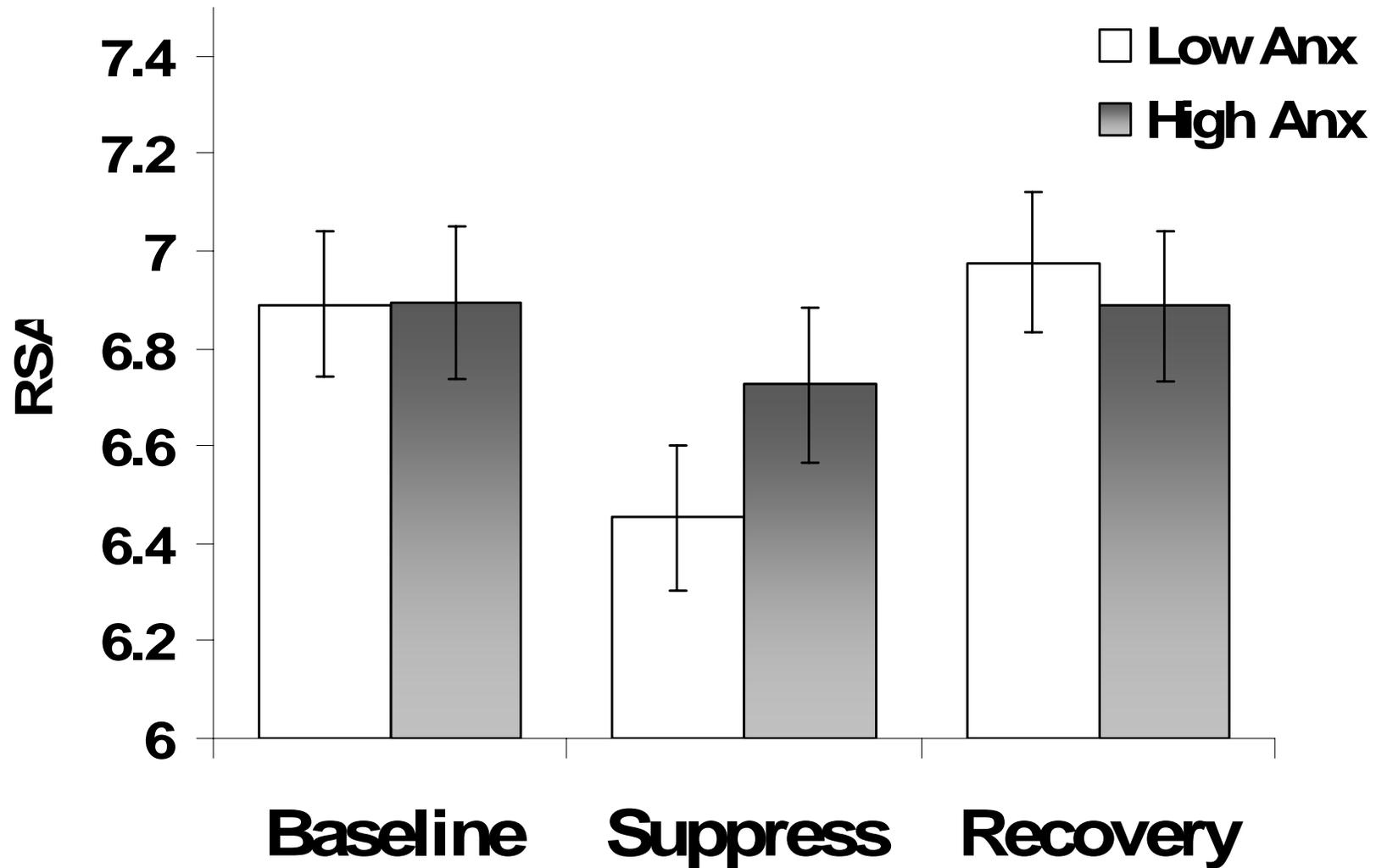


*A bit more*  
*Cardiovascular Psychophysiology*

*and then...*

*Electromyography*

# Task-related and Emotion-related modulation



# 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

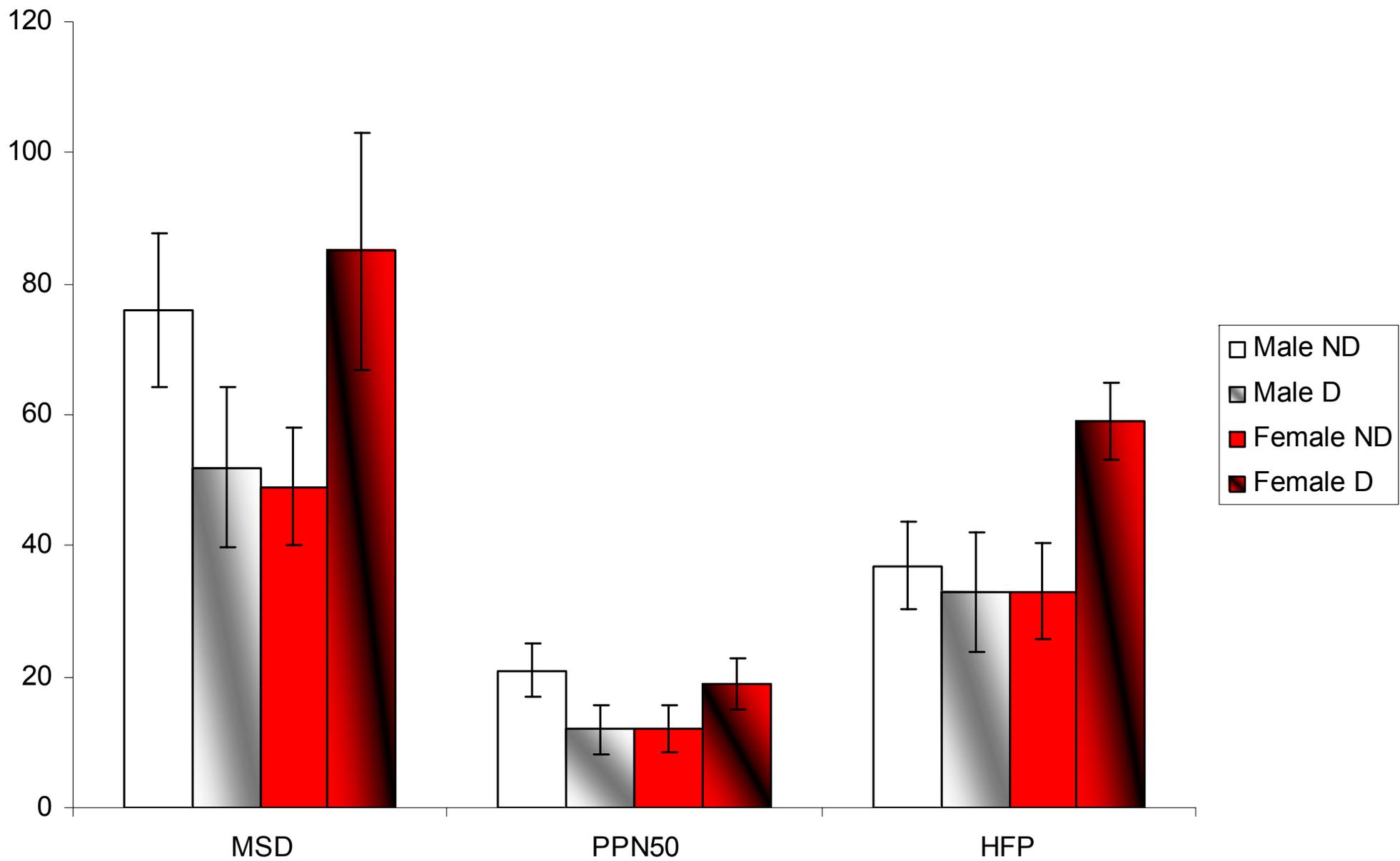
- Depression characterized by lower Vagal tone?
- Gender may moderate ([Thayer et al., 1998](#))
  - Note small sample: 15 depressed, 11 controls
- State dependent? ([Chambers & Allen, 2002](#))



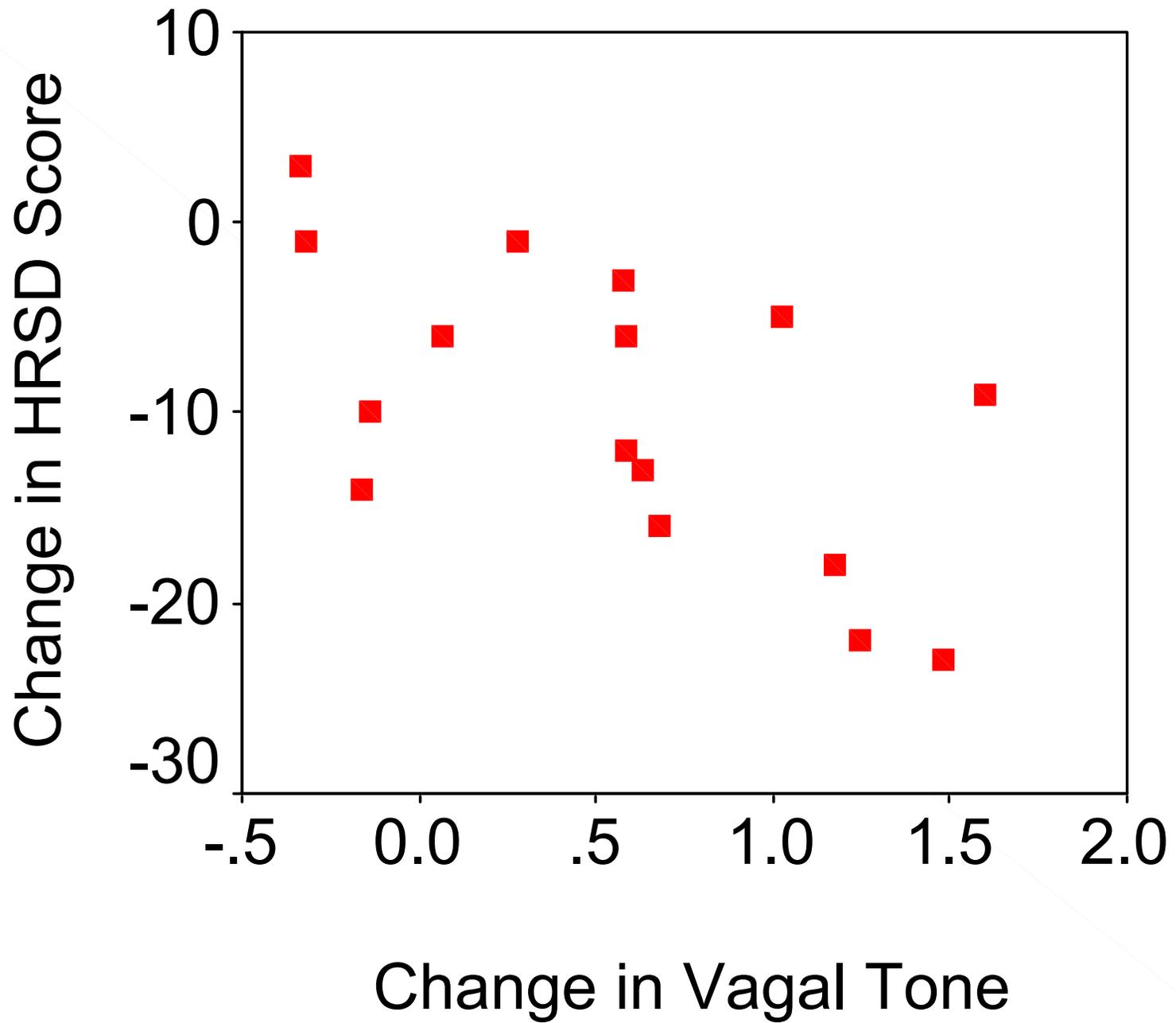
Table 1  
Significant contrasts among panickers, blood phobics, and controls

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

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



Data from Thayer et al., 1998, *Bio Psychiatry*



# Trait Vagal Tone (cont')

- Defensive Coping ([Movius & Allen, 2005](#))
- Integrative Developmental Model

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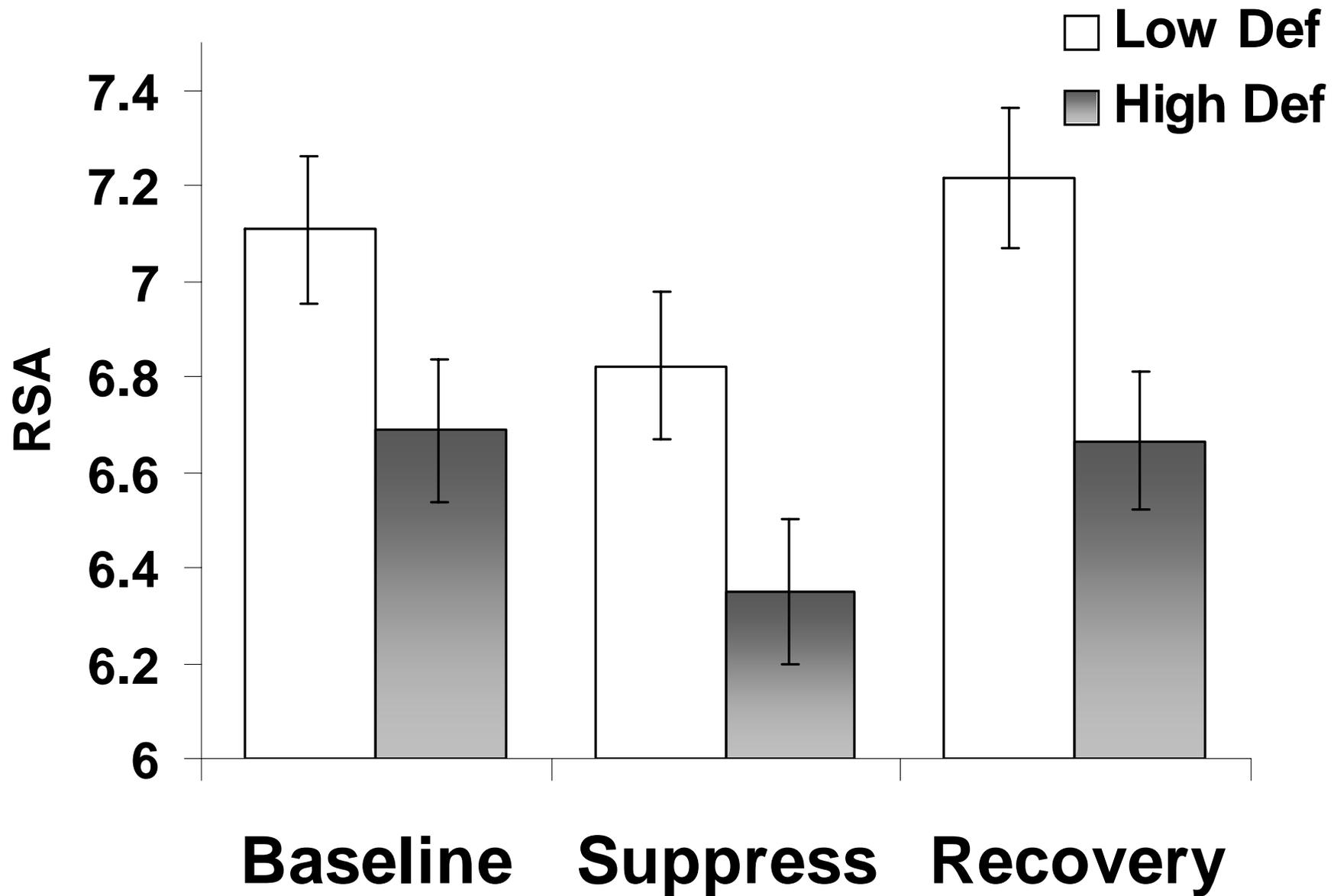
T. Beauchaine

**Table 1.** Patterns of autonomic nervous system functioning in common psychopathologies and personality types

Motivational Predisposition	Behavioral Manifestation	Motivational System (SNS)		Regulatory System (PNS)	
		Activation (BAS)	Inhibition (BIS)	Emotional Trait (RSA)	Emotional State (RSA Reactivity)
Disinhibition	Impulsivity (ADHD)	High	Low	—	—
	Aggression (UACD)	High	Low	Low	High
	Panic	High	High	Low	High
	Extraversion	High	—	—	—
Inhibition	Anxiety	—	High	Low	—
	Depression	Low	High	Low	—
	Panic	High	High	Low	High
	Introversion	—	High	—	—
None	Emotional stability	—	—	High	—
	Emotional lability	—	—	—	High

*Note:* High, atypically high activity; Low, atypically low activity. Dashes represent normal activity. Entries in the BIS, RSA, and RSA reactivity columns are supported by the literature reviewed herein. Entries in the BAS column are more speculative and require empirical confirmation.

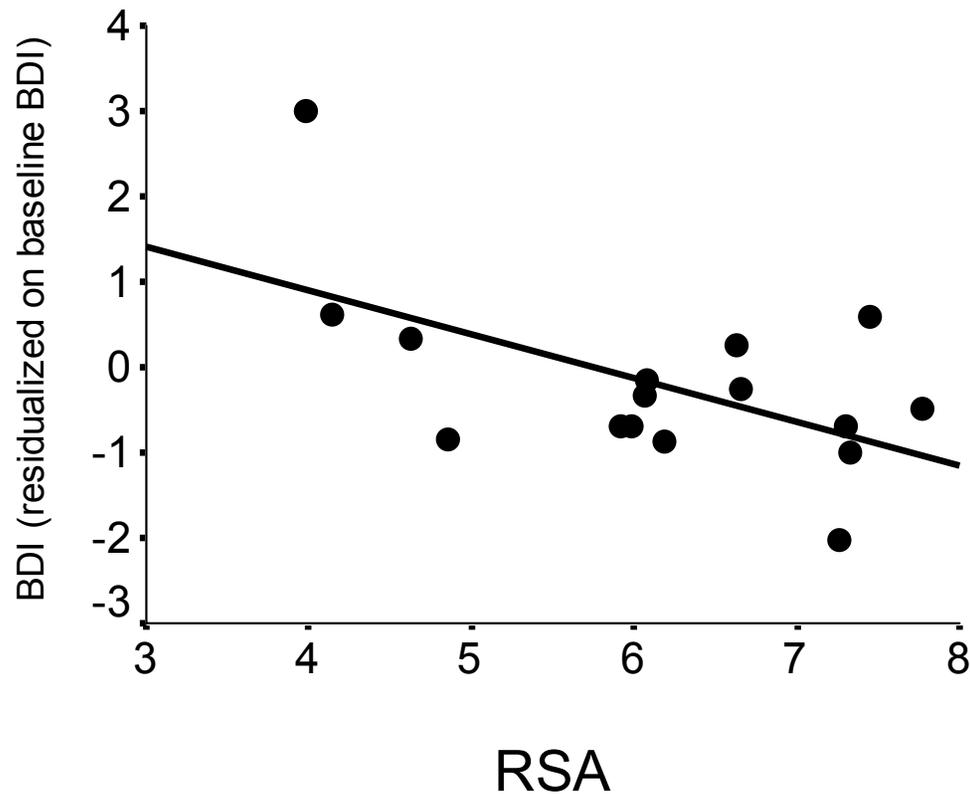
Beauchaine (2001),  
*Development and  
Psychopathology*



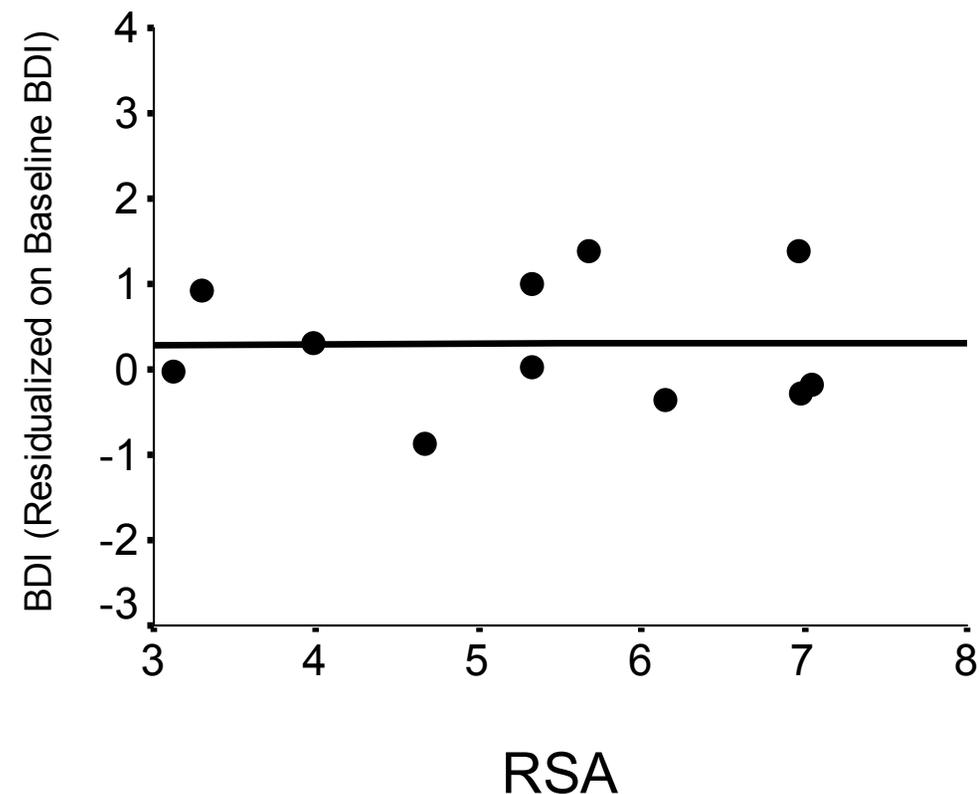
# Trait Vagal Tone as Moderator of Response following Bereavement

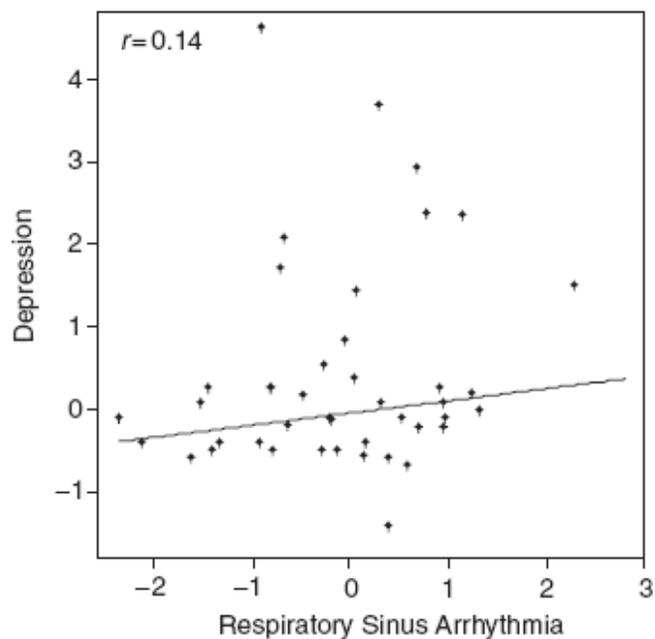
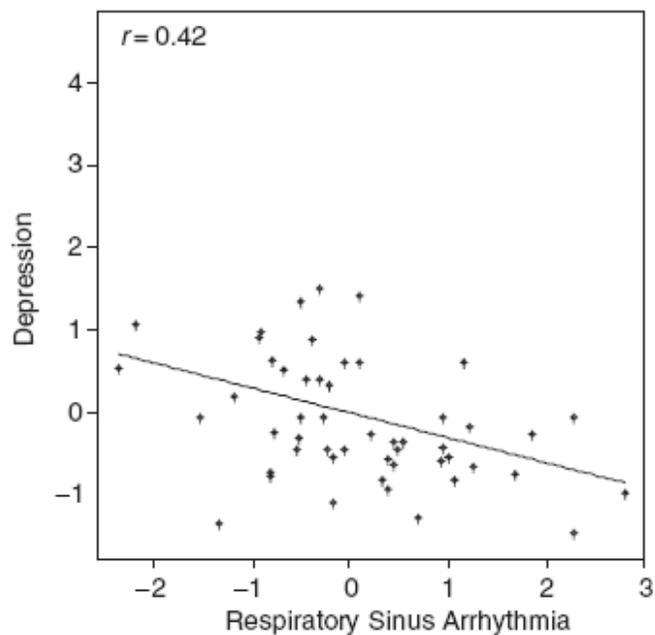
- ❑ Bereavement as a period of cardiovascular risk
- ❑ Disclosure as an intervention for Bereavement (O'Connor, Allen, Kaszniak, 2005)
- ❑ Overall, all folks get better, but no differential impact of intervention
- ❑ BUT... Vagal Tone as moderator

## Intervention Group

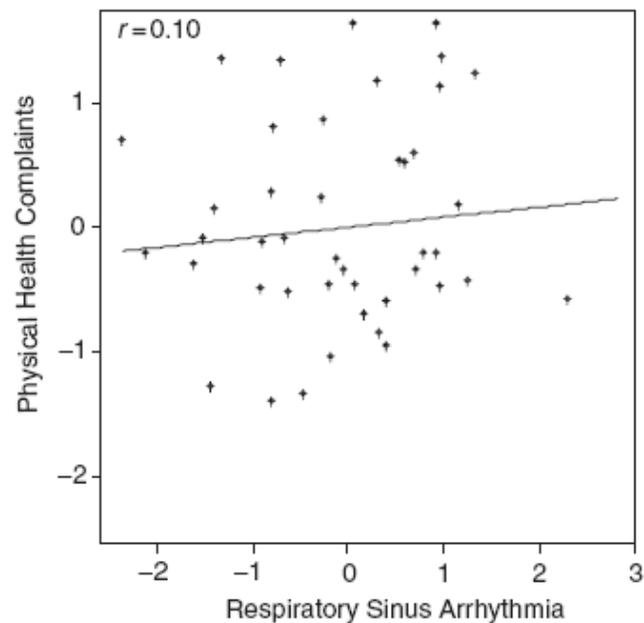
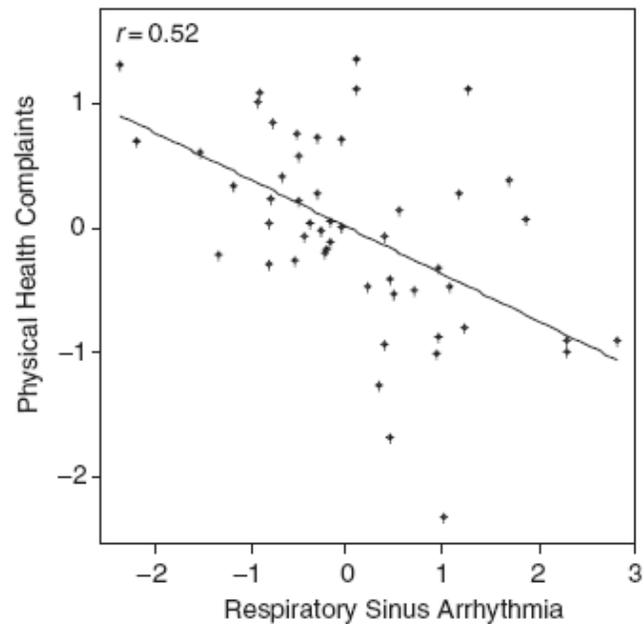


## Control Group



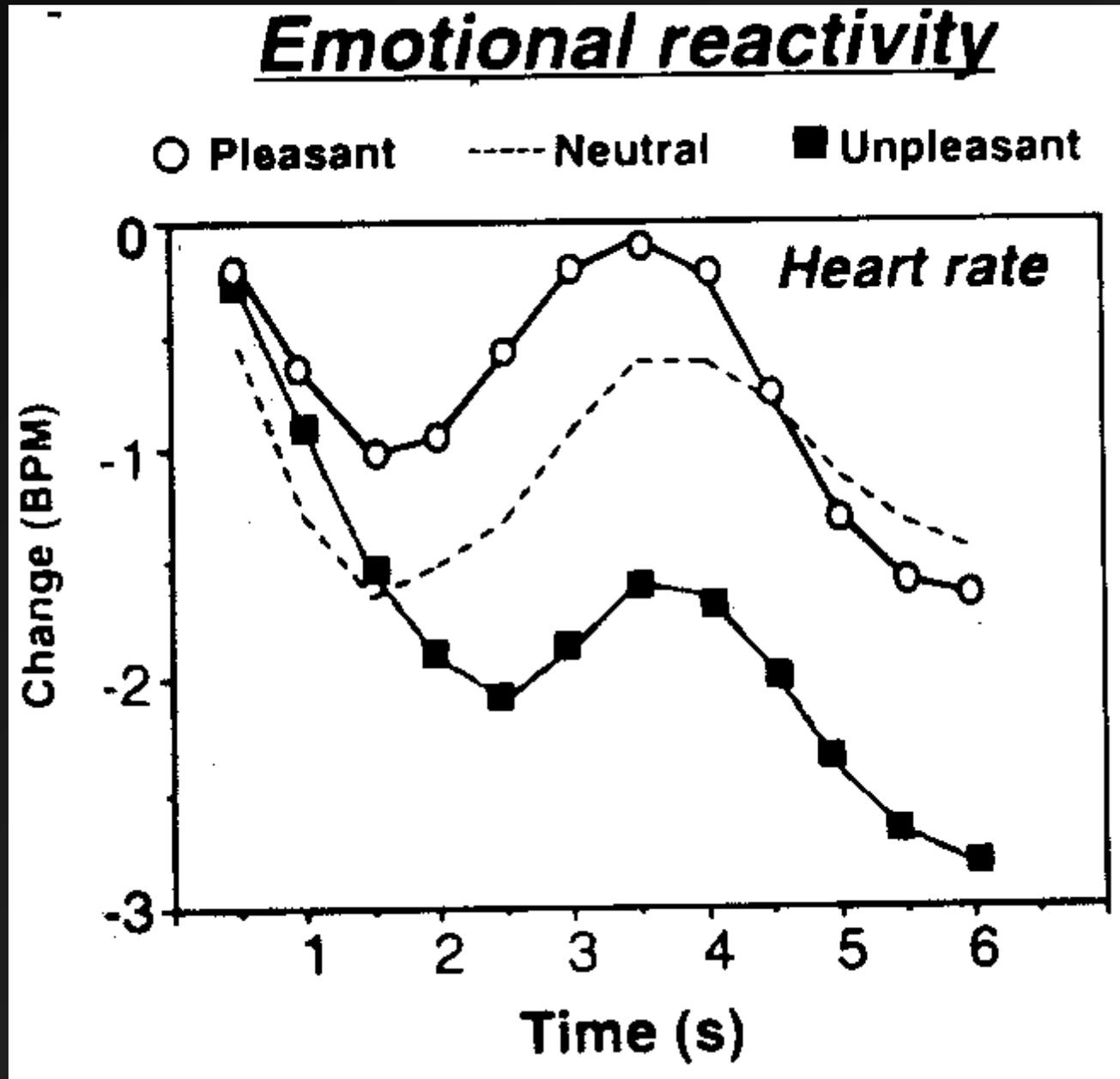


**Figure 1.** Scatterplot, prediction line, and prediction equation for the relationship between respiratory sinus arrhythmia (log of the variance of the band-limited [12–40 Hz] IBI series) and depression score (residualized on baseline depression score), for the disclosure group (top panel) and the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

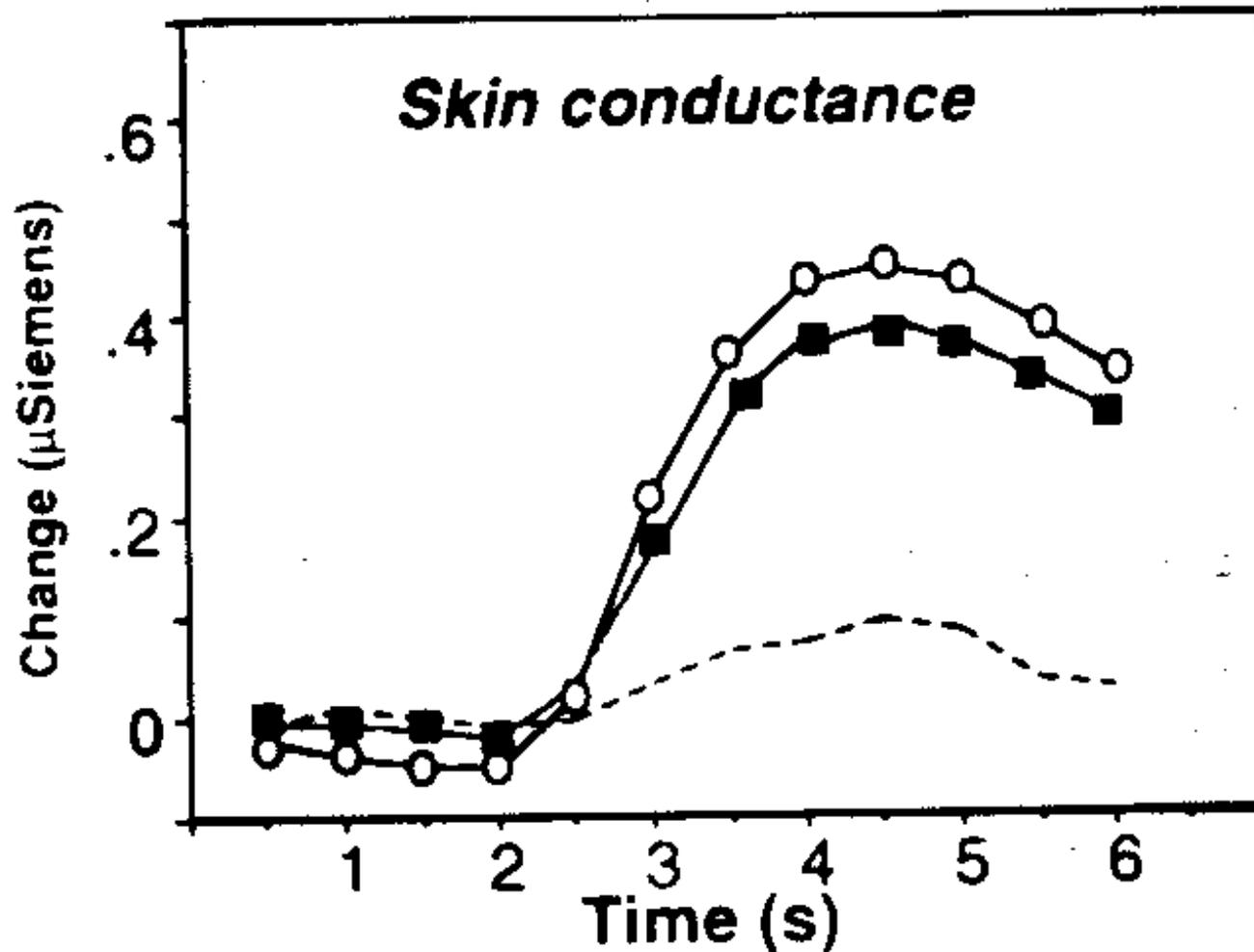
# Orienting, Attention, and Defense

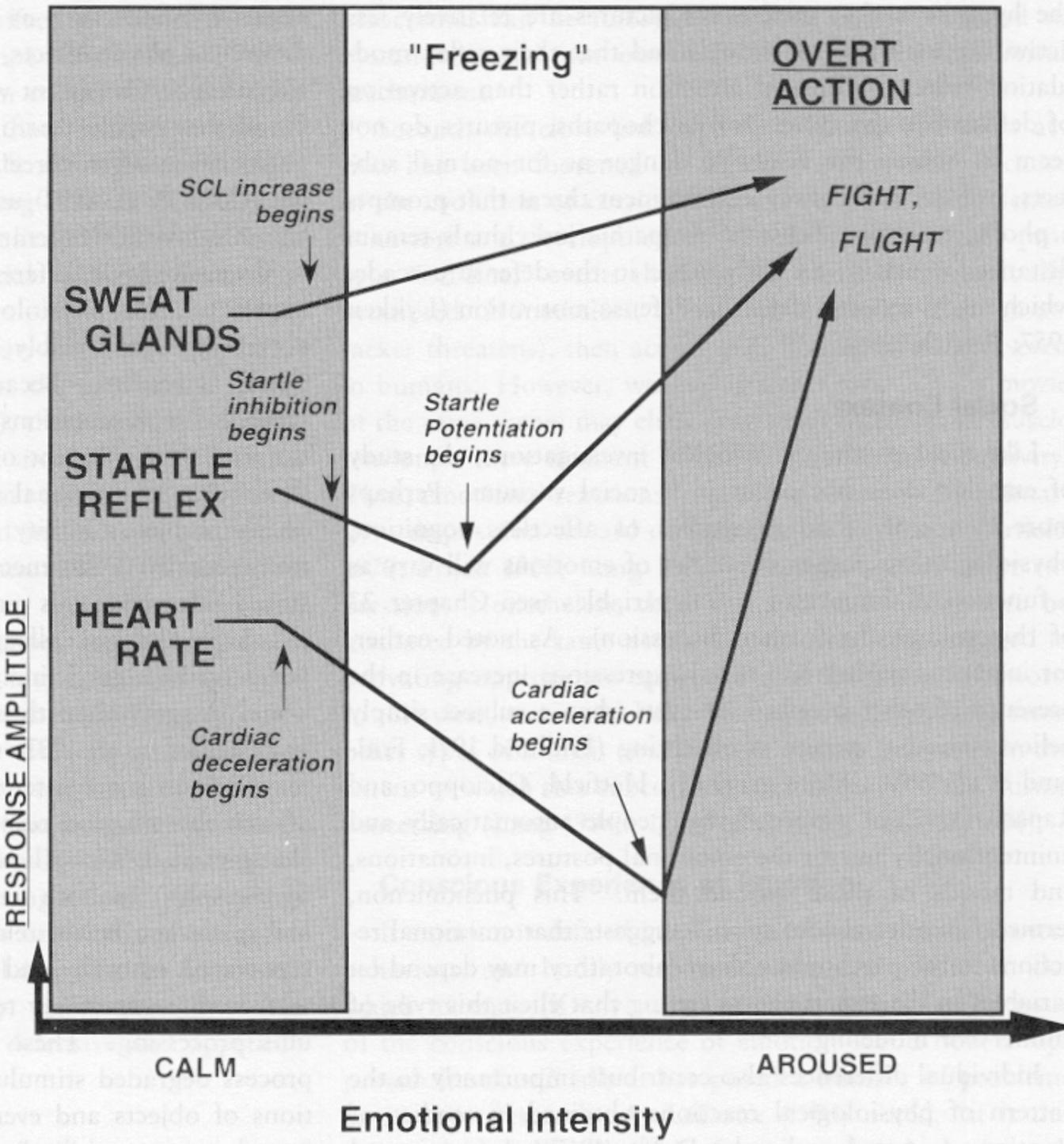


# SCR (by contrast)

## Emotional reactivity

○ Pleasant    - - - - Neutral    ■ Unpleasant





OR Vs DR

# Electromyography

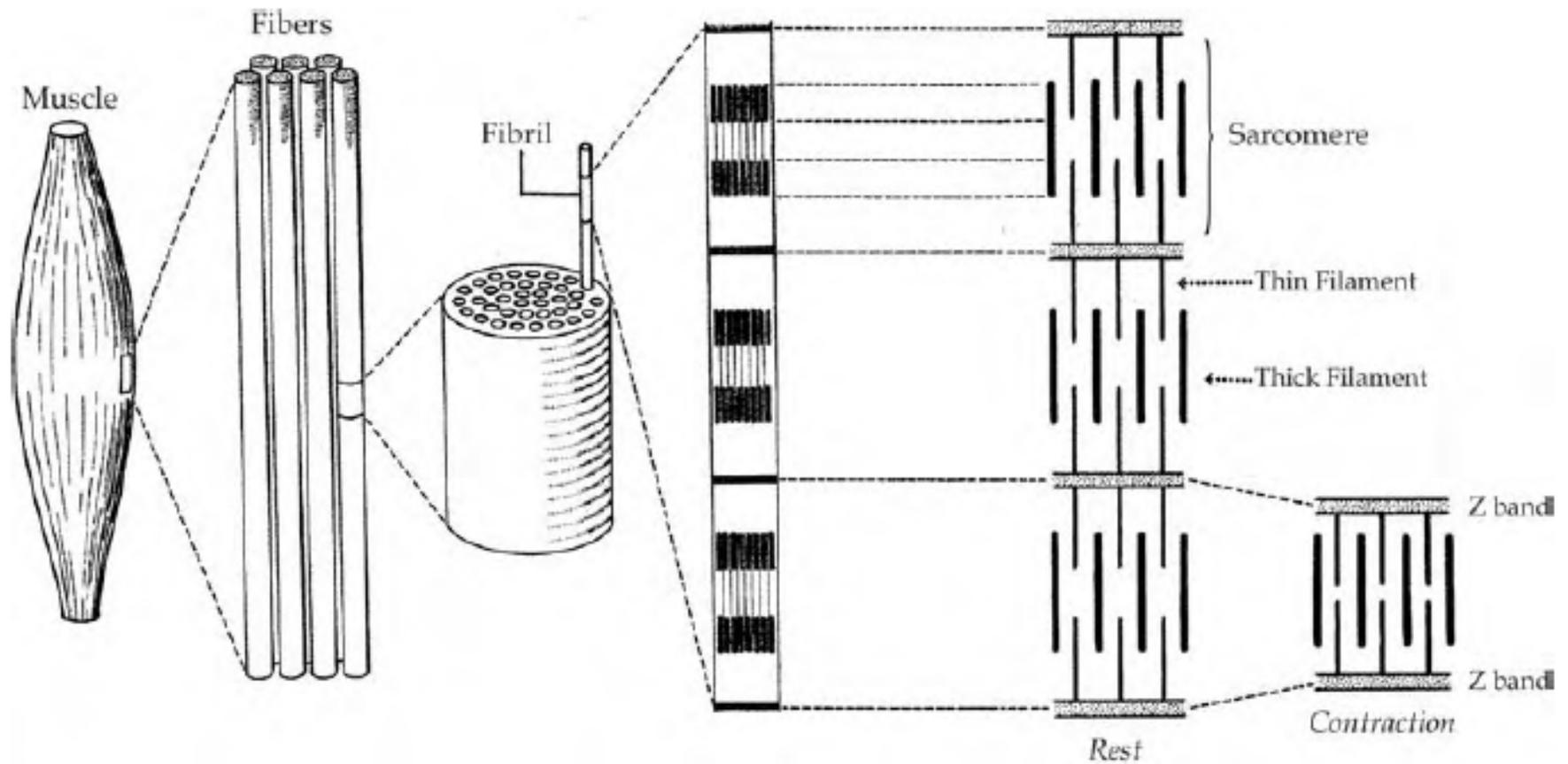
# Why Record EMG?

- 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)

# Striated Muscle

- Large number of muscle fibers arranged in parallel
- “Striated” reflects that these fibers are actually comprised of 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

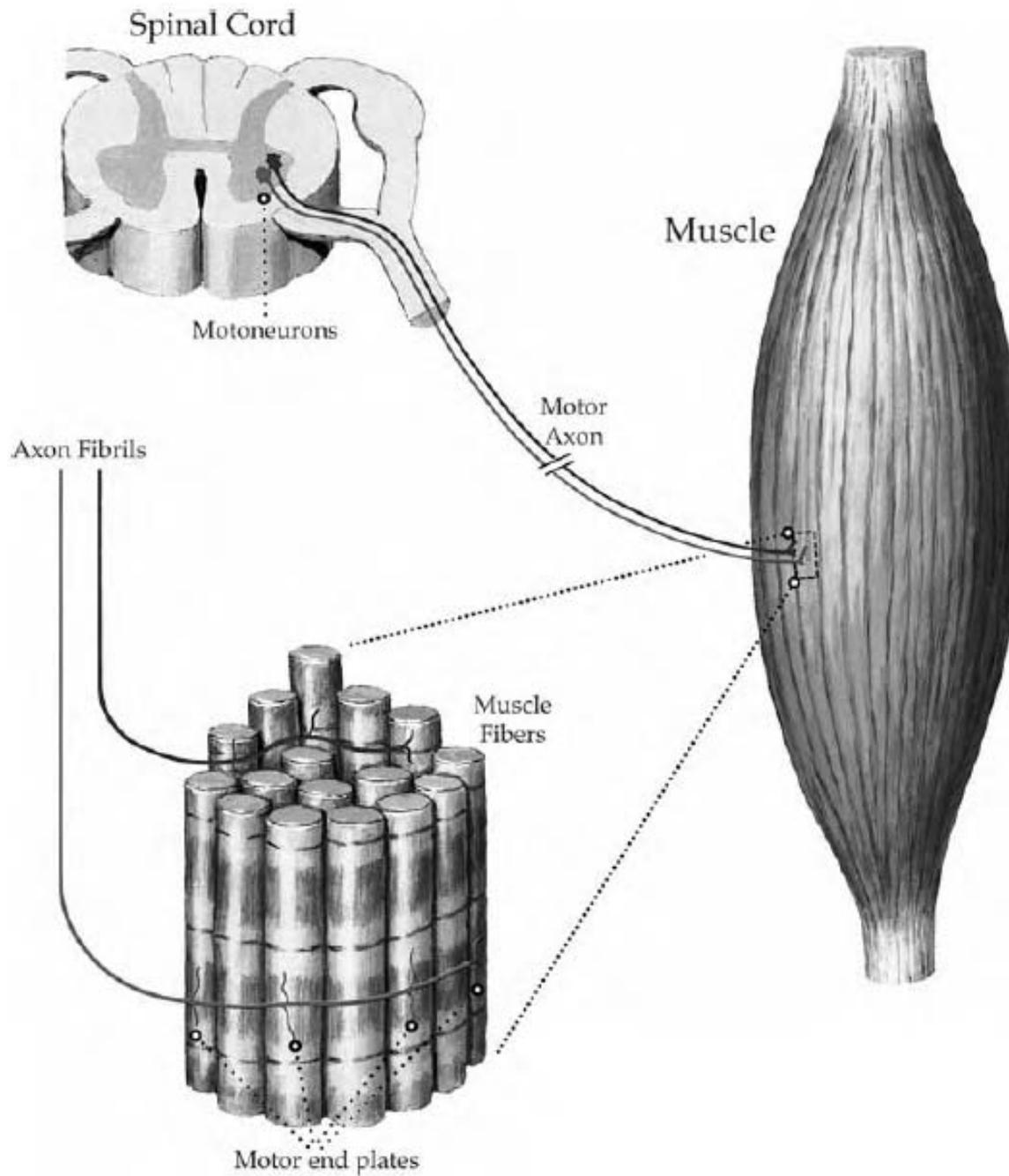
# The Muscle



**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).

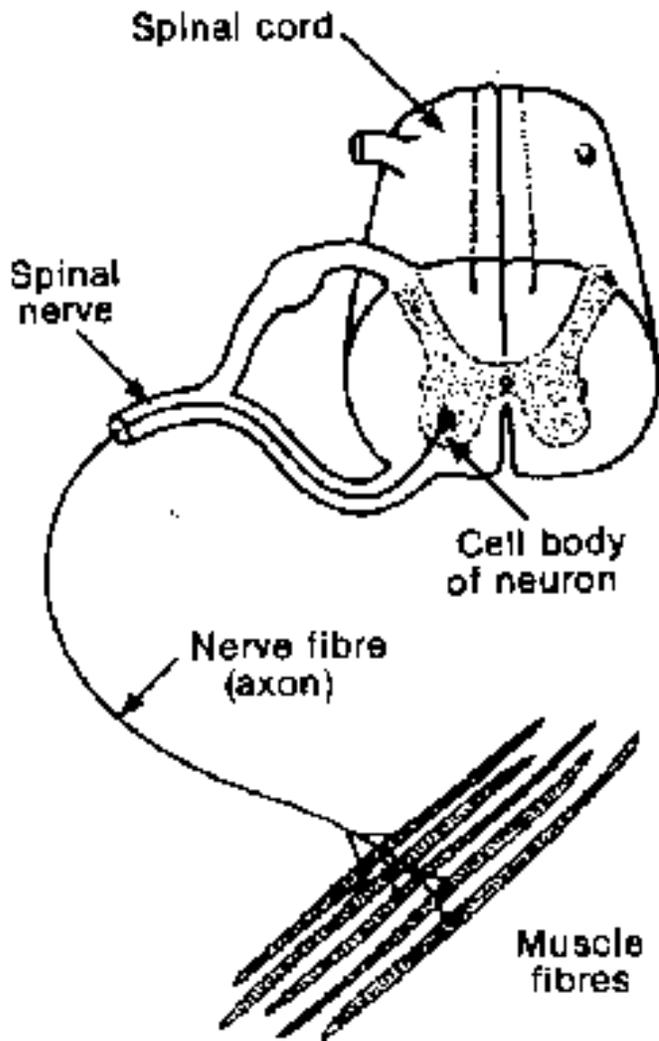
# Innervation

- 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

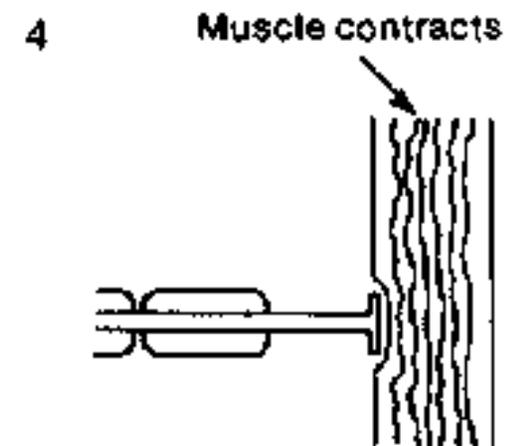
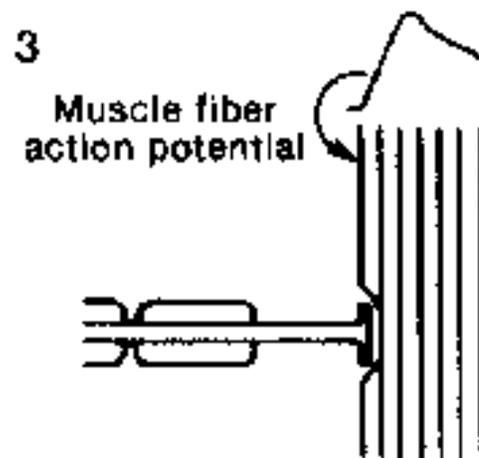
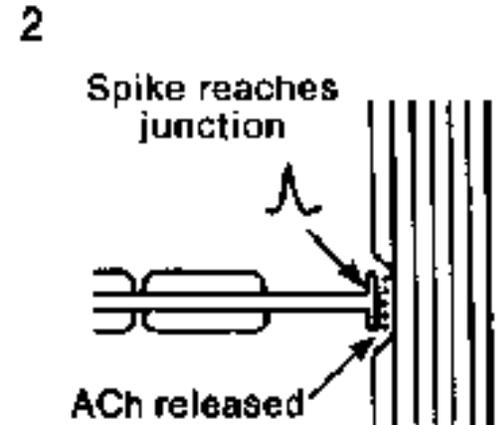
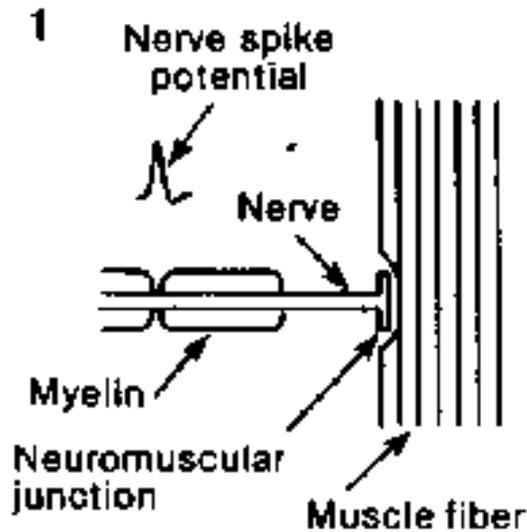


**Figure 12.3.** Diagram of two motor units. (Modified from slide 3705 of Netter, 1991).

# Cartoon of how it works



(a)

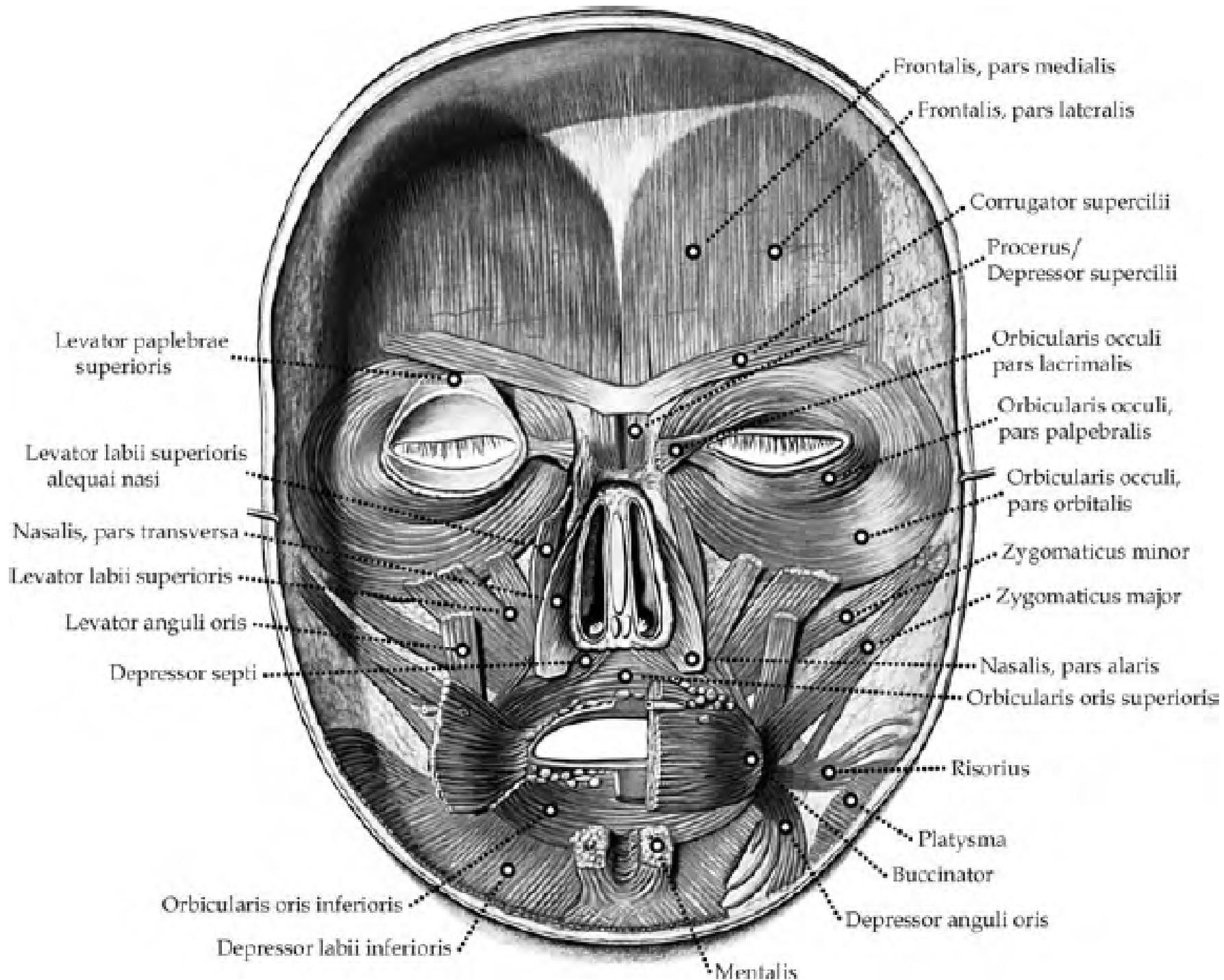


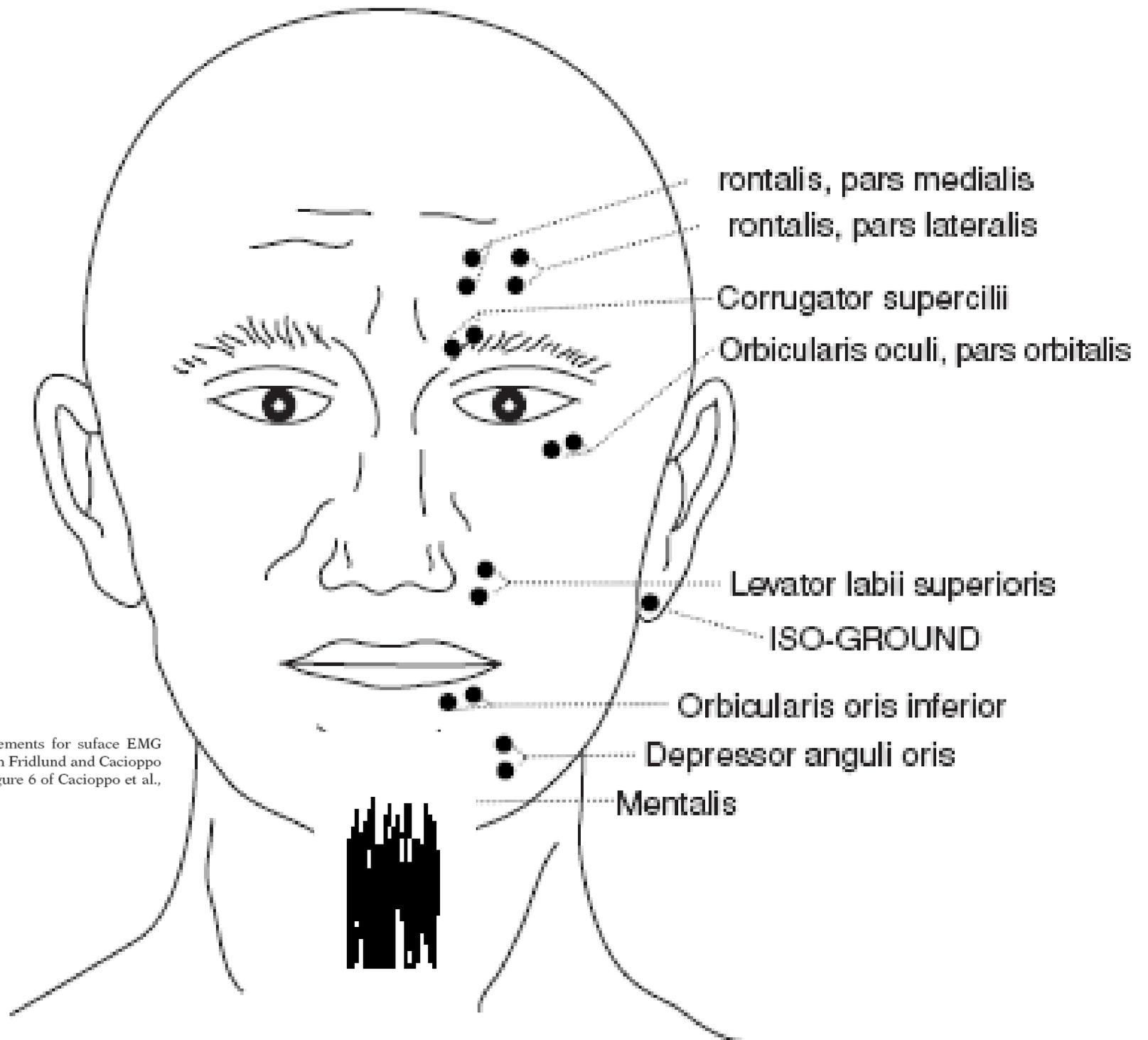
(b)

# What is EMG signal?

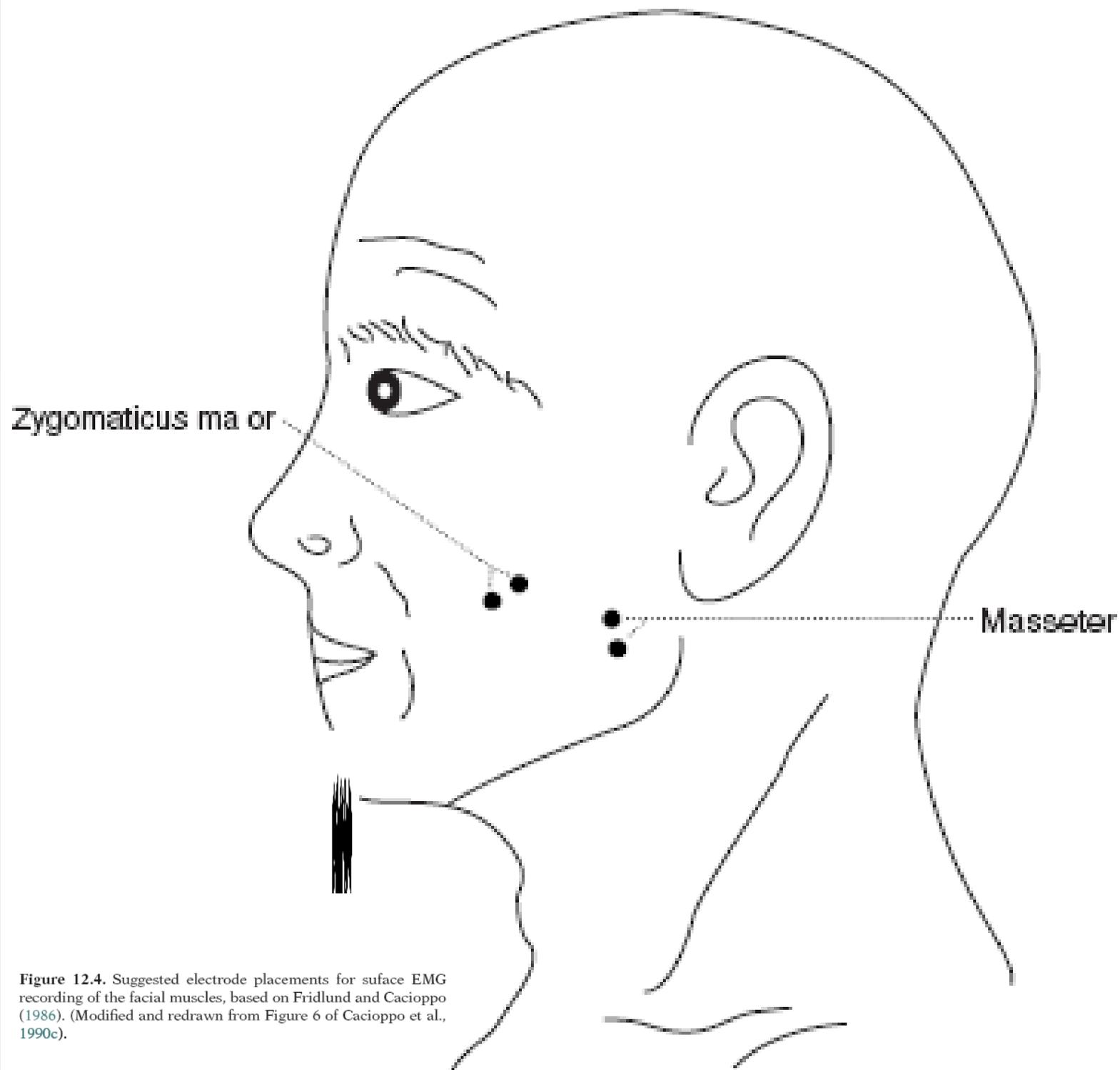
- Reflects electrical field generated by Muscle Action Potentials (MAPs)
- Small portion conveyed to surface via extracellular fluids to skin
- Can also record invasively with subcutaneous needle electrodes

# The Facial Muscles

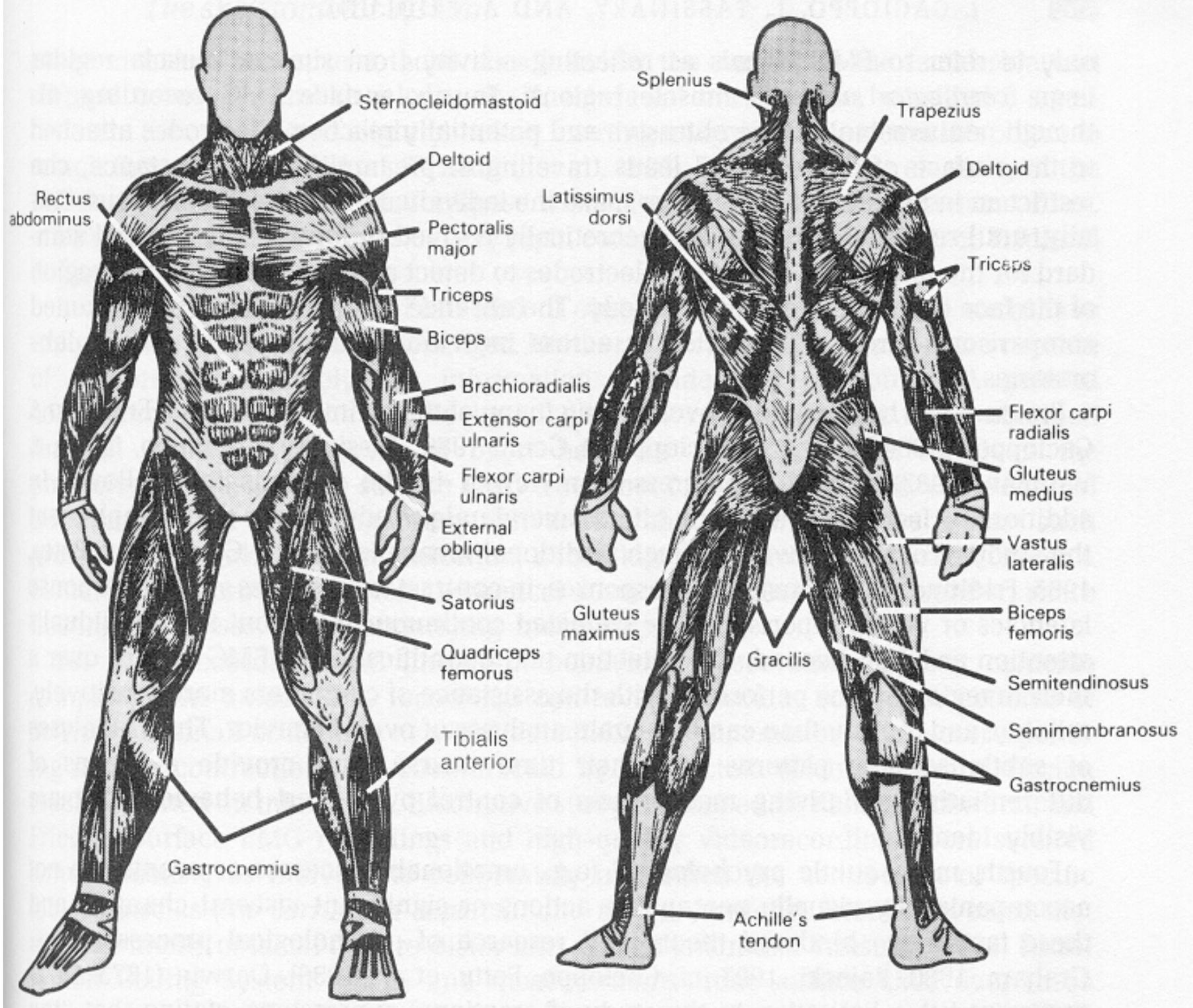


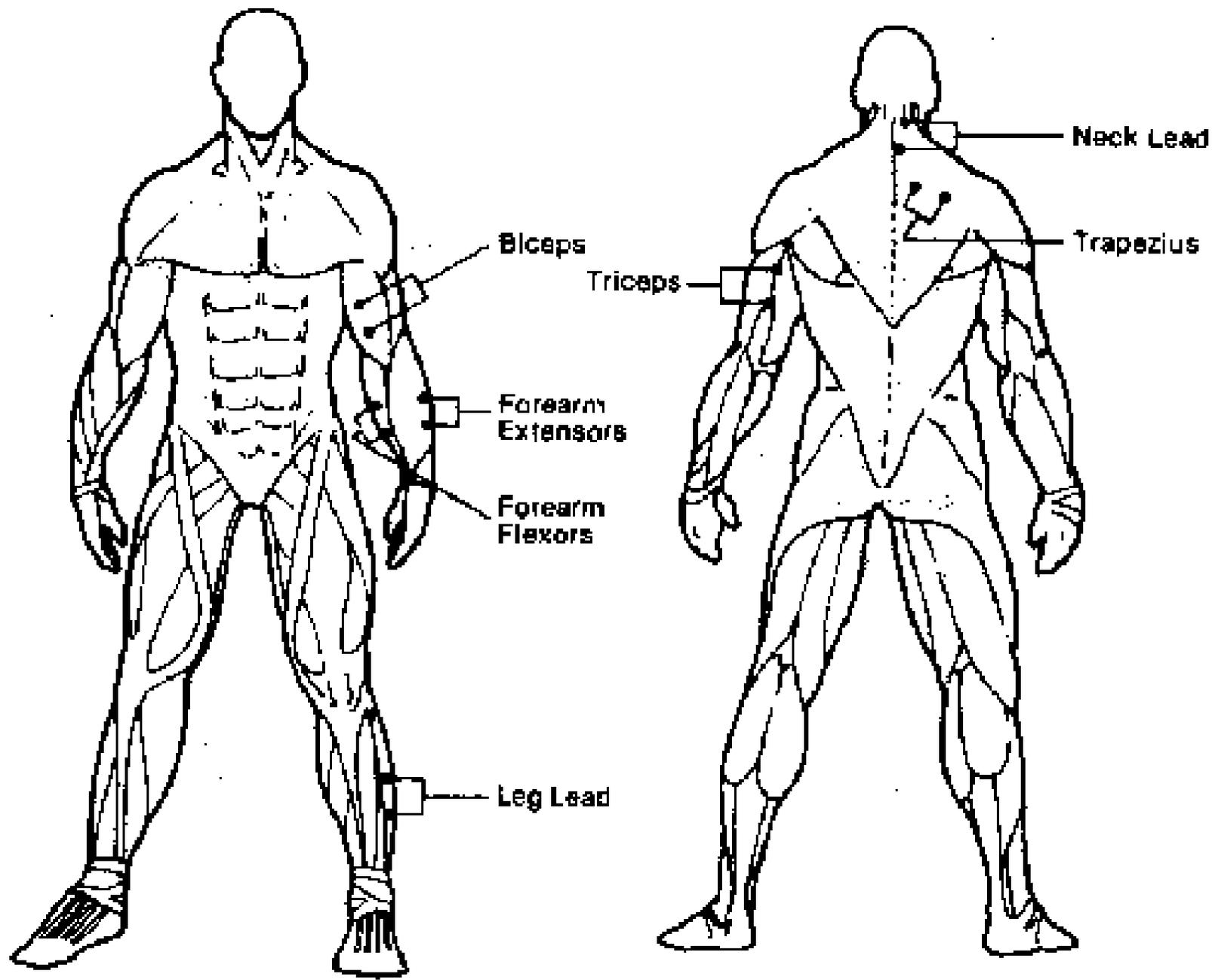


**Figure 12.4.** Suggested electrode placements for surface EMG recording of the facial muscles, based on Fridlund and Cacioppo (1986). (Modified and redrawn from Figure 6 of Cacioppo et al., 1990c).



**Figure 12.4.** Suggested electrode placements for surface 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”

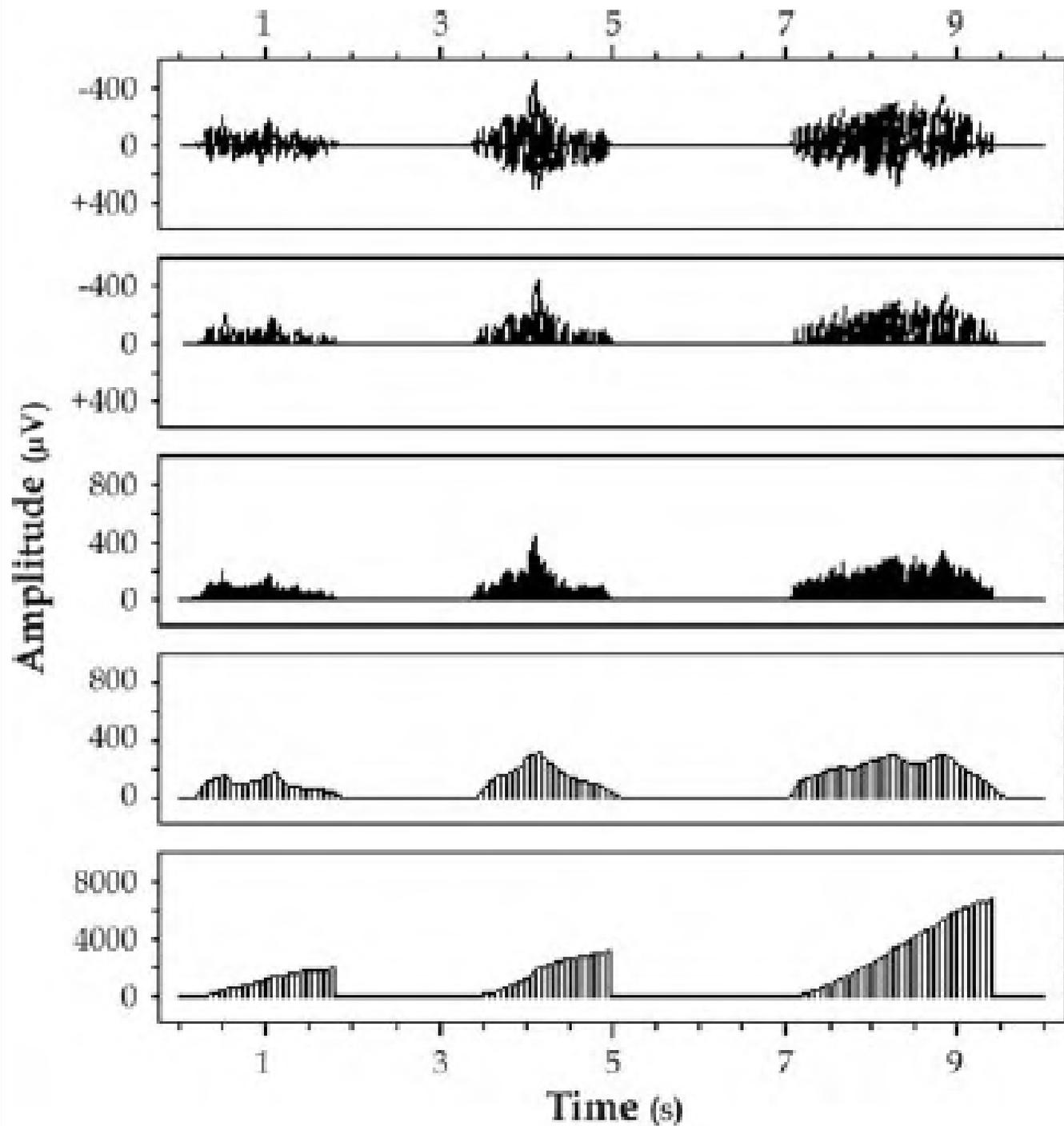
# Signal Recording (cont')

- Can use wide variety of electrodes
  - Ag-AgCl still preferred
  - Small size increases specificity of recording
- Skin Prep
  - Abrade to reduce impedance to  $< 5K \Omega$
- 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

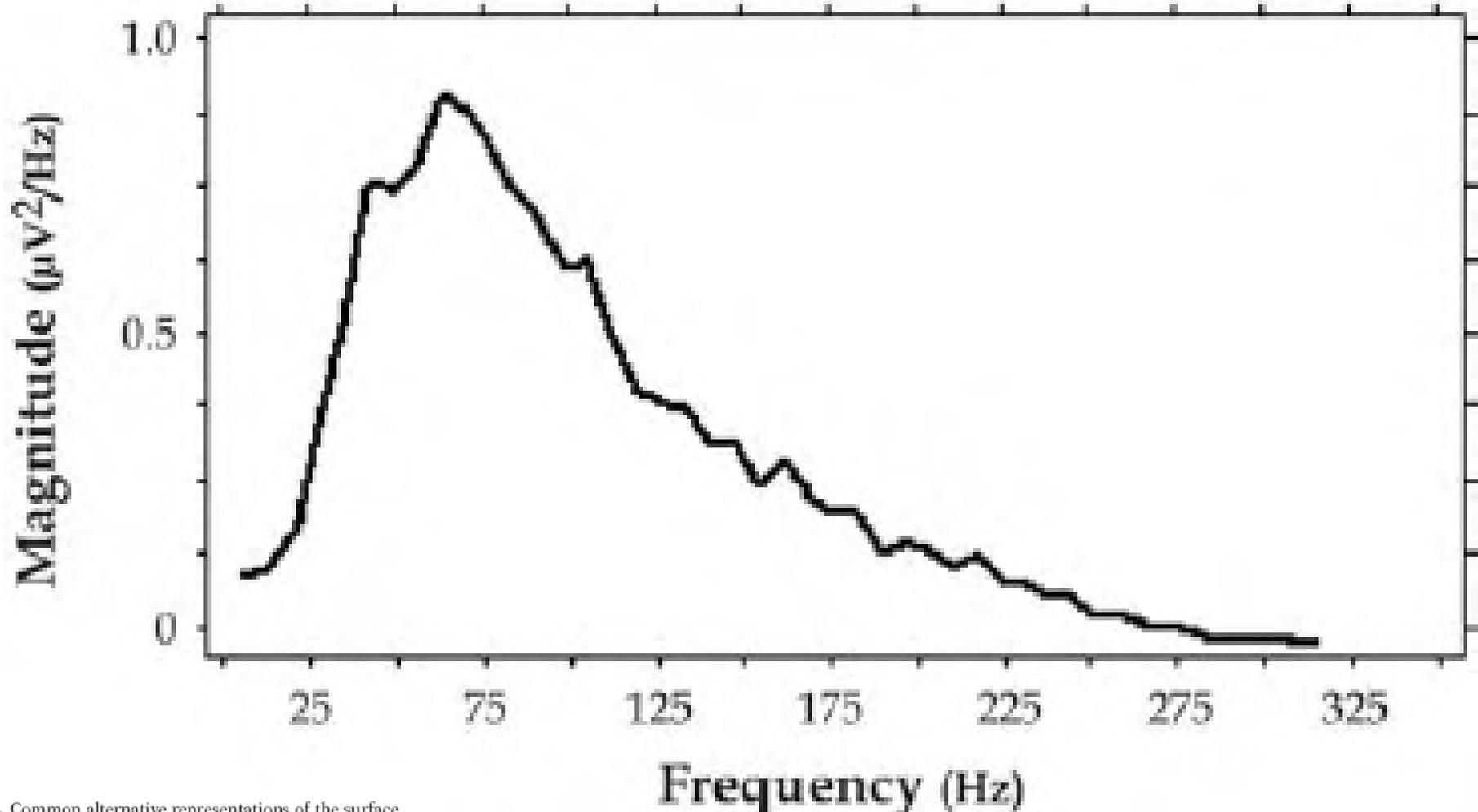
## Signal Transformations



**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).

Demos

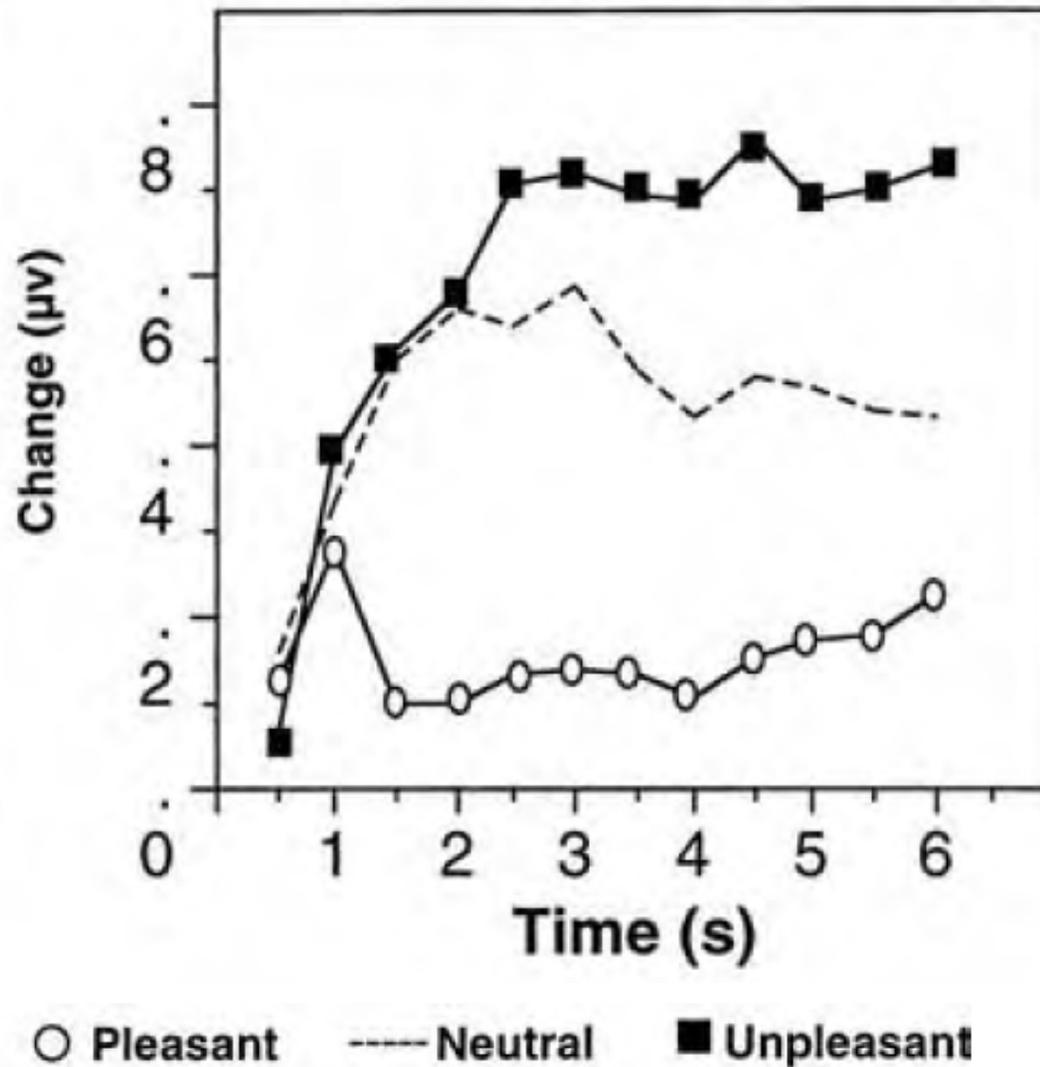
# EMG Power



**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”

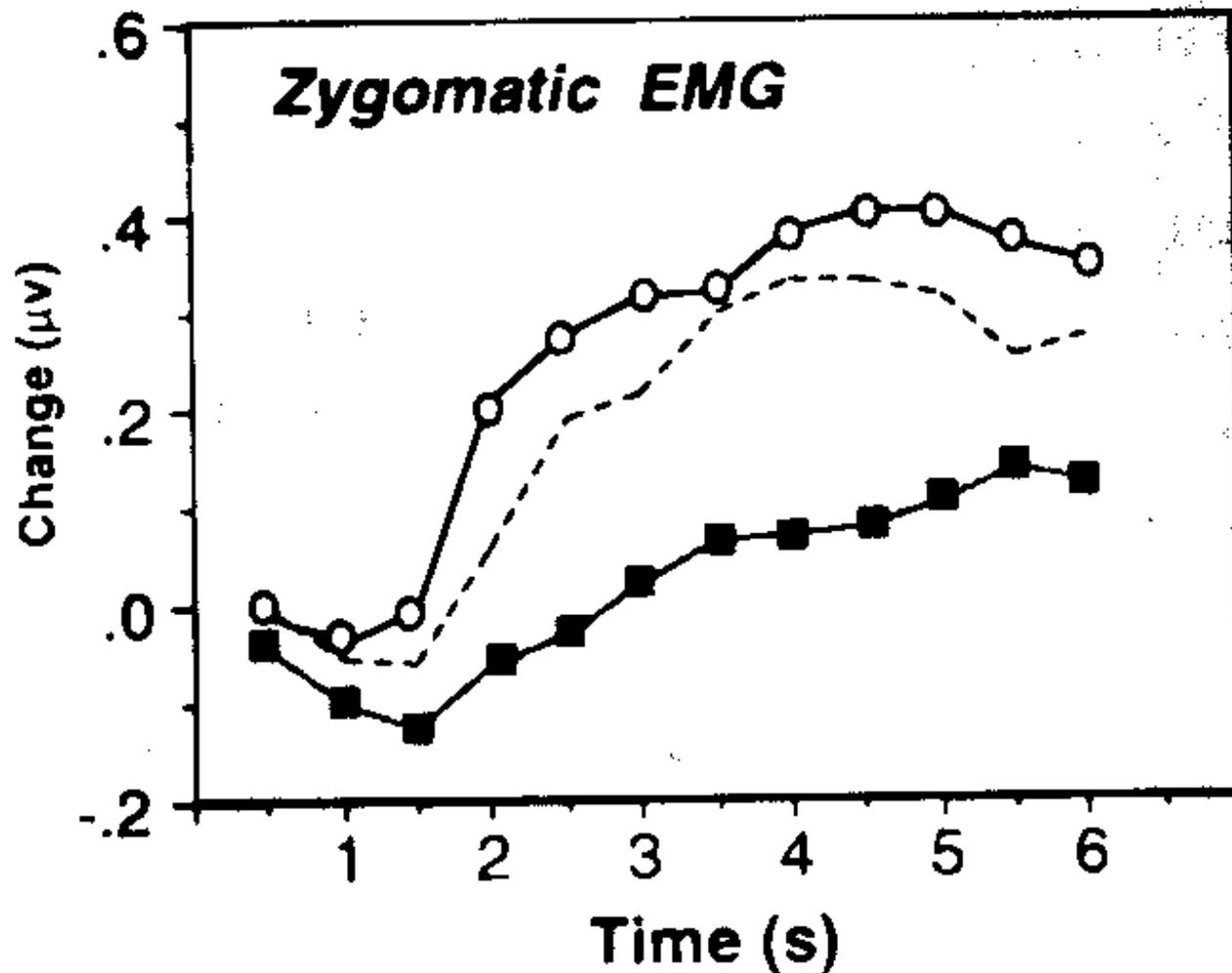
## Corrugator EMG



# Zygomatic “Smile”

## Emotional reactivity

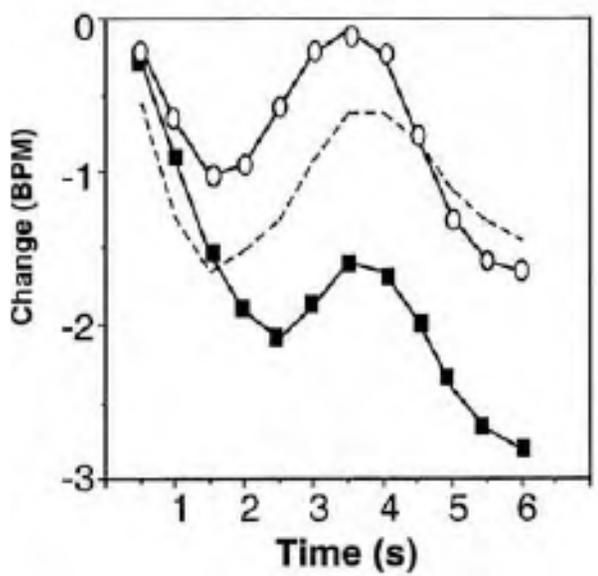
○ Pleasant    - - - - Neutral    ■ Unpleasant



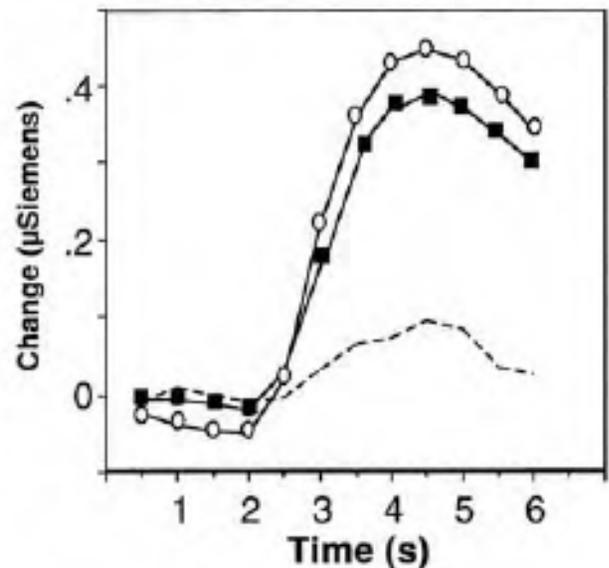
# Looking at PICTURES

○ Pleasant    — Neutral    ■ Unpleasant

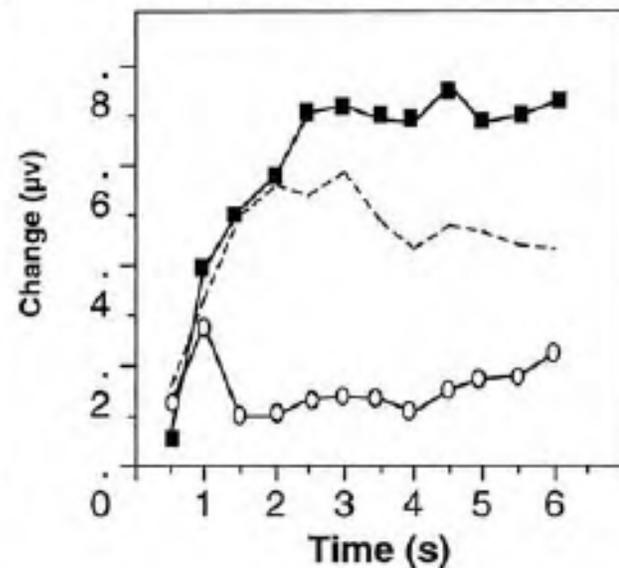
### Heart rate



### Skin Conductance



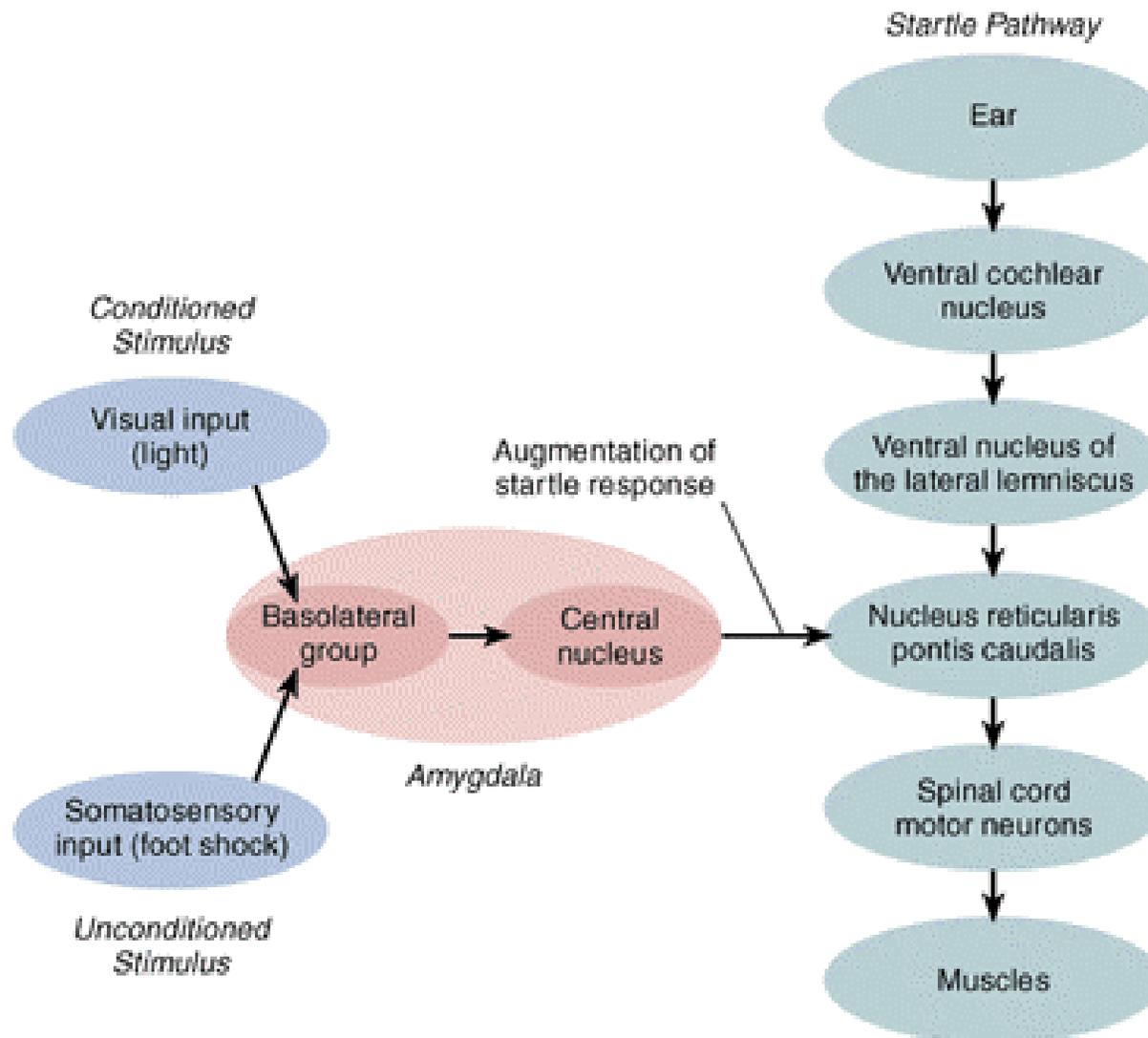
### Corrugator EMG



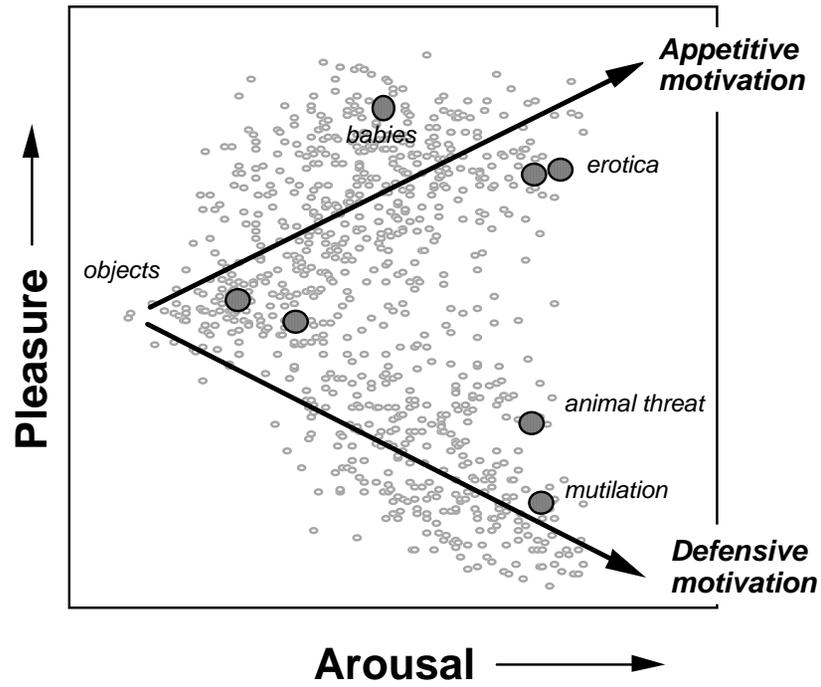
# A few Applications

- Startle Probe
- Subtle affect
  - Mere Exposure
  - Mortality Salience
  - Biofeedback of EEG -- outcome measure

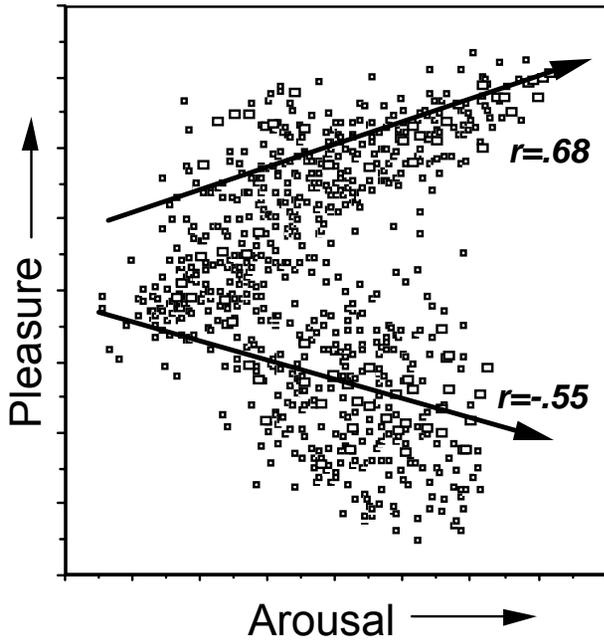
## ► Neural Circuits Responsible for an Auditory Startle Response and for Its Augmentation by Conditioned Aversive Stimuli



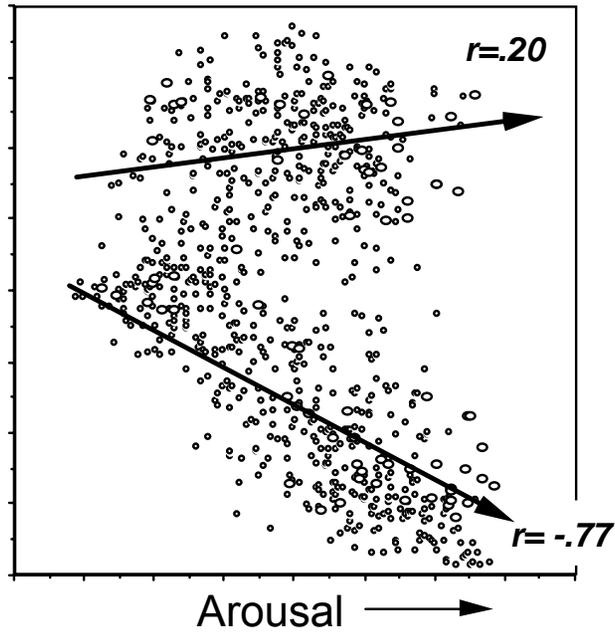
# International Affective Picture System (IAPS)



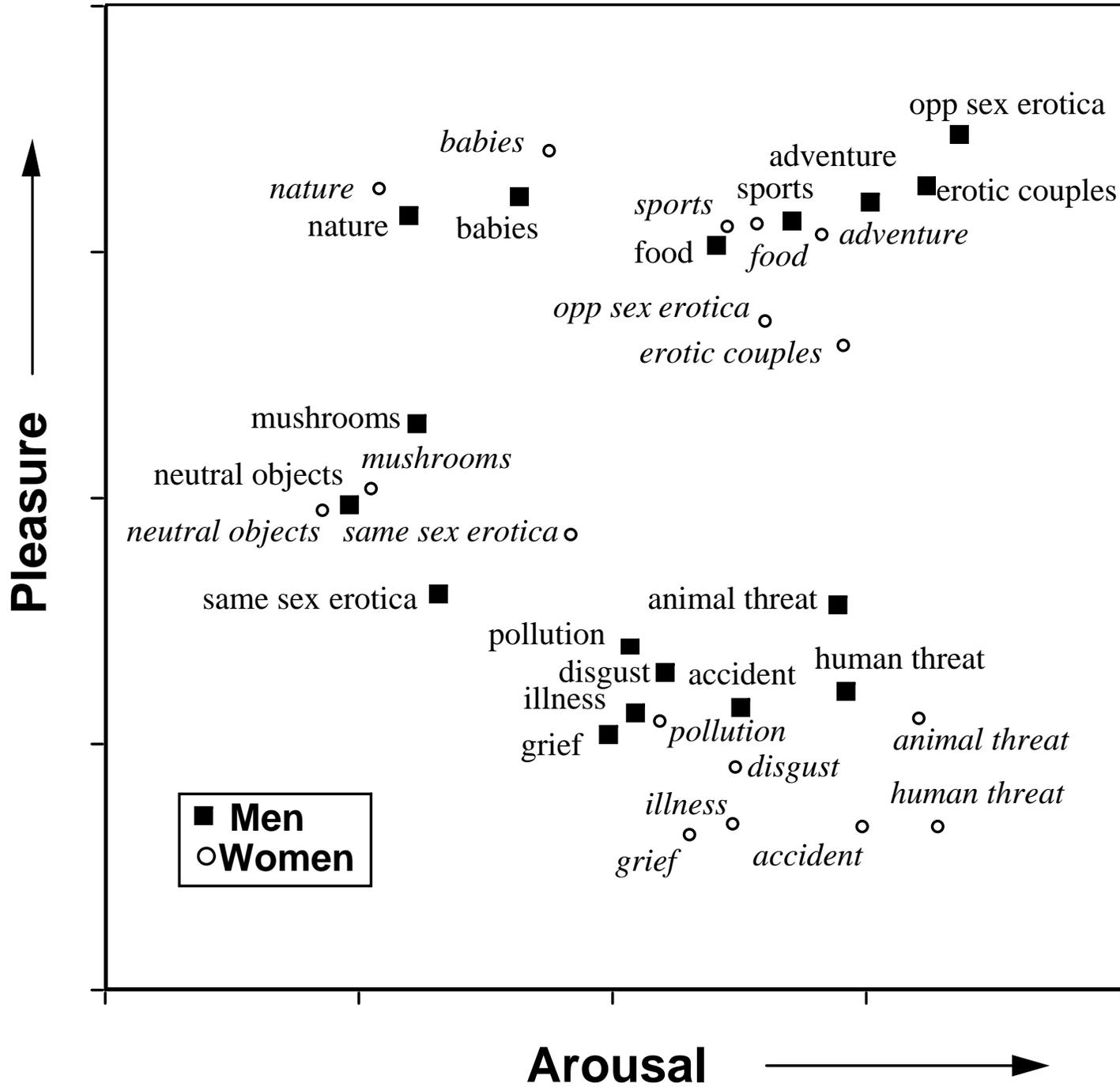
Men

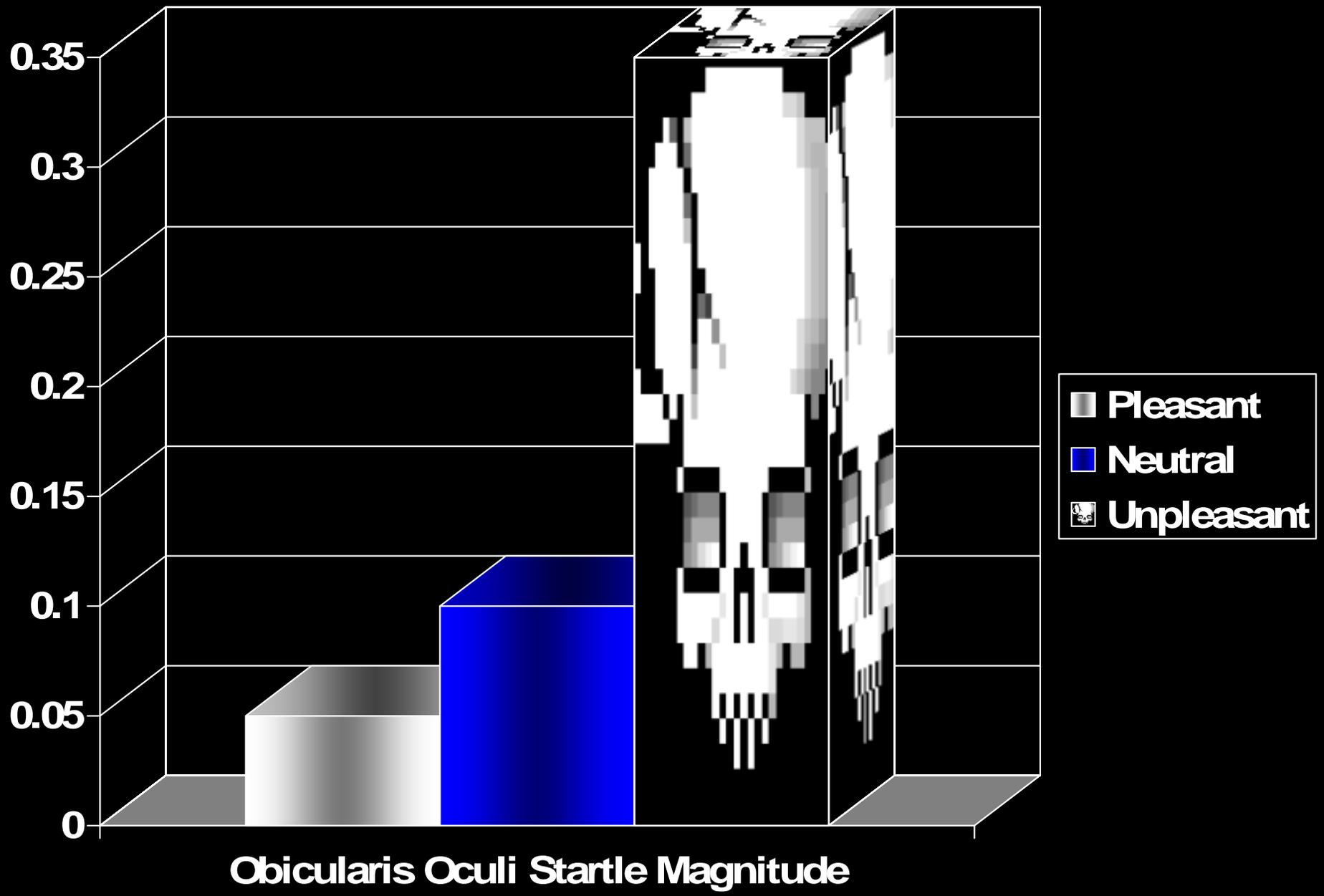


Women

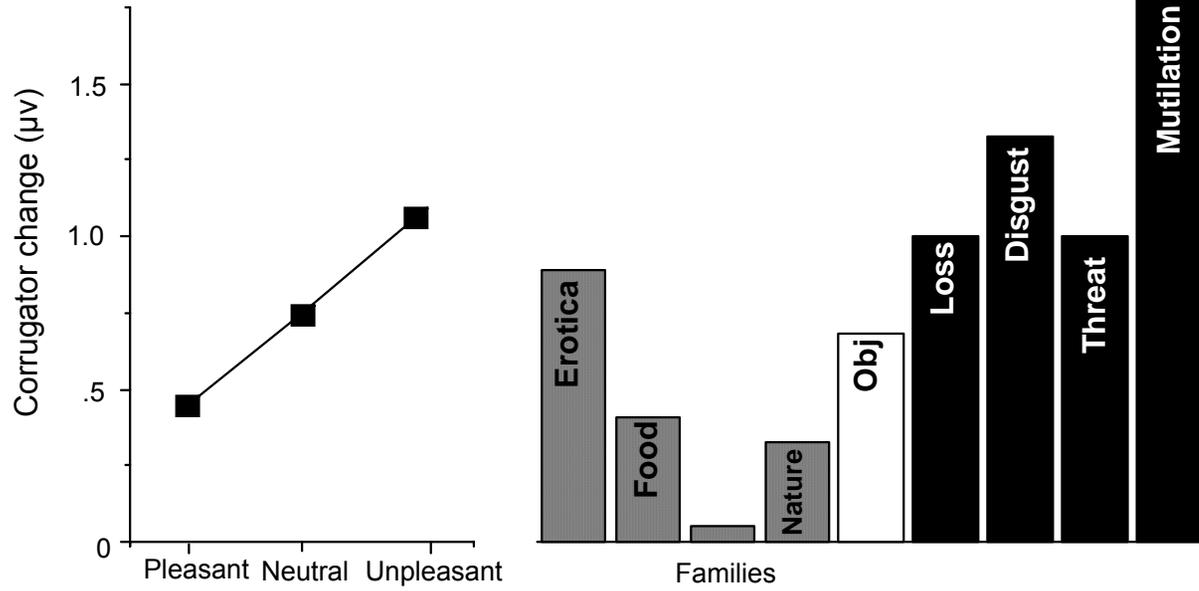


# Affective Space: Picture Content and Gender

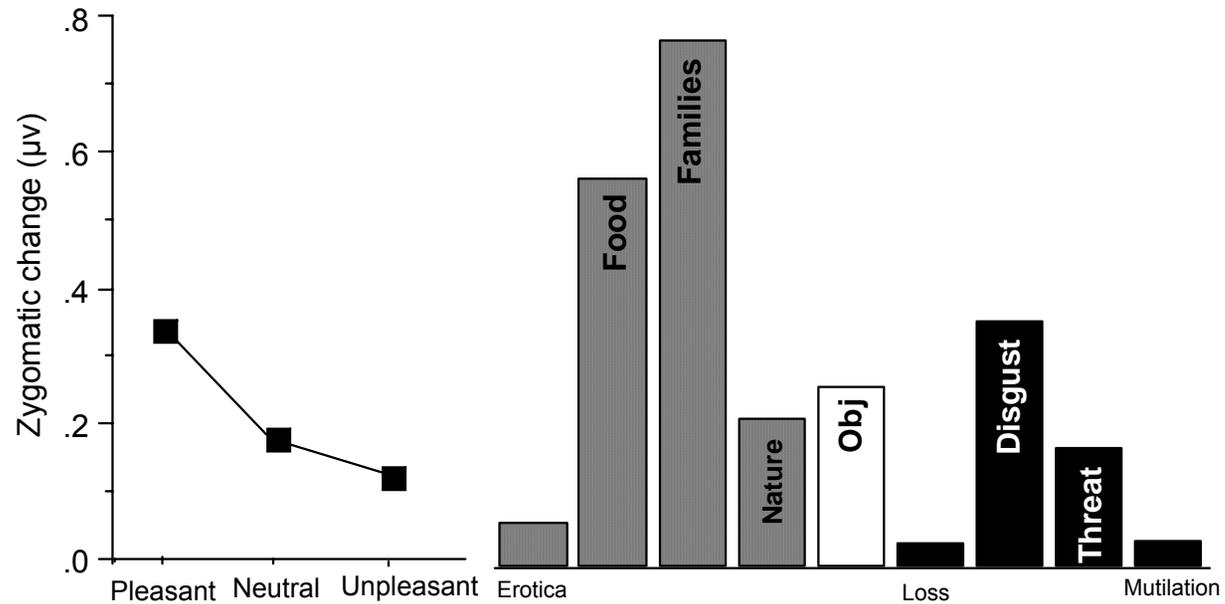


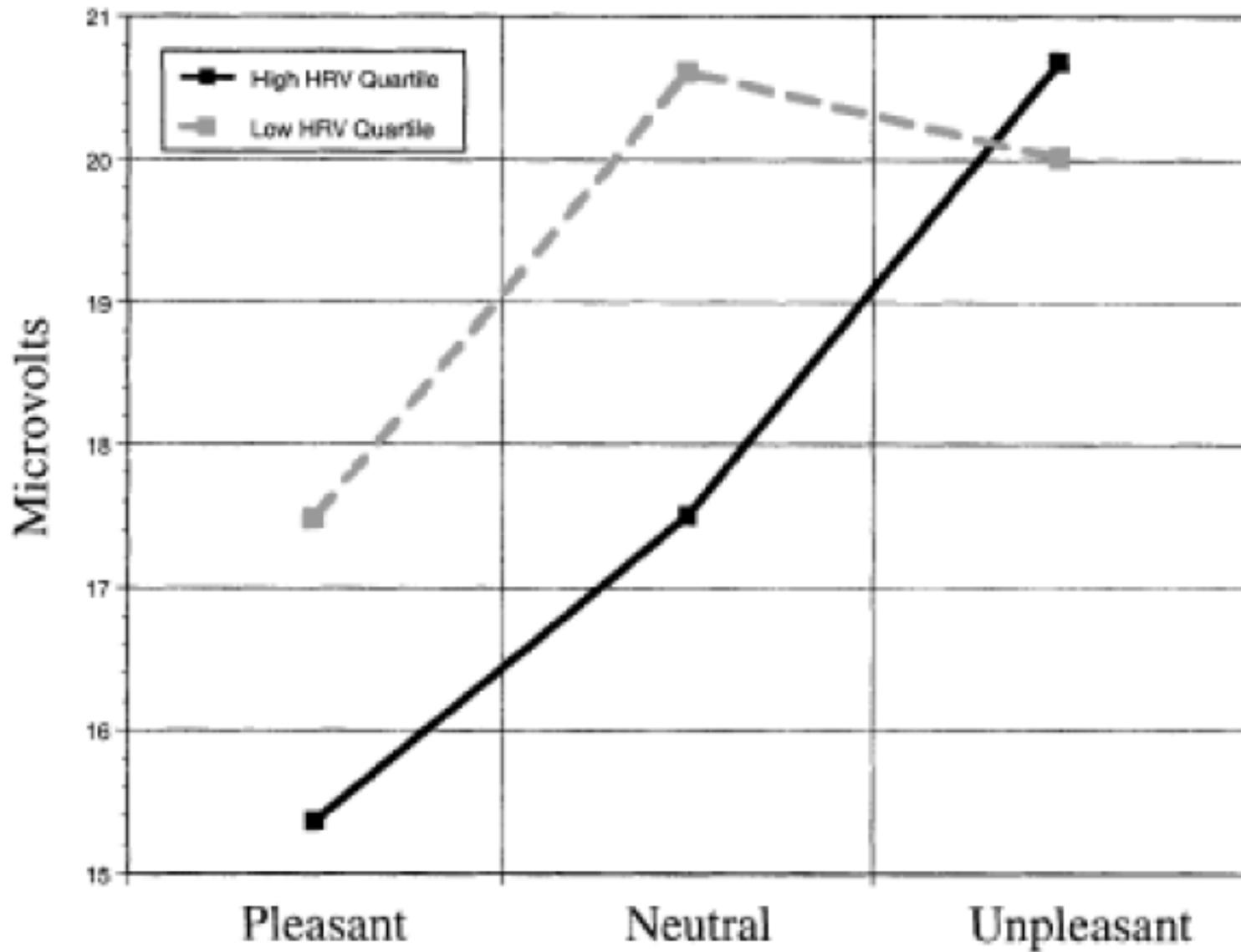


# Corrugator EMG



# Zygomatic EMG



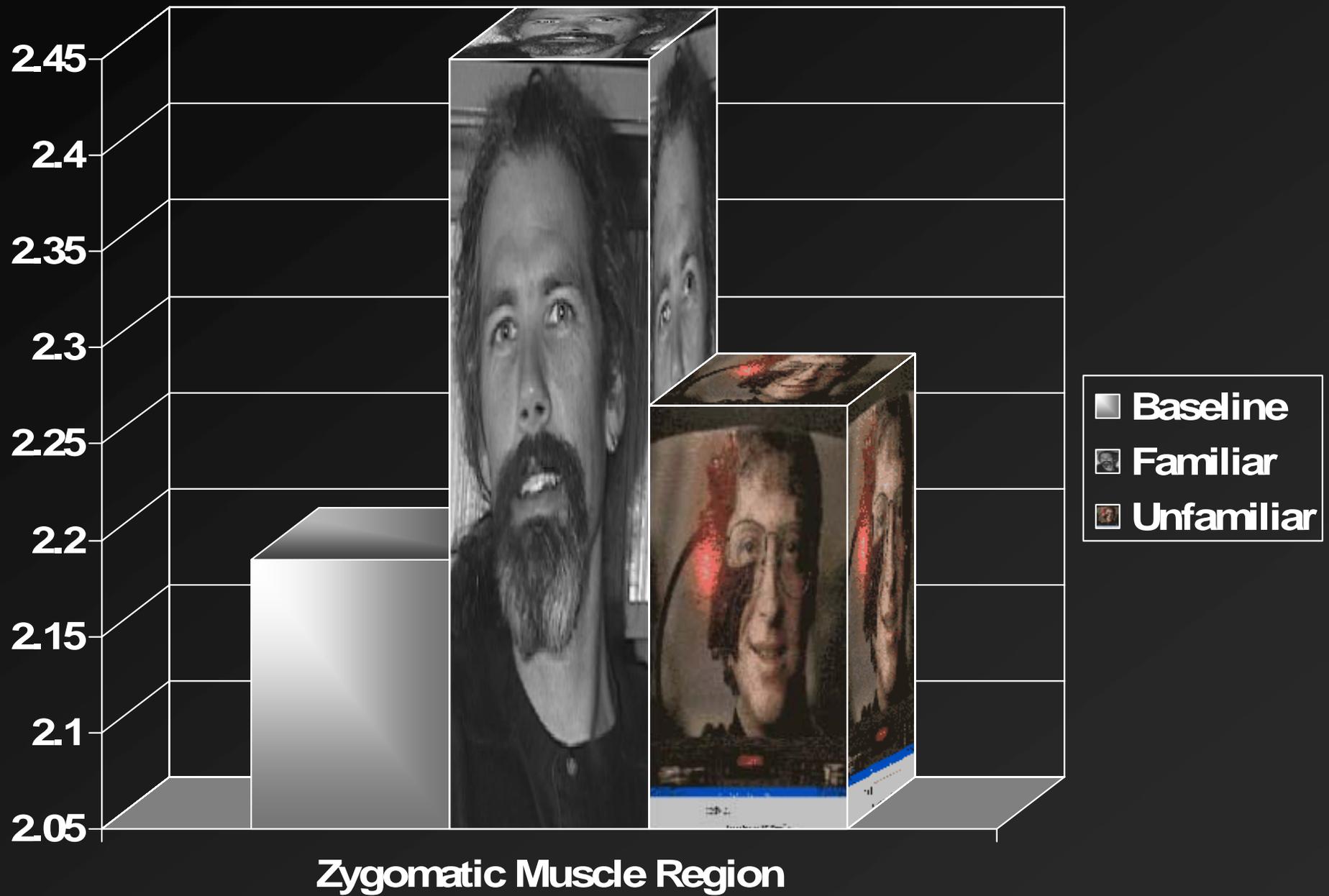


**Figure 1.** Mean startle amplitude as a function of baseline HRV and valence. Startle amplitudes are in microvolts.

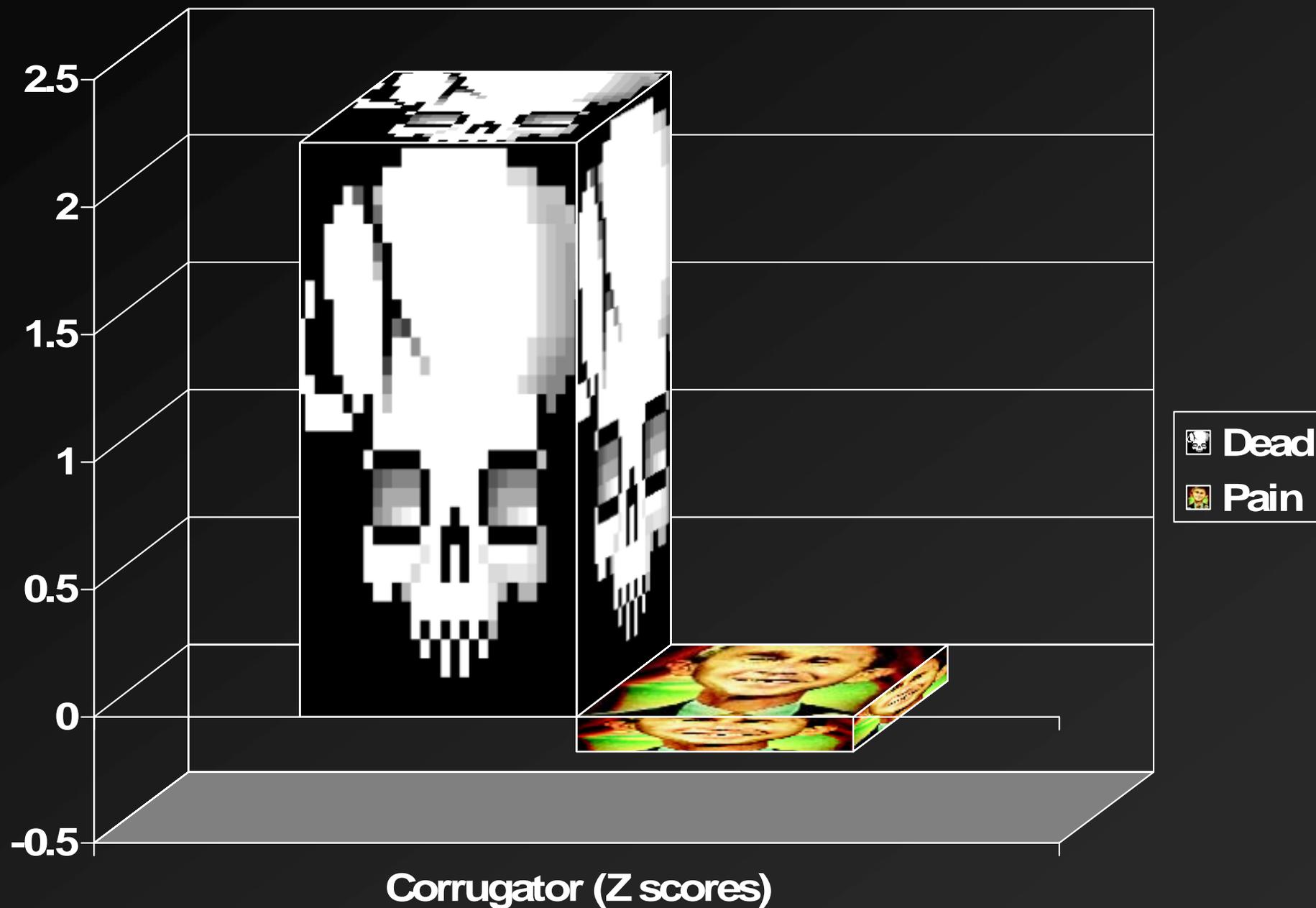
From: Ruiz-Padiala, Sollers, Vila, & Thayer (2003) *Psychophysiology*

# 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)

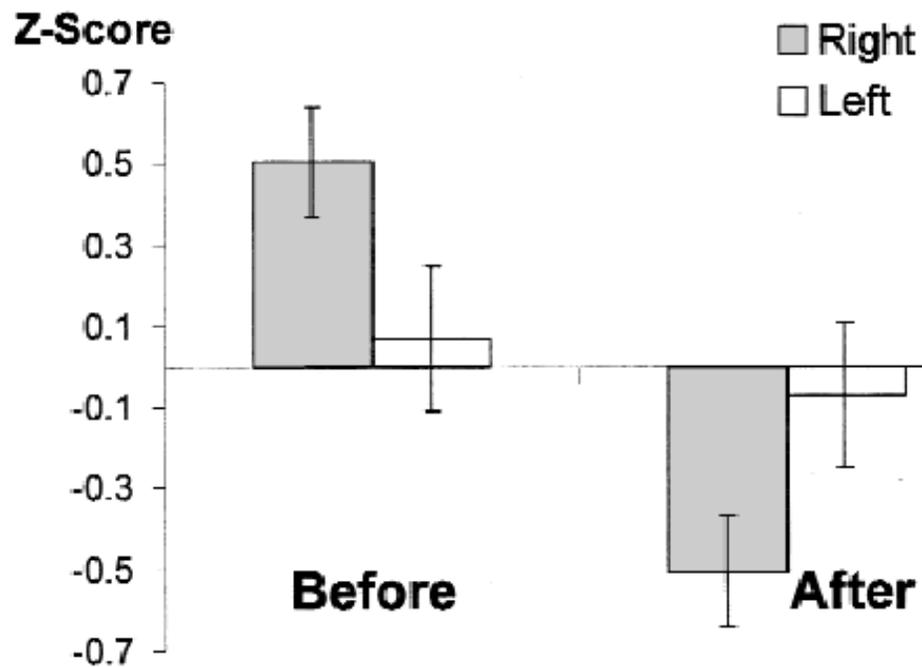


Loosely translated from Harmon-Jones & Allen, 2001

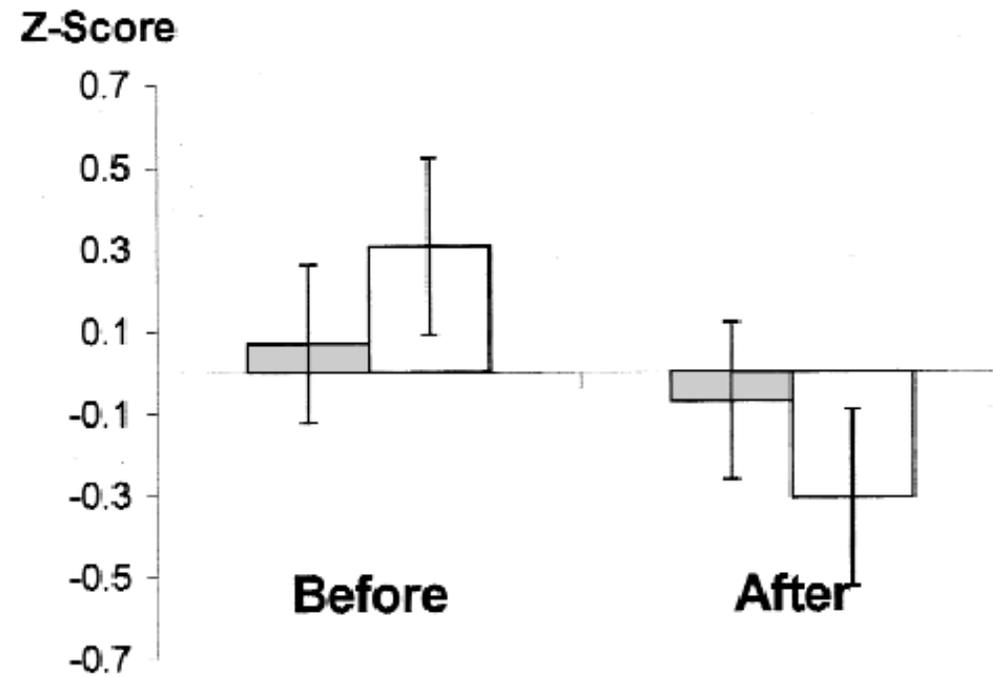


Another loose translation: Arndt, J., Allen, J.J.B., & Greenberg, J. (2001). Traces of terror: Subliminal death primes and facial electromyographic indices of affect. *Motivation and Emotion*, 25, 253-277.

## Zygomatic



## Corrugator



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