QUICK START GUIDE FOR THE BCIA BIOFEEDBACK DIDACTIC WORKSHOP

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What is biofeedback?

Biofeedback Alliance and Nomenclature Task Force (2008)

"Biofeedback is a process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance. Precise instruments measure physiological activity such as brainwaves, heart function, breathing, muscle activity, and skin temperature. These instruments rapidly and accurately 'feed back' information to the user. The presentation of this information — often in conjunction with changes in thinking, emotions, and behavior — supports desired physiological changes. Over time, these changes can endure without continued use of an instrument."

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What is biofeedback?

The main elements of this definition are that:
(1) biofeedback is a learning process that teaches an individual to control their physiological activity
(2) biofeedback training seeks to improve health and performance
(3) instruments rapidly monitor an individual's performance and display it back to them
(4) the individual uses this feedback to produce physiological changes
(5) changes in thinking, emotions, and behavior often accompany and reinforce physiological changes
(6) these changes become independent of external feedback from instruments

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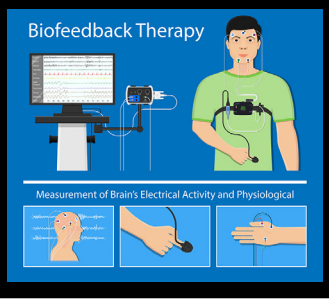
What is biofeedback?



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What is a biofeedback modality?

- A modality is sensor channel (e.g., EMG or temperature) that monitors physiological activity (Graphic courtesy of Thought Technology, Ltd.)

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Biofeedback Modalities

Modality	Description	Sensors
Brainwave (EEG)	EEG biofeedback uses scalp sensors to monitor the brain's electrical activity. Neurofeedback (also called EEG biofeedback) is used to treat ADHD, anxiety, alcoholism/substance abuse, depression, epilepsy, headache, and post-traumatic stress disorder (PTSD), and traumatic brain injury, and to teach optimal performance.	
Breathing (RESP)	Respiratory biofeedback uses flexible bands placed around the abdomen and/or chest to monitor breathing pattern and respiration rate. Respiratory biofeedback is used to treat asthma, chronic obstructive pulmonary disease (COPD), and high blood pressure, and to teach optimal performance.	
Heart rate (HR)	HR biofeedback uses chest, earlobe, and/or finger sensors to measure the time interval between adjacent heartbeats. HR biofeedback is used in training for cardiac arrythmia, meditation, optimal performance, and stress management.	

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Biofeedback Modalities

Heart rate variability (HRV)	HRV biofeedback uses chest, earlobe, and/or finger sensors to measure the time interval between adjacent heartbeats. HRV biofeedback is used to treat anxiety, asthma, depression, high blood pressure, post-traumatic stress disorder (PTSD), preeclampsia, unexplained abdominal pain, and to teach optimal performance.	
Muscle (SEMG)	Surface EMG (SEMG) or muscle biofeedback uses sensors placed over skeletal muscles to monitor the electrical activity that causes muscles to contract. EMG biofeedback is used to treat anxiety, asthma, cerebral palsy, fecal and urinary incontinence, headache, high blood pressure, low back pain, pelvic pain, temporomandibular muscle and joint disorder (TMJD), paralysis and muscle weakness due to peripheral nerve injury and stroke, and to teach optimal performance.	

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Biofeedback Modalities

Peripheral blood flow (PPG)	Photoplethysmographic (PPG) biofeedback uses infrared sensors to detect relative blood flow from earlobe, finger, and/or temporal artery sites. PPG biofeedback is used to treat high blood pressure, Raynaud's disease, tension-type and vascular headache, and to teach optimal performance.	
Sweat gland (EDA)	EDA biofeedback uses sensors placed around the fingers or on the palm to monitor changes in skin moisture produced by sweating. EDA biofeedback is used to treat anxiety, excessive sweating, and high blood pressure, and to teach optimal performance.	
Temperature (TEMP)	Temperature biofeedback uses sensors placed on the hands and/or feet to measure relative blood flow to the skin. Temperature biofeedback is used to treat high blood pressure, Raynaud's disease, swelling, and tension-type and vascular headache, and to teach optimal performance.	

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Biofeedback Modalities

Modality	Acronyms	What It Measures	Sensor	Placement	Normal Resting Values
electrocardiograph	ECG/EKG	heart rate, HRV			HR = 60-80 bpm SDNN = > 50 ms (brief) RMSSD = 30-100 ms (brief) LnHF = 4.5-7.5
electrodermograph	EDA, GSR, SC, SP	eccrine sweat gland activity			SCL ≤ 5 μS (fingers)
electroencephalograph	EEG	EPSPs and IPSPs, slow cortical potentials			alpha/theta ratio < 3:1
electromyograph	EMG/SEMG	muscle action potentials			EMG ≤ 3 μV (most muscles)* ≤ 5 μV (large muscles)* * wide bandpass

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Biofeedback Modalities

feedback thermometer	TEMP	peripheral blood flow			TEMP > 88-95° F (fingers) > 85-93° F (toes)
photoplethysmograph	PPG	peripheral blood flow, heart rate, HRV			HR = 60-80 bpm SDNN = > 50 ms (brief) RMSSD = 30-100 ms (brief) LnHF = 4.5-7.5
respirometer	RESP	abdominal/chest movement, respiration rate			RR = 12-14 bpm

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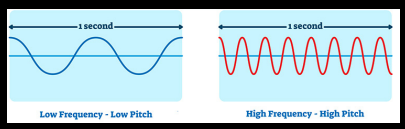
What is frequency?

- Frequency is the number of cycles per second (Hz) and is the basis of pitch



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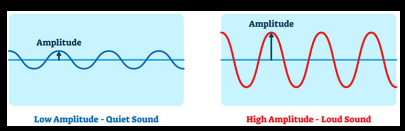
What is amplitude?

- Amplitude measures signal strength (in microvolts) and is the basis of loudness



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What is a millivolt? microvolt? picowatt?

- A millivolt is one-thousandth of a volt (Skin Potential Level)
- A microvolt is one-millionth of a volt (EEG and EMG)
- We also measure the EEG in picowatts (trillionths of a watt)

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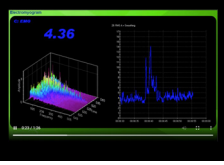
EMG values are not absolute

- EMG values are not absolute in the sense of degrees C or F
- They depend on electrode size, distance from each other, placement on the muscle, filter settings (bandpass), calculation method, and adipose tissue
- This means that we can't automatically compare SEMG values across equipment and individuals



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What is the recommended sequence for SEMG skin preparation?

- Explain the procedure and obtain the client's permission
- Palpate the muscles and mark active sites with a china pencil
- Wipe with an alcohol pad and gently abrade the skin
- Work gel into the skin within the circles you've drawn with a cue tip
- Apply EMG electrodes and check impedance

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What is the maximum acceptable EMG skin-electrode impedance?

- Skin-electrode impedance is the opposition to the movement of a biological signal (e.g., EMG) from beneath the skin to the electrode measured in thousands of ohms (Kohms)
- A conservative rule is that each measurement between an active electrode (blue and yellow) and common reference electrode (black) should be less than 10 Kohms and within 5 Kohms of each other (Graphic courtesy of Thought Technology, Ltd.)

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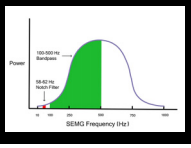
What is a filter?

- A filter selects the frequency an electromyograph analyzes; a notch filter (red in the graphic below) rejects a narrow frequency band that contains artifacts (e.g., 58-62 Hz)
- A high-pass filter selects frequencies above a cutoff frequency (e.g., 100 Hz)
- A low-pass filter selects frequencies below a cutoff frequency (e.g., 500 Hz)
- Combine them and you have a 100-500 Hz bandpass filter shown in green. The bandwidth is 400 Hz



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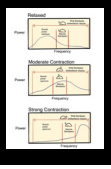
How does bandpass affect signal strength?

- The wider the bandpass, the greater the EMG signal strength
- Why? A wide bandpass counts lower- and higher-frequency activity excluded by a narrow bandpass
- A narrow bandpass will underestimate EMG activity as your client contracts a muscle more strongly



1 vs. 2 µV

4 vs. 6 µV

2 vs. 9 µV

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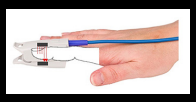
What is blood volume pulse?

- Blood volume pulse (BVP) is the brief change in blood volume with each heartbeat measured using a photoplethysmograph (PPG)
- BVP is another relative measurement; it doesn't measure the absolute volume of blood through a digit
- A PPG sensor shines an infrared light through or off the tissue beneath (Graphics courtesy of Danielle Matto and Thought Technology, Ltd.)



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How does BVP differ from skin temperature?

- BVP responds to a stressor in 0.5 – 2 seconds instead of 20-30 seconds for temperature; the drop in amplitude can be 50-60% instead of 10%

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What is skin potential and how is it measured?

- Skin potential (SP) is the voltage difference between sweat glands and internal tissues
- We measure SP endosomatically (from within the body) by placing electrodes overactive (palmar surface of the hand) and relatively-inactive (forearm) sites
- SP is measured in millivolts with normal values ranging between +10 to -70 mV
- SP doesn't depend on electrode surface area

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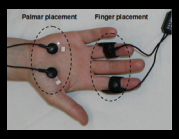
What is skin conductance and how is it measured?



- Skin conductance (SC) is the ability of the skin to conduct electricity
- Skin conductance and resistance are exosomatic since we run an imperceptible current from the electrodes through the skin
- Electrodes are placed on the fingers or palms to assess changes in conductivity when eccrine sweat glands produce sweat

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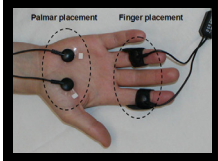
What is skin conductance and how is it measured?



- Skin conductance is measured in microsiemens (older micromhos) and ranges from 1-30 $\mu S/cm^2$
- Values are not absolute but depend on electrode surface area
- palmar values will be higher than finger values because their recording surface is larger

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What is heart rate?

- Heart rate (HR) refers to the number of beats per minute. HR is important because a high rate can reduce heart rate variability

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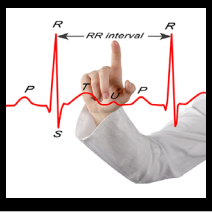
What is heart rate variability?

- Heart rate variability (HRV) refers to the moment-to-moment change in the time intervals between adjacent heartbeats (McCraty & Shaffer, 2015)



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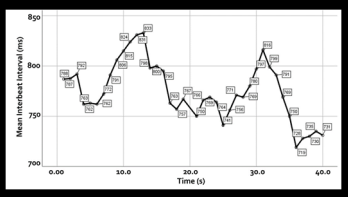
What are interbeat intervals?

- Time intervals between adjacent heartbeats are called interbeat intervals (IBIs) (McCraty & Shaffer, 2015)



Graphic courtesy of Dick Gevirtz

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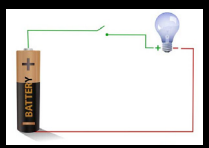
What are open and closed circuits? Which impedance values would we see with each?

- In an open circuit, the current path is interrupted by a break, preventing current movement (light bulb off)
- Impedance is infinite (really high)



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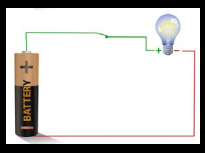
What are open and closed circuits? Which impedance values would we see with each?

- In a closed circuit, there is a continuous current path (light bulb on)
- Impedance should approach 0 Kohms



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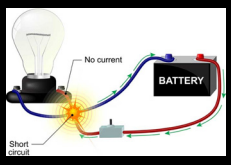
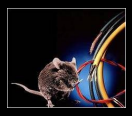
What is a short circuit? Which impedance values would we see?

- In a short circuit, an unintended lower-resistance path creates a shock hazard
- Impedance should approach 0 Kohms





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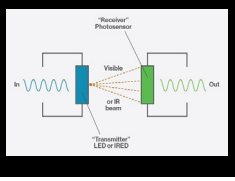
How does optical isolation work?

- Optical isolation protects clients from injury due to AC current
- An optical isolator converts a biological signal into a beam of light, the light crosses a gap (open circuit), and a photoreceptor converts the light into an electrical signal



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