A Quick Introduction to ERP in Language Research

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Why use Event-Related Potentials (ERP) in language research?

• Allows us to investigate how language processing unfolds in real-time.
  – Can monitor “covert” processing when there is no “overt” behavioral response.
  – Can ask which stage is affected by a given experimental manipulation.

• Allows us to test models of cognitive processes and evaluate how these models map onto the brain.
The General Set-Up
Two ends of the production line

Raw Data (EEG)  End Products (ERP)
The production line

Raw Data (EEG)

- Isolate the data of interest (e.g., response during the 1000ms after seeing particular words)
- Remove noise (reject bad trials; average across trials and participants)

End Products (ERP)
The production line

Raw Data (EEG)

Isolate the data of interest (e.g., response during the 1000ms after seeing particular words)

Remove noise (reject bad trials; average across trials and participants)

End Products (ERP)
Isolate the data of interest

EEG recorded from one electrode

Epoch (sliced-up) EEG

 Luck (2005)
The production line

Raw Data (EEG)

Isolate the data of interest (e.g., response during the 1000ms after seeing particular words)

Remove noise (reject bad trials; average across trials and participants)

End Products (ERP)
Remove noise

Luck (2005)
Remove noise_2 (averaging)

Individual Averages

- Average of 80 Xs
- Average of 20 Os

Grand Average

- Average of 9 Subjects

Luck (2005)
The production line

Raw Data (EEG)

Isolate the data of interest
(e.g., response during the 1000ms after seeing particular words)

Remove noise
(reject bad trials; average across trials and participants)

End Products (ERP)
What info is in an ERP?

**Quantitative:**
- Latency
- Amplitude

**Qualitative:**
- Polarity
- Topographic distribution

![Graph showing ERP components](image)

- 600-900ms
- 5µV
- 600-900ms
- 4.0µV
- 5µV
- N400
- MMN
- N1
- P2
- P600/SPS
- -4.0µV
- +4.0µV
Using ERP for Language

• Violation Paradigms
  – Expectations set up, then violated.

• Brian drinks coffee with a spoonful of _______ \textbf{dirt}

• Mary spends all her morning reading the _______ \textbf{menu}

• Before Dave arrived to the breakfast session, the last bagel had been _____ \textbf{eat}
N400
N400

• Broad negative deflection of the ERP
• Latency (onset $\sim$200-300ms post stimulus onset)
• Peak amplitude ($\sim$400ms)
• Distribution (central-parietal)

Federmeier & Laszlo (2007)

Voss & Federmeier (2010)
N400

Semantic anomaly:
*I like my coffee with cream and… [sugar/socks]*

Word pairs:
*tire…sugar*  
*flour…sugar*

Federmeier & Laszlo (2007)  
Voss & Federmeier (2010)
Case Study: N400

Federmeier & Kutas (1999):

• Does the N400 appear to be sensitive to the organization of semantic knowledge?

_They wanted to make the hotel to look more like a tropical resort. So along the driveway they planted rows of._

(a) _palms_ $\leftarrow$ an expected exemplar

(b) _pines_ $\leftarrow$ a within-category violation

(c) _tulips_ $\leftarrow$ a between-category violation
Case Study: N400

Predictions:

• If N400 is sensitive to the organization of semantic knowledge
  – then N400 will differ for within-category relative to between-category violations.

• If N400 is not sensitive to the organization of semantic knowledge
  – then the same N400 for both kinds of violation.
Case Study: N400

Federmeier & Kutas (1999)

- Yes! The N400 appear to be sensitive to the organization of semantic knowledge.

“They wanted to make the hotel look more like a tropical resort. So along the driveway they planted rows of ...”

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Expected Exemplars

Within Category Violations

Between Category Violations

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trends in Cognitive Sciences
Designing your own ERP experiments
Design Considerations

• Minimize eye-movements and other artifacts
  – Stimulus presentation
  – Tasks

• Statistical power vs. Length of experiment
  – Number of trials
  – Number of conditions

• Fillers
  – quantity & content
  – Filler-Target ratio
Filler-Target Ratio

• the proportion of trials with violation affects different components differentially

Hahne & Friederici (1999)
Interpreting ERP data
Interpretation?

• Reminder:
  – Scalp distribution ≠ source of activation
  – Functional significance of ERP components still work in progress

• Look out for:
  – Potential component overlaps
  – Baseline problem
Interpretation?

• Variation matters
  – Within-group variation differs across populations
    • e.g., non-native vs. native speakers
  – Averages can be misleading

• Recommendation:
  – Know your data well, *very well*

Luck (2005)