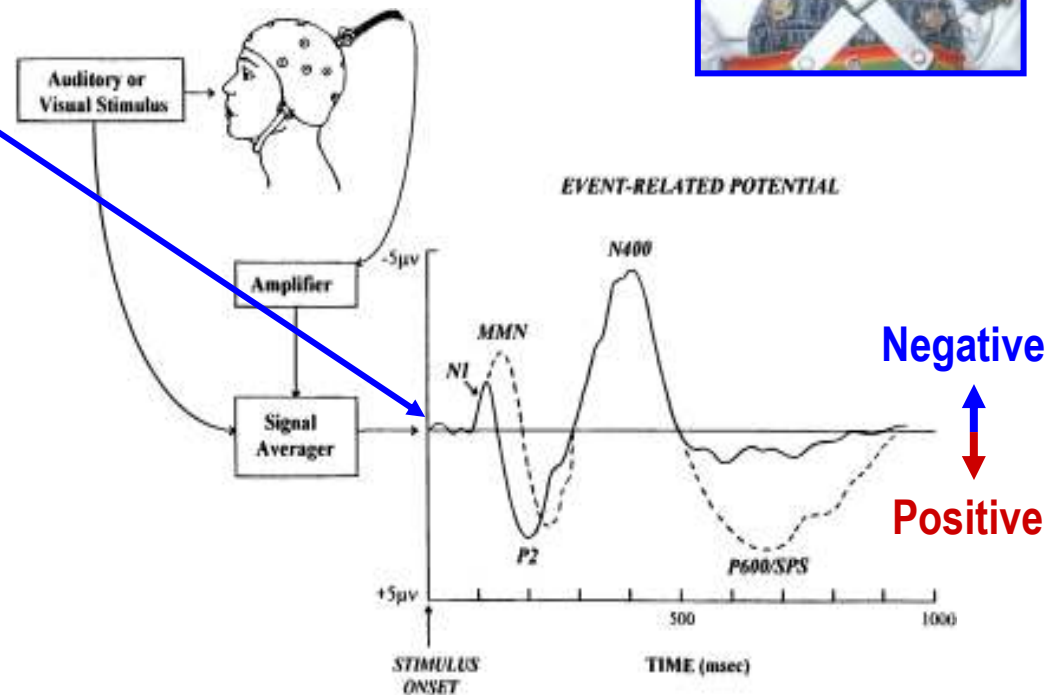

Processing syntax

Neural Bases of Language

Fall 2008

What are 'ERP's'?

- Event-related potentials:
 - patterned voltage changes embedded in the ongoing EEG
- Reflects a process related to an **event**
 - The train was **blue** - The sky was **blue**
- Activity is **time-locked**
- **Averaging** over many trials allows extraction of 'signal' from 'noise'



What are ERP's good for?

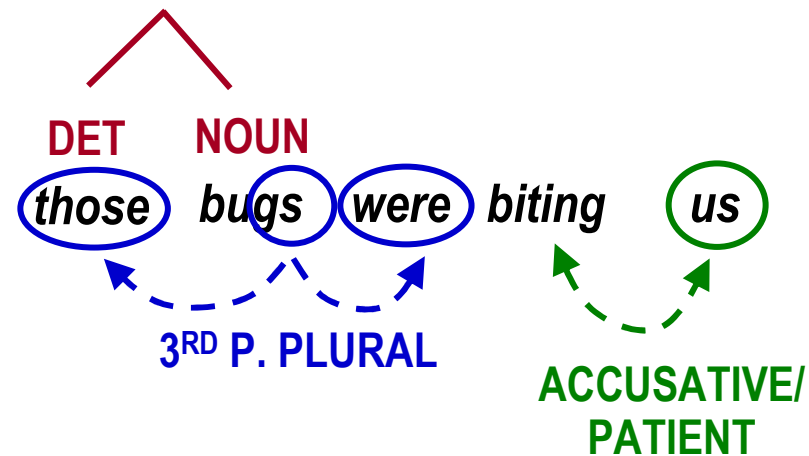
- Find out when (and to a lesser extent, where) linguistic operations take place in the brain.
- With respect to sentence level processing...
 - Are the neural correlates of computing syntax and semantics different?
 - Do the different operations involved in sentence processing occur one after another, or all at the same time? (serial vs. parallel)?
 - If serial: Does syntax come first?

What processes need to take place for you to be able to understand a sentence?

- Extract morphemes/words from the auditory string
- Analyze the grammatical relationships between these morphemes

- Phrase structure

NOUN PHRASE



- Agreement

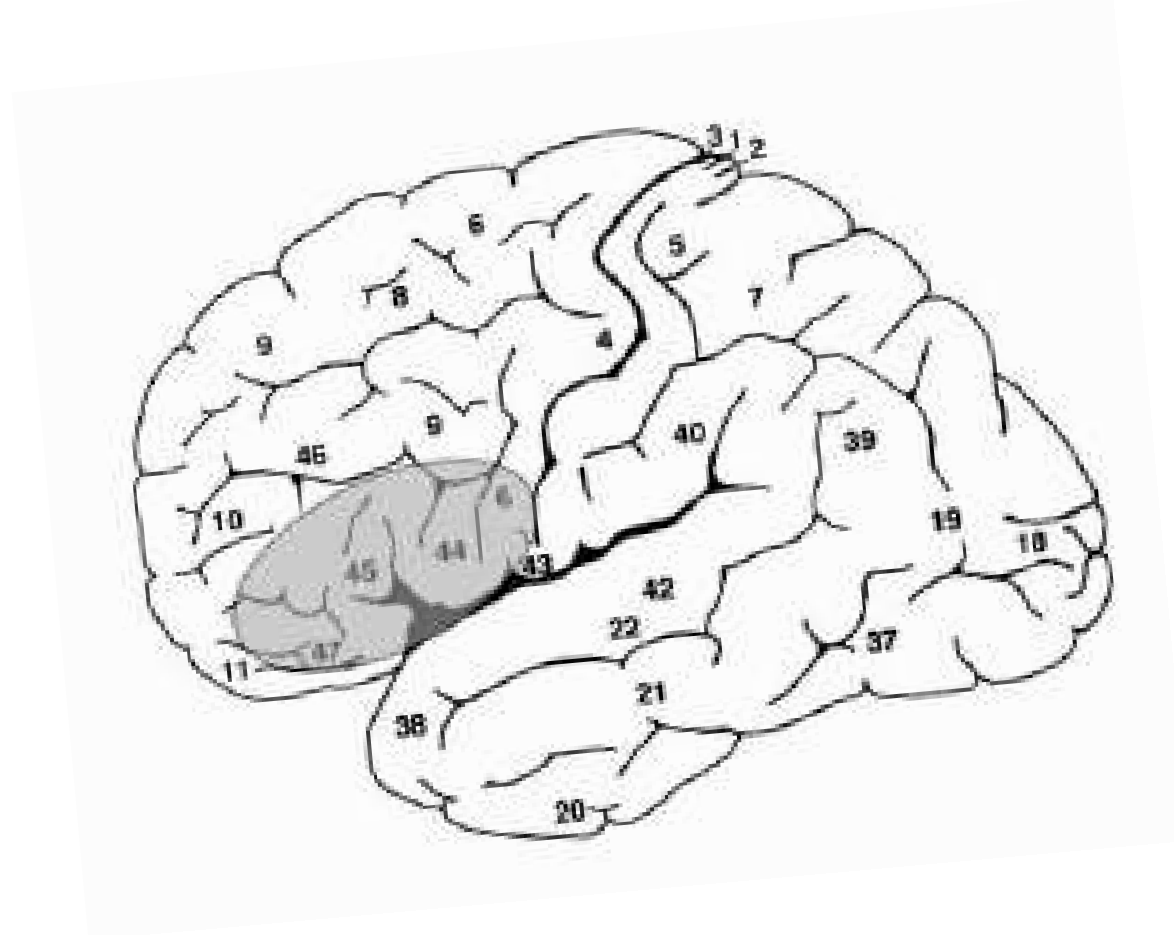
- Case/Thematic functions

- Analyze the meaning of the words within the sentence
- Evaluate your analysis of the full sentence

bug
animal

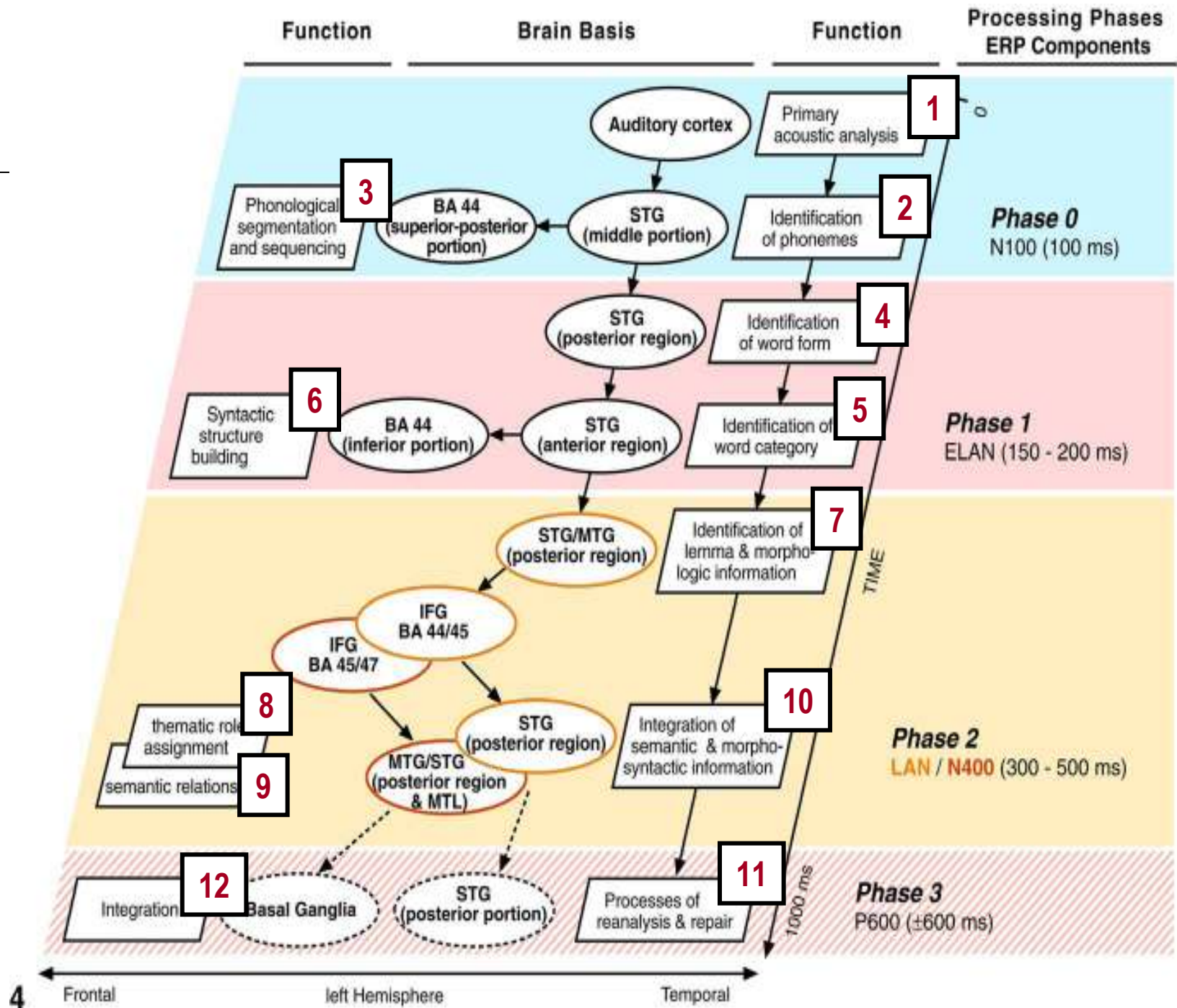
~~*bug*
spying device~~

Mapping ERP components onto the brain



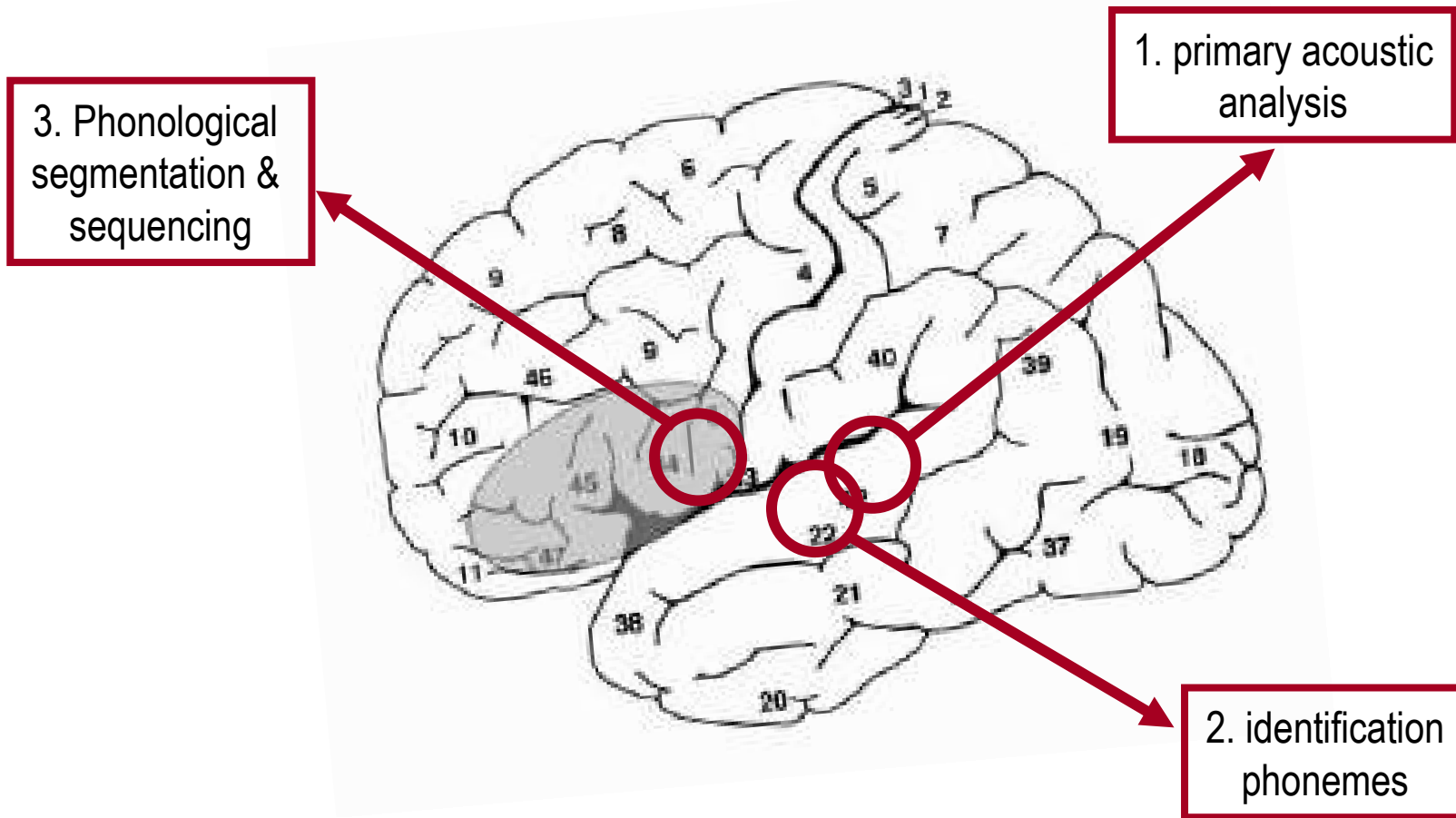
Friederici (2002)

- Most comprehensive model of the neural correlates of sentence processing



time

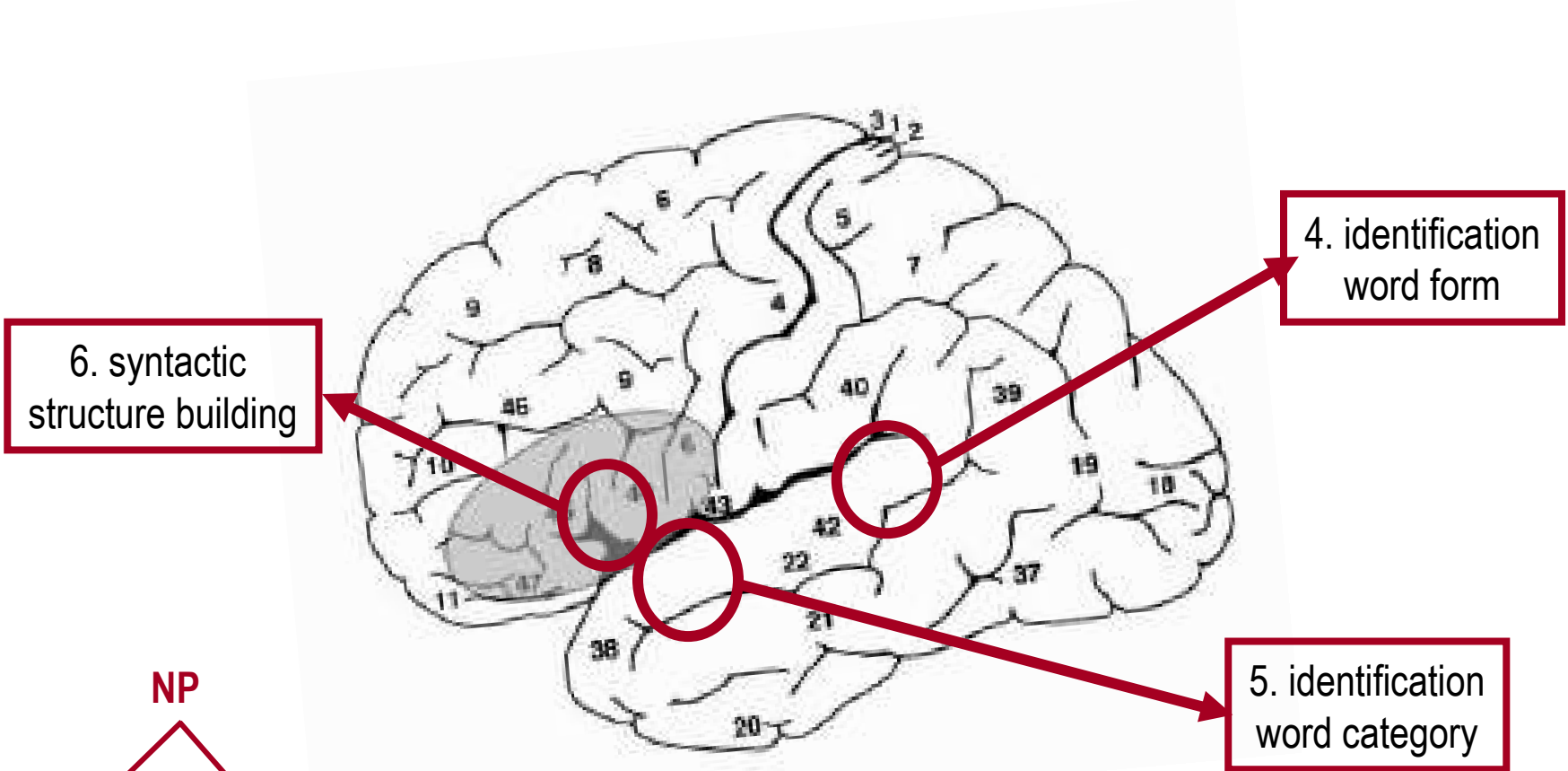
100ms



time

100ms

150-200ms



How do we know where certain operations take place?

- Very common design:
 - Violation paradigm: compare correct to incorrect sentences
 - E.g., I believed John's stories about Africa
vs.
I believed John's about stories Africa
- Rationale: whenever there is 'extra' or later/earlier brain activity associated with the ungrammatical words, the brain response that shows this modulation reflects the relevant processing (here: phrase-structure).

time

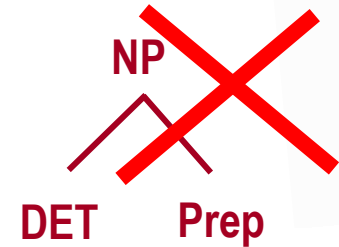
100ms

150-200ms

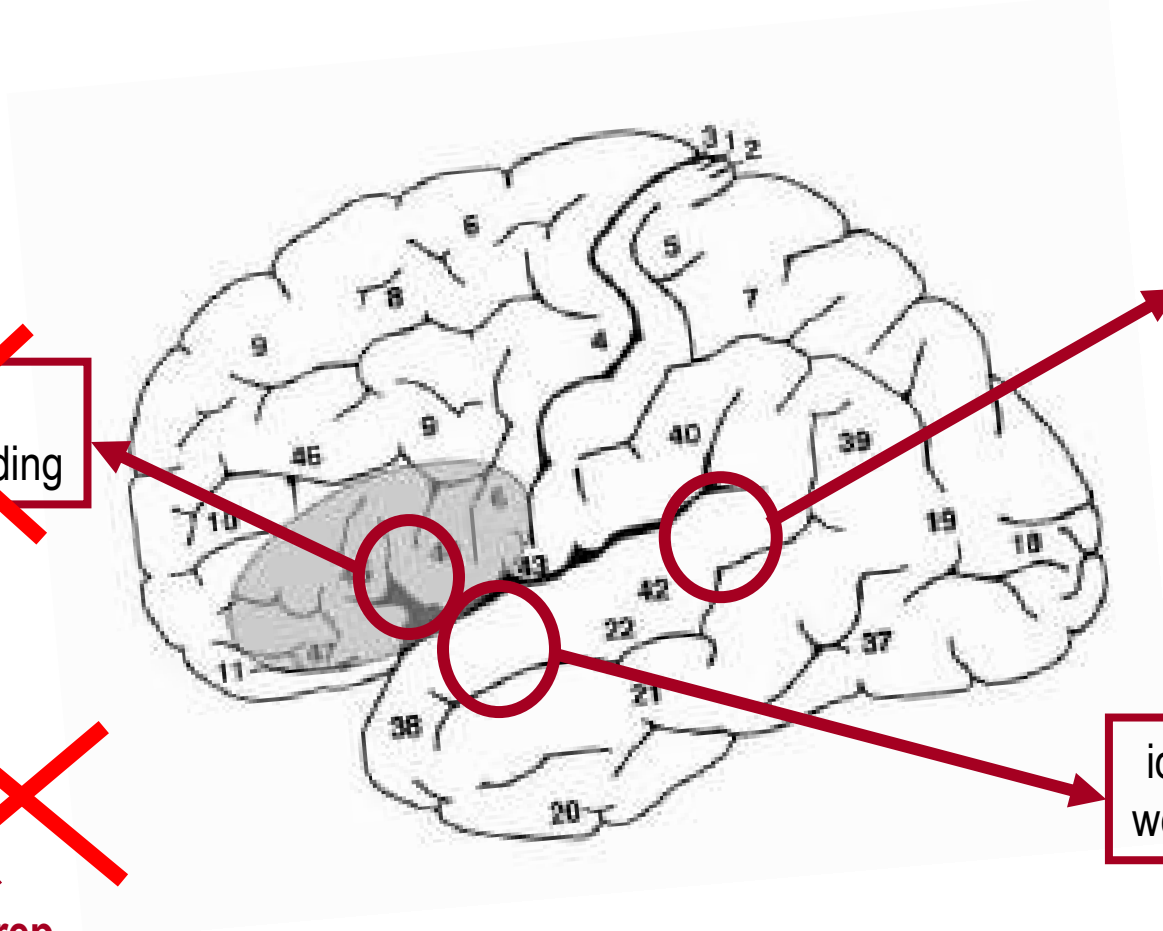
~~syntactic
structure building~~

identification
word form

identification
word category



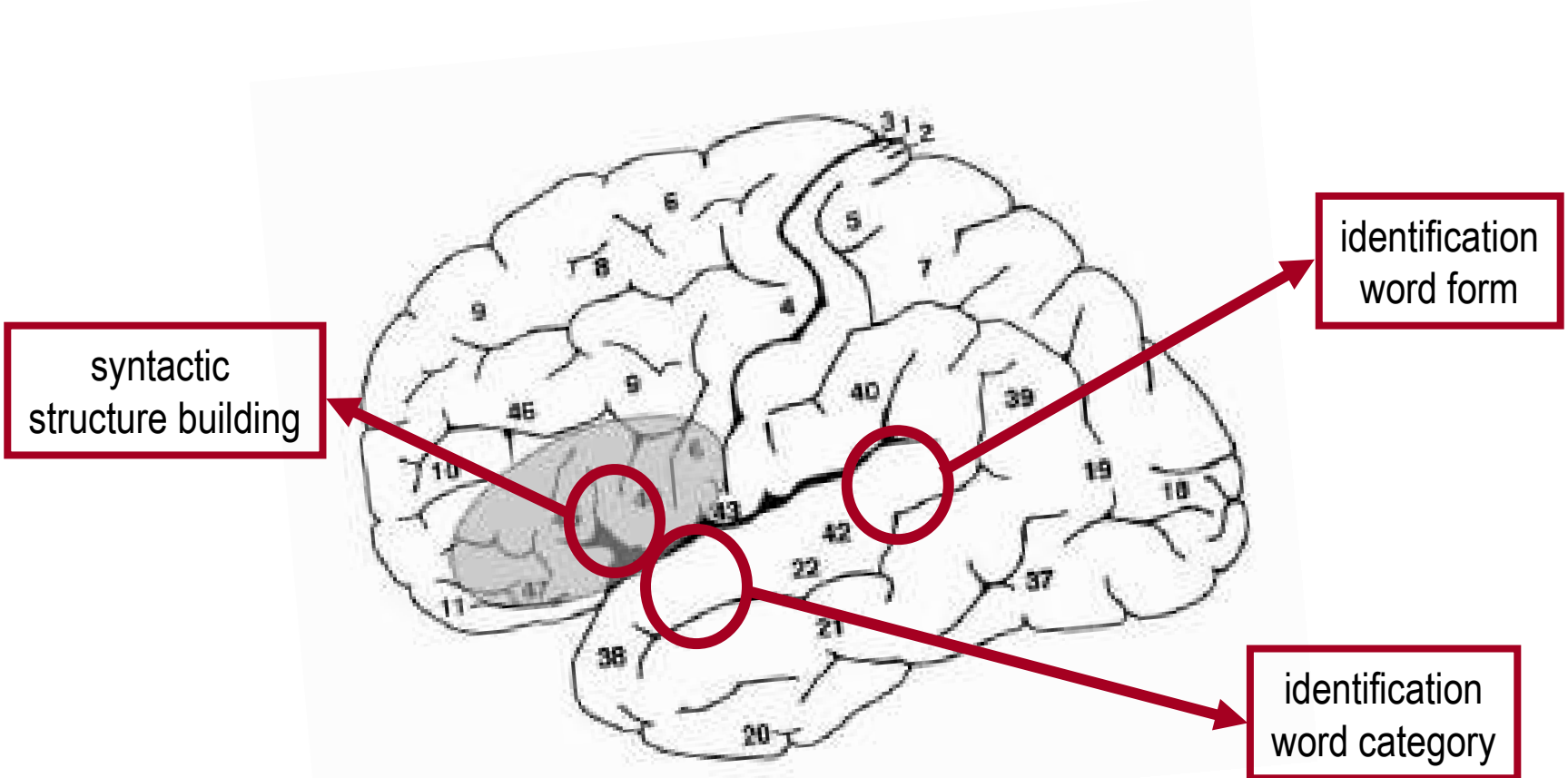
John's about stories Africa



time

100ms

150-200ms



Joe's stories about Africa

Joe's about stories Africa

More activity

ELAN
(early left-anterior negativity)

How can this Early Left-Anterior Negativity be so early?

**Sensory analysis
of visual/auditory
properties**

0ms

100ms

150

200ms

600ms

**ELAN response
to syntactic
properties**



How can the ELAN be so fast?

- Prediction plays a crucial role (Lau et al. 2006)
 - The parser is always 'active' and 'pre-processes' upcoming words

The scientist criticized Max's ~~of~~ proof of the theorem

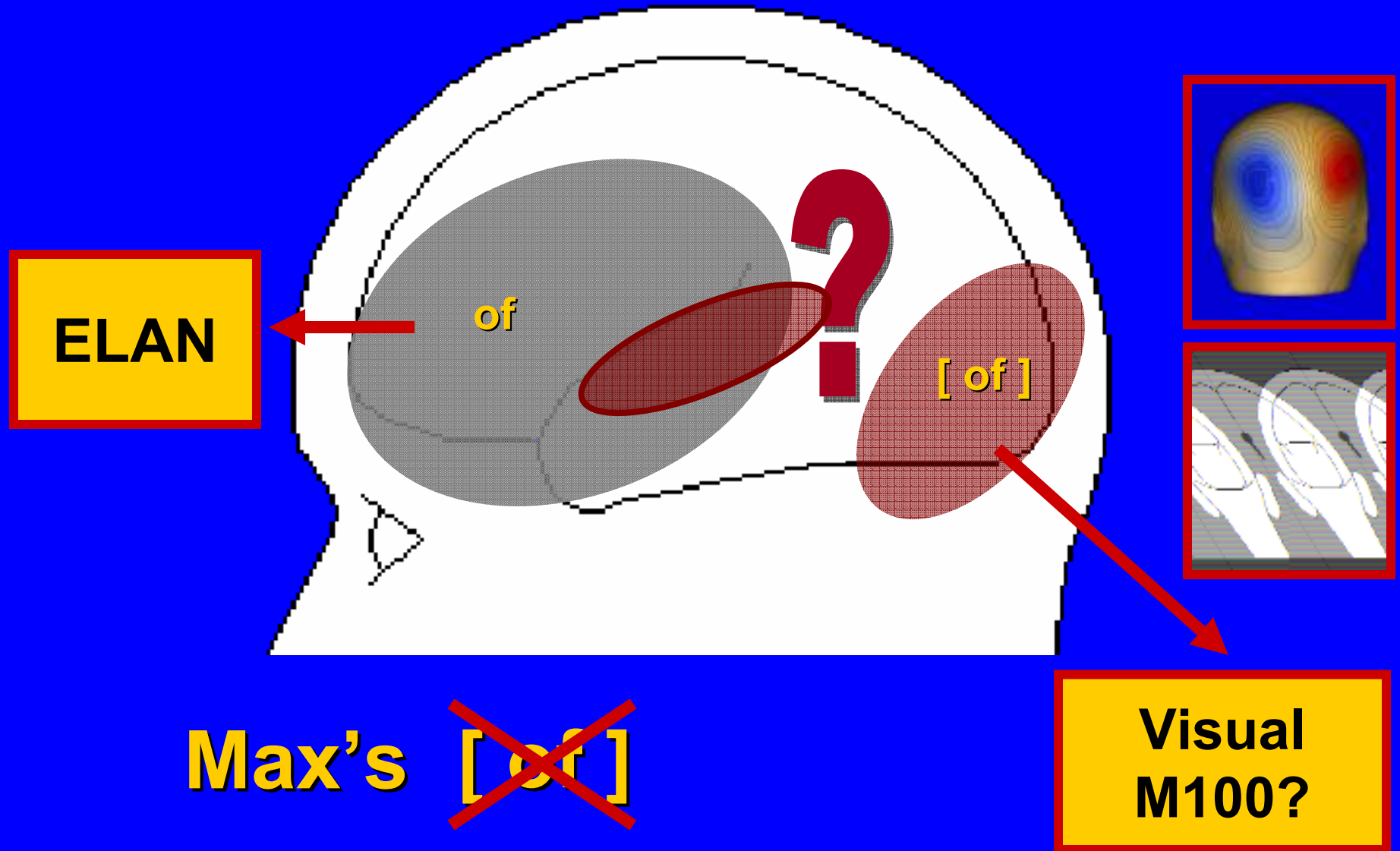
~~Noun~~

**ELAN:
word category mismatch**

(Friederici 2002)

(Neville et al., 1991)

Is word category prediction so detailed that it includes actual physical form estimates of the expected category?

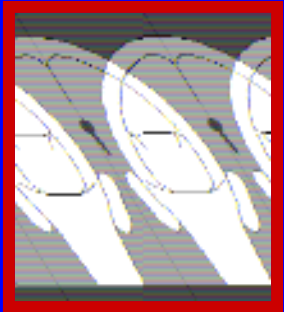
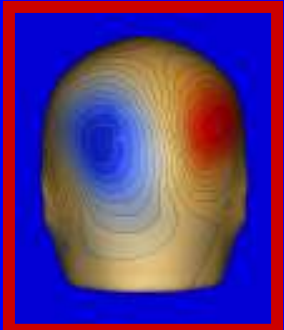


ELAN

of

?

[of]



~~Max's [of]~~

Visual M100?

And if visual cortex has access to these detailed predictions, then how can it 'check' them? I.e., what might the M100 respond to?

of → Preposition

reported → Participle


report → ?
→ Verb
→ Noun

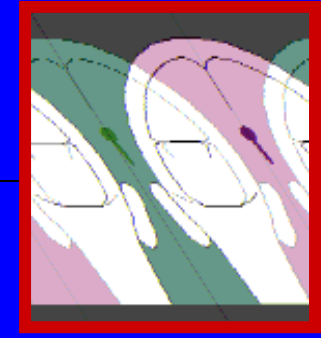
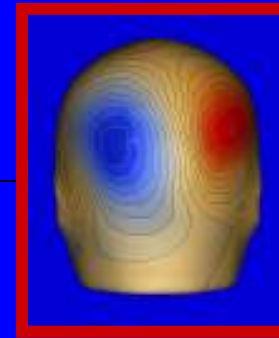
No perceivable word category marker

Are early responses to word category mismatches limited to cases where the mismatch is overtly indexed?

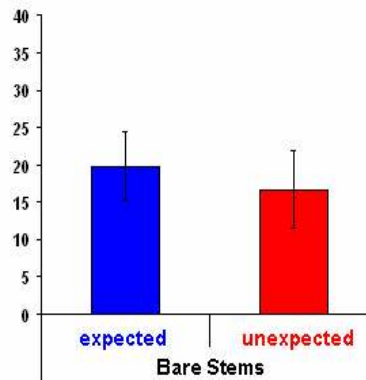
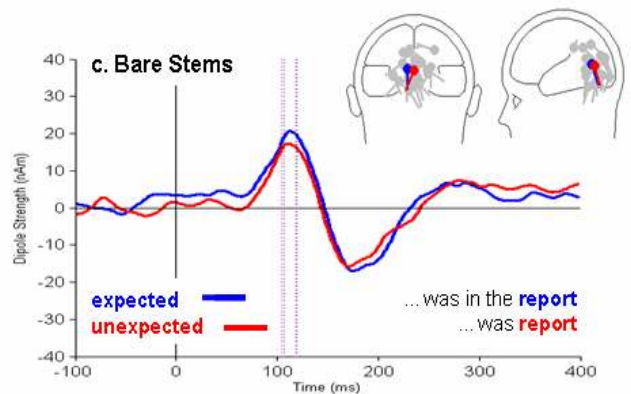
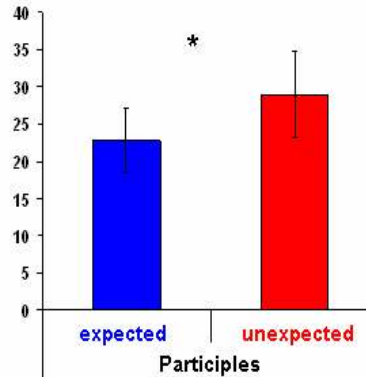
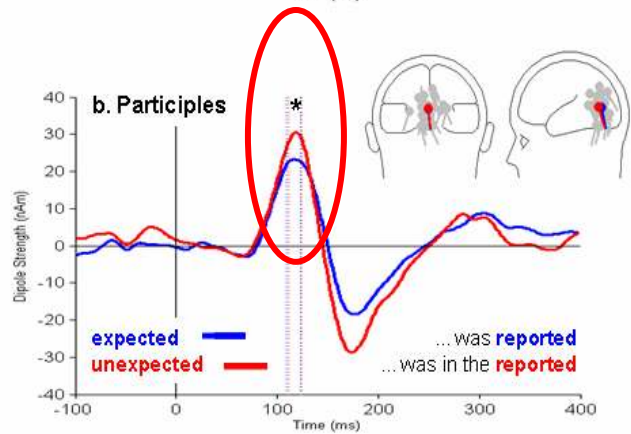
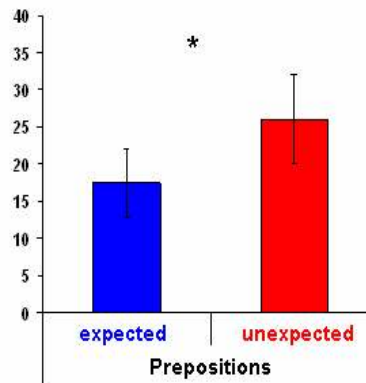
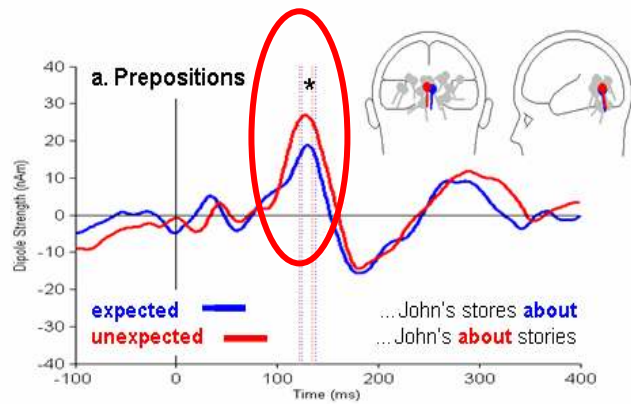
Are early responses only obtained for perceivable category markers?

PREPOSITION	The scientist criticized Max's proof <u>of</u> the theorem	The scientist criticized Max's <u>of</u> proof the theorem
PARTICIPLE	The discovery was <u>reported</u>	The discovery was in the <u>reported</u>
BARE STEM	The discovery was in the <u>report</u>	The discovery was <u>report</u>



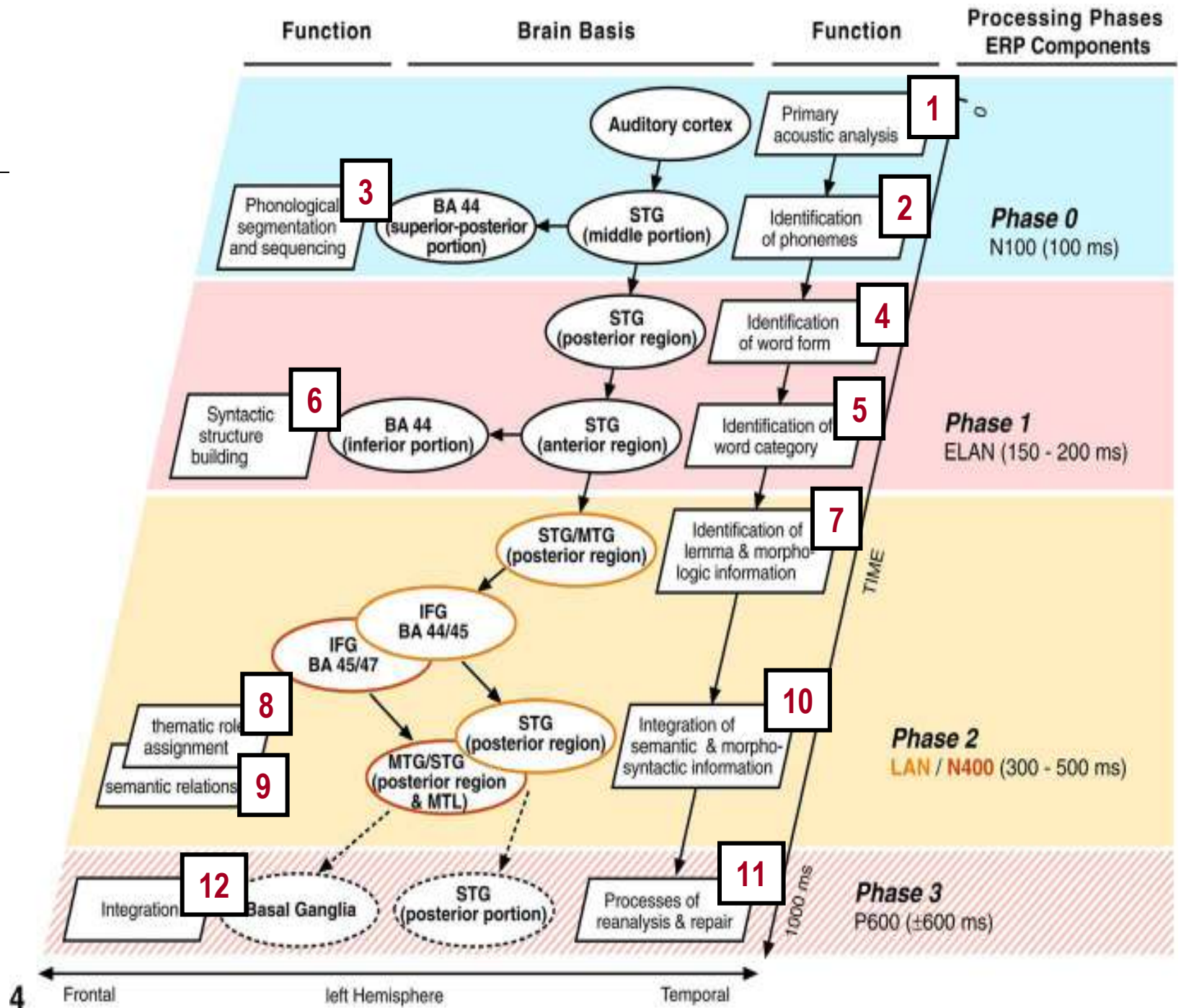


**Visual M100 effect
Only for closed-class
category-marking
morphemes**



How can the ELAN be so fast?

- Prediction plays a crucial role
- Rapid recognition category-marking closed-class morphemes (like *-ed*)
- Maybe even at the earliest stages of visual/auditory analysis
- I.e., the last word hasn't been said about the underlying neural correlates of sentence-level grammatical operations

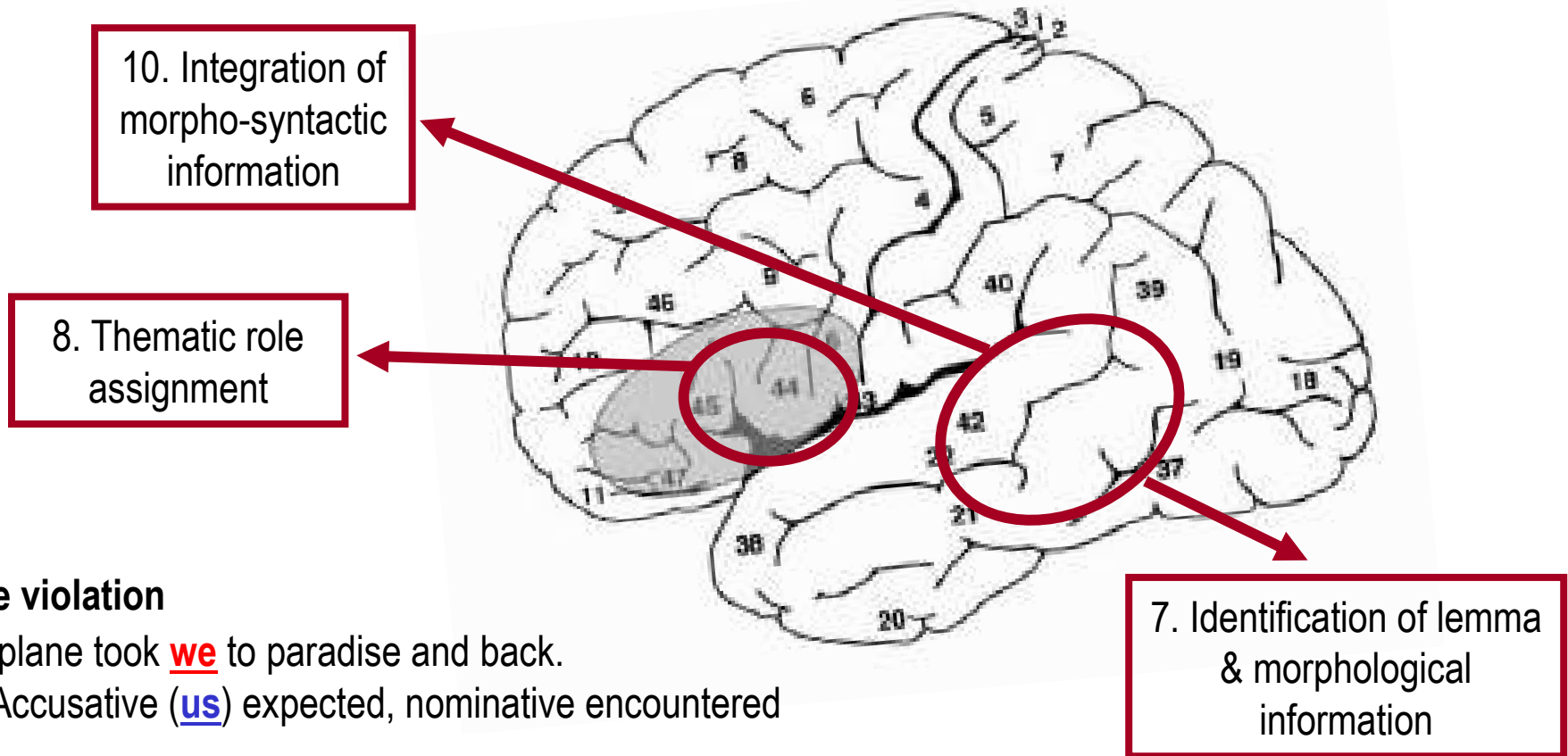


time

100ms

150-200ms

300-500ms



Case violation

The plane took **we** to paradise and back.

→ Accusative (**us**) expected, nominative encountered

Agreement violation

The elected officials **hope**s to succeed.

→ plural (**hope**) expected, singular encountered

“LAN”
Left-anterior negativity

time

100ms

150-200ms

300-500ms

9/10. Integration of semantic information

N400

Highly predicted

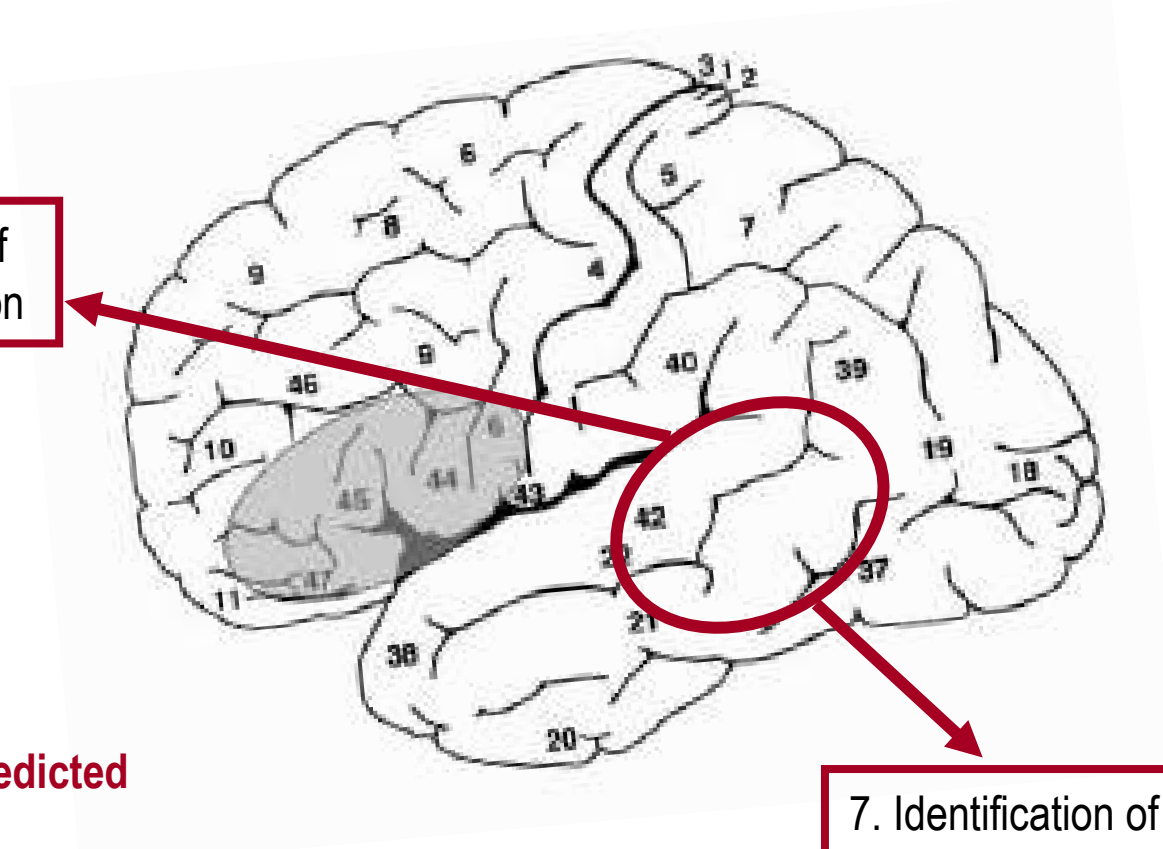
The sky was blue

The train was blue

The rose was blue

More activity

7. Identification of lemma & morphological information



time

100ms

150-200ms

300-500ms

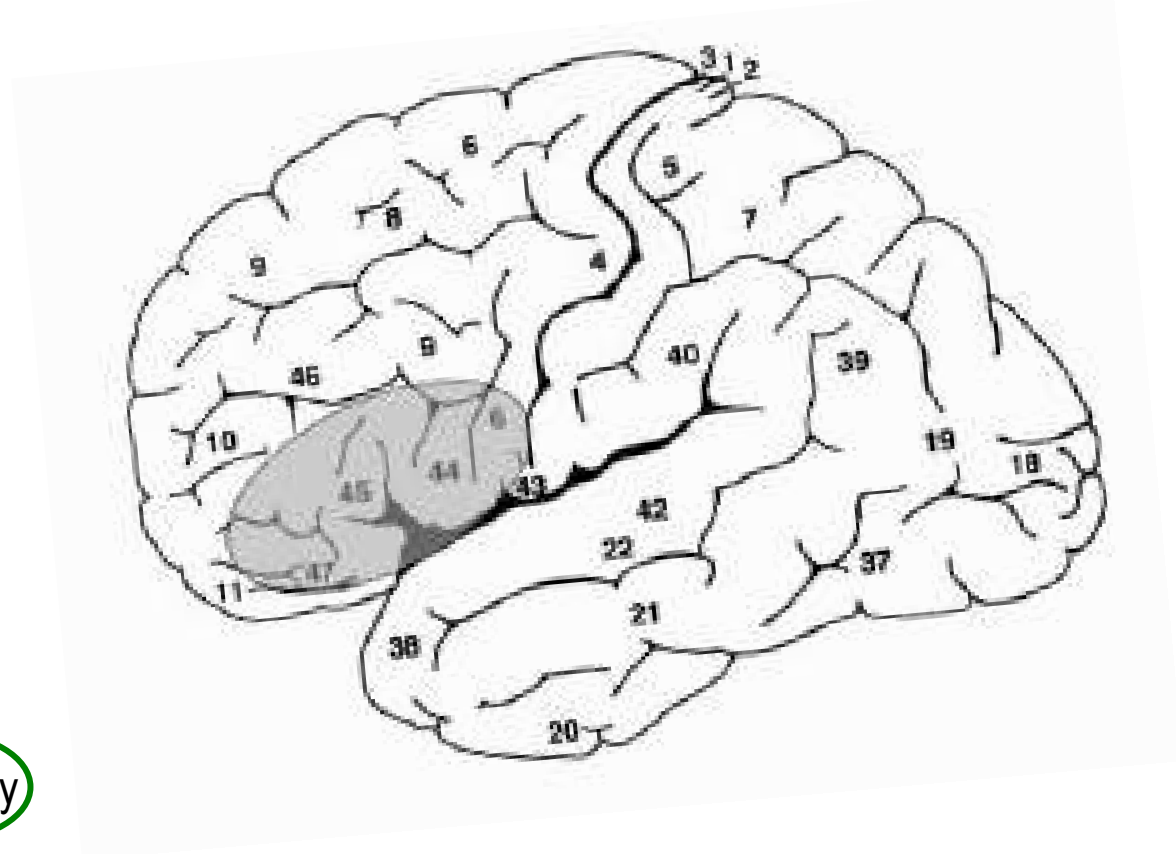
± 600ms

Garden-Path sentence

1. Word-by-word analysis

OBJECT

The judge believed the story



time

100ms

150-200ms

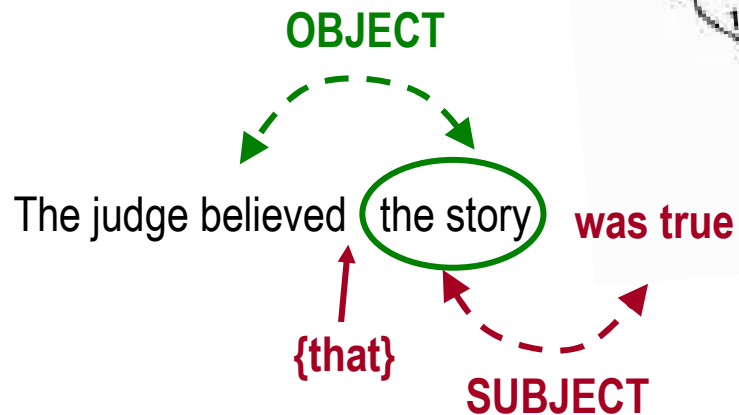
300-500ms

± 600ms

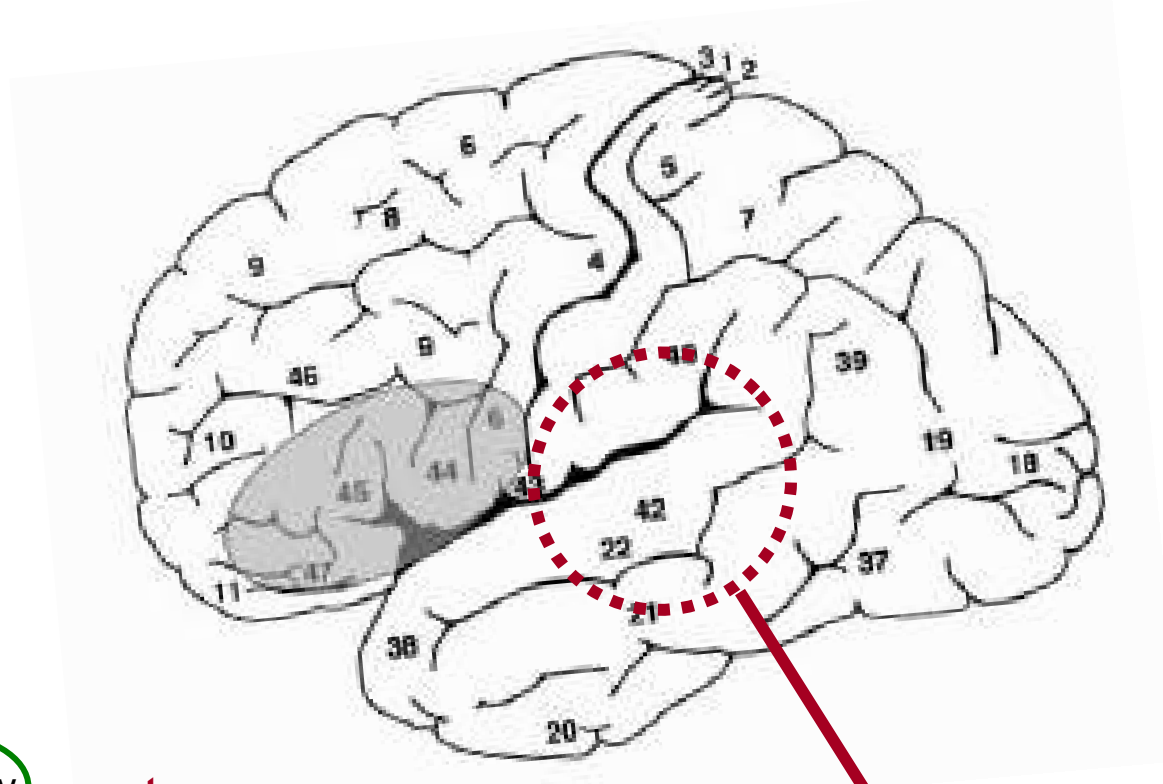
P600

Garden-Path sentence

1. Word-by-word analysis



2. Re-analysis



11/12. Integration/
reanalysis & repair
P600

What processes need to take place for you to be able to understand a sentence?

- Extract morphemes/words from the auditory string
- Analyze the grammatical relationships between these morphemes

ELAN

- Phrase structure

LAN

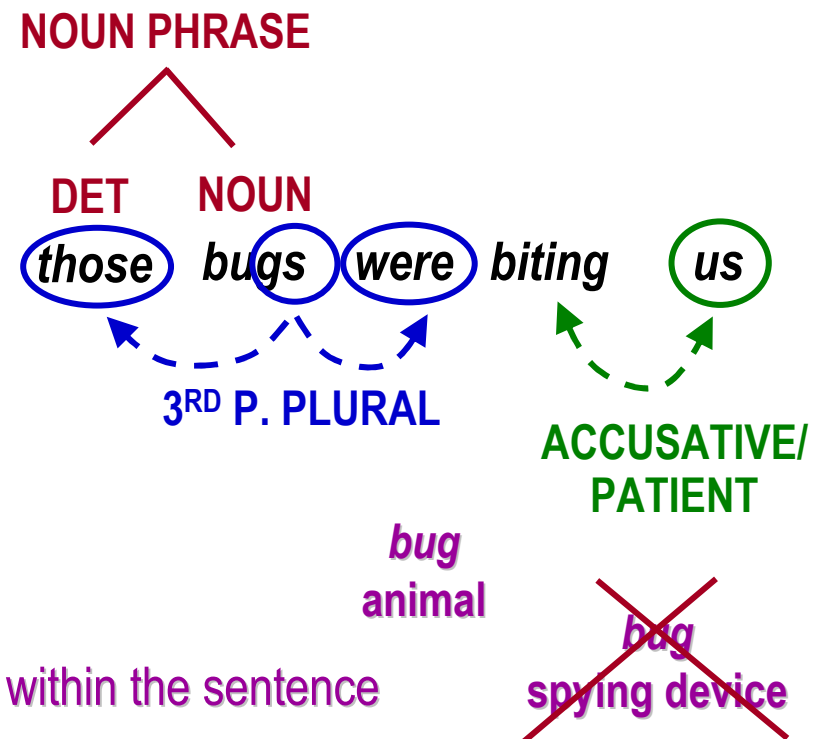
- Agreement

N400

- Analyze the meaning of the words within the sentence

P600

- (re)evaluate the analysis of the full sentence



What are ERP's good for?

- Find out when (and to a lesser extent, where) linguistic operations take place in the brain.
- With respect to sentence level processing...
 - Are the neural correlates of computing syntax and semantics different?
 - Do the different operations involved in sentence processing occur one after another, or all at the same time? (serial vs. parallel)?
 - If serial: Does syntax come first?

