Electromyography (EMG) is the detection and recording of the electrical signal produced by muscle tissue as it contracts.

Why Record EMG?

- **Emotion Research**
  - Facial "expressions"
  - Bodily expressions
  - Motivational tendencies
- **Cognitive Research**
  - Processing effort
  - Verbalization
  - Response tendencies (e.g., mirroring, errors, etc)
- **Health research:**
  - Muscle tension in disorders and stress

What is EMG signal?

- Electricity generated by Muscle Action Potentials (MAPs).
- Or more technically:
  - "EMG records the changes in electrical potential that result from the conduction of action potentials along the muscle fibers, or rather the motor units during muscle contraction (MUAP – motor unit action potential)." Hess, 2009

- Most psychologists use "surface EMG", measuring small currents conveyed to surface via extra cellular fluids to skin.
  - However, one can also record invasively with subcutaneous needle electrodes

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**

The bottom line

- In general, the stronger the muscle activity, the more action potentials, the stronger the EMG signal.
- **Other factors**
  - Skin impedance (preparation)
  - Subcutaneous fat (insulator)
  - Muscle size
  - Distance to electrodes and between electrodes
  - Alignment of electrodes (with respect to muscle fiber direction)
Some cautions

- EMG is not absolute; it is a relative measure only.
- Based on voltage value of EMG, we cannot compare directly between muscles or between people.
- We can use EMG values to compare between different conditions for same muscle.
- Converting values to standardized (z) scores within subjects and within muscles, can facilitate comparisons.

EMG recording

- The small signals detected by the active pair of electrodes on the surface of the skin are compared to the signal detected by a reference electrode placed over connective tissue (especially bone). This reference electrode may be called a "ground" or "earth" electrode.

Signal Recording

- To produce a smooth contraction, there is overlapping of motor unit firing (5-100 pulses/s but commonly 10-30 pulses/s).
- There are asynchronous volleys of impulses traveling down the many axons innervating a single muscle
- MAPs summate in quasi-random, "noise-like" fashion to produce resultant signal.
  - Range of ~10-500 Hz
  - Amplitude of sub-microvolt to around 1000 microvolts

EMG Power

- Frequency (Hz)
- Magnitude (μV² / Hz)
Möbius syndrome

- results from the underdevelopment of the **VI** and **VII cranial nerves**
- 1 in 100,000

Basic muscles of facial expressions

Basic muscles of facial expressions:
- **Fig 2 a**
  - Corrugator supercilii
  - Orbicularis oculi
  - Oculi
  - Orbicularis oculi pars orbitalis
  - Frontalis
  - Levator labii
  - Alaeque nasi
  - Zygomaticus major
  - Oris
  - Oris
  - Mentalis
  - Depressor anguli oris
  - Corrugator supercilii

EMG can measure reflexes

- **Fig 4**
  - Defensive reflex (eye)
  - Appetitive reflex (ear)

Postauricular muscle

- **Fig 4**
  - Auricularis posterior -- draws the ear backward

Basics of signal recording
Signal Recording (cont’)

- Amplification
  - Differential amplifiers with common mode rejection
  - Actually double differential (electrodes against each other, and against ground)
- Sample at 4x the highest frequency (i.e. 2000 Hz)
- Amplify voltages 1000-20,000 times and digitize the signal.
- May record wide frequency and filter off-line, may use on-line filter
  - Should pass 10-500 Hz (the energy above 250Hz is negligible)

EMG quantification

- Full-wave rectify the signal (all negative voltages are converted to positive)
- Integrate the signal by calculating the area under the curve during a certain period

EMG uses

Startle

Method Used by Davis and His Colleagues to Investigate the Augmented Startle Response

Brain circuit of auditory startle
**Procedure of startle modification study**

54 Pictures from IAPS and faces:
- Positive
- Neutral
- Negative

Startle:
- Loud 96 db noise presented for 50 ms. after picture onset at varying intervals (around 3 seconds)

Measures:
- Blink response (obicularis, 30-120 ms)
- Facial electromyography (zygomaticus, corrugator)
- Rating of the picture (1 = positive, 9 = negative scale)

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**Stimuli**

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**Affective Startle Modification in Autism and Typical Participants**

![Graph showing mean standardized log EMG activity over zygomaticus and the corrugator supercilii. First 2000 ms of viewing affective picture stimuli.]

**Ratings of picture valence in autism and typical participants**

![Bar graph showing mean rating of picture valence.]

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**Summary of startle modification study**

- Autism participants show an atypical pattern of affective startle modulation, indicating deficits in early affective processing.
- These deficits could be related to the activity of the amygdala, supporting the “amygdala theory of autism.”
- However, participants show NO differences from typicals when rating the valence of pictures.
Other theories of Autism

“Broken-mirror” theory

- Mirroring = recreation (simulation) of the state in oneself
- Perhaps supported by the “Mirror-neuron” system that maps other’s behavior to one’s own reactions.
  - Animal Example: Monkey see – monkey do
  - Human Example: Finger-movement “mimicry”

FMRI evidence for the role of the “mirror-neuron-system” in perception of emotional facial expressions (Carr et al., 2003)

Autistic participants show less mirroring