



# EEG Biofeedback Instrumentation



# INTRODUCTION



- **“Biofeedback is any technique that increases the ability of a person to control voluntarily physiological activities by providing information about those activities”**
- Uses instrumentation to record the physiological responses of organisms
- Then in real time give information about those physiological responses back to the organism.



# Clinical Biofeedback

(continued)



- The purpose of biofeedback is to teach people with stress-related disorders to recondition their responses so that they gain control over the physiological system responsible for their symptoms.



# Biofeedback



- Biofeedback teaches people how to monitor and change the frequency and amplitude of the electronic signals by controlling (relaxing) the body region to which the electrodes are attached. The three phases of biofeedback are:
  - Awareness of physiological response
  - Control of physiological response
  - Application of reconditioned response in everyday routines



# Clinical Biofeedback



- Clinical biofeedback, to strengthen the conditioned response, combines sophisticated technology and various other forms of relaxation, including:
  - diaphragmatic breathing
  - autogenic training
  - progressive muscular relaxation
  - mental imagery



# INTRODUCTION



- By getting such timely feedback about physiological responding,
  - the organism will learn how to control the desired physiological response
  - through a trial and error basis



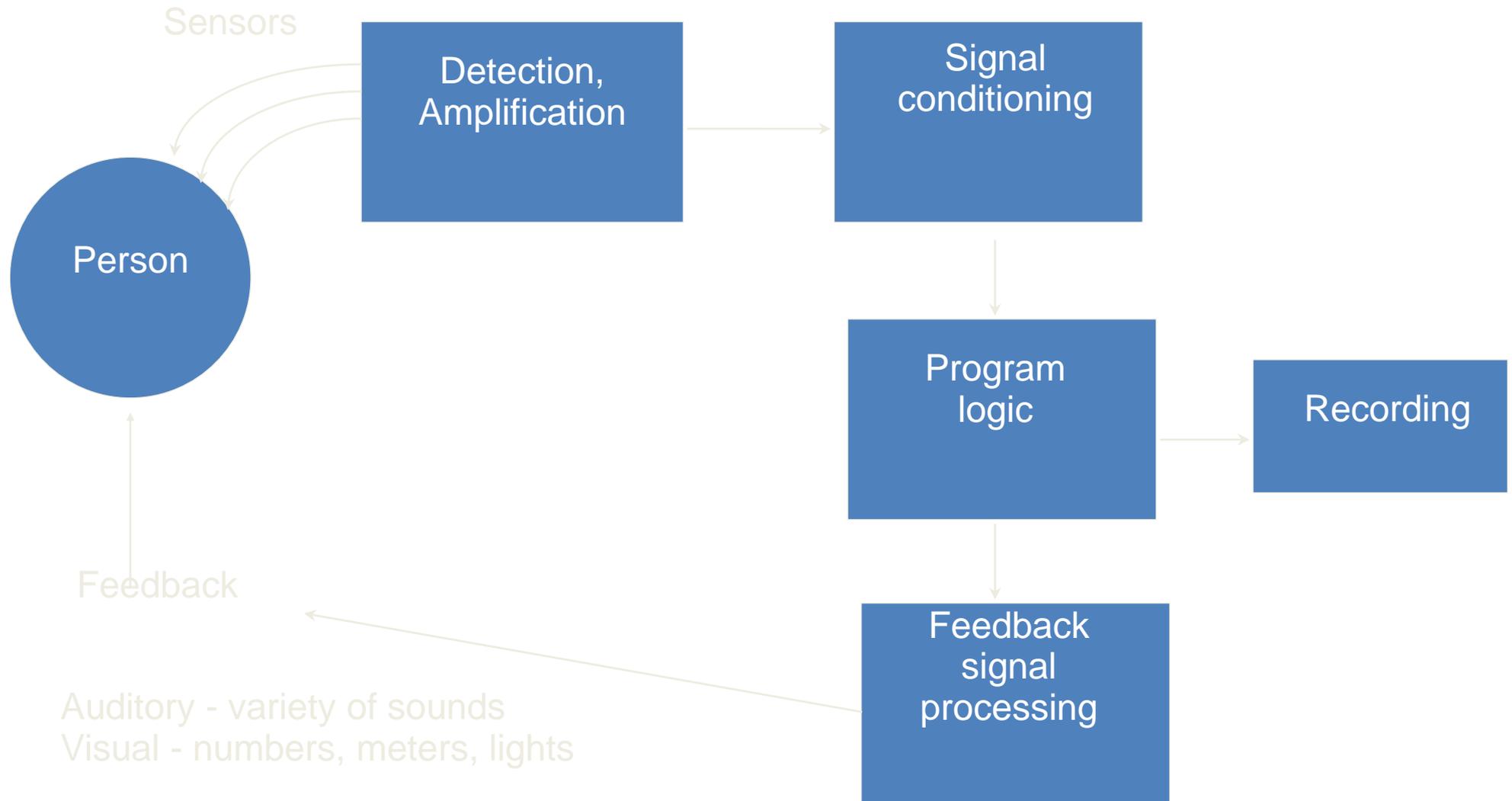
# BIOFEEDBACK INSTRUMENTATION



- Involves the use of a machine (usually a computer-based system)
- Allows a therapist to monitor the patient's bodily responses
- Information concerning the patient's physiological responses are then relayed back to the patient
- Through this physiological feedback,
  - patient will learn how to control his/her bodily responses through mental means.



# The Biofeedback Loop





# SIGNAL ACQUISITION



- EEG instruments acquire signals on the scalp generated by brain cellular activity below
- EMG activity in this region is considered artifact
- Care must be taken in EEG signal processing to minimize EMG contamination
- When large EMG artifacts cannot be removed from the EEG signal,
  - **feedback must be blocked or held constant until the EMG artifact has passed.**



# SIGNAL ACQUISITION



- Signals of interest - Range of 0.5–100 V (p–p), over the frequency range of 1–30Hz.
- Newer clinical research extends the frequency range to 1–50 Hz.



# ELECTRODES

- Surface electrodes are used, 10–20 system is followed
- **Bipolar recordings** are made between (2) active scalp electrodes
- Neutral site serve as amplifier common (i.e., center forehead)
- **Monopolar recordings** are made with a single scalp electrode (+) with respect to a chosen reference site (-)
- Amplifier common is placed at a third (neutral)



# ELECTRODES

- Multichannel systems are monopolar having a scalp electrode for each of the (20) sites in the 10–20 system, all having the same (forehead) reference and instrument common.
- An Electro-Cap having 20 scalp and one reference - common electrode, sized to the subject, is worn
- Electrode sites are prepared through holes in each electrode
- A cable harness connects the cap to a



# ELECTRODES



- Gold, silver–silver chloride, and tin - active electrode materials
- Silver–Silver chloride - common electrode materials
- Electrode sites are prepared by mild abrading and infusing a conductive “prep” gel
  - to stabilize and improve conductance of the scalp.



# AMPLIFIERS

- High performance differential amplifiers increase and condition the signals.
- Low internal voltage and current noise (<1 mV, 100 Pa, p-p)
- High input impedance ( $Z_{in} > 10^8$ ).
- Bandwidth (1–50 Hz).
- Frequency cutoffs (>18 dB/octave).
- High common mode rejection ratio (>107).
- Common mode input range (greater than  $\pm 200$  mV).
- Static electricity shock protection (>2000 V).
- Gain stability (all causes) greater than  $\pm 1\%$ .



# FILTERS



- Modern EEG biofeedback instruments perform digital filtering on the amplified and conditioned EEG signal
  - to obtain the frequency band(s) or full spectrum of interest (i.e., fast fourier transform, FFT)
- Viewing the full frequency spectrum EEG signal is of interest
  - in assessing brain state(s) and
  - sometimes used as feedback



# EEG DISPLAYS AND FEEDBACK



- The modern EEG instrument utilizes a computer
  - to perform the signal processing,
  - auditory and visual display generation,
  - data collection– reduction, and
  - reporting necessary for effective assessment and training
- high performance computer are required to perform all these tasks in apparent real time



# REQUIREMENTS



- An electrically quiet environment is also desirable.
- Power lines, TV and radio antennas, and mobile communications are frequent sources of interference.
- Basement locations usually offer the electrically quietest locations
- Well placed electrodes along with carefully routed leads provide the best immunity under the therapist's control.