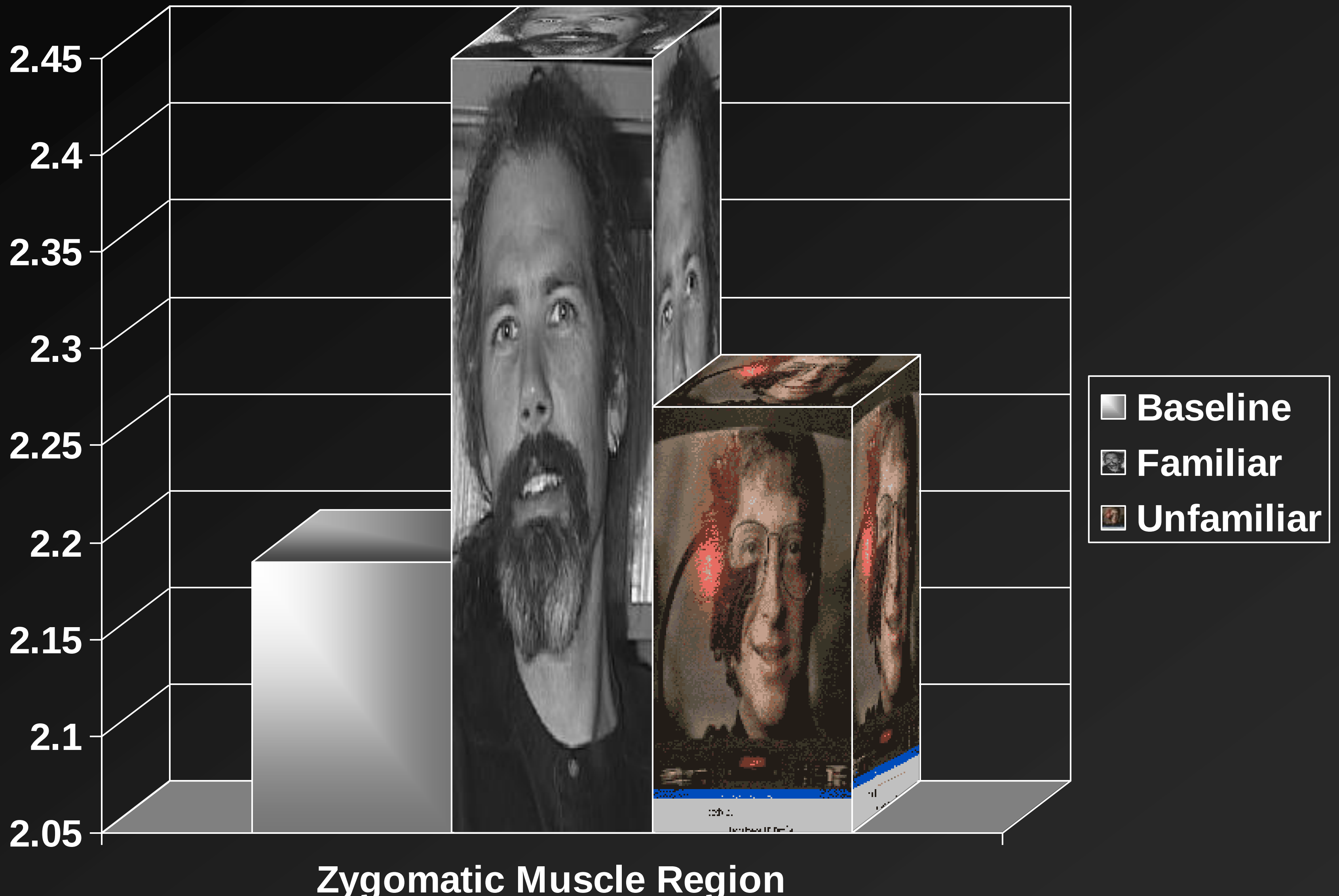
  - Emotion Regulation – outcome measure
  - Empathy – individual difference measure

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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30 ms

5 ms


Dimberg et al *Psychological Science* 2000

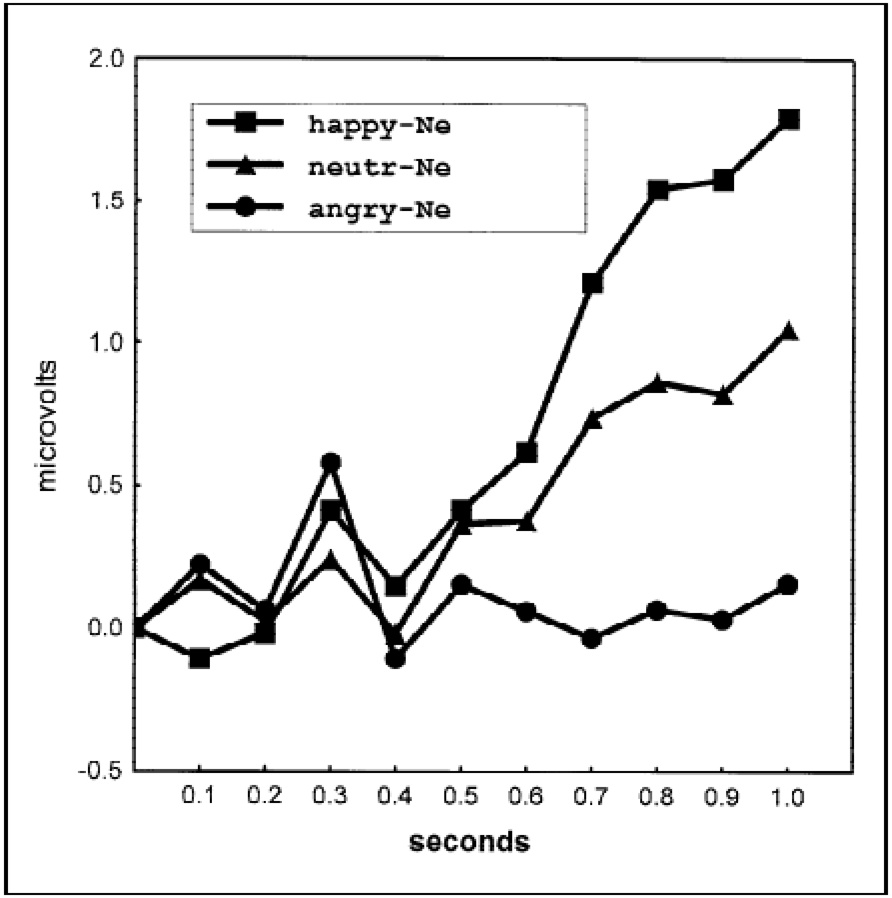

Fig. 1. Mean facial electromyographic response for the *zygomatic major* muscle, plotted in intervals of 100 ms during the first second of exposure. Three different groups of participants were exposed to identical neutral faces ("Ne"), preceded by unconscious exposure of happy, neutral ("neutr"), or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

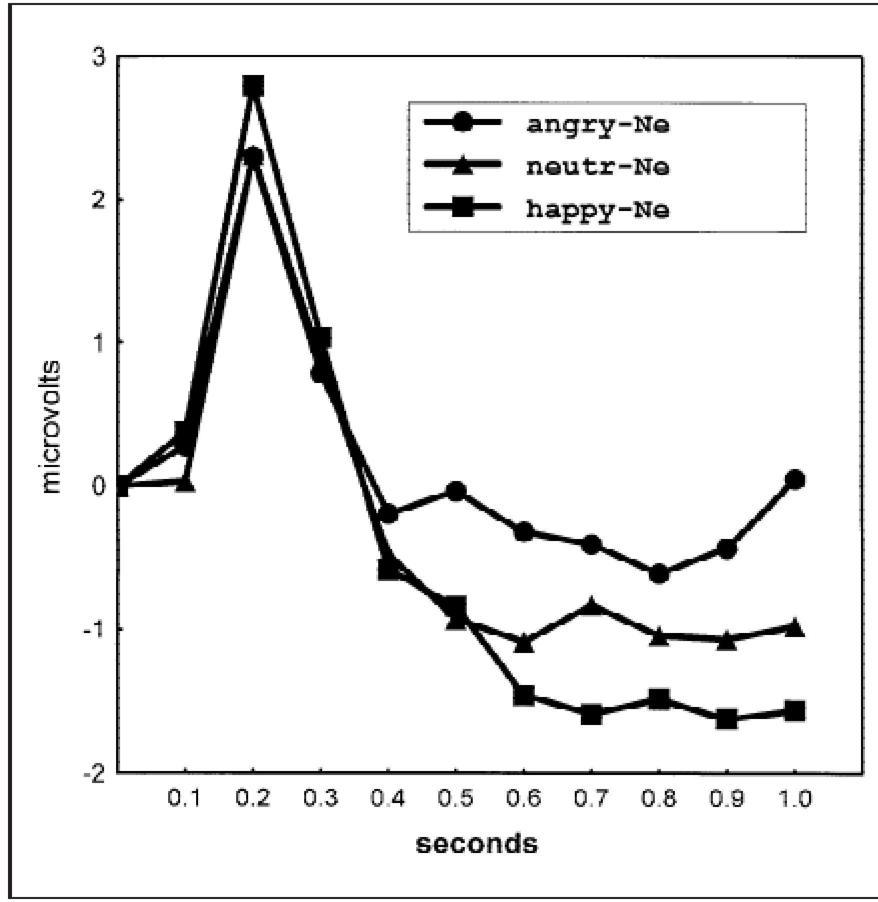

Fig. 2. Mean facial electromyographic response for the *corrugator supercilii* muscle, plotted in intervals of 100 ms during the first second of exposure. Three different groups of participants were exposed to identical neutral faces ("Ne"), preceded by unconscious exposure of angry, neutral ("neutr"),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

Dimberg et al *Psychological Science* 2000

A few Applications

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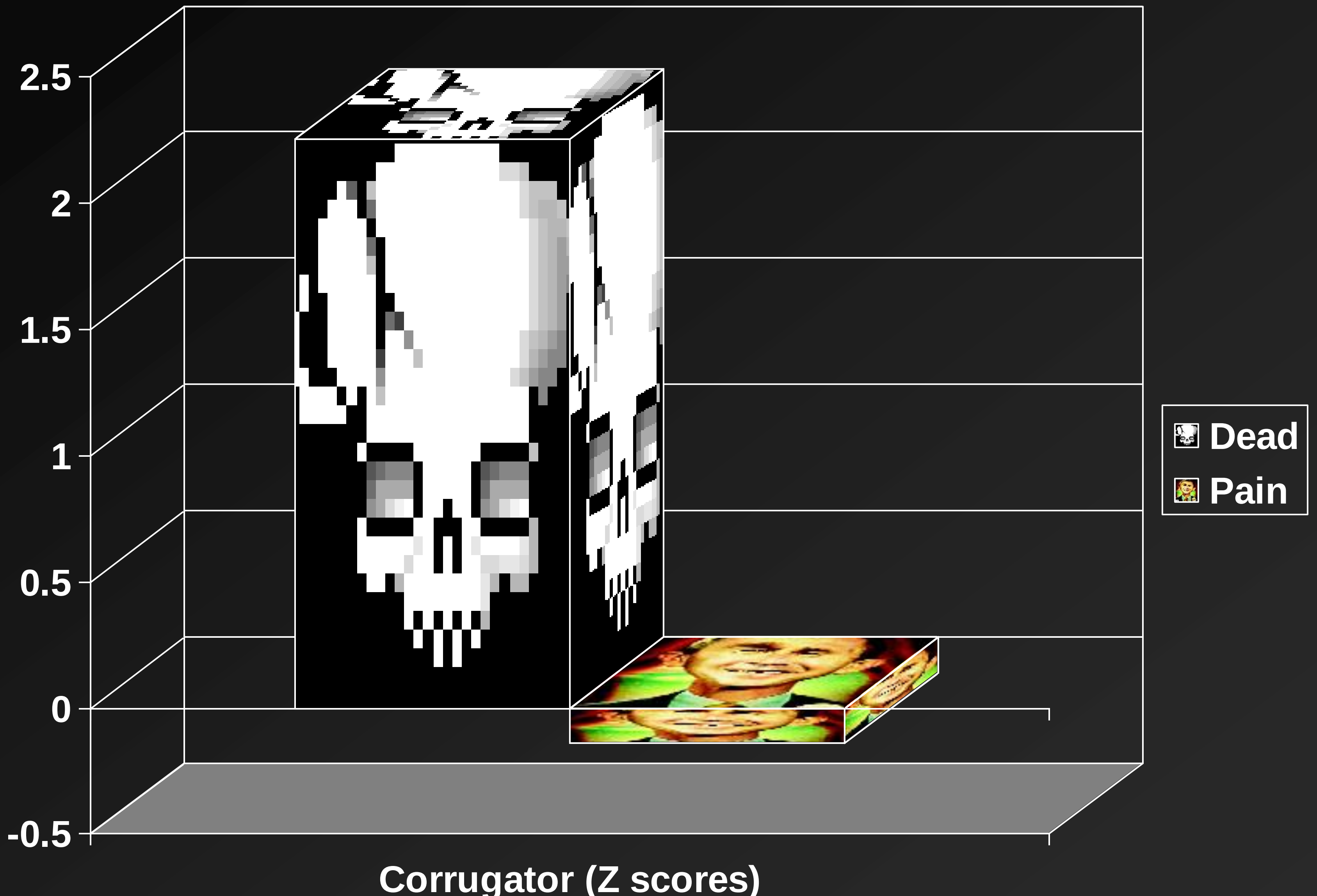

Another loose translation: Arndt, J., Allen, J.J.B., & Greenberg, J. (2001). Traces of terror: Subliminal death primes and facial electromyographic indices of affect. *Motivation and Emotion*, *25*, 253-277.

A few Applications

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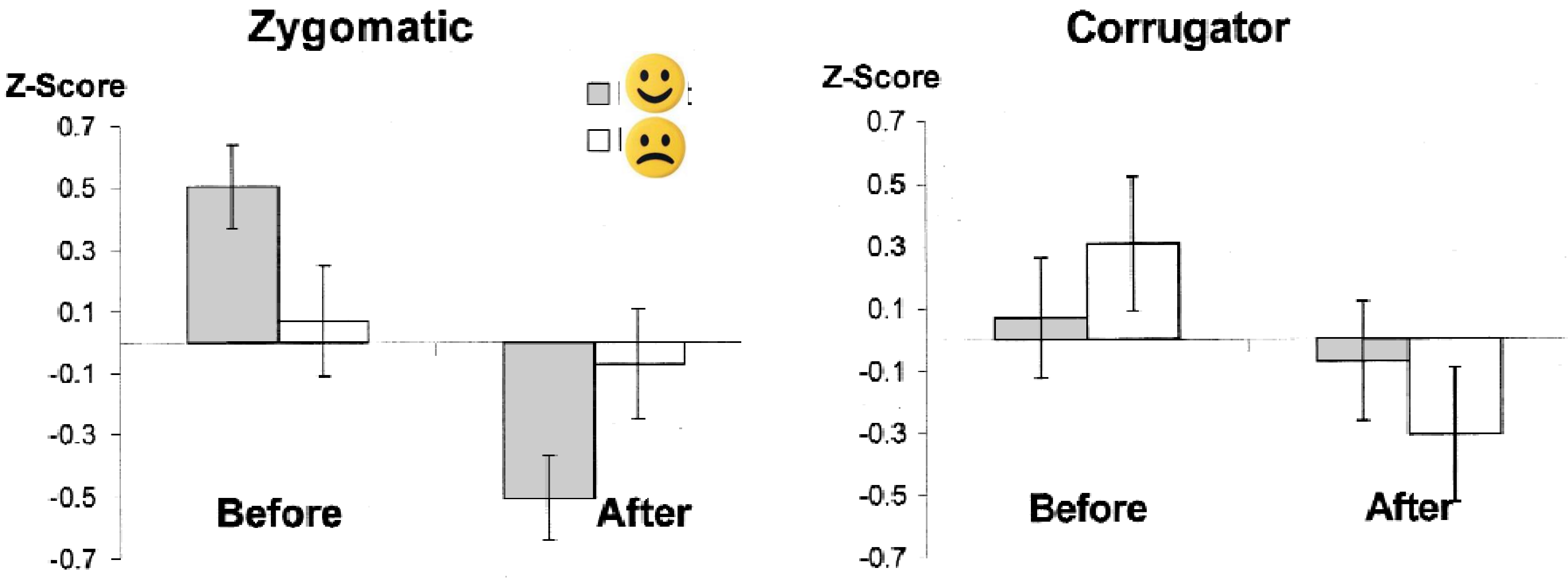

Allen, Cavender, Harmon-Jones, *Psychophysiology* 2001

A few Applications

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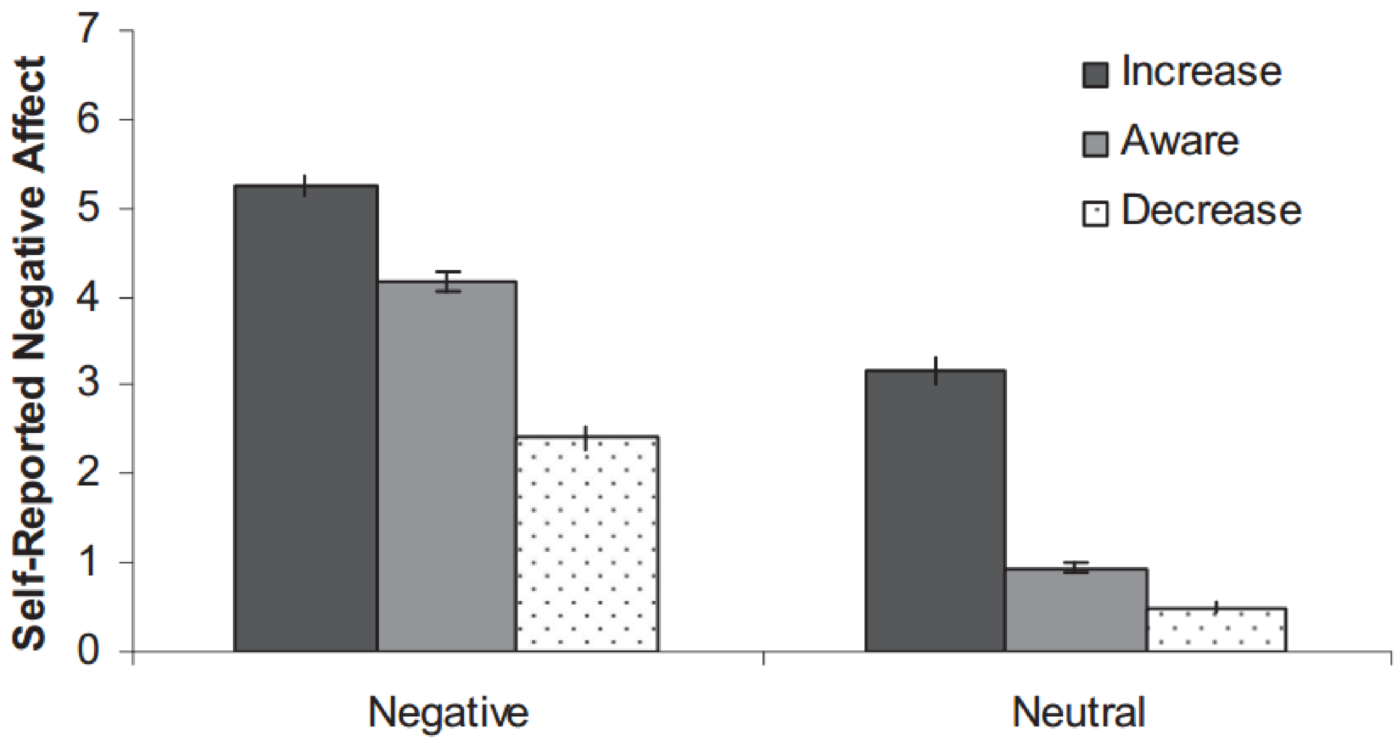

Figure 1. Self-reported negative affect on a 7-point Likert scale, where 0 = "not negative at all" and "7" = "strongly negative."

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

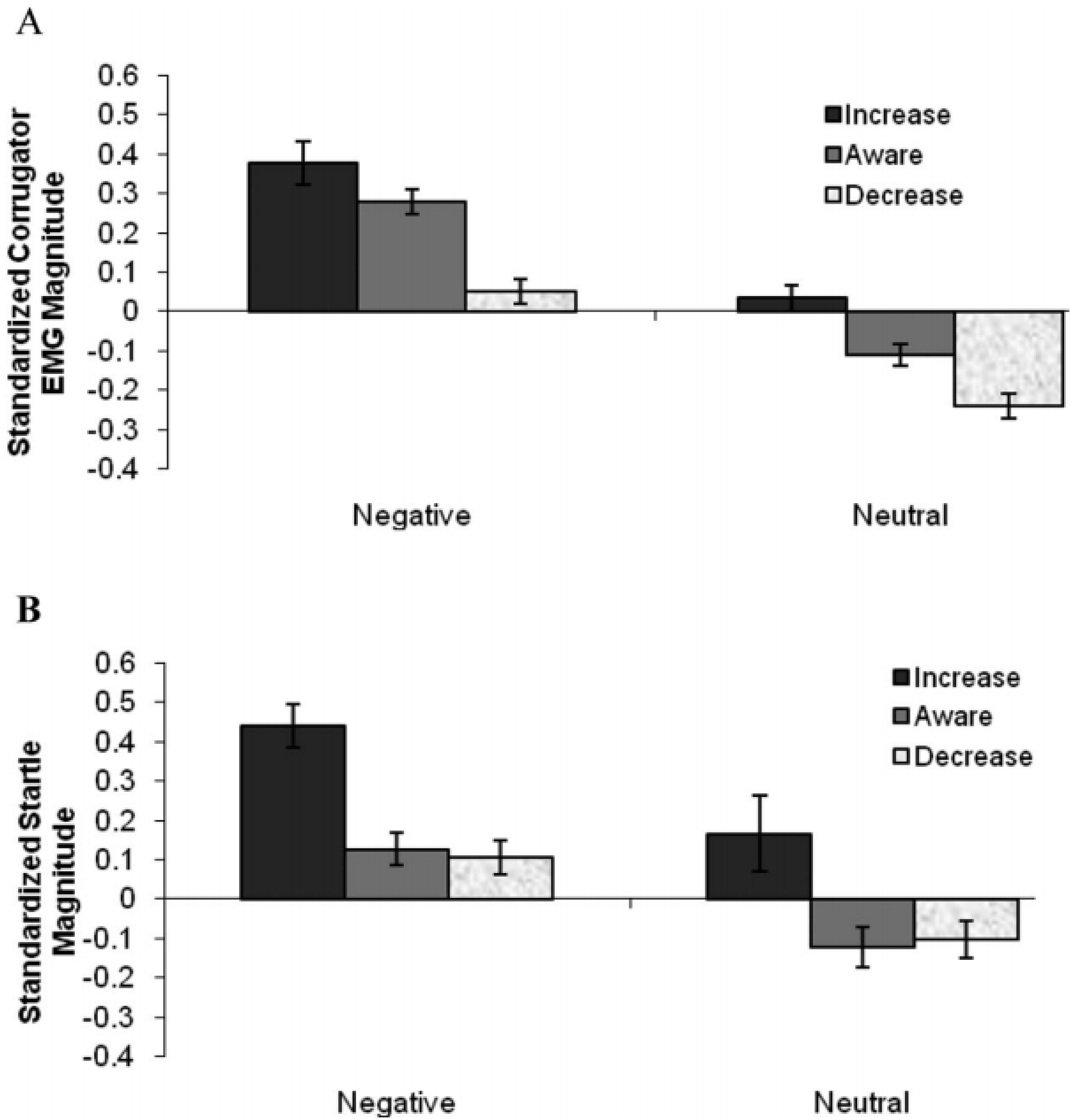

Figure 2. Standardized (A) corrugator EMG and (B) startle magnitude (averaged over Times 1 and 2).

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

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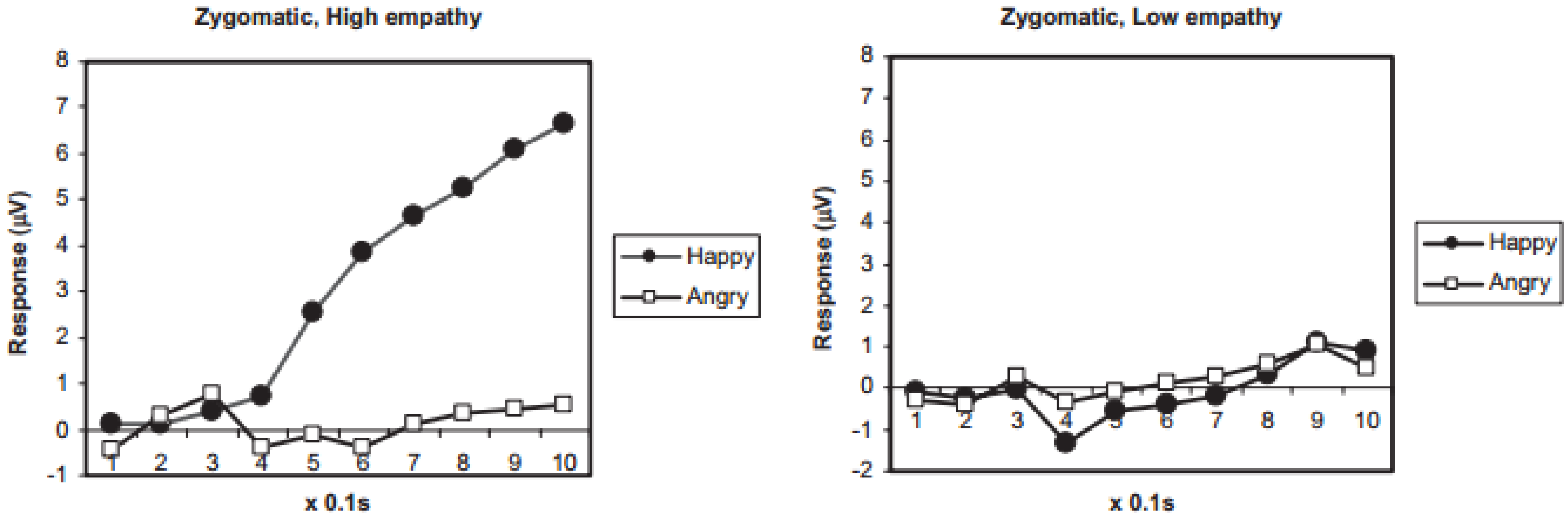

Figure 1. The *zygomaticus major* muscle response to pictures of happy and angry facial expressions for the High and Low empathy groups, plotted as a function of 100-ms intervals during the first second after stimulus onset.

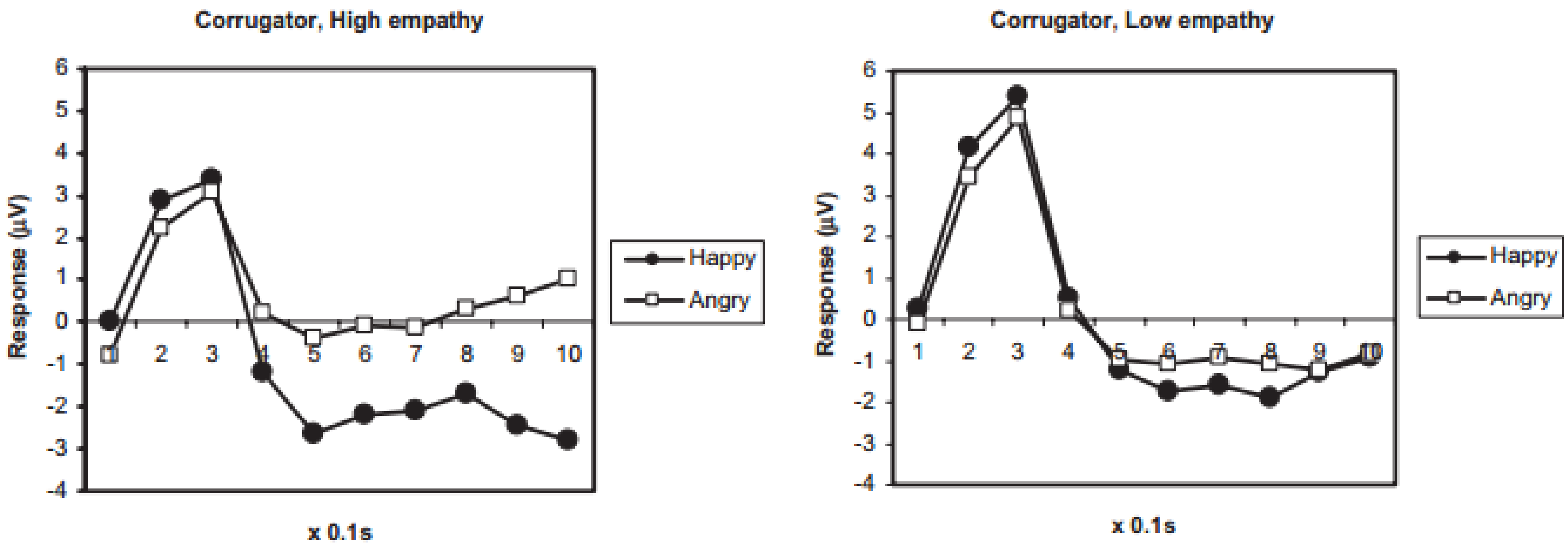

Figure 2. The *corrugator supercilii* muscle response to pictures of happy and angry facial expressions for the High and Low empathy groups, plotted as a function of 100-ms intervals during the first second after stimulus onset.

Dimberg & Thunberg (2012) *PsyCh Journal*