EEG PREPROCESSING

1. what is Preprocessing

Preprocessing refers to the set of transformations applied between raw EEG data collection and actual analysis. The goal is to maximize the **signal-to-noise ratio** while preserving meaningful brain signals.

2. Preprocessing Pipeline

Based on the textbook chapter, the recommended order of EEG preprocessing is:

1. **Filtering (Continuous Data Only)**

   Removes noise such as slow drifts (high-pass filter ~0.1–0.5 Hz), muscle artifacts (low-pass filter), and electrical line noise (50/60 Hz notch filter).

   - **High-pass filter (~0.1–0.5 Hz)** → removes slow drifts.
   - **Low-pass filter (40–80 Hz)** → removes muscle and high-frequency noise.
   - **Notch filter (50/60 Hz)** → removes electrical line noise.

   > **Why First?**
   >
   > Filtering on continuous data avoids edge artifacts that occur if filtering is applied after epoching.

2. **Re-referencing**

   - EEG is measured relative to a reference electrode.
   - Common choices: linked mastoids, earlobes, or average reference.
   - This reduces global artifacts and makes signals more spatially specific.
   - Poor referencing can bias signals across the scalp.

Why Here ?

- Referencing is done early so that subsequent steps (epoching, artifact rejection) are applied to clean, referenced data.

3. **Epoching**
    - Continuous EEG is segmented into time-locked trials (stimulus onset or response).
    - Epoch length must cover both pre- and post-event activity.
    - Include a **baseline window** (e.g., -200 to 0 ms).
    - **Epoch length** depends on analysis:
        - ERP → short epochs (–200 to 800 ms).
        - Time-frequency → longer epochs with buffer zones to avoid edge effects.

Why After Referencing?

- Trials are cleaner and more consistent when referenced before cutting into epochs.

4. **Baseline Correction**
    - Subtract the mean activity in the pre-stimulus baseline window from the entire epoch.
    - **Purpose**:
        - Removes slow drifts.
        - Normalizes trials for fair comparison.

Why After Epoching?

- Baseline correction requires a per-trial reference (pre-stimulus period).

5. **Artifact Rejection / Correction**
    - Methods:
        - Trial rejection (automatic/manual removal of noisy trials).
        - ICA → removes eye blinks, muscle artifacts while preserving brain signals.

> **Why Here?**
>
> - Perform artifact rejection **after epoching and baseline correction**, so that trials/channels with strong artifacts do not contaminate averages.

6. **Interpolating Bad Electrodes**
    - Replace noisy/dead channels with interpolated values from neighbors.
    - Better to fix during recording

> **Why Here?**
>
> Ensures no channel artificially biases averages.

7. **Spatial Filtering(Optional)**
    - Examples: Surface Laplacian..
    - **Purpose**: Improve localization and reduce volume conduction.

> **Why Hater?**
>
> - Applied only once data are relatively clean, often just before time-frequency or connectivity analysis.

8. **Trial Count Matching (Optional, for experiments with conditions)**
    - Important for condition comparisons: ensures one condition doesn't appear stronger simply because it had more trials.

- Equalize number of trials across conditions (random selection, first-N, or based on behaviorioural metrics like reaction time etc).

Why Here?

- Prevents bias: conditions with more trials shouldn’t appear stronger just due to averaging.