INTRODUCTION TO EEG & P300 SPELLER

Definition

EEG (Electroencephalography) is the measurement of the brain's electrical activity using electrodes placed on the scalp.

Key points:

- Measures **voltage fluctuations** caused by synchronous activity of millions of cortical neurons.
- Very high temporal resolution (**1–5 ms**)
- Low spatial resolution (signal spreads through skull/scalp)
- Very small amplitudes: **5–100 microvolts (μV)**
- Uses **10–20 electrode placement system**

Why it's done

An EEG can find changes in brain activity that might aid in diagnosing brain conditions, especially epilepsy or another seizure condition. An EEG also might be helpful for diagnosing or treating:

- Brain tumors.
- Brain damage from a head injury.
- Brain disease that can have a variety of causes, known as encephalopathy.
- Inflammation of the brain, such as herpes encephalitis.
- Stroke.
- Sleep conditions.
- Creutzfeldt-Jakob disease.

Brain → Neurons fire → Electric fields → Electrodes detect → Amplifier → Digital signals

Key components in EEG signals:

- **Delta (0.5–4 Hz)** → Sleep
- **Theta (4–8 Hz)** → Drowsiness
- **Alpha (8–13 Hz)** → Eyes closed, relaxed
- **Beta (13–30 Hz)** → Thinking, problem-solving
- **Gamma (30+ Hz)** → Very fast responses

What is an ERP? (Event-Related Potential)

Definition

ERP = A brain response time-locked to a specific sensory or cognitive event.

Examples:

- Seeing a flash
- Hearing a beep
- Making a decision
- Detecting a target stimulus

How it is obtained

- Cut EEG into **epochs** (small windows) around the event
  e.g., −200 ms to +800 ms
- Average multiple epochs → noise cancels out → ERP emerges

🔹 Why averaging?

Single EEG trial = too noisy.
ERP = consistent cognitive response + noise removed via averaging.

Physiology of the P300 Response

What is P300?

- A positive voltage peak around **300 ms** after detecting a “target” stimulus.
- Also called **P3** or **P3b**.
- Classic cognitive marker of attention and decision-making.

When does it occur?

- When the brain detects something **rare**, **important**, or **task-relevant**.

Origin:

Mostly generated in:

- Parietal cortex
- Frontal cortex
- Hippocampus involvement (novelty detection)

Why “300 ms”?

It reflects **stimulus evaluation**, not sensory perception.
The brain first sees → evaluates → recognizes the target → generates P300.