Design and ERP data: Basic concepts

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Describe ERPs in terms of:

- Peaks (positive or negative)
- Latency (post stimulus onset)
- Duration (e.g., slow wave)
- Scalp topography (maximal peak location)
- Source (location within the brain)

Remember that:

- Current flow across the scalp
- Produces latency shifts from one part of scalp to another
- Also produces amplitude shifts across scalp
- Signals sum across the scalp
  - large positive wave on scalp meeting large negative wave could sum to flat line!
What info do we collect?

- **Time**
- **Space**
  - 2D: Scalp topographies
  - 3D: Source estimation
- **Person-specific characteristics**
  - Demographics: Age, gender, SES, etc.
  - Constructs: Reading ability, temperament, emotion regulation, social responsiveness, IQ, etc.
P1 / P50 / P70

- Peak amplitude and latency decrease with age (disappear, even)
- P50: Auditory inhibition → Sensory gating: 2 clicks presented quickly. 1st amplitude < 2nd amplitude. Reduced suppression in schizophrenia, neurodegenerative diseases.
- P1: Use pattern reversal (e.g. flickering checkerboard) task. Largest over occipital regions. May relate to attention / arousal.
**N1 / N100**

- Selective attention to basic stimulus characteristics (necessary for later pattern recognition and discrimination processing).
- Auditory stimuli $\rightarrow$ larger N1 with shorter latency than visual stimuli (Hugdahl, 1995).
- Amplitude is larger in discrimination tasks, but smaller (if it exists at all) if short inter-stimulus intervals (ISIs).
P2/ P200

- Low inter-individual variability and high replicability.
- Often occurs together with the N1, yet peaks can be dissociated.
- Can be double-peaked.
- Amplitude increases with complexity of stimuli.
N2/ N200

- Like Mismatch-negativity (e.g. Oddball paradigm), detection of deviation of subject’s expectation but N2 – only if subject is paying attention to stimuli. MMN – requires no attention!
- Interpretations: Orienting response, stimulus discrimination, target selection, response inhibition (e.g. Go-NoGo)
- N2 smaller in amplitude and shorter in latency for shorter ISIs.
Time: Components

N170
- Human face-processing (face vs. natural or human-made objects)
- Turns out, not specific to faces but to expert object recognition! (Tanaka & Curran, 2001)
P3a/ P300a
- Orienting reflex
- Occurs when not required to actively respond to the targets
- Involuntary attention as well as inhibition (e.g. NoGo > Go)

P3b/ P300b
- Controlled processing
- Subject must pay attention and respond to stimuli. Also fewer targets → larger peak.
- Variability: Amplitude (attention, stimulus relevance). Latency: stimulus complexity
N4 / N400
- Larger for unexpected, low probability (e.g. sentence endings):
  - It was the first day at work.
  - He spread the warm bread with socks.
- Amplitude: Incongruent > Congruent
- Modality: Earlier in visual than auditory in temporal & frontal electrode sites.
Late positive component

- Explicit and implicit recognition memory: (e.g. “Old/new” effect).
Time: Components – Statistics?

- How do we decide what part of time to look at?
  - A priori
  - Principal Components Analysis

![Graph showing time components and statistics](image)

- Centroid
- Factor 1
- Factor 2
- Factor 3
- Factor 4
- Factor 5
- Factor 6

- Total Variance
  - Factor 1: 31%
  - Factor 2: 15%
  - Factor 3: 8.4%
  - Factor 4: 6.6%
  - Factor 5: 5.7%
  - Factor 6: 4.7%

- Time (ms): 0, 100, 200, 300, 400, 500, 600, 700

12-Year-Old: n=68
Time: Components – Statistics?

• How do we decide what part of time to look at?
  • A priori
  • Principal Components Analysis

<table>
<thead>
<tr>
<th>Centroid</th>
</tr>
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<tbody>
<tr>
<td>Factor 1</td>
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ms 0 100 200 300 400 500 600 700

Factors

Total Variance

31%
15%
8.4%
6.6%
5.7%
4.7%

Centroid
Space (and Time)

• Electrode sites: Which sites reflect the variance in the ERP waveform?
• Example: Pattern-reversal task (800ms → 4000ms)
2D Space – Statistics?

- Step 1: Identify what part of the waveform.
- Step 2: Run Analysis of Variance (ANOVA) on comparison of interest (e.g. Prism condition).

ANOVA results
3D Space – Source Localization

- Step 1: Identify what part of the waveform. Base upon temporal PCA factors and ANOVA results.
3D Space – Source Localization

• Step 2: Using dipole models, estimate what sources are most likely to generate the ERPs we see on the scalp.
3D Space – Source Localization

• Step 3: Direct comparison of all dipoles across variable (e.g. prism condition).

<table>
<thead>
<tr>
<th>No Prisms</th>
<th>With Prisms</th>
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<tbody>
<tr>
<td>• Somatosensory</td>
<td>• Vision</td>
</tr>
<tr>
<td>• Primary somatosensory cortex</td>
<td>• V1</td>
</tr>
<tr>
<td>• Primary motor cortex</td>
<td>• V2</td>
</tr>
<tr>
<td>• Premotor cortex</td>
<td>• V3</td>
</tr>
<tr>
<td>• Frontal eye fields</td>
<td>• Semantic</td>
</tr>
<tr>
<td>• Polysensory association center</td>
<td>• Hippocampus</td>
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<tr>
<td>• Primary gustatory cortex</td>
<td>• Parahippocampus</td>
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<tr>
<td>• Language</td>
<td>• Cingulate cortex</td>
</tr>
<tr>
<td>• Broca’s area</td>
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<tr>
<td>• Wernicke’s area</td>
<td></td>
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<tr>
<td>• Executive and Memory</td>
<td></td>
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<tr>
<td>• Prefrontal cortex</td>
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<tr>
<td>• Dorsolateral prefrontal cortex</td>
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Person-specific characteristics

• How are people different?
  • Across development – infants vs children vs adults
    • Cross-sectional – different individuals of the same age
    • Longitudinal – same individuals at different ages/times
  • Gender
  • SES
  • Amount of sleep
  • Cognitive abilities
    • IQ
    • Reading ability
    • Task performance
Increasing Positive Voltage

Increasing Negative Voltage

Front of Head

Back of Head

LEFT

RIGHT

Yellow

Red

Purple

Dark Blue

20 μV

1 sec.
ERP to speech syllable “ba”
QUESTIONS ???