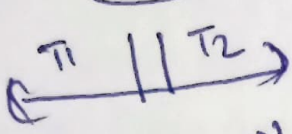
Quiz-1

→ Lecture slides
→ Notes
→ Highlighted points in TB
→ Any previous year papers.
→ Understanding Matlab Code.
(whatever is shared).
→ Read ch-7,8,9 & write
Notes

RoeP

Trails



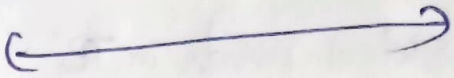
Intertrail / Intra trail

timing blw the end of one trail & start of next trail

⇓

timing blw events with in a trial

① Trail



1. Pilot test
2. Trail onset
3. alpha power / activity
4. Edge Artifacts.
5. Avg, Bipolar Reference

⇒ need of Base line period.

⇒ for TFD,
Baseline should be before trail onset
eg: -500 to -200ms

Typical Intertrail intervals
- Fixed ⇒ participants know exactly when next trail starts
- variable
  ↳ can't predict exactly

⇓
atleast 1000ms = 1sec

→ Brain Responses linger
→ Baseline in TFA should end before stimulus, not at stimulus onset

→

① Preprocessing

- Organizing data — Cutting continuous data into epochs (no change to signal)
- Removing bad data — rejecting artifact trails (only deleting bad segments/electrodes)
- Transforming clean data — changes data itself
  - eg. filtering, rereferencing, ICA, Spatial Filters.

→ Avoid introducing biases
⇓
Do same preprocessing steps.

② Balance blw Signal & Noise

EEG Data

Signal ⇓ Neural Activity

Noise ⇓ Artifacts + Random fluctuations + Non-neural activity

→ ERP ⇒ ?
→ TF ⇒ ?
} How they treat high brain activity?

EEG ⇒ time x Electrodes (2D)

③ Creating Epochs :

↓
For studying brain activity around specific events (stimulus, response etc.)

⇒ Cut into epochs

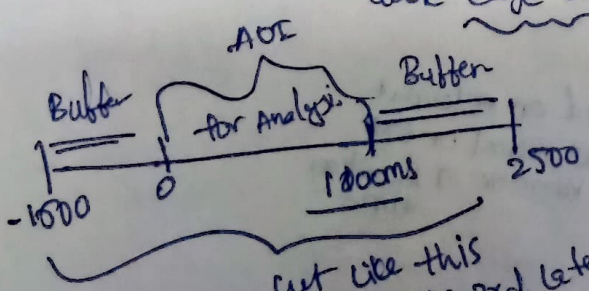
EEG: electrodes x time x trails (3D)

Epoch

Enough buffer before & After.

ERP → relatively short buffer (-200ms → 800ms)

TF → need longer epochs with buffer 2ons to avoid edge artifacts



Rule of thumb
⇓
they last about 3 cycles of FOI

Special cases → Overlapping epochs? Happens when trails were close
problematic for ICA.
↓
Shouldn't see same time points

→ If epochs are too short? (Already cut)
i) use Reflection Method ⇒ flip data Before vs After
create Artificial buffer → Analyze & trim off

→ Tapering out → fading in/out
→ distorts baseline & power estimates

Simplified workflow

1. Pick a event at t=0
2. Add enough pre & post event time
   - ERP shorter
   - TF longer → But why?
3. Include buffer zones
4. Discard buffer zone before Analysis / plotting

④ Unequal Trail count = Biased Results? Yes (said in class)

Analysis type

1. Phase Based ⇒ more sensitive ⇒ small No. of trails ⇒ +ve Bias
2. Power Based → Noise will increase → Because power is always +ve
3. ERP ⇒ Not much Bias
   Voltages ⇒ +ve & -ve ✓
   But Effects "SNR"

Soln:

Match trail count

- Select first N in bigger set → total in smaller
- Random 'N' → No Bias
- Based on relevant Behavioral or ERP variable ⇒ Reaction time

(5) Filtering :

↳ helps remove noise from EEG Data

- High fre Artifacts
- Low fre Drifts → slow shifts in Baseline
- Line Noise 50Hz ⇒ (Asia), 60Hz ⇒ (US)

⇓

Use a Notch filter at 50/60Hz ✓

Use High pass filter ✓ (0.1–0.5 Hz) to reduce slow drifts ⇒ must be applied for continous Data.

Edge Artifacts ∝ 6 sec — much longer than Typical epochs

low freq allowing ✓ High fre ✗

low pass filter: No need

Wavelets, FFT, Hilbert already filter data

i) ERP ⇒ careful Bandpass filtering

ii) TF ⇒ often rely on other methods

(6) Trail Rejection : Rejecting trails with Artifacts ✓

Approaches

Manual

- visual Inspection (Better) ⇒ Recommended Sir said in cls
- Time consuming

Automatic

- Algo / Tool box / fn based
- Risk of FP ⇒ May reject too much
- Diff Thresholds ⇓ diff results

sharp in data ⇒ Less prominent in ERP ⇒ Smoothing while averaging

(7) Spatial Filtering :

Localization of Sources

- which part of Brain?

Separating overlapping brain processes

- using surface laplacian

Preprocessing for connectivity analyses

- Same signal appearing at multiple electrodes
-

- when to apply spatial filters?

i) ERP source localisation → fit dipole on grand avged ERP's

ii) Connativity Analyses → Apply laplacian before TF Analyses

iii) Dimensionality reduction → PCA on power

⑧ Referencing:

EEG → ref electrode
→ every voltage recorded is relative to some reference

Surface Laplacian → Reference Independent

* Avoid Referencing near AOI *
* Always clean your ref electrode signals *
* Using one of the scalp electrode as ref is suboptimal *

Electrode
- Bipolar Ref ⇒ Measures diff blw 2 electrodes directly (EEG or ECG)
- Avg reference (all Electrodes) >100
- Mastoids (behind ears) ⇒ picks up less Brain activity

⑨ Interpolation of Bad Electrodes:

↓

Process by which data from missing electrodes are estimated based on activity & location of other electrodes

Determine whether a noisy electrode?

⇓

Apply a low pass filter to data at 30Hz

⇓

Compare the activity with surrounding Electrodes

Ch 8

→ ICA for Artifact Removal: (Independent Component Analysis)

- source separation technique
- preprocessing, Data Reduction
  - ⇓ Subtract them
  - ⇓ Analyze component time series instead of electrode time series

* Max no. of components that can be isolated in EEG Data = Max No. of Electrodes *

→ Removing trails because of ... (Electromyography)

1. Blinks
   - correction Methods
     i) ICA
     ii) Regression Based
   - Only Missed Stimulus ⇒ remove
2. Oculomotor Activity
   - ⇓ Eye movements
   - Use central fixation points
   - Use short stimulus duration
   - Ref choice: Nose (more contamination) / Earlobe (use ...)
   - Research Focus: Frontal ⇒ Big problem; central ⇒ Not an issue
3. Based on EMG in EEG Channels
   - High freq, Burst like (20-40 Hz)
   - Subject sneezed, coughed, moved their jaw
   - Reject trails, (if localized)
   - Baseline Normalisation
   - ICA
4. Based on Task performance
   - Error trails, No resp trails, Too many response
   - unrealistic response
   * Not always visible in EEG *

Spatial filtering & ICA ←

5. Based on Response Hand EMG
   - why Response EMG ? ↳ ideally
   - ⇓ Detects partial Errors
   - But How?
     1. record
     2. preprocess
        i) Take derivative of EMG → Z-tranf → rectify
        ii) Normalise ↓
     3. Criteria:-
        - Zscore of incorrect hand > 2 blw stimulus & Resp button
        - Peak = 2x larger than baseline
6. Train Subjects to minimize Artifacts
   - Explain them clearly
   - Awareness helps alot !!
7. Minimize during Data collection
   - ⇓ our own Responsibility
   - No other choice !!

Risk of Filtering → Ripple Artifacts ⇒ Narrow transition zones cause Artifical Oscillations
Systematic Biases
loss of Temporal precision

(Inspite of ERP's)
↓
Already a LPF

Non Phase locked
↓
high freq activity ⇒ cancels out

* Filtering ERP's ⇒ optional ok
If done :- choose the range of filter properly

- Butterfly plots & Global Field power & Topographical variance

Butterfly plots
↓
plots ERP's from all Electrodes overlaid on same axis

Global Field power
↓
SD of voltage across all the electrodes at each time point

Topographical variance
same but visualised to highlight changes

Flicker Effect → Entrainment of neural activity to external rhythmic stimulus
SSEP, SSVEP, SSAEP, Frequency tagging
↓
Allows us to "tag" specific stimuli with diff frequencies.

→ Is it oscillations? or Repeated ERP's?

Analysis

i) compare flicker freq power before vs during flicker or against neighbouring non-flicker freq

→ Topographical Maps → Shows spatial distribution of EEG/ERP activity across scalp.

- Constructed by Interpolating voltages b/w electrodes
- Identify Bad electrodes
- Easy to interpret

Micro States → EEG scalp topography remains stable ⇒ "Quasi stable" for ≈70–130 ms then Rapidly shifts

⇒ Each stable period is microstate

⇒ linked to cognitive fn's :- perception, memory, language

Global map Dissimilarity
⇓
Diff btw Scalp map at $t=t$ & $t=t+1$

low = stable state
sudden Increase = Transition

→ **ERP Images**

- 2D representation of single trail EEG at one electrode
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