



**TURNS OUT:
YOU CAN “SEE” SYNTAX**

Measuring Brainwaves

ERP

event-related brain potential

neural responses to certain events, especially unexpected/incongruent ones;

show up in the data we get from an EEG experiment

- great for investigating the time-course of events
- not great for (as in, *useless* for) analyzing **where** something happens in the brain

EEG

electroencephalography

the experiment/method/setup to record brain activity; yields information on ERP's



EEG Setup

What are we Measuring? - Some Background

- neural transmission involves charged particles travelling from location A to location B
- these “currents” of charged particles generate electric potentials
- ... which surface as voltage differences between two electrodes on the scalp

Kutas & Federmeier 2007



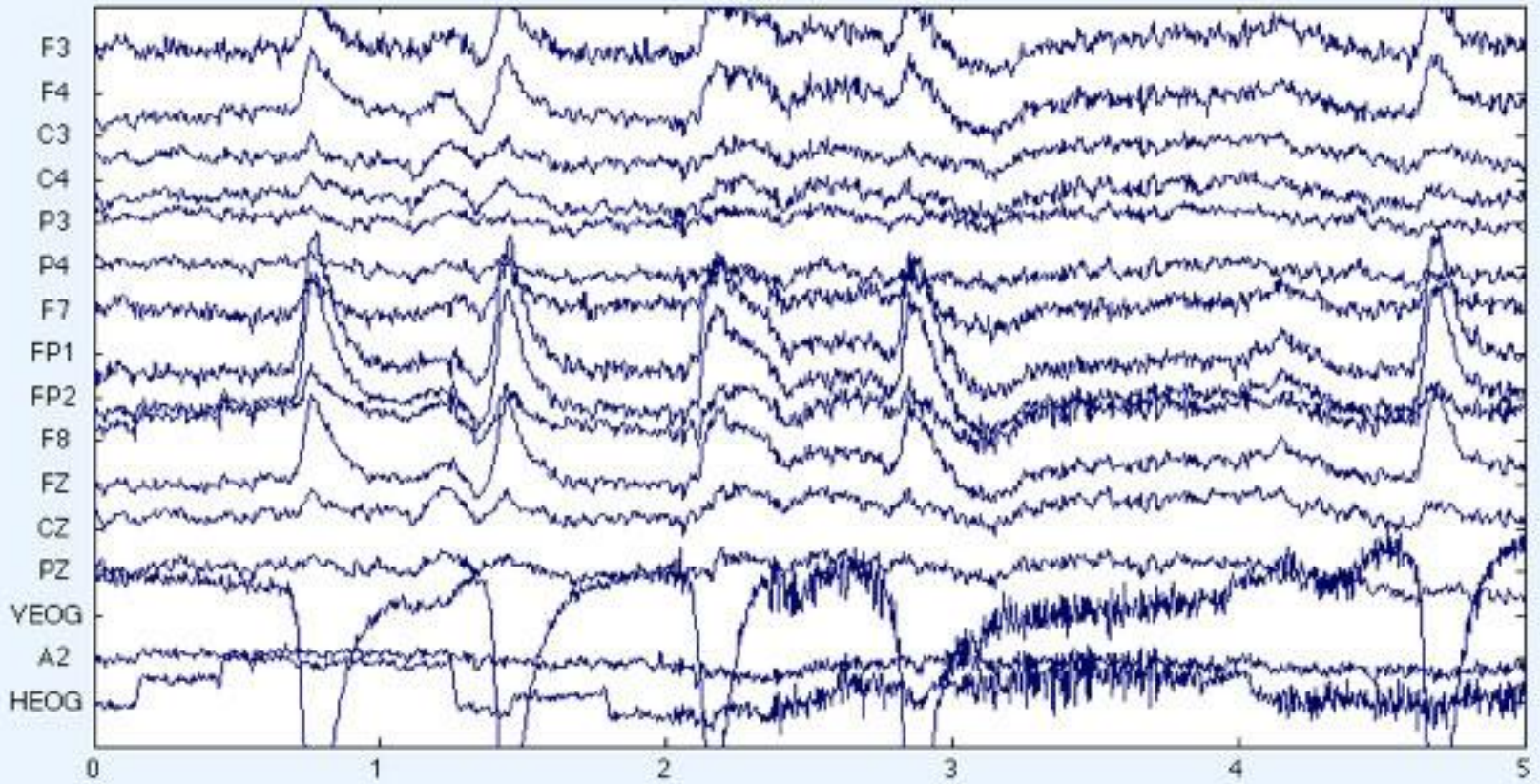
Trials

- participant reads/listens to sentence
- we measure their neural response throughout

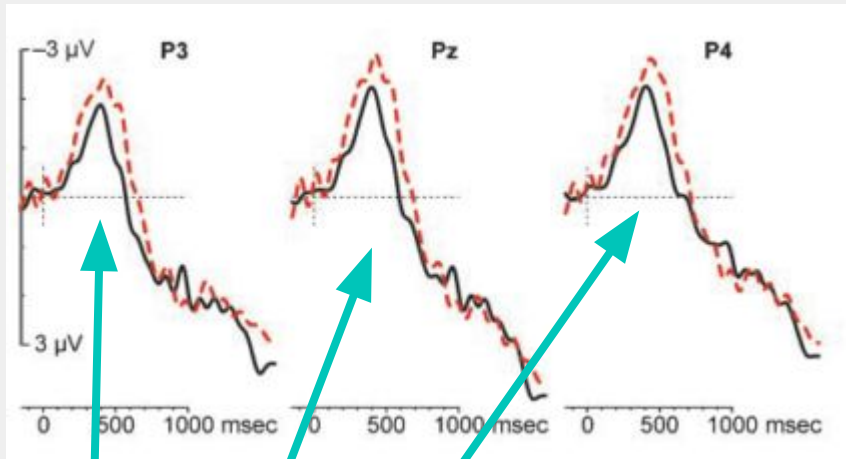
Raw EEG Data

Scroll channel activities -- eegplot()

Figure Display Settings Help



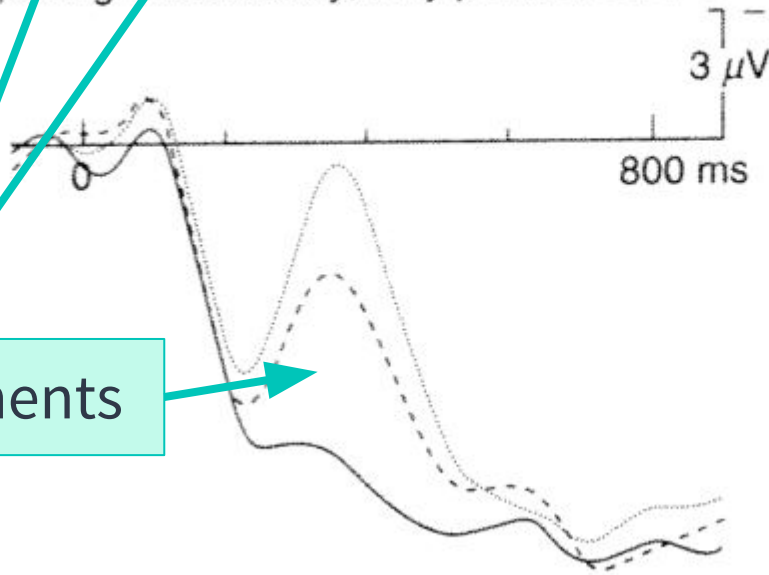
CANCEL Event types << < U > >> Chan Time Value HEOG 3.8984 36.9471 69 + - REJECT



van Berkum et al. 2008, Fig. 3, p. 586

“Cleaned-up” ERP Data

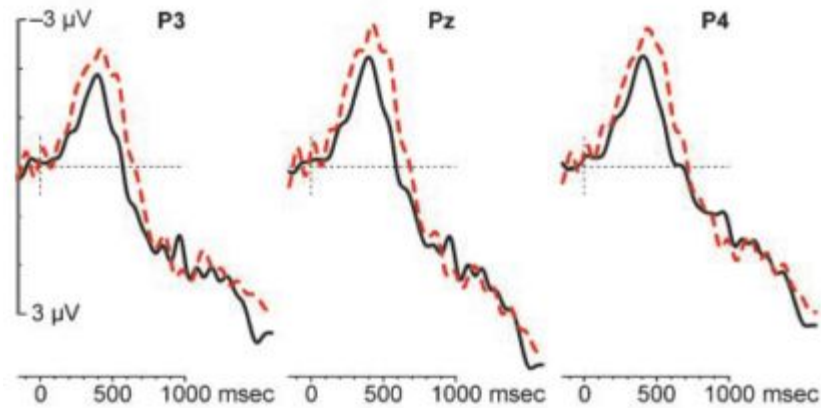
They wanted to make the hotel look more like a tropical resort. So, along the driveway, they planted rows of ...



ERP components

Kutas & Federmeier 2007, Fig.23.1, p.390

ERP Components have Names!



van Berkum et al. 2008, Fig. 3, p. 586

N400

negative voltage difference

peaking at 400ms after stimulus onset

What Triggers ERP Responses?

- everything! (literally.)
 - pictures, words, gestures, sounds...
 - e.g. words in open classes trigger larger responses than those in closed classes, etc.
- components represent activation of cognitive and neural processes
 - analysis, memory retrieval, etc.
- so what we are looking for is not what triggers a neural response, but *what triggers a neural response that is substantially different (larger, smaller, longer,...) from the others.*

What Triggers Those “Different” ERP Responses?

- semantic anomalies, incongruent or improbable events - **N400**
 - in e.g. “The red car ate the cake.”
- **syntactic violations/complexities - P600**
- magnitude of responses is in addition influenced by:
 - word frequency
 - repetition
 - sentence position
 - and others.

Kutas & Federmeier 2007

The P600 Makes Syntax Visible!

- is usually broad, with a flat “dip”
- occurs between 500 to 800ms
- in response to:
 - violations of subject-verb agreement
 - wrong verb or case inflection
 - ungrammatical phrase structure
 - syntactic ambiguities
 - dispreferred syntactic structures (the *garden path effect*)
 - syntactically complex sentences

A Wild P600 Appeared!

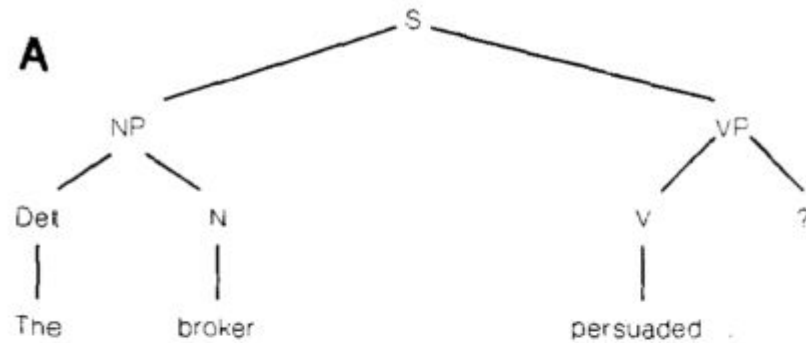
As it does not just occur after syntactic violations, it is assumed to reflect syntactic processing difficulty, or syntactic re-analysis. [Kutas & Federmeier 2007](#)

The broker persuaded ...

has (at least) two interpretations:

The P600 Makes Syntax Visible!

preferred/
expected



dispreferred/
less expected

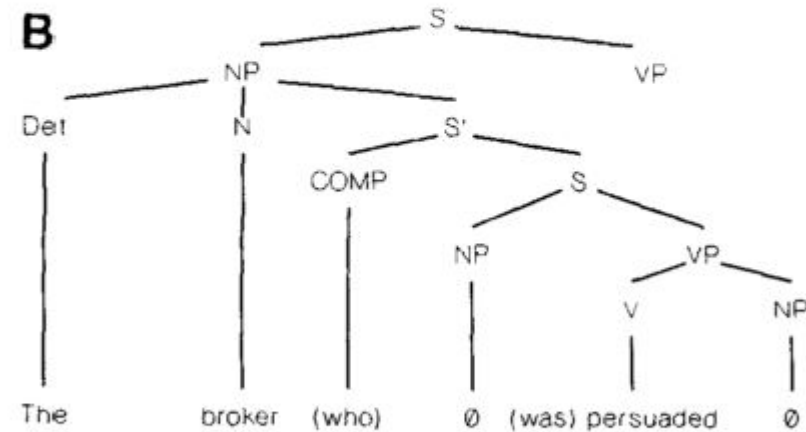


FIG. 1. Two possible interpretations of the word string “The broker persuaded . . .”: (A), a simple active interpretation; (B), a reduced relative clause interpretation.

The Broker Persuaded...

The broker persuaded the woman.

no P600

expected syntactic continuation

The broker persuaded sold his shares.

triggers P600

unexpected syntactic continuation

Osterhout & Holcomb 1992

A Real-Life Example - Dutch Gender Agreement

correct: Ik wil een reis naar China maken, omdat **de [*het] cultuur** daar zo anders is dan hier.

*I want to make a trip to China, because **the culture** there differs from the one over here.*

syntactic error - gender agreement violation: Mijn moeder belde in paniek op, omdat een ***dure [dur] juweel** uit haar tas was gestolen.

*My mother panicked because **expensive jewelry** had been stolen from her bag.*

semantic error - control condition: Het was vannacht best koud, dus ik had een dikke ***avond** op mijn bed gelegd.

*It was very cold last night, so I put a thick ***evening** on my bed.*

A Real-Life Example - Dutch Gender Agreement - N400

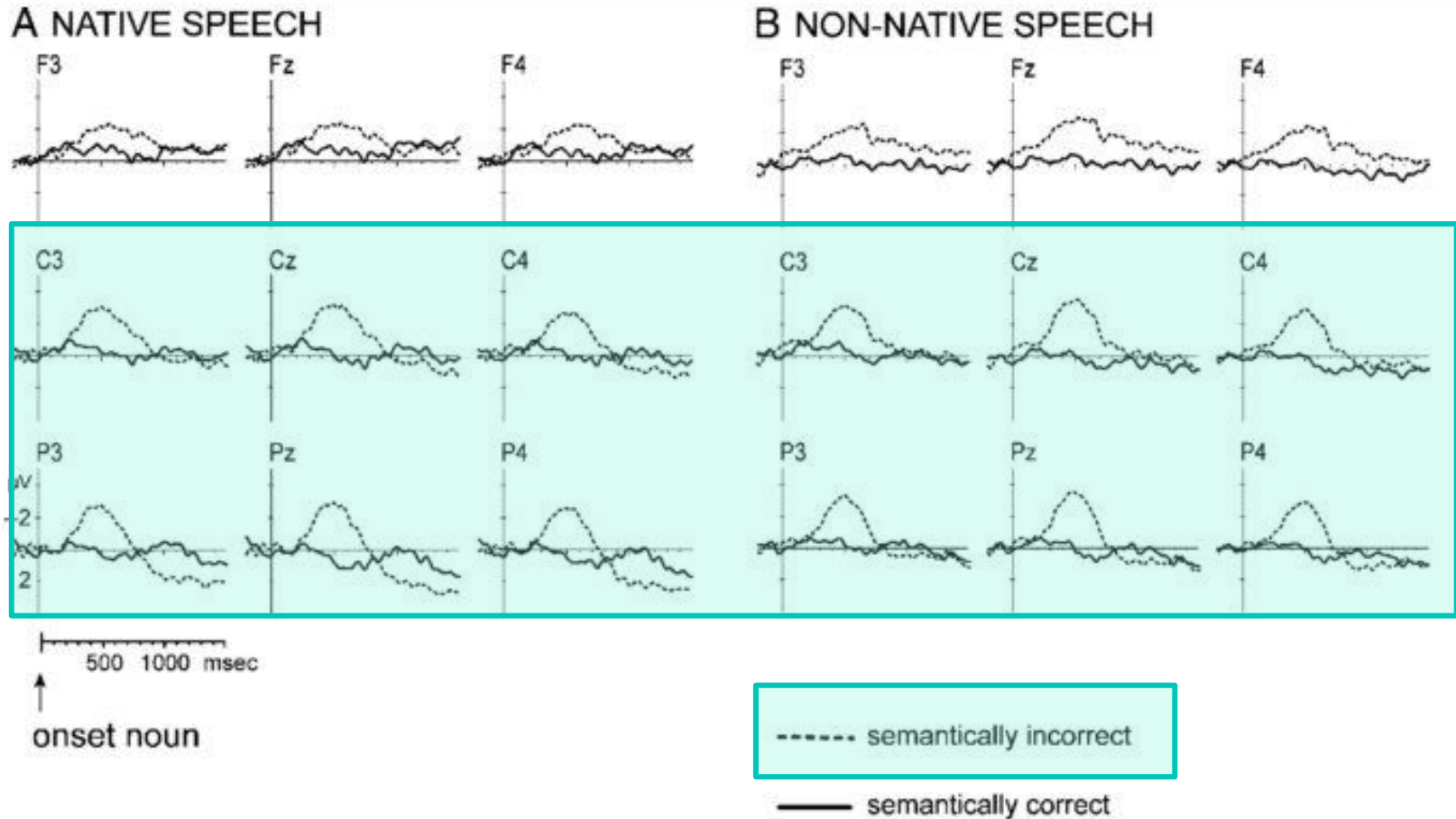


Figure 3. (A, B) Grand average ERPs from nine scalp sites elicited by semantically correct nouns (dashed lines) and semantically incorrect nouns (solid lines) in native speech (A) and non-native speech (B).

A Real-Life Example - Dutch Gender Agreement - P600

Figure 2. Grand average ERPs from the parietal site Pz elicited by syntactically incorrect nouns (dashed lines) and syntactically correct nouns (solid lines) in native and non-native speech in the first and second block.

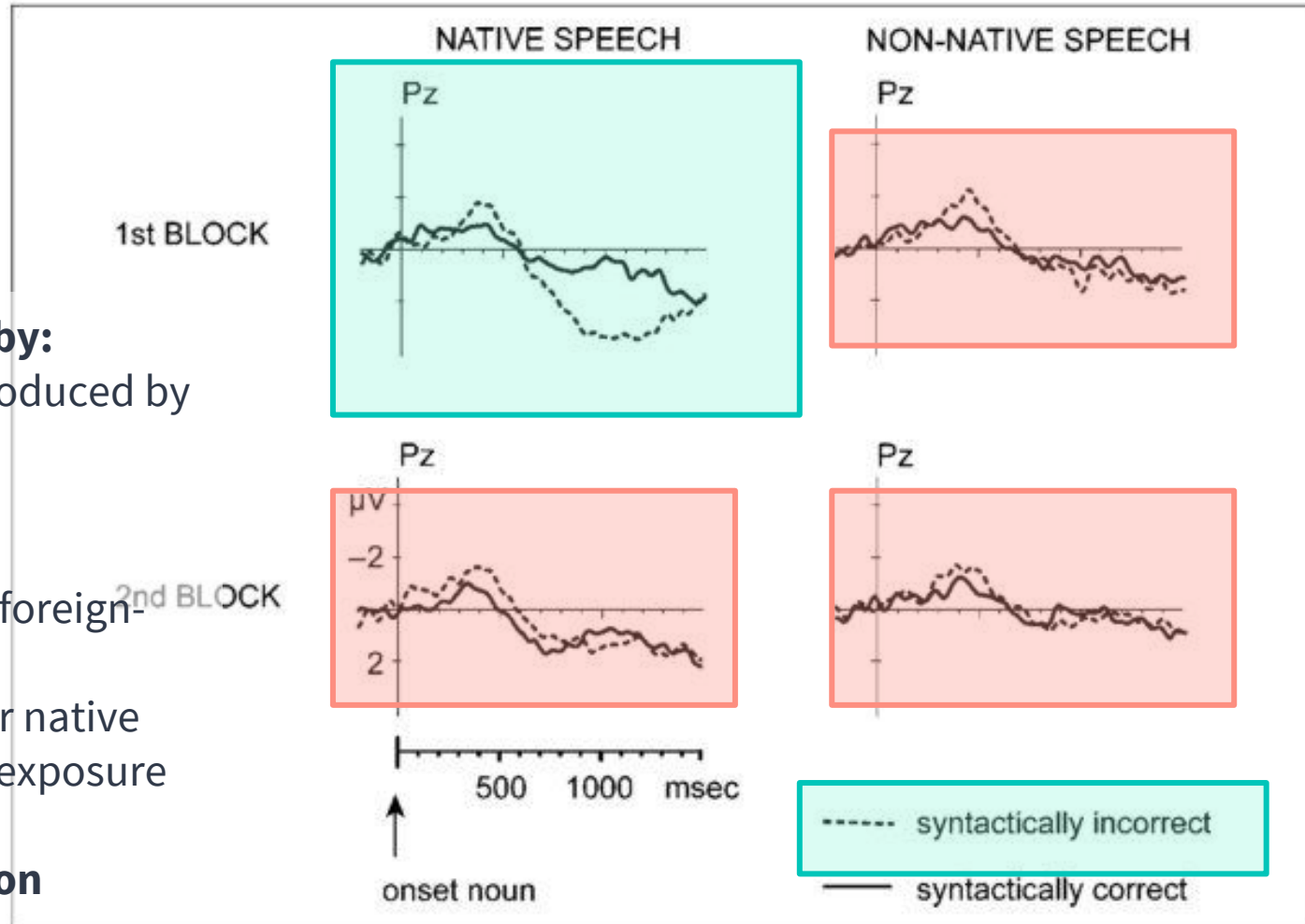
The P600 is triggered by:

- syntactic errors produced by a native speaker

There is *no* P600 for:

- syntactic errors in foreign-accented speech
- it vanishes even for native speech after prior exposure

expectations/prediction



Summary

- **Syntactic anomalies (errors, complexities) become visible as ERP components.**
- The relevant ERP component is called **the P600 (a positive ERP response around 600ms.)**
- When spoken with a foreign accent, syntactic errors do **not** seem to throw listeners off.
- The ERP component that is triggered by semantic anomalies is called **the N400** (negative, around 400ms.)
- This N400 persists, no matter if native or accented speech.
- **Syntactic understanding helps if you want to conduct psycholinguistic research.**
- Also, psycholinguistics is awesome and you should do it :)

REFERENCES

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Thanks!

Any questions?

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