A bit more
Cardiovascular Psychophysiology

and then…

Electromyography

Returning to finale
of the last lecture

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 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

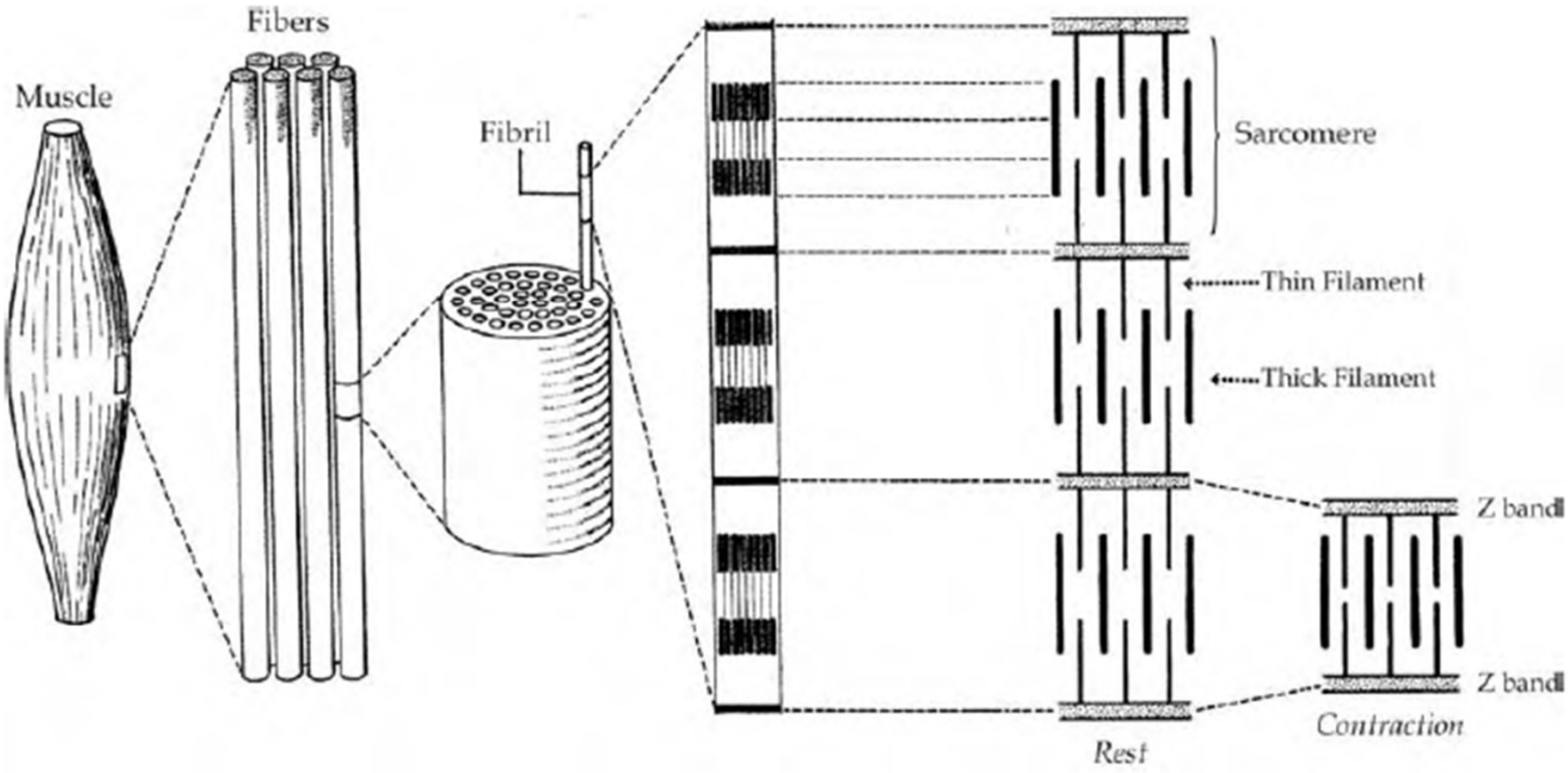


Figure 12.2. Diagram of the structure of the muscle with increasing magnification going from left to right. The bottom right corner of the figure illustrates the microgeometric changes that occur with contraction. (Modified from Figure 10.7 of Schmidt-Nielsen, 1997).

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

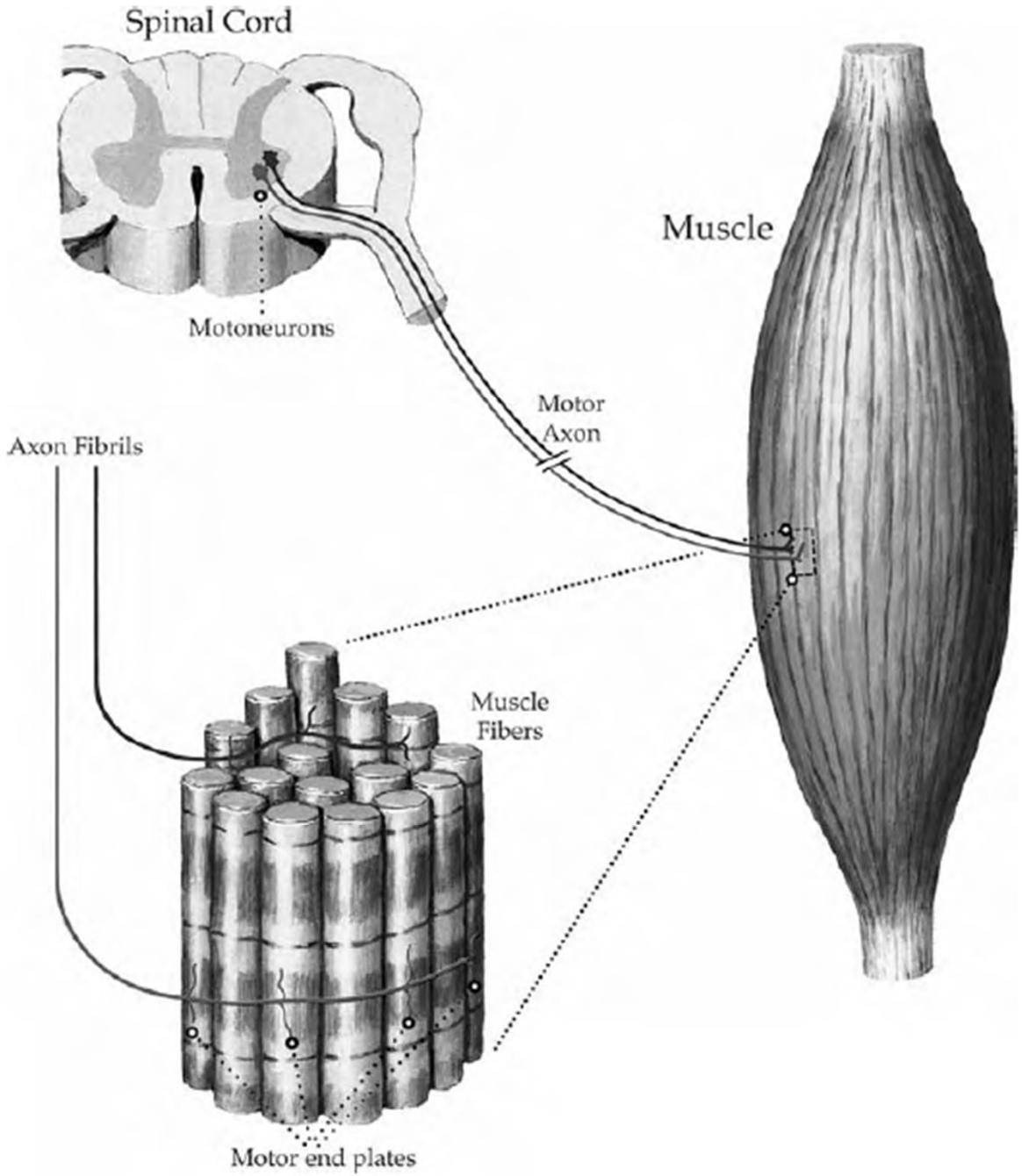
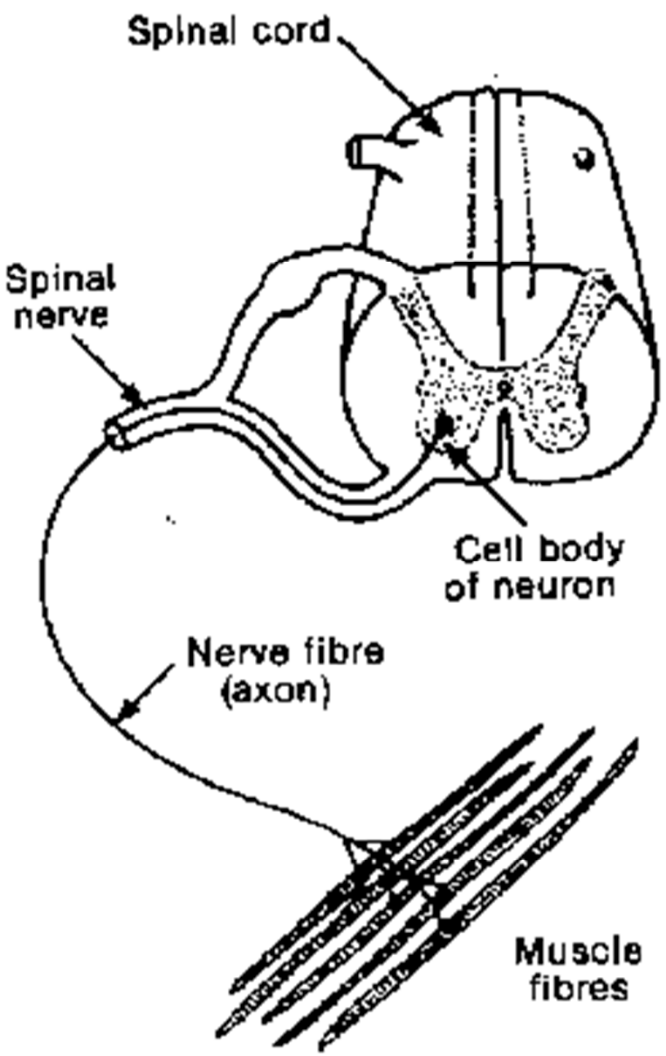
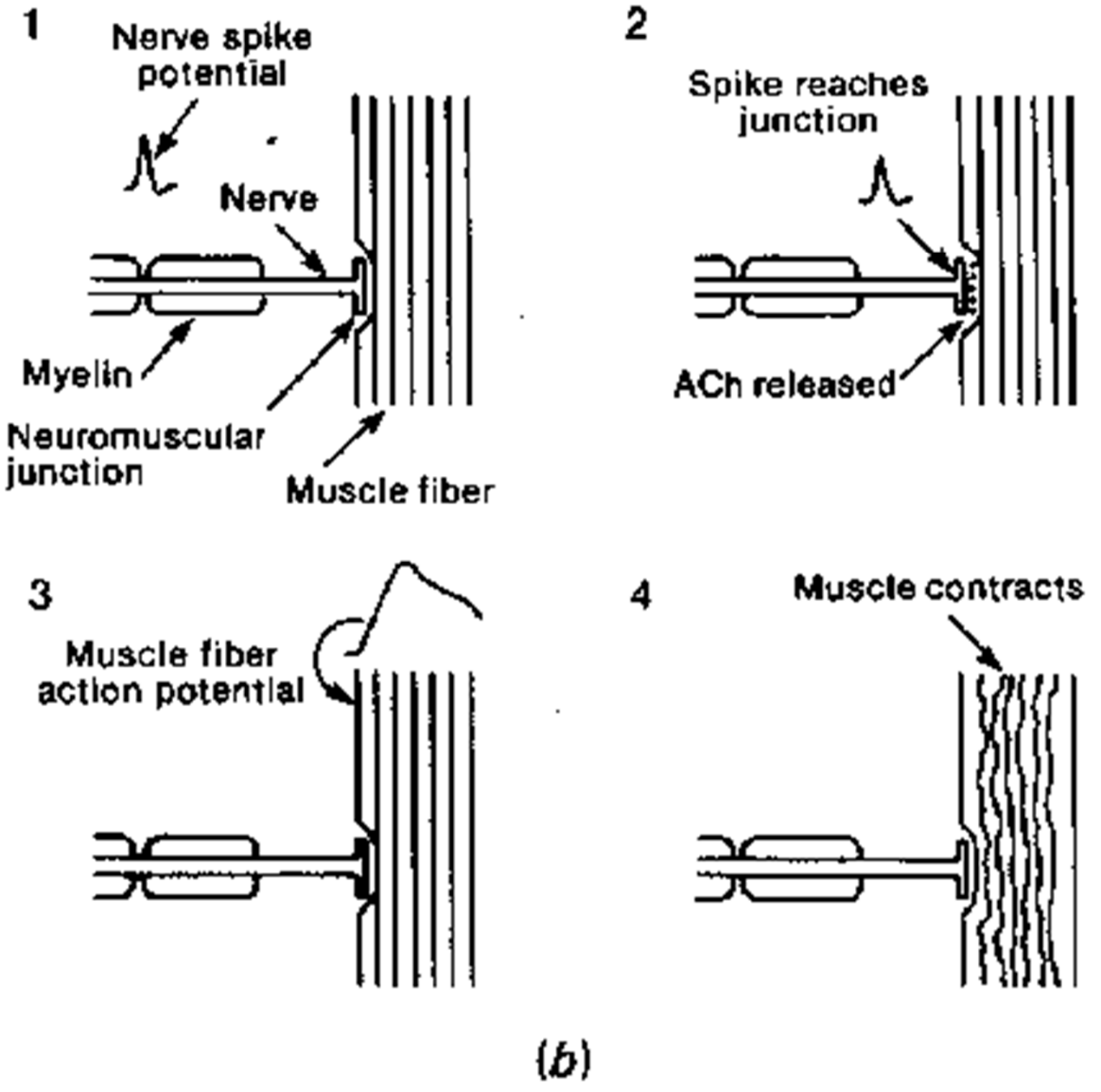


Figure 12.3. Diagram of two motor units. (Modified from slide 3705 of Netter, 1991).

Cartoon of how it works



(a)



(b)

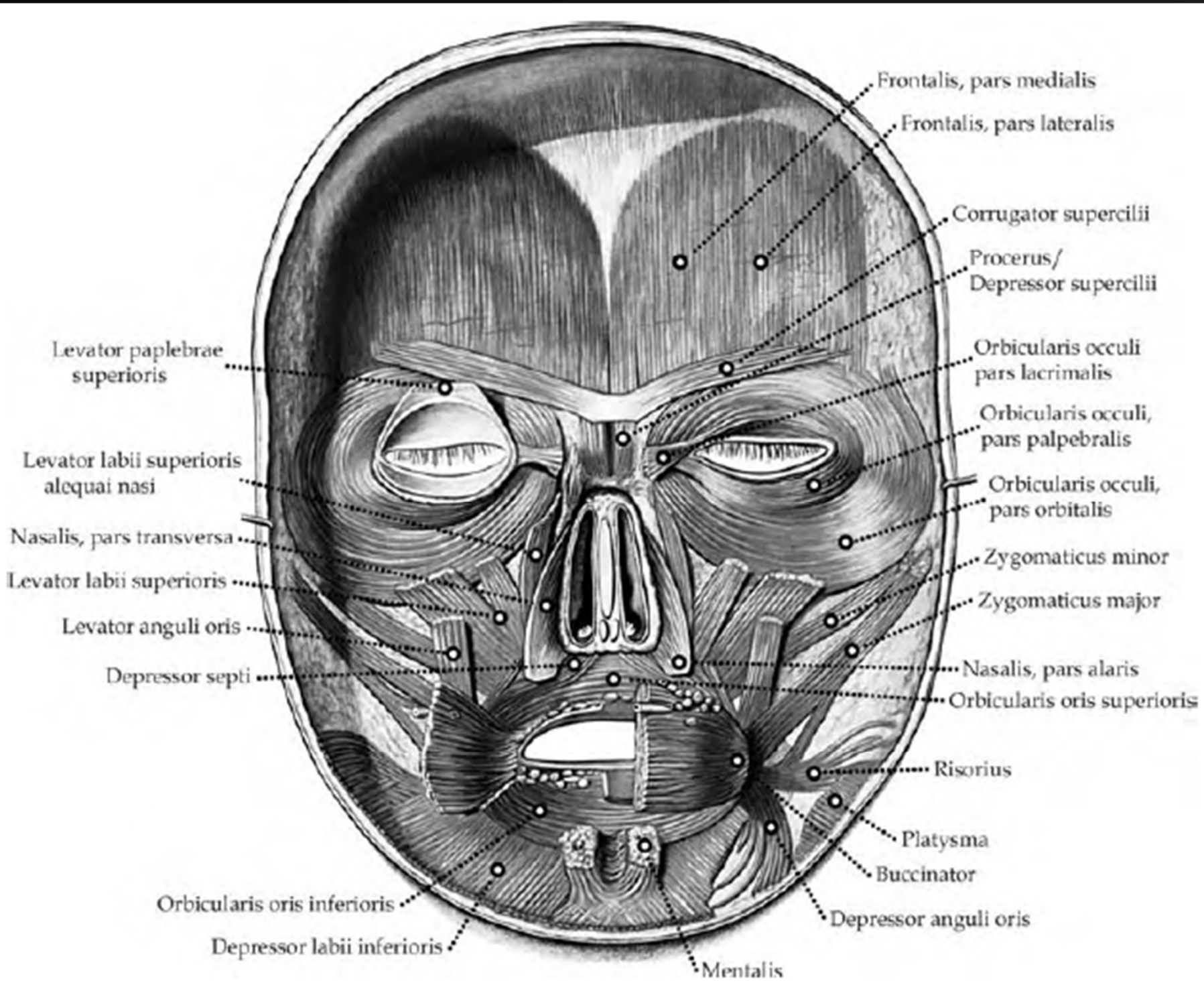
Before

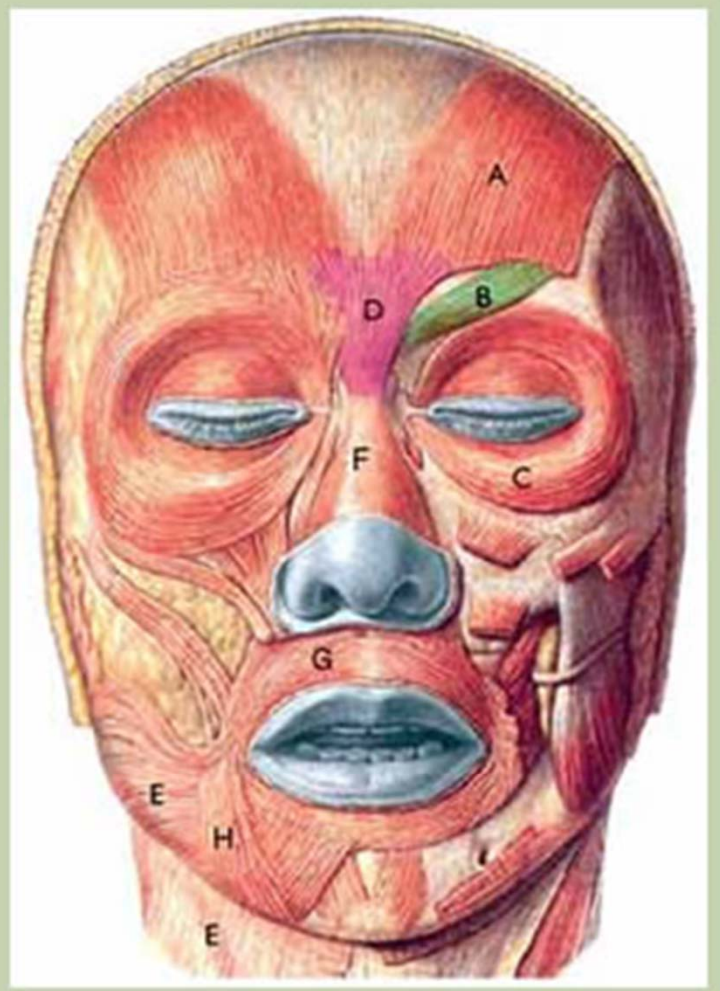
After

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

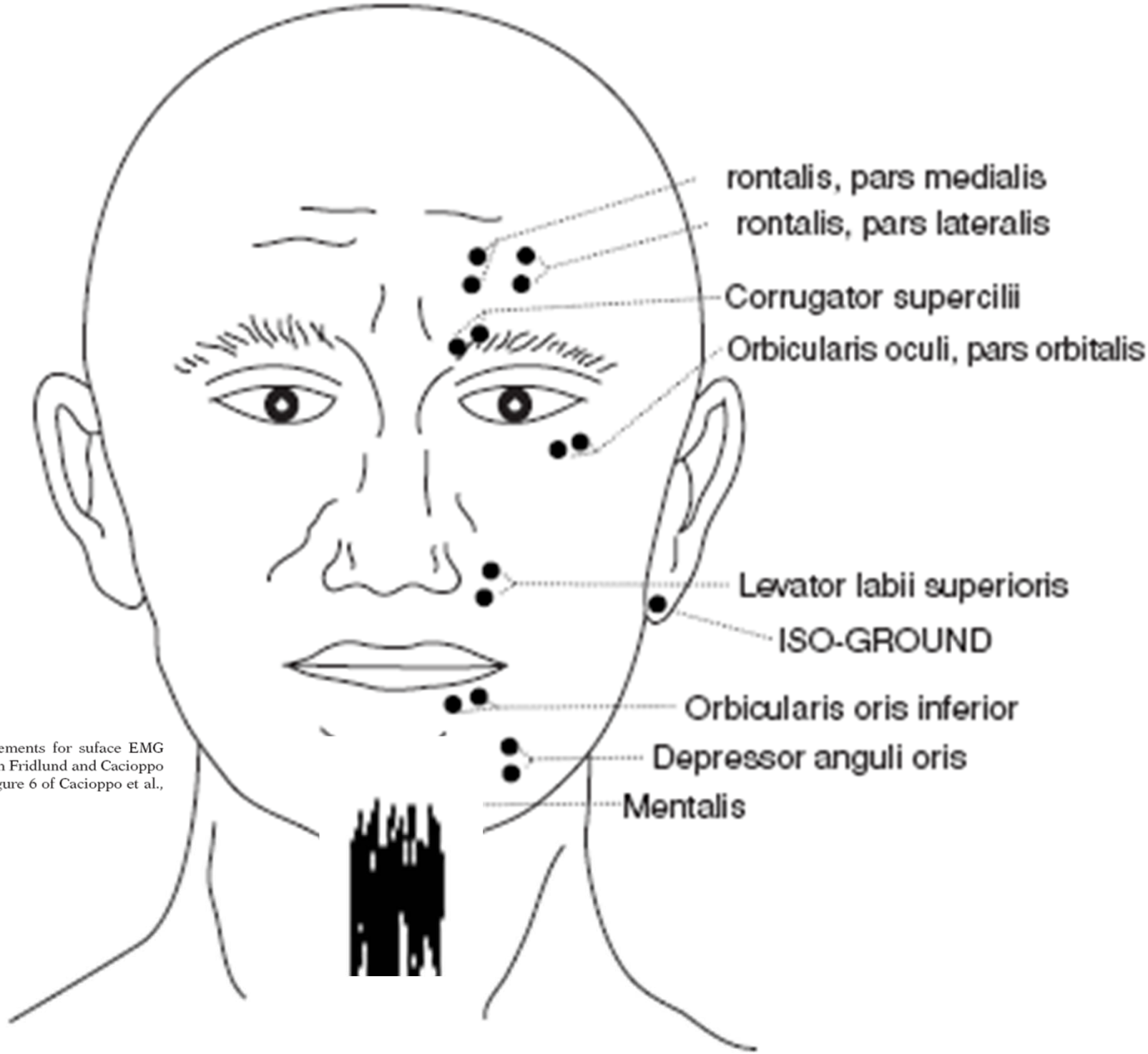
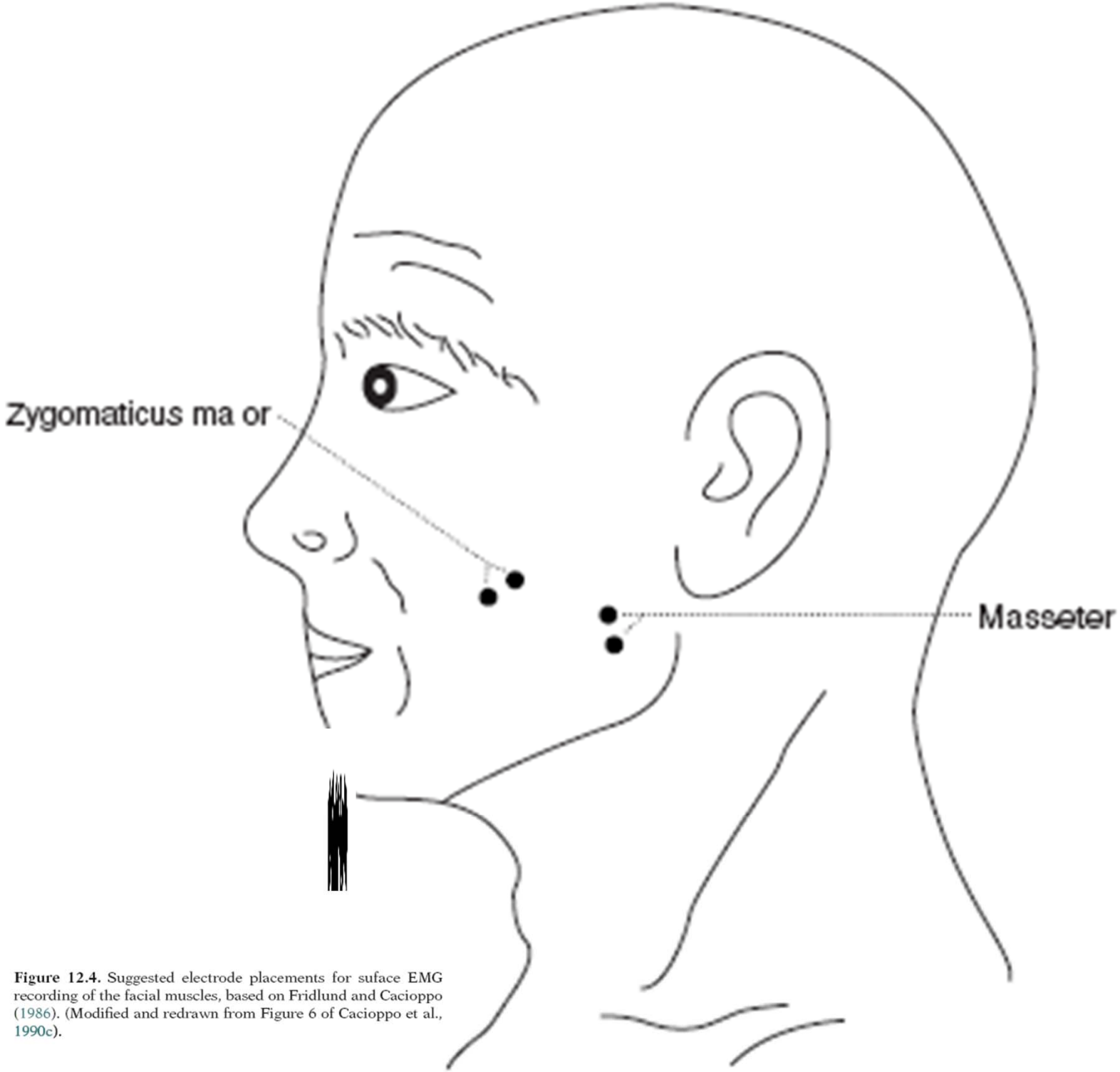


Figure 12.4. Suggested electrode placements for suface EMG recording of the facial muscles, based on Fridlund and Cacioppo (1986). (Modified and redrawn from Figure 6 of Cacioppo et al., 1990c).



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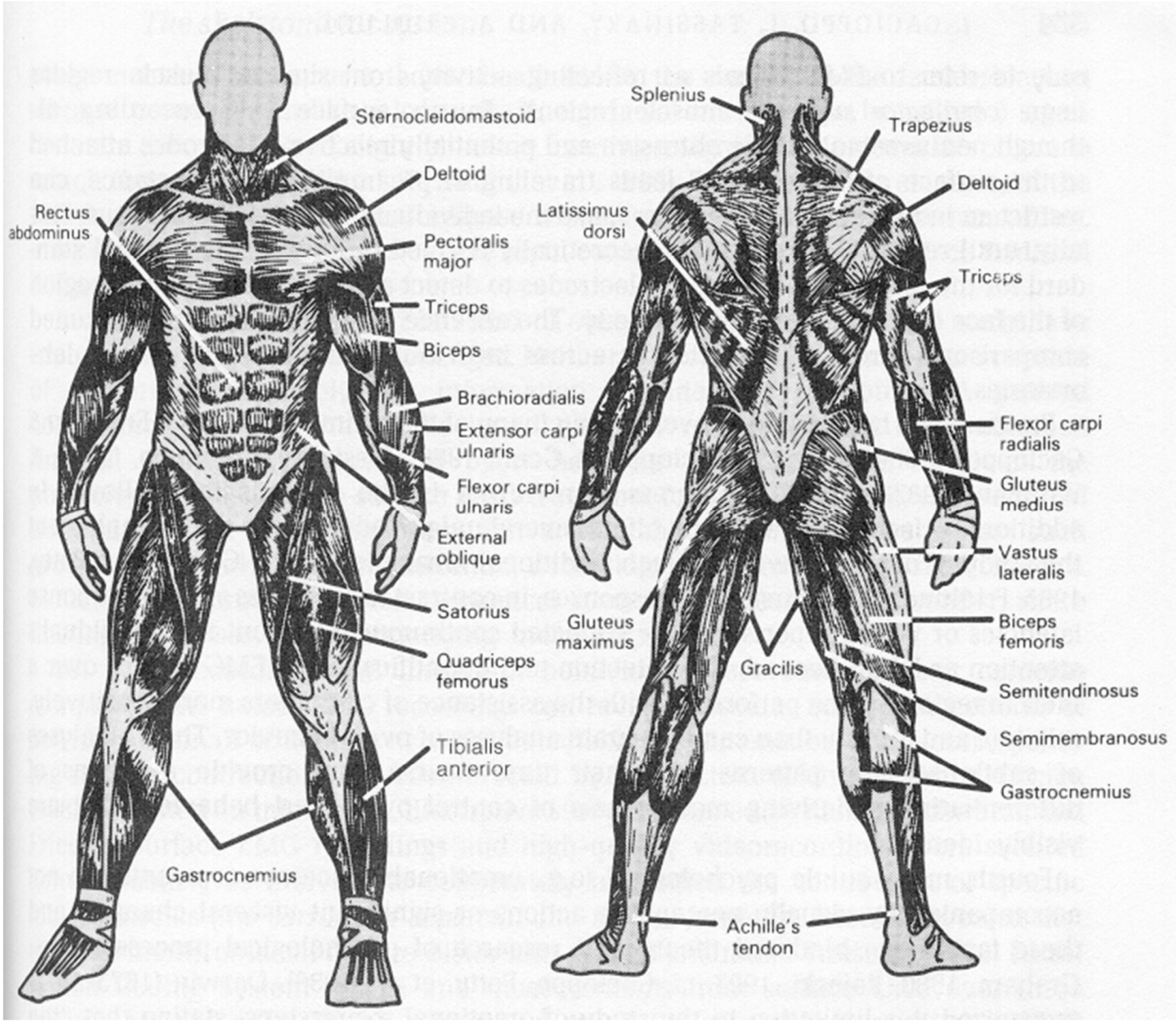
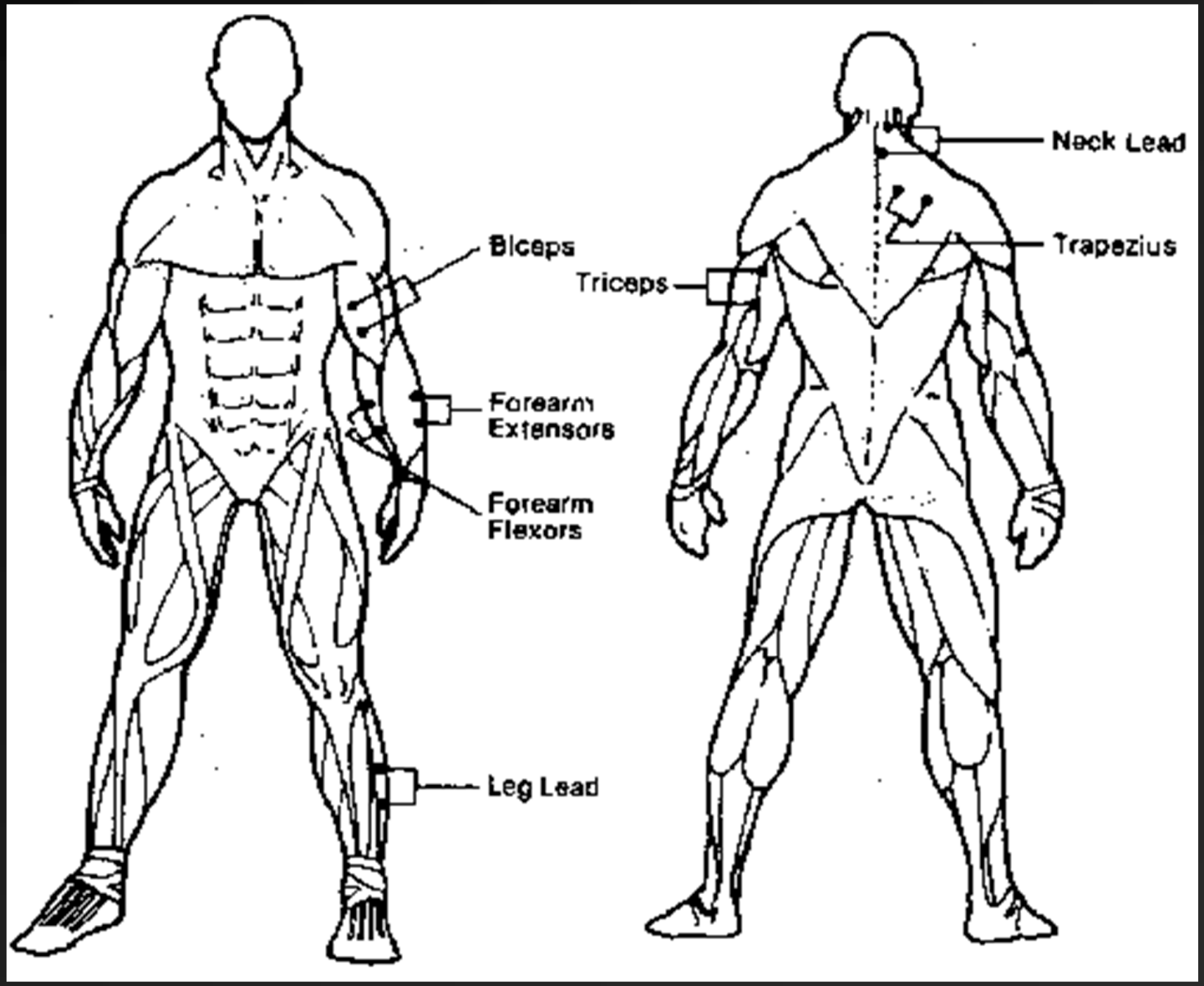

Sternocleidomastoid
Deltoid
Rectus abdominus
Pectoralis major
Triceps
Biceps
Brachioradialis
Extensor carpi ulnaris
Flexor carpi ulnaris
External oblique
Satorius
Quadriceps femorus
Tibialis anterior
Gastrocnemius
Splenius
Trapezius
Deltoid
Latissimus dorsi
Triceps
Flexor carpi radialis
Gluteus medius
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

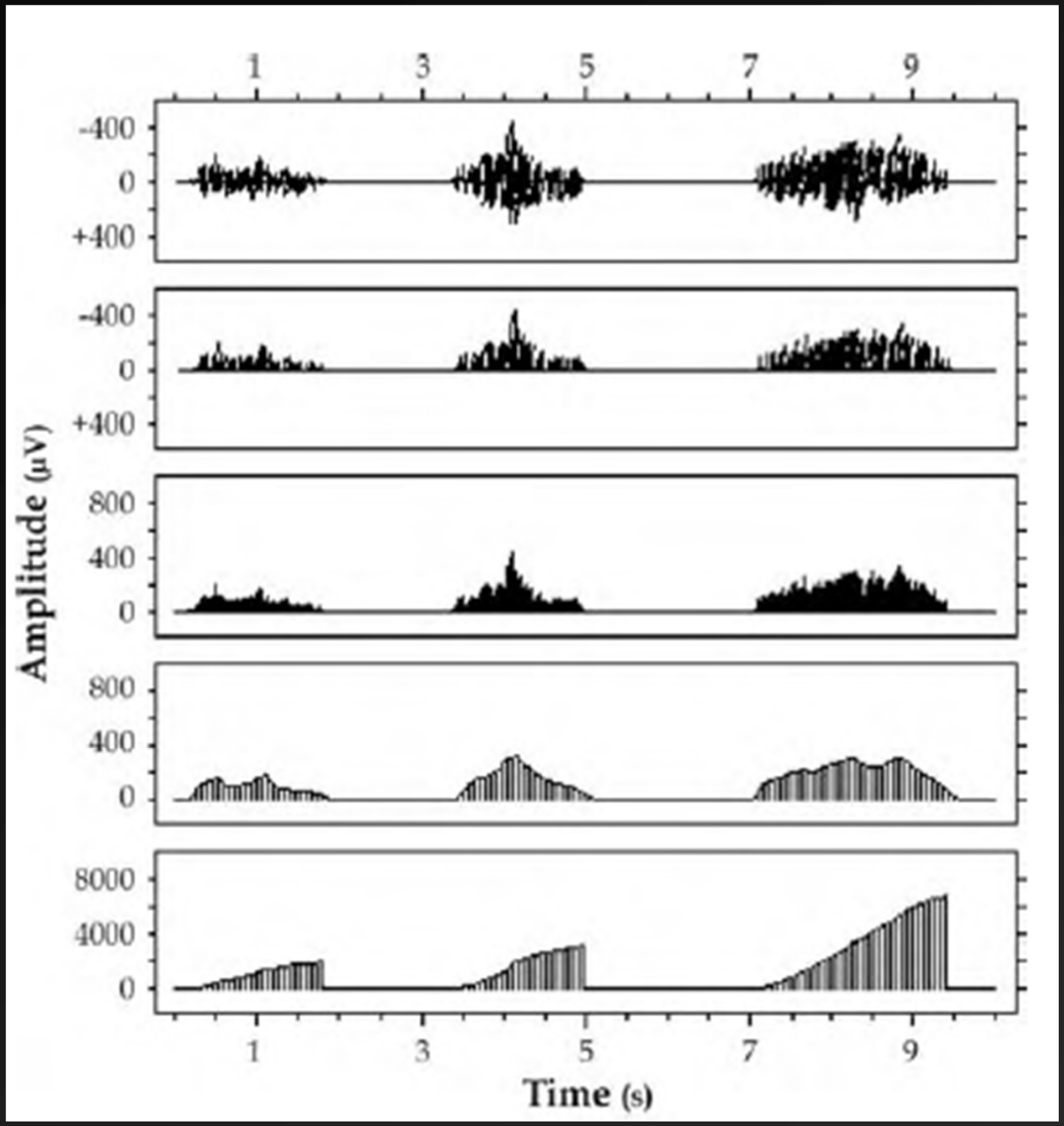
- MAPs summate in quasi-random fashion to produce resultant signal
  - Range of ~10-500 Hz
  - Amplitude of sub-microvolt to over 1000 microvolts
- Note overlap with 60 Hz range
  - Prepare ground site carefully; Differential amplifier will assist in removing 60 Hz
  - Prepare recording sites carefully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

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

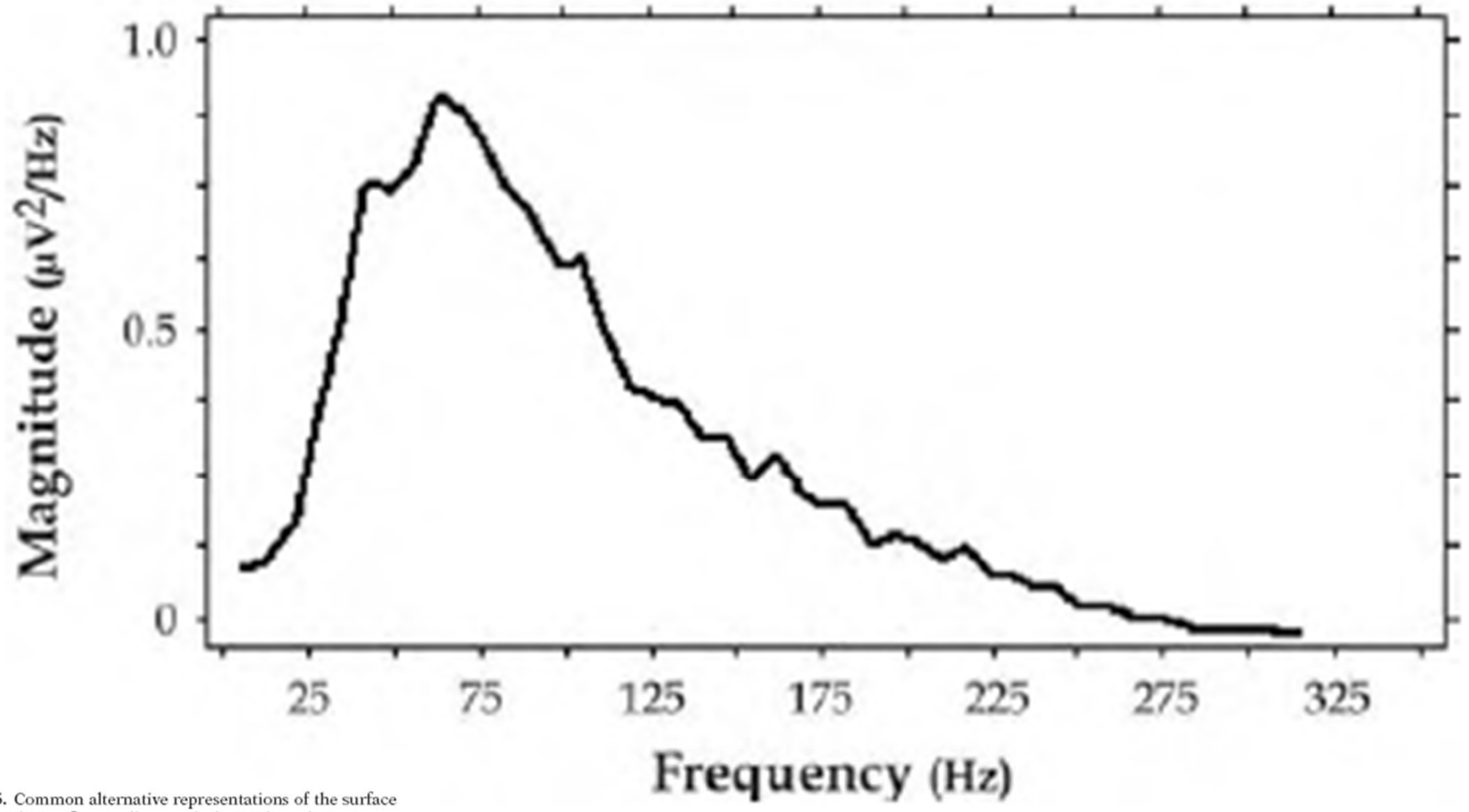


Signal Transformations

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).

Demos

EMG Power



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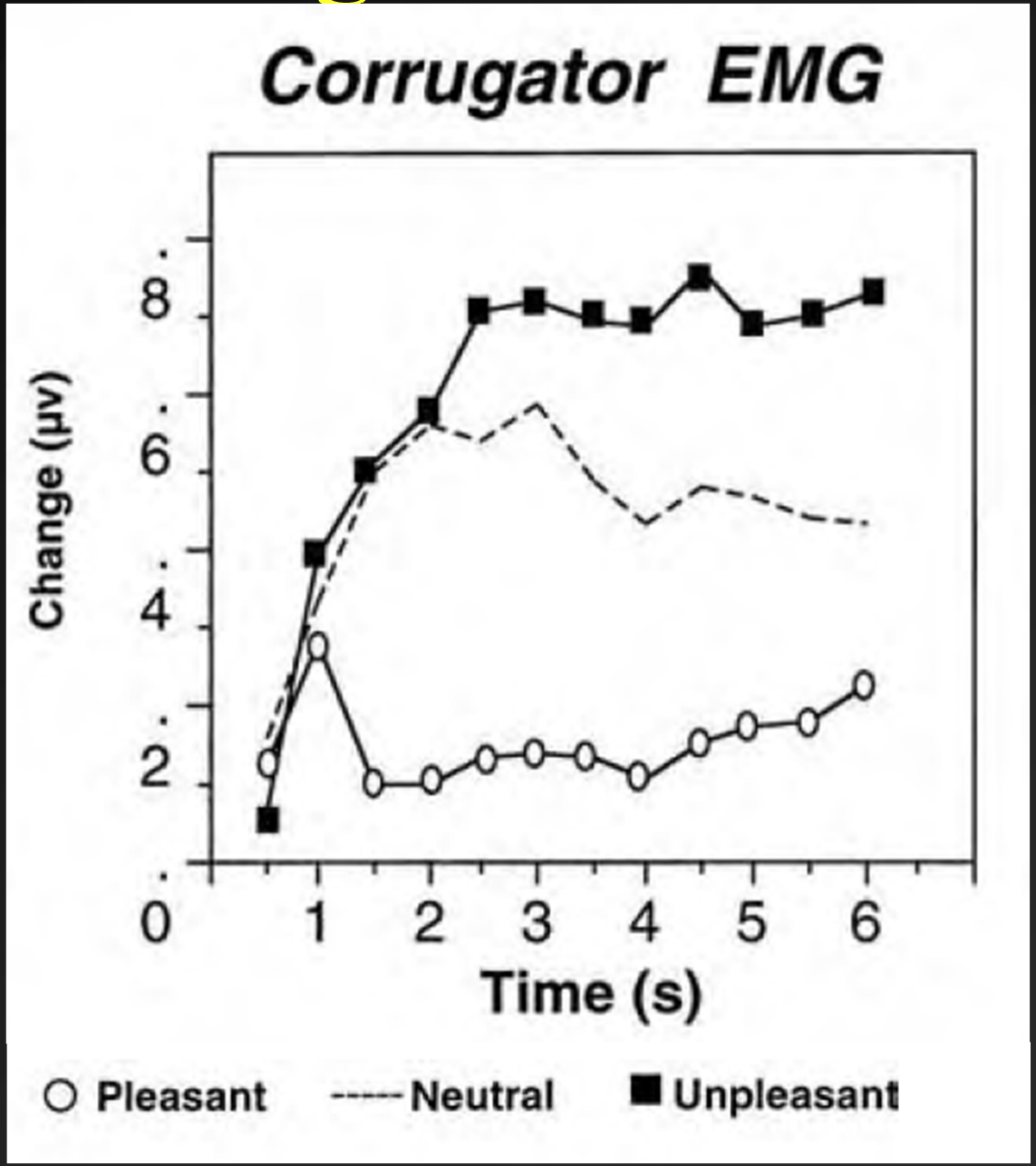
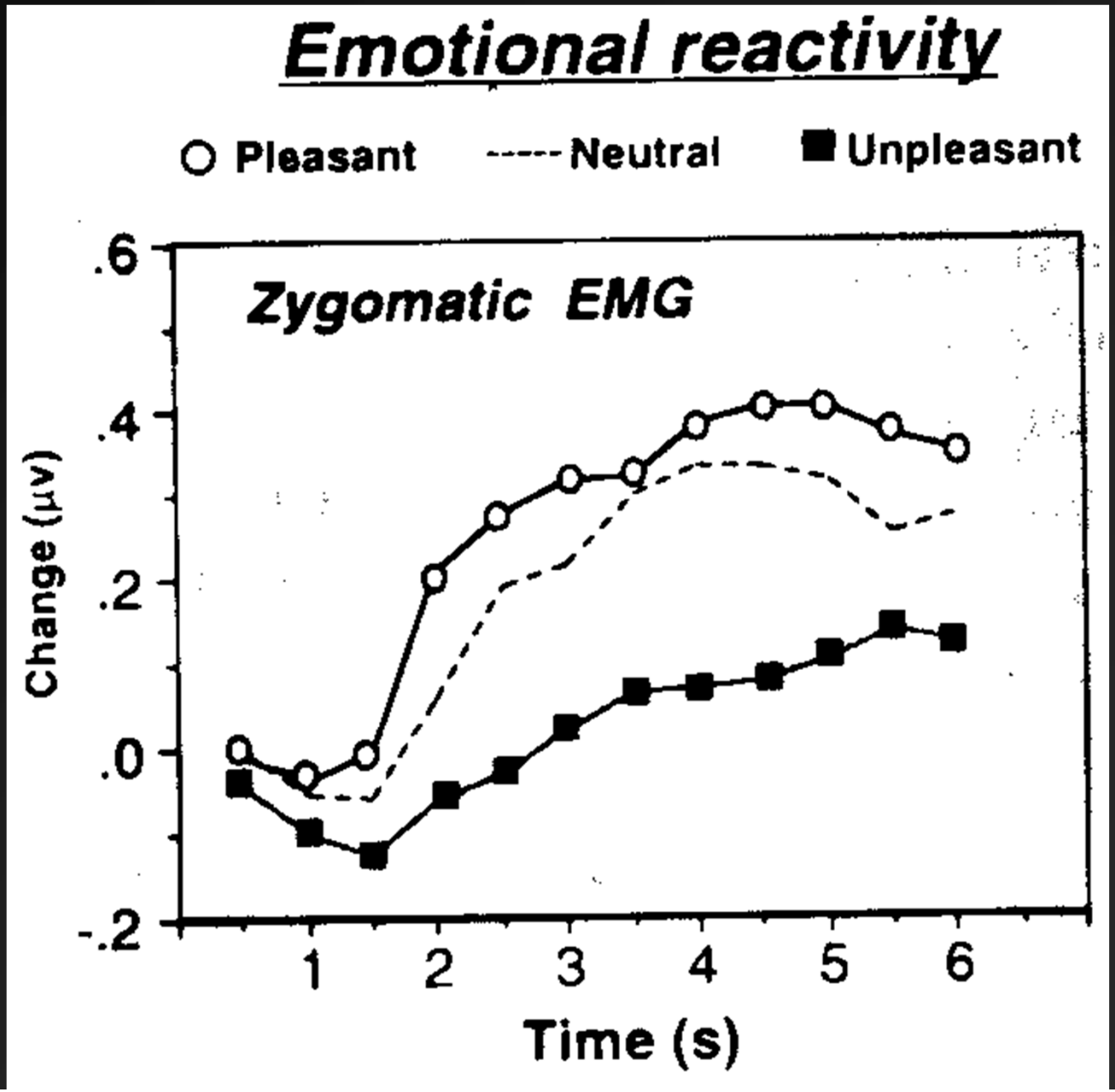
Demo with Volunteer

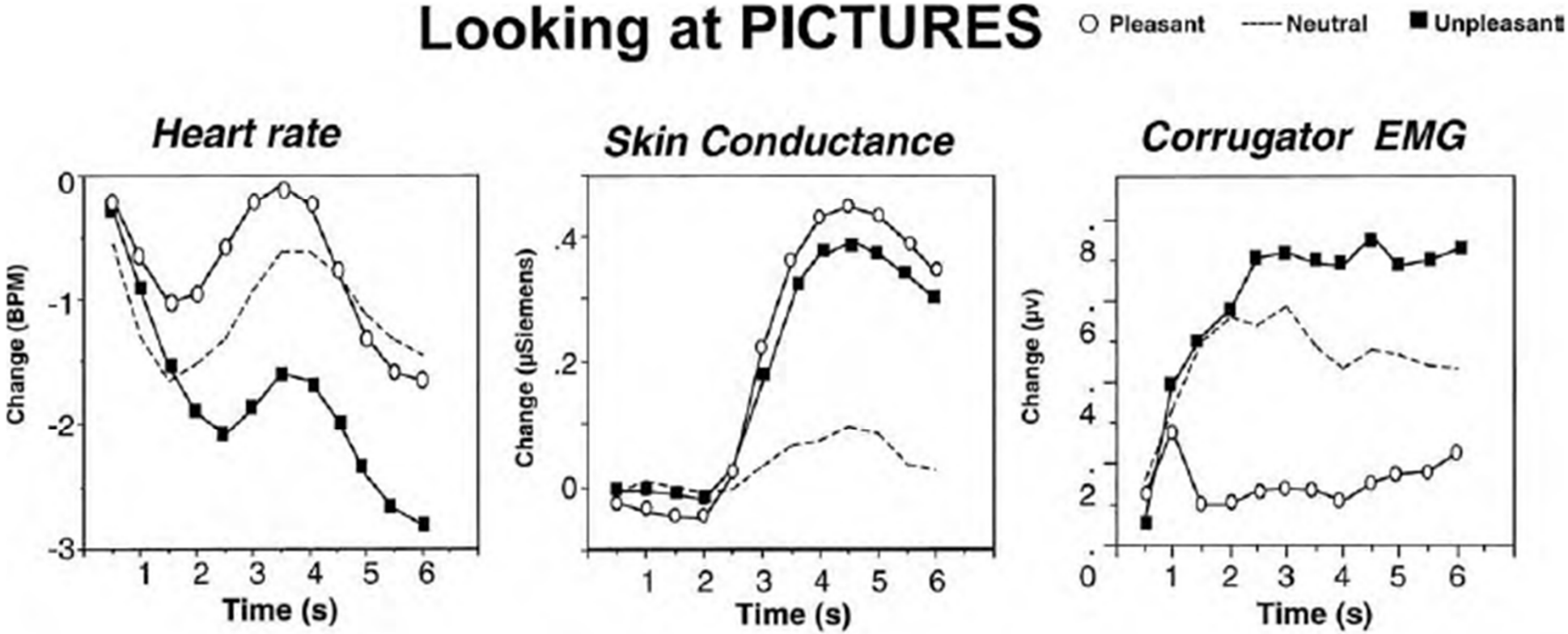
Corrugator "Frown"



Zygomatic "Smile"



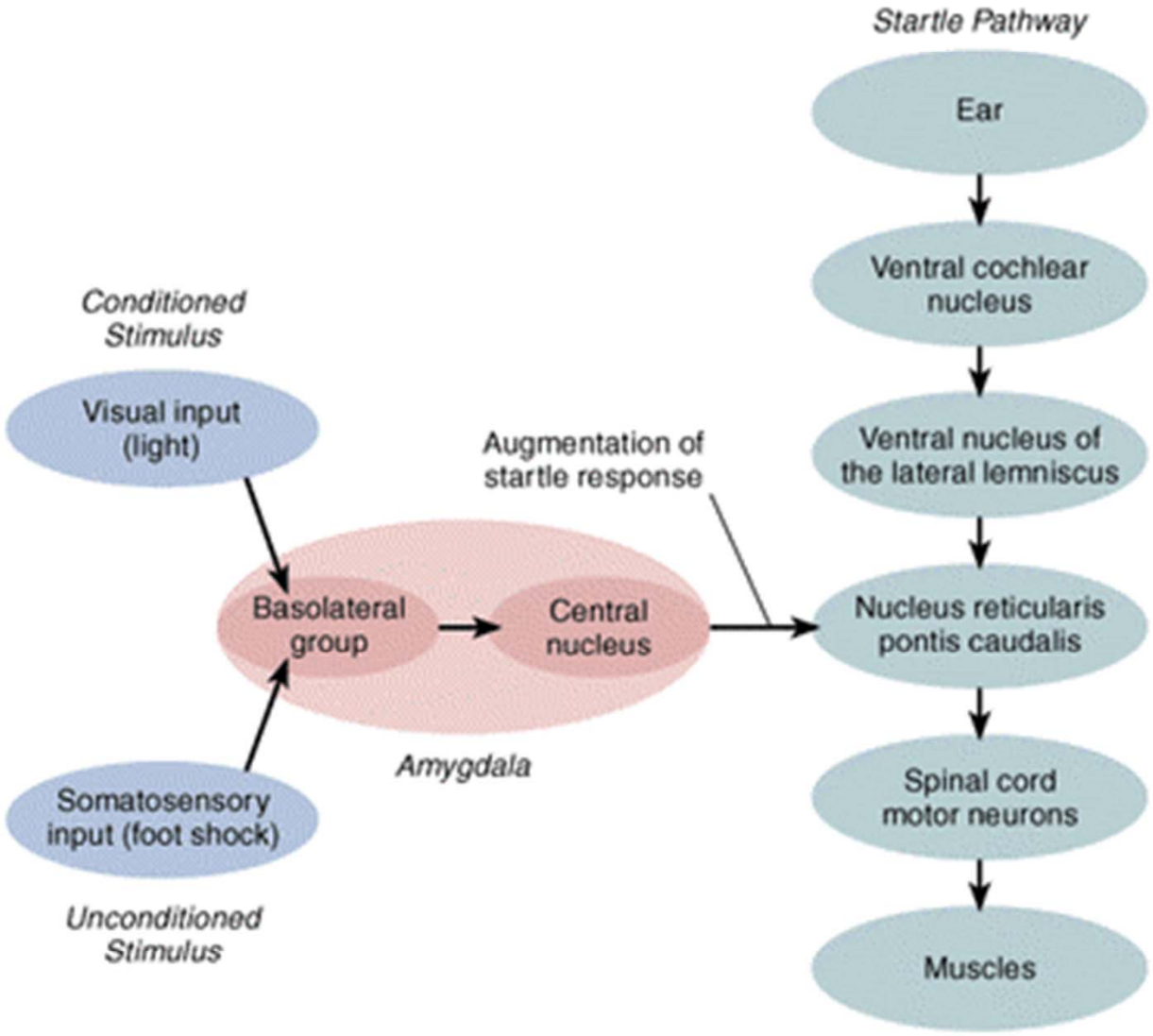
Looking at PICTURES



A few Applications

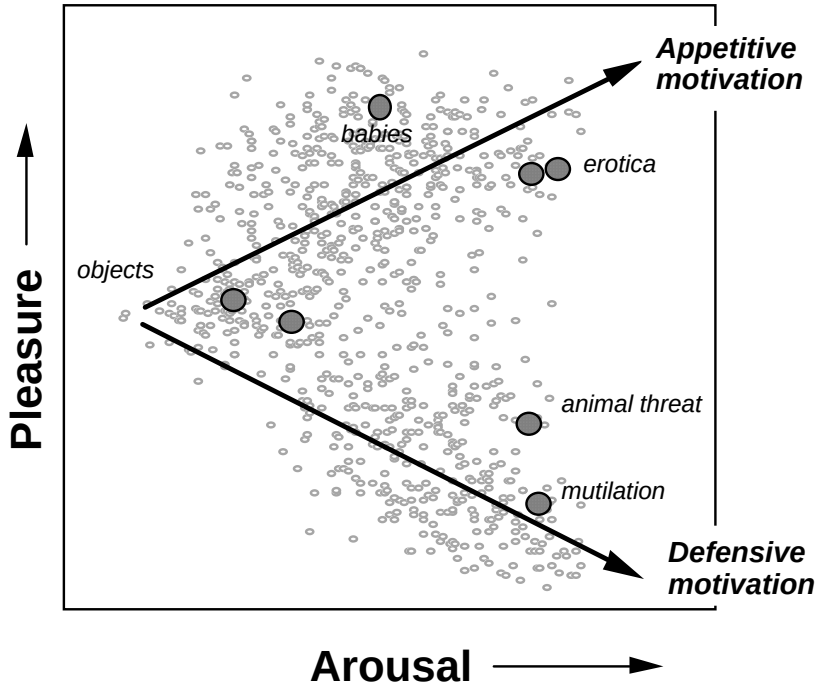
- Startle Probe
- Subtle affect
  - Mere Exposure
  - Subliminal effects
  - Mortality Salience
  - Biofeedback of EEG -- outcome measure
  - Emotion Regulation – outcome measure

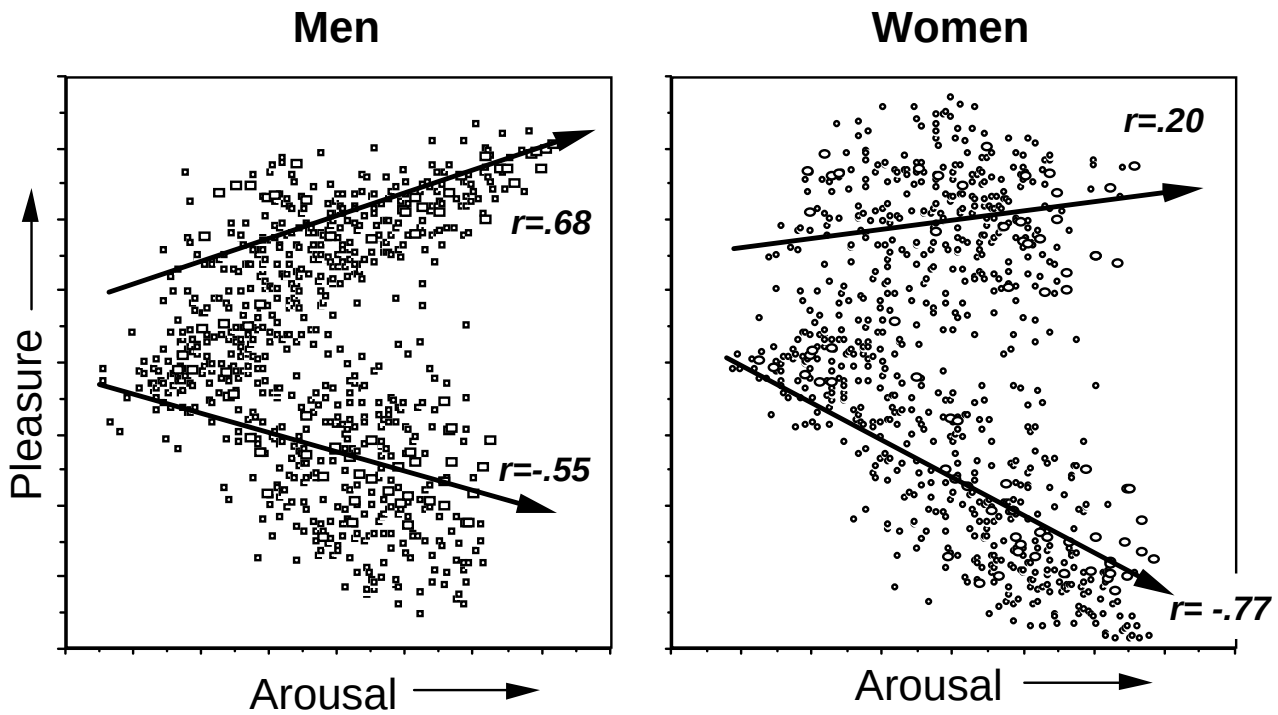
► Neural Circuits Responsible for an Auditory Startle Response and for Its Augmentation by Conditioned Aversive Stimuli



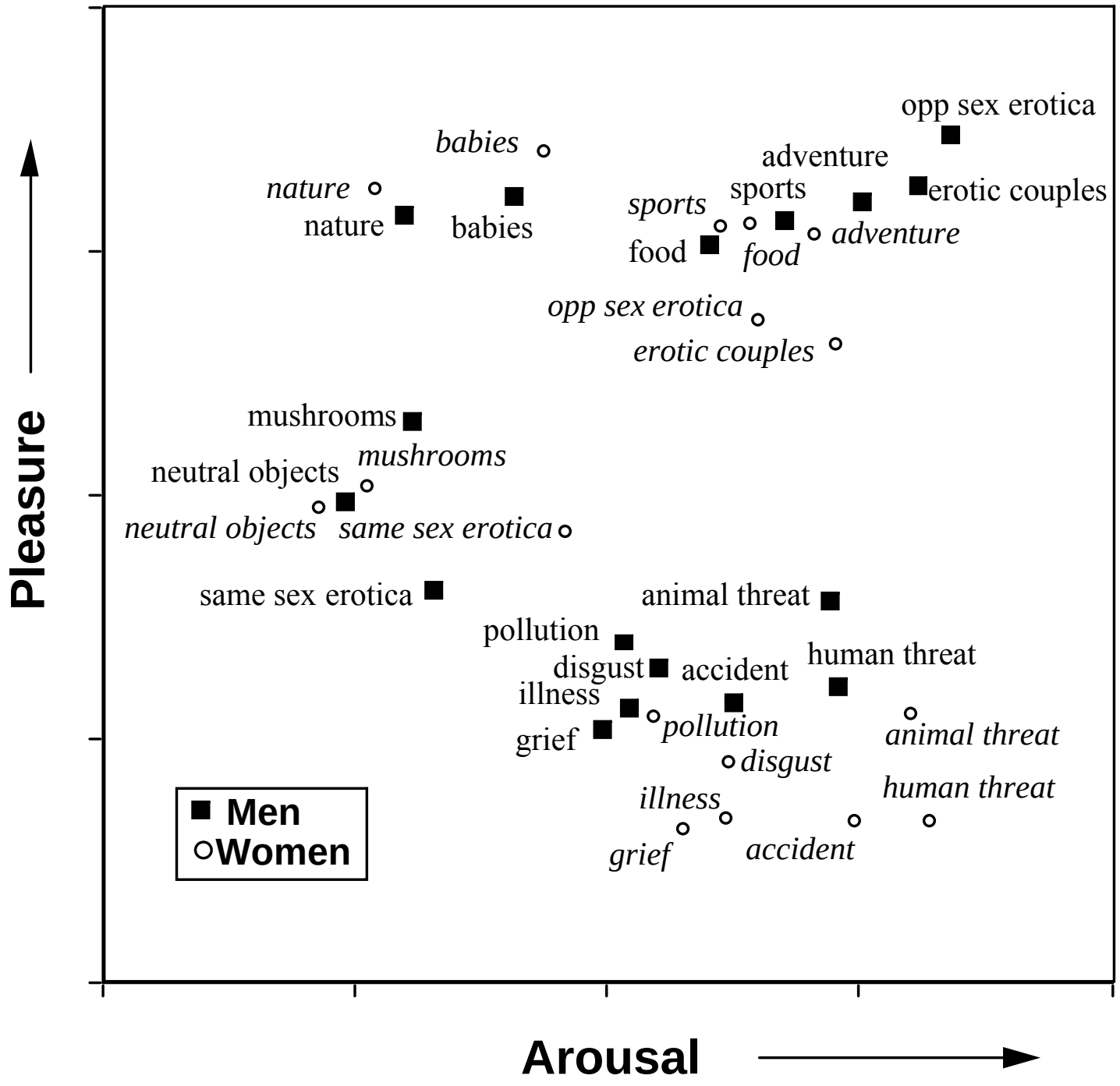
Source: Adapted from Davis, M., *Trends in Pharmacological Sciences,* 1992, *13,* 35–41.

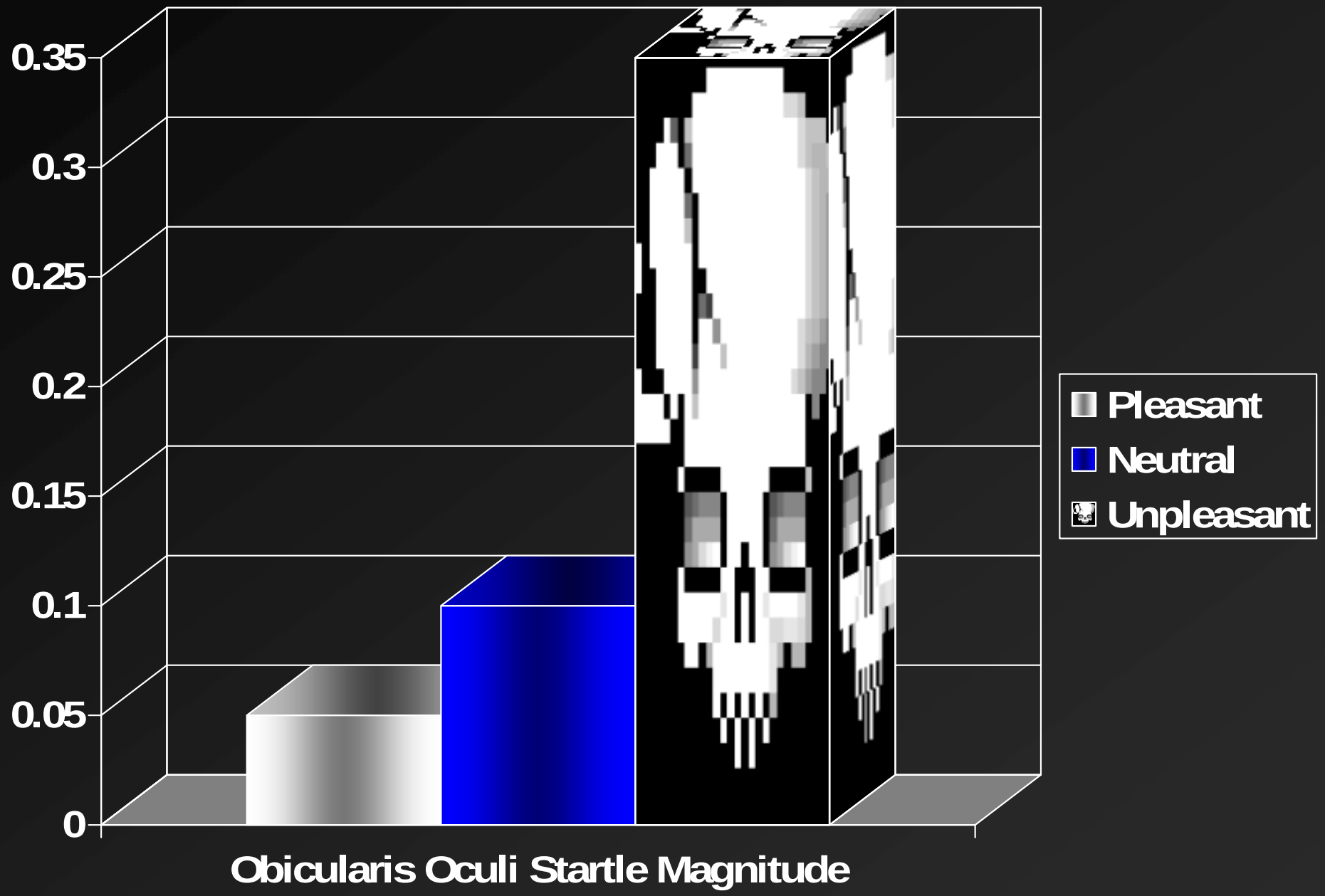
International Affective Picture System (IAPS)



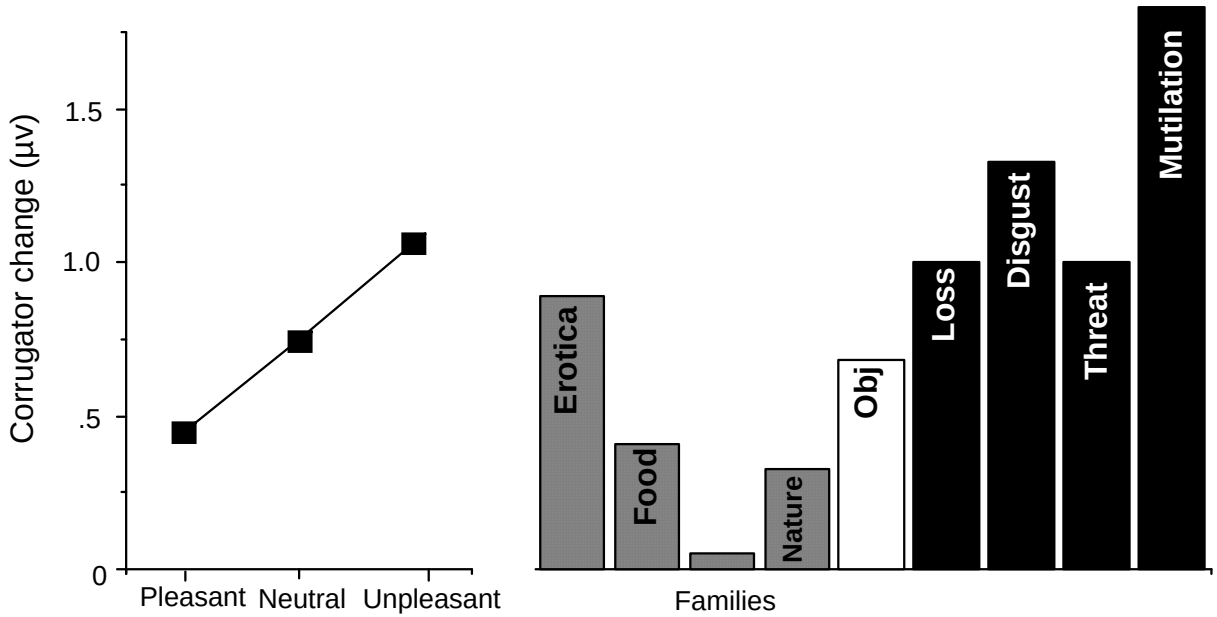


Affective Space: Picture Content and Gender

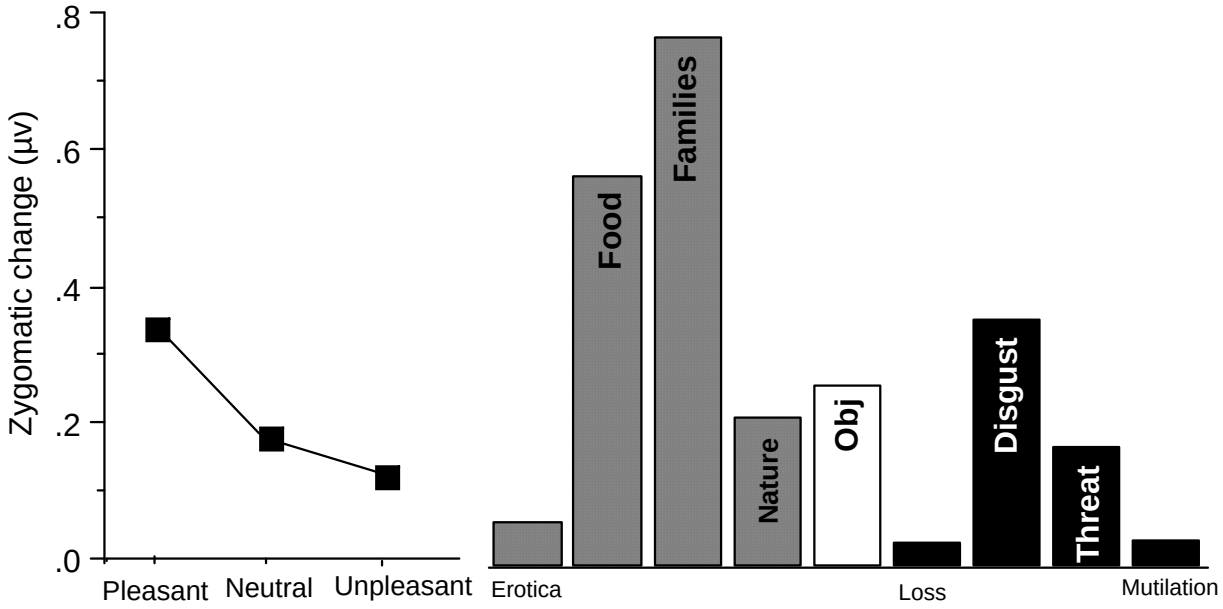



0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
Pleasant
Neutral
Unpleasant
Obicularis Oculi Startle Magnitude

Corrugator EMG



Zygomatic EMG



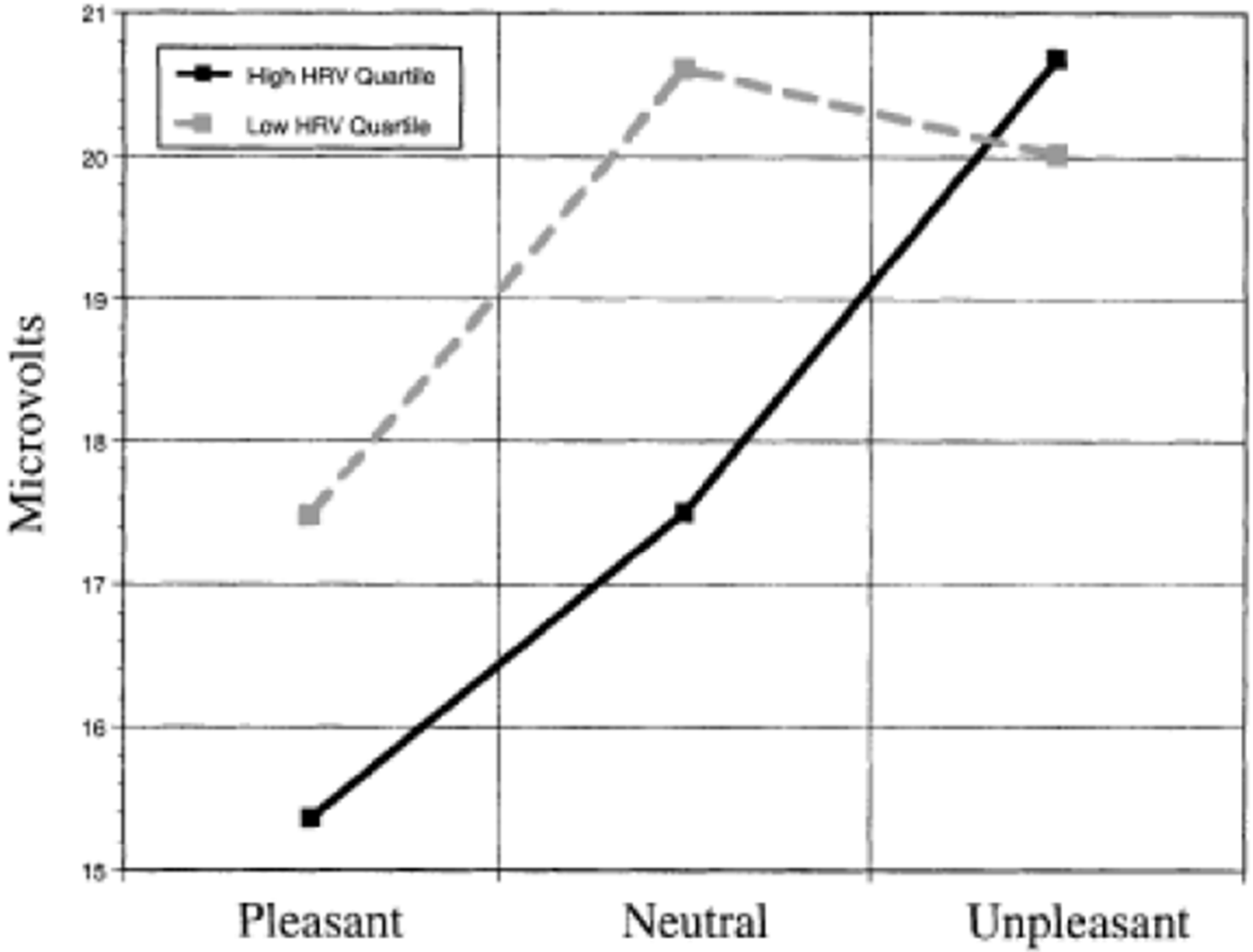
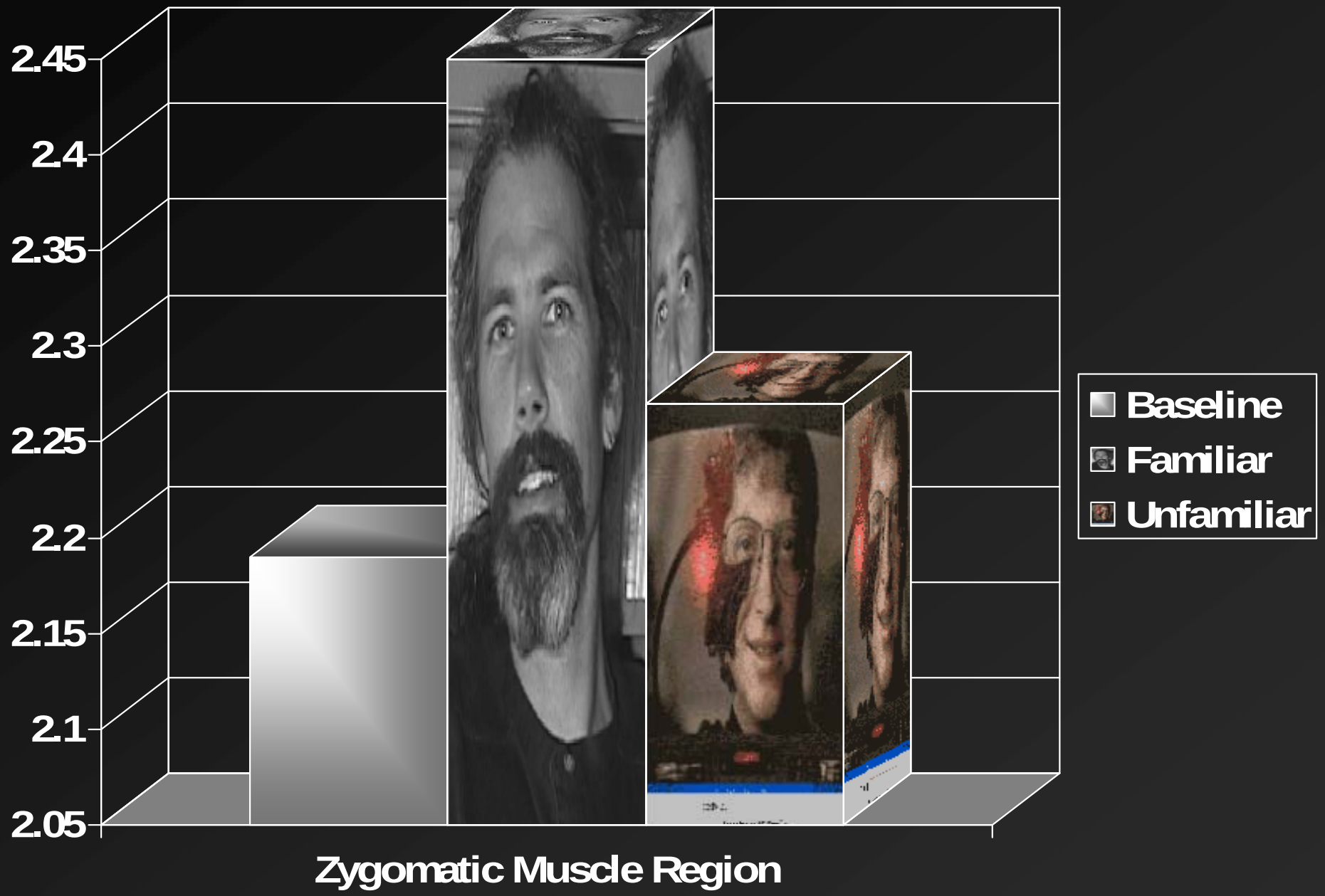


Figure 1. Mean startle amplitude as a function of baseline HRV and valence. Startle amplitudes are in microvolts.

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

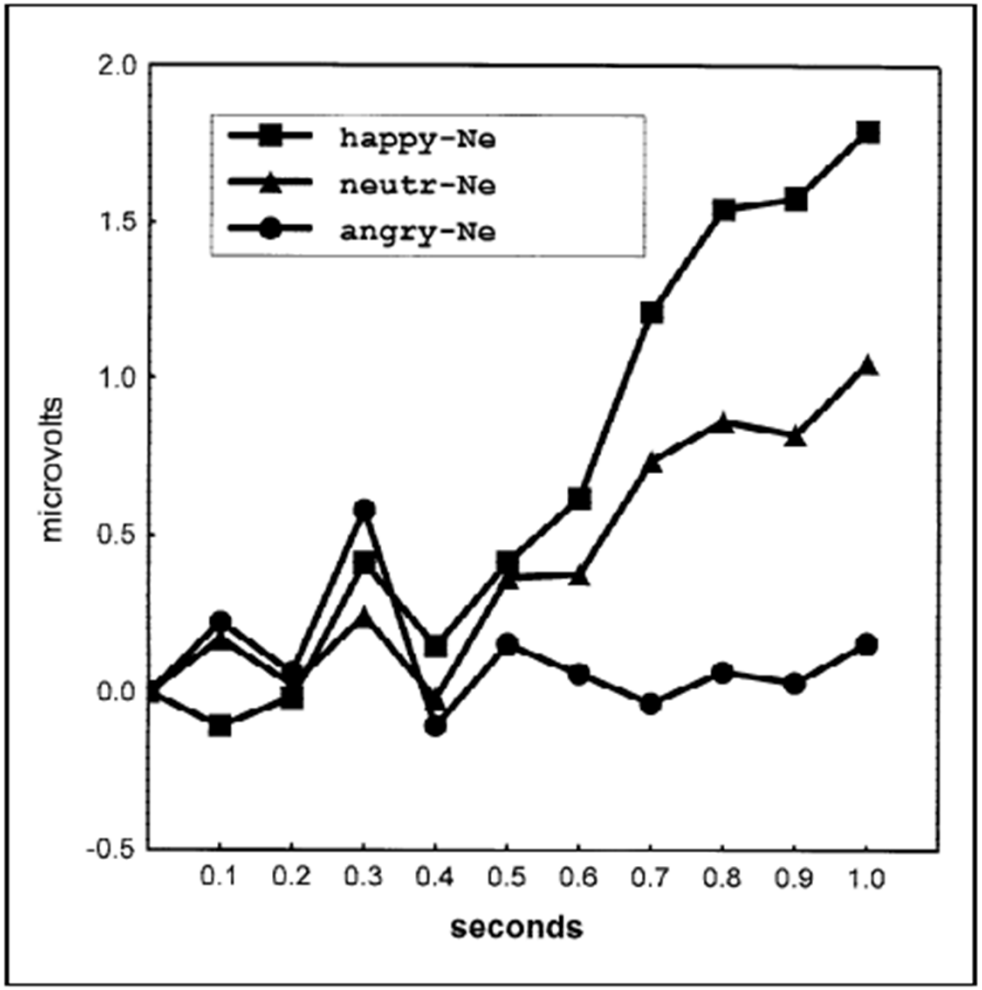
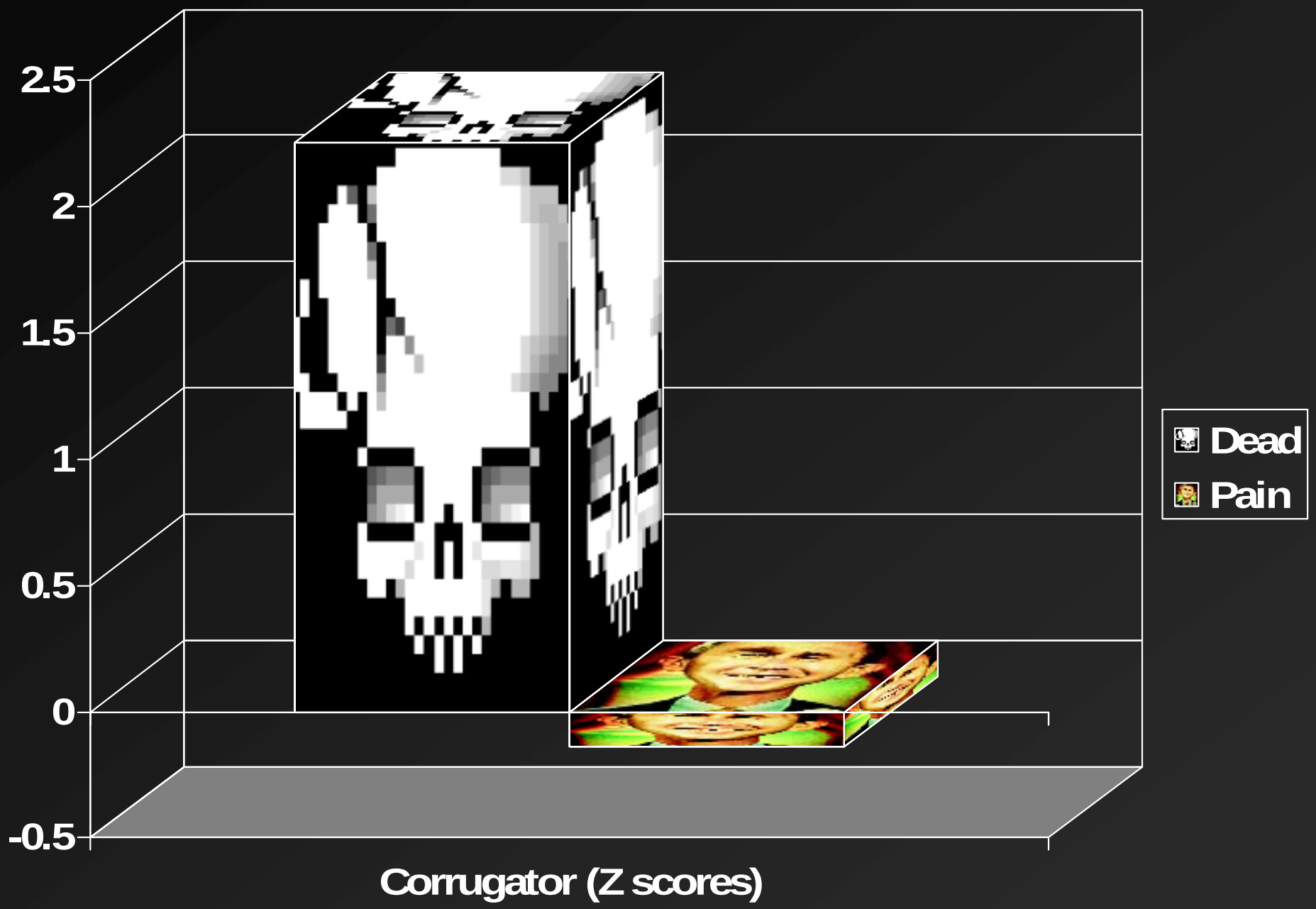
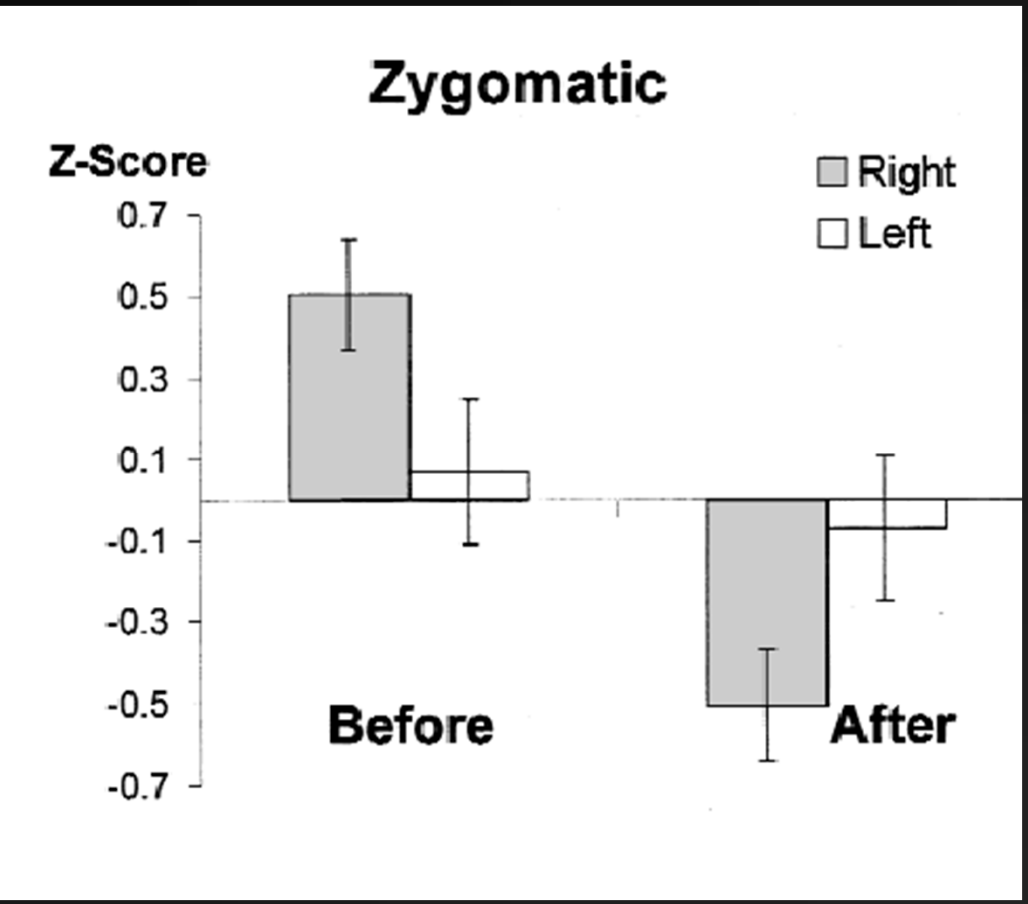
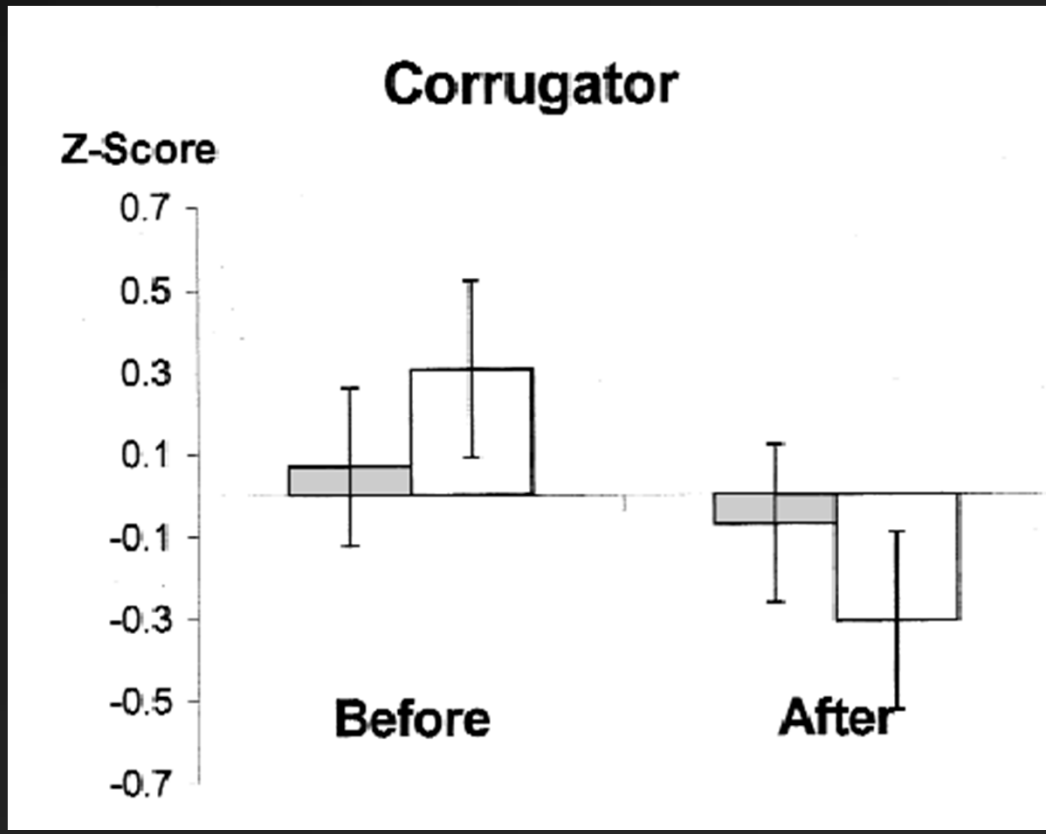


Fig. 1. Mean facial electromyographic response for the *zygomatic major* muscle, plotted in intervals of 100 ms during the first second of exposure. Three different groups of participants were exposed to identical neutral faces ("Ne"), preceded by unconscious exposure of happy, neutral ("neutr"), or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



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.





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

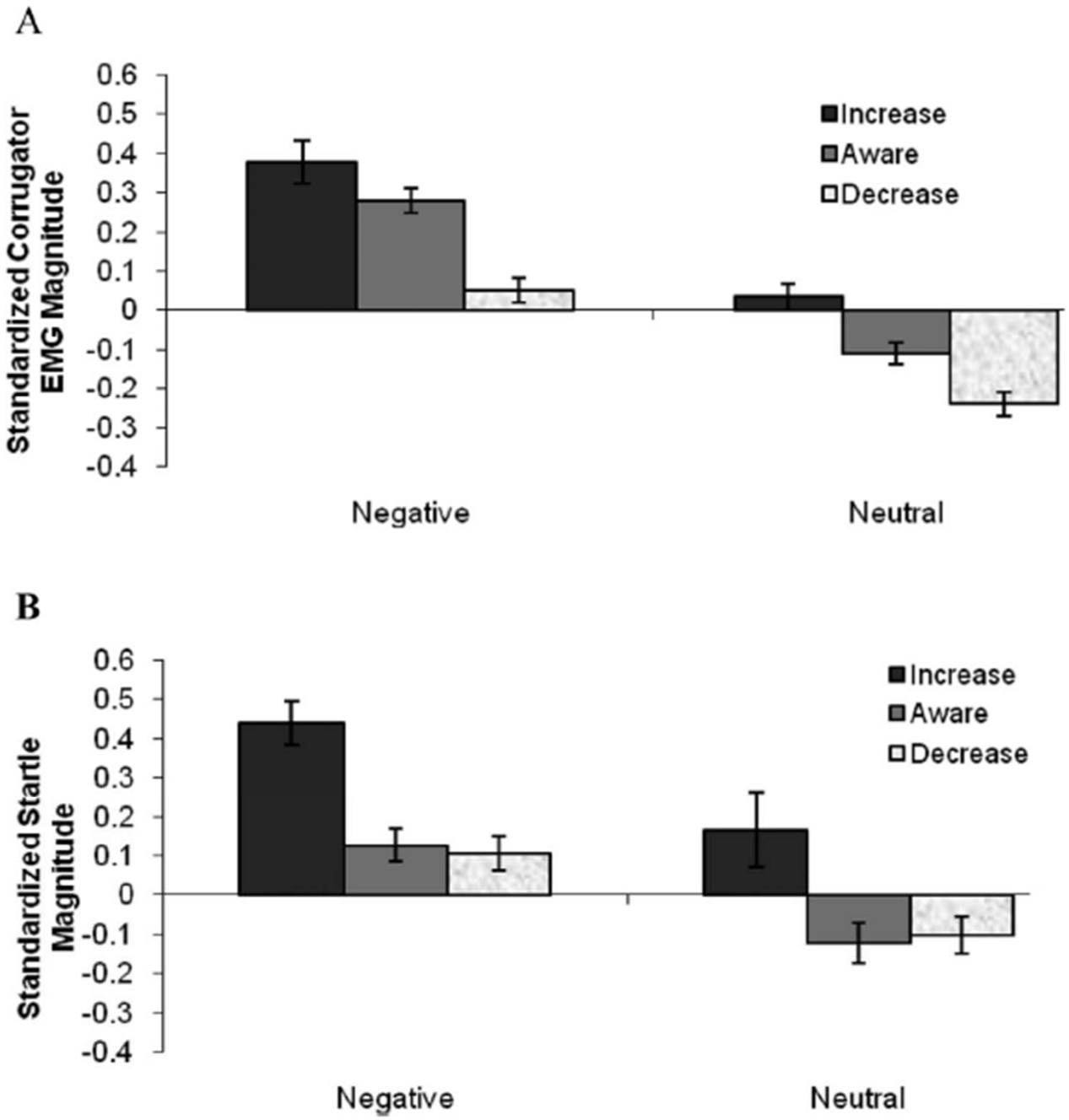


Figure 2. Standardized (A) corrugator EMG and (B) startle magnitude (averaged over Times 1 and 2).

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