Main bodies of research in the cognitive neuroscience of combinatory syntax & semantics
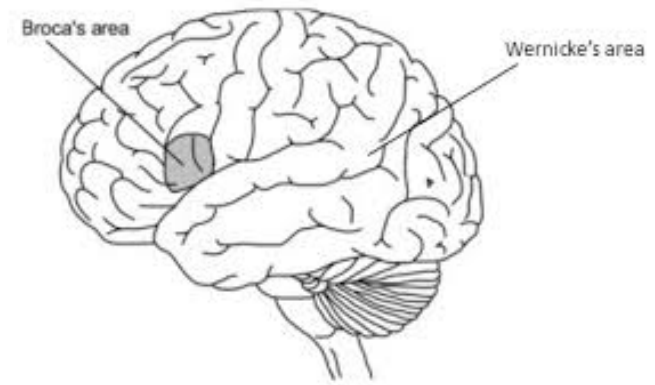
- Violation studies
  - Comprehension of expressions that violate your knowledge of how words should combine together
  - Primarily EEG

- Hemodynamic research on Broca's area
  - Long debate about whether and how Broca's area contributes to syntactic processing
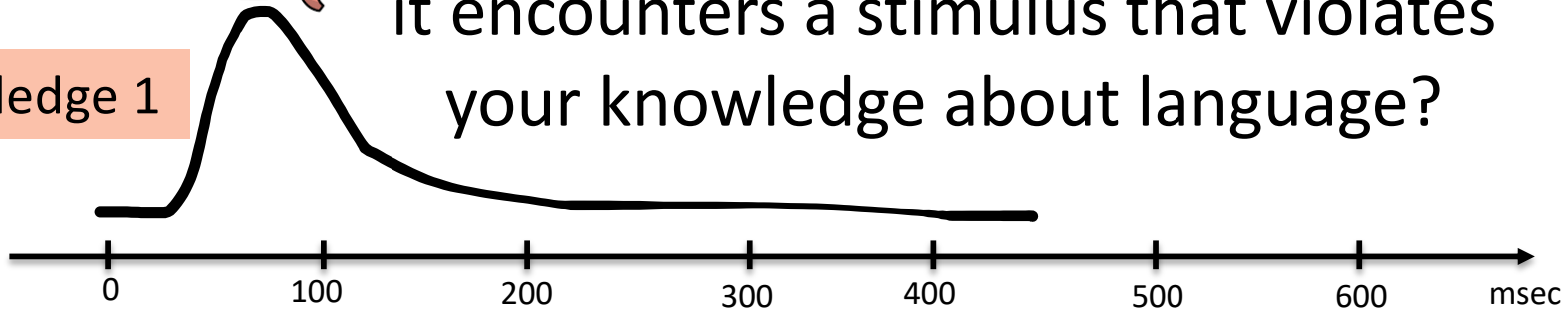
- Basic composition
  - What neural activity reflects the basic operation of composing elements together into larger expressions?
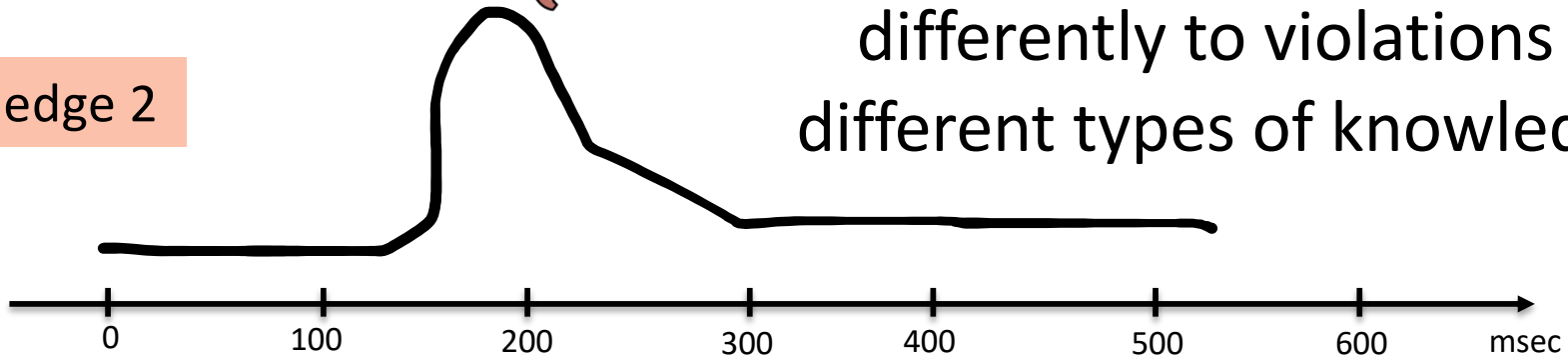
black   cat

Knowledge 1

How does your brain respond when it encounters a stimulus that violates your knowledge about language?
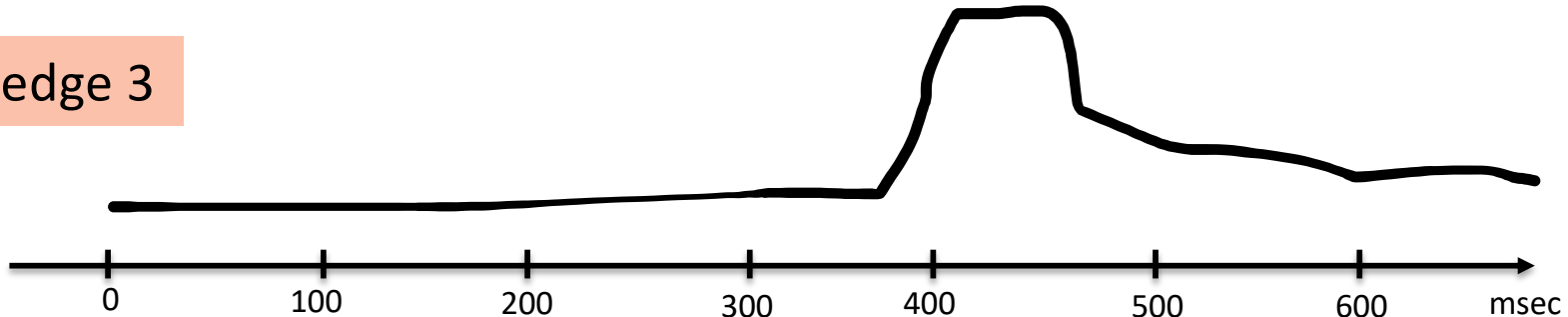
| 0 | 100 | 200 | 300 | 400 | 500 | 600 | msec |

Knowledge 2

Does your brain respond differently to violations of different types of knowledge?

| 0 | 100 | 200 | 300 | 400 | 500 | 600 | msec |

Knowledge 3

| 0 | 100 | 200 | 300 | 400 | 500 | 600 | msec |

Three types of knowledge guiding the construction of sentence structure

1. How words combine syntactically
2. How words combine semantically
3. Knowledge about the world

Syntactically Based Sentence Processing Classes: Evidence from Event-Related Brain Potentials

Helen Neville
Neuropsychology Laboratory,
Salk Institute for Biological Studies

Janet L. Nicol, Andrew Barss, Kenneth I. Forster, and Merrill F. Garrett
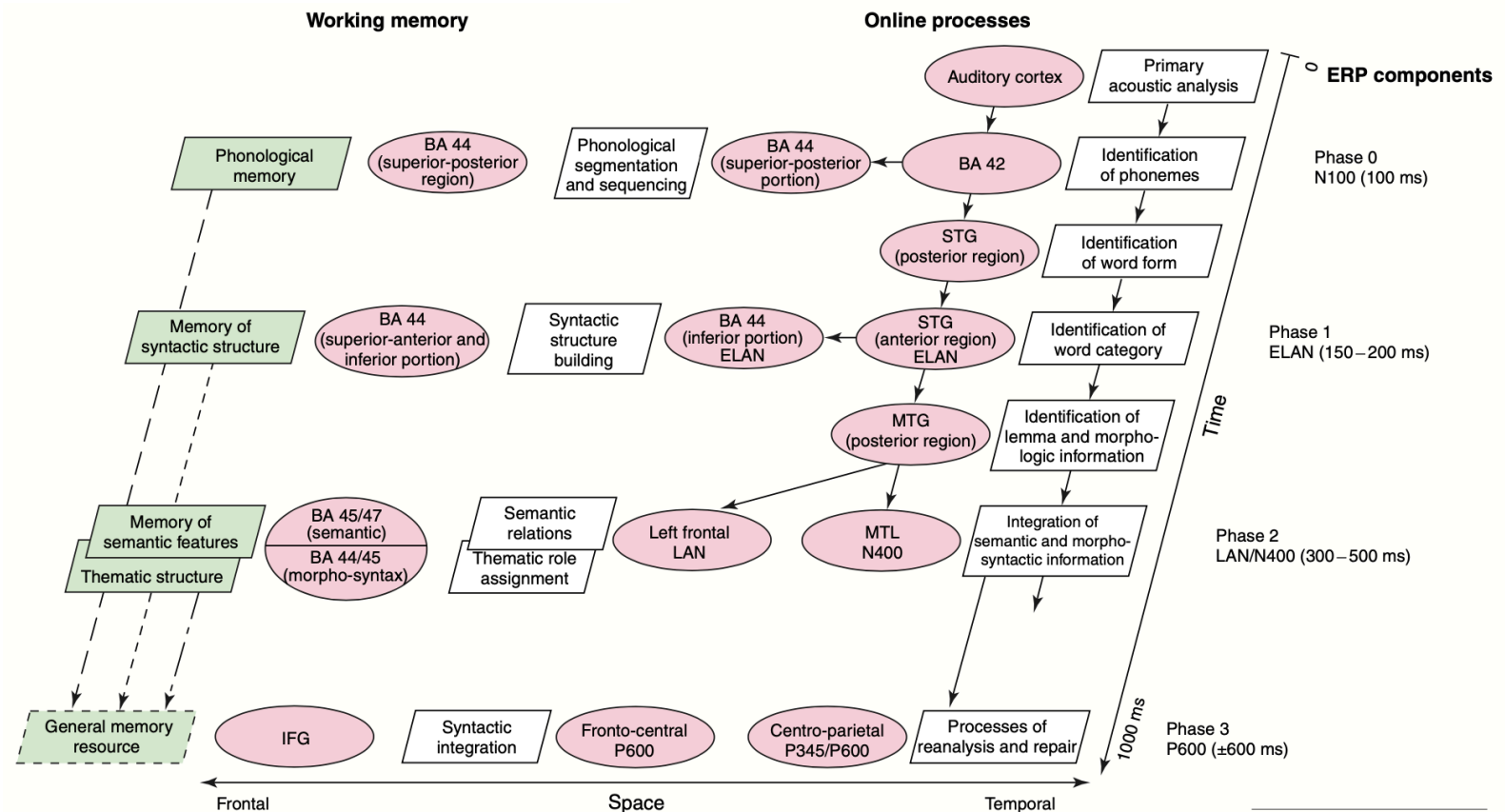University of Arizona

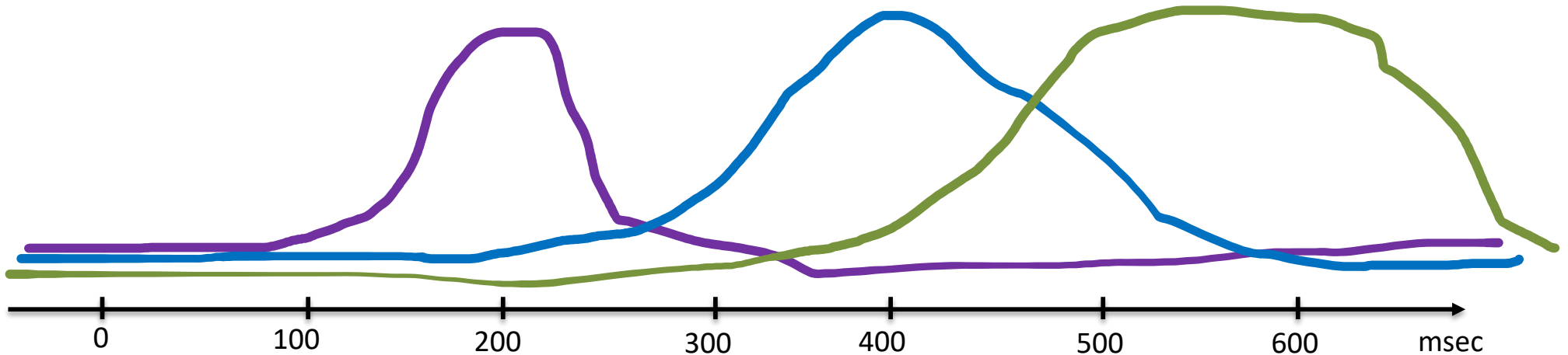# Towards a neural basis of auditory sentence processing

Angela D. Friederici

Three stages of syntactic processing
(Friederici model)

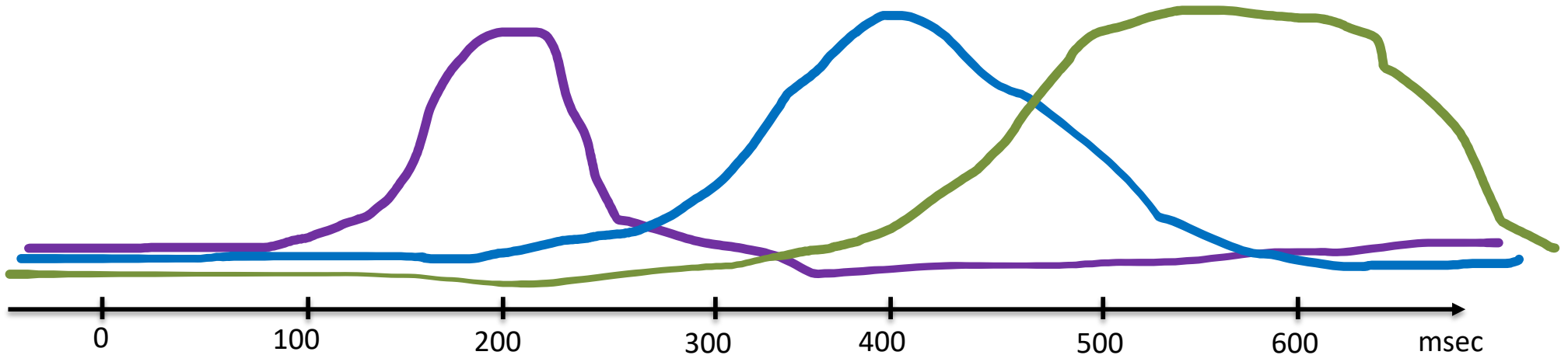0   100   200   300   400   500   600   msec

How syntactic categories combine ("phrase structure")

The scientist saw Max's **of** proof the theorem. (violation)

VS.

The scientist saw Max's proof **of** the theorem.

Three stages of syntactic processing
(Friederici model)

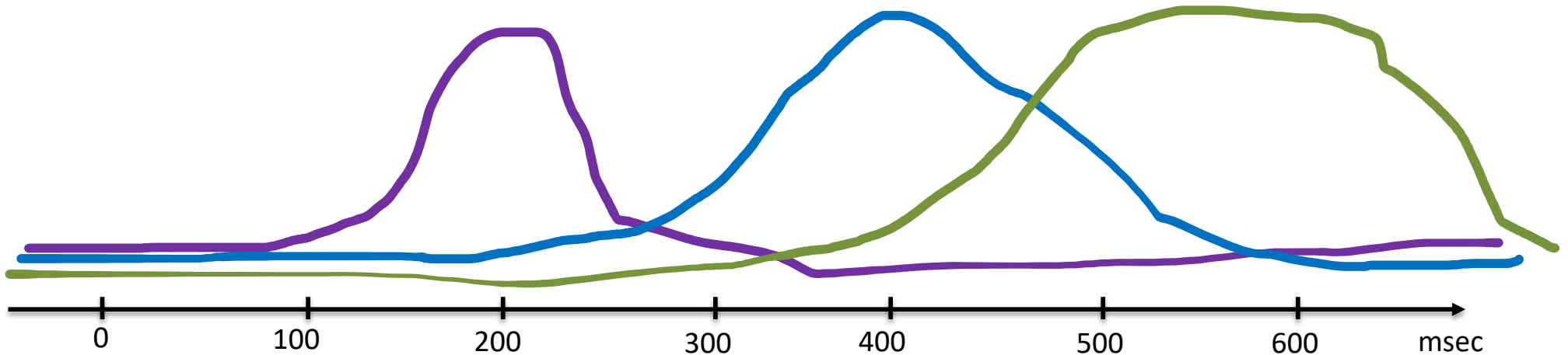**How syntactic categories combine ("phrase structure")**

Case and agreement

Case violation: The plane took **we** to paradise and back.
accusative (us) expected, nominative encountered

Agreement violation: The elected officials **hopes** to succeed.
plural expected, singular encountered

Three stages of syntactic processing

(Friederici model)

How syntactic categories combine ("phrase structure")
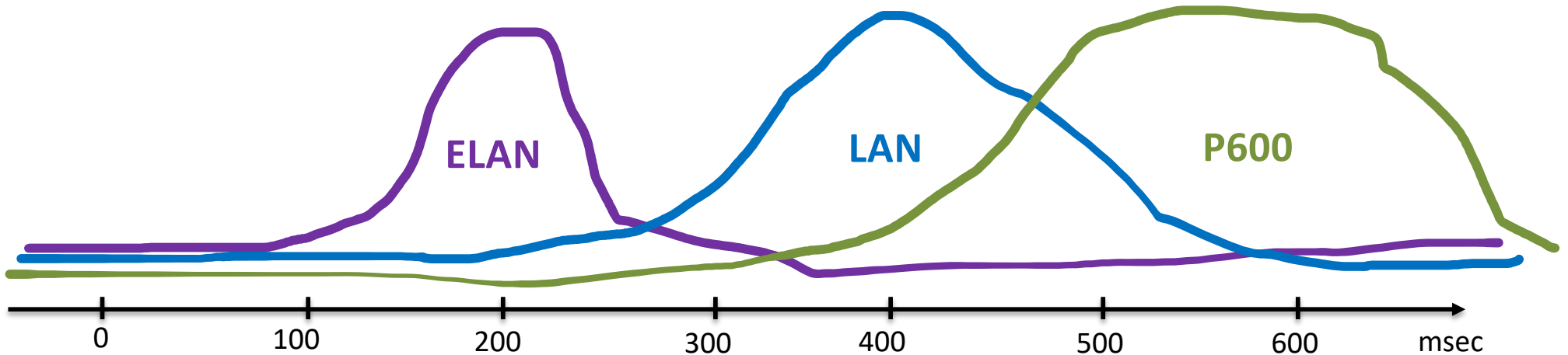
Case and agreement

Reanalysis

"Garden path":
The judge believed the defendant *was* lying.

the defendant has been analyzed as an object but was forces reanalyzing it as a subject.

Three stages of syntactic processing
(Friederici model)

ELAN

LAN

P600

| 0 | 100 | 200 | 300 | 400 | 500 | 600 | msec |

How syntactic
categories combine
("phrase structure")

Case and
agreement

Reanalysis

Early
Left
Anterior
Negativity

Left
Anterior
Negativity

Positivity
Peaking around 600ms

Three stages of syntactic processing
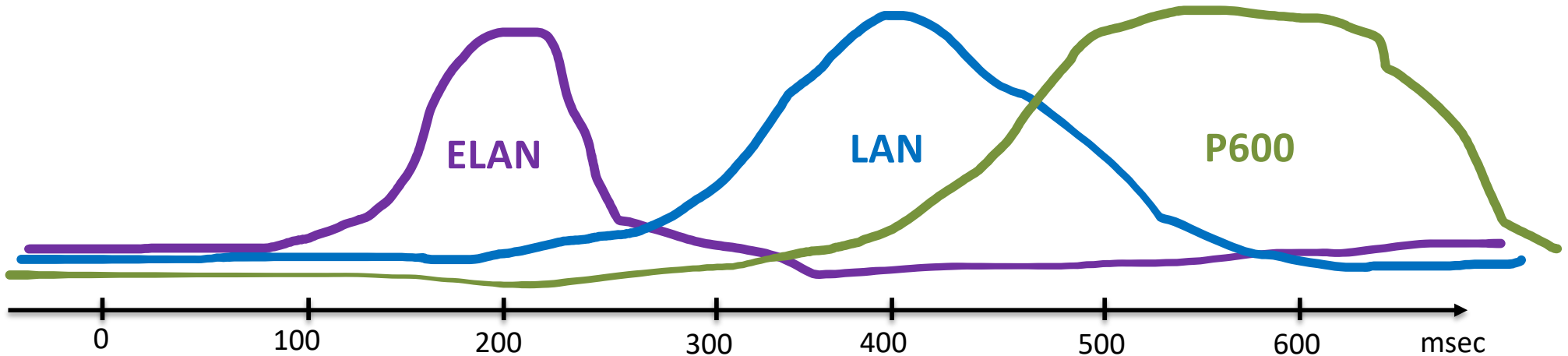
(Friederici model)

ELAN   **LAN**   **P600**

0   100   200   300   400   500   600   msec

How syntactic categories combine ("phrase st

Case and agreement

Reanalysis

N400

(a)

He spread the warm bread with butter.
He spread the warm bread with BUTTER.
He spread the warm bread with socks.

Kutas & Hillyard (1980)

5µV

300   600   900
msec

ELAN

LAN
N400

P600

0   100   200   300   400   500   600   msec
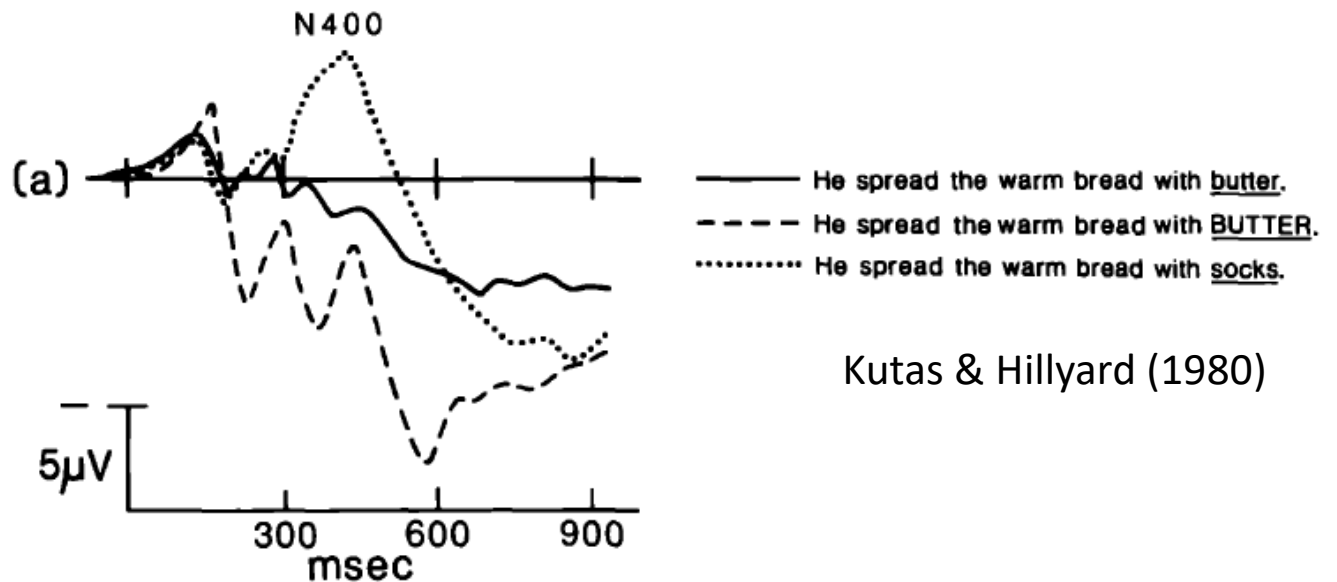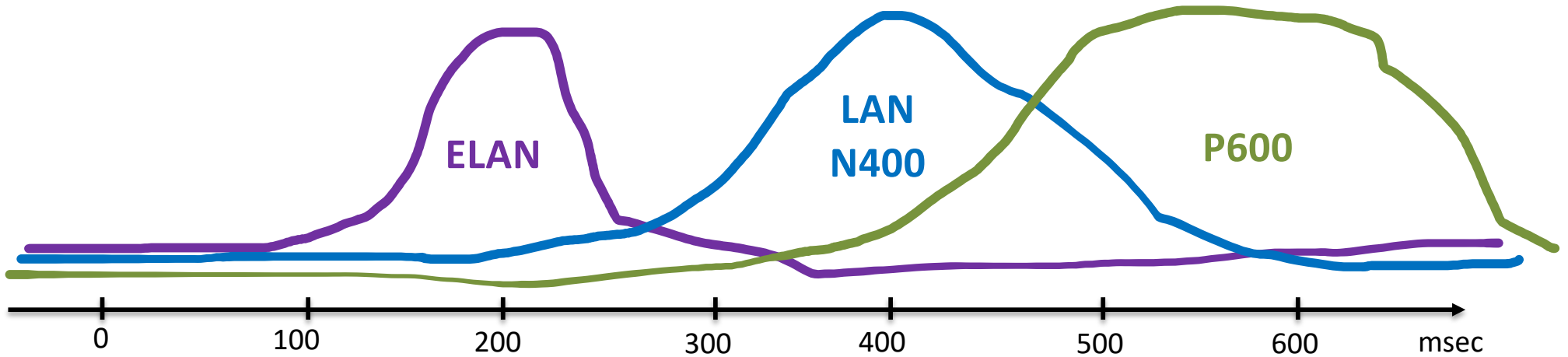
SYNTACTIC KNOWLEDGE

How syntactic categories combine ("phrase structure")

Case and agreement

Reanalysis

SEMANTIC KNOWLEDGE?

very few violation studies

WORLD KNOWLEDGE

Plausibility

NB: this EEG literature typically calls world knowledge violations "semantic" violations

CNL Semantics vs. world knowledge in prefrontal cortex

Liina Pylkkänen, Bridget Oliveri, and Andrew J. Smart
*Department of Linguistics and Department of Psychology, New York
University, NY, USA*

- ## Semantic constraints on verbal un-prefixation

  - Generally reversative meaning: I unbuttoned my jacket.

    I unbraided my hair.

  - But very picky about its verbal stems: I unleft for work. ☹

    I unflushed the toilet. ☹

    I unswitched the lightbulb. ☹

  - Verbal –un wants its verbal stem to describe an event that has a complex structure (process leading to a result; Dowty, 1979) and that describe actions which put something "into a more marked or specialized state" (Covington, 1981; Horn, 2002).
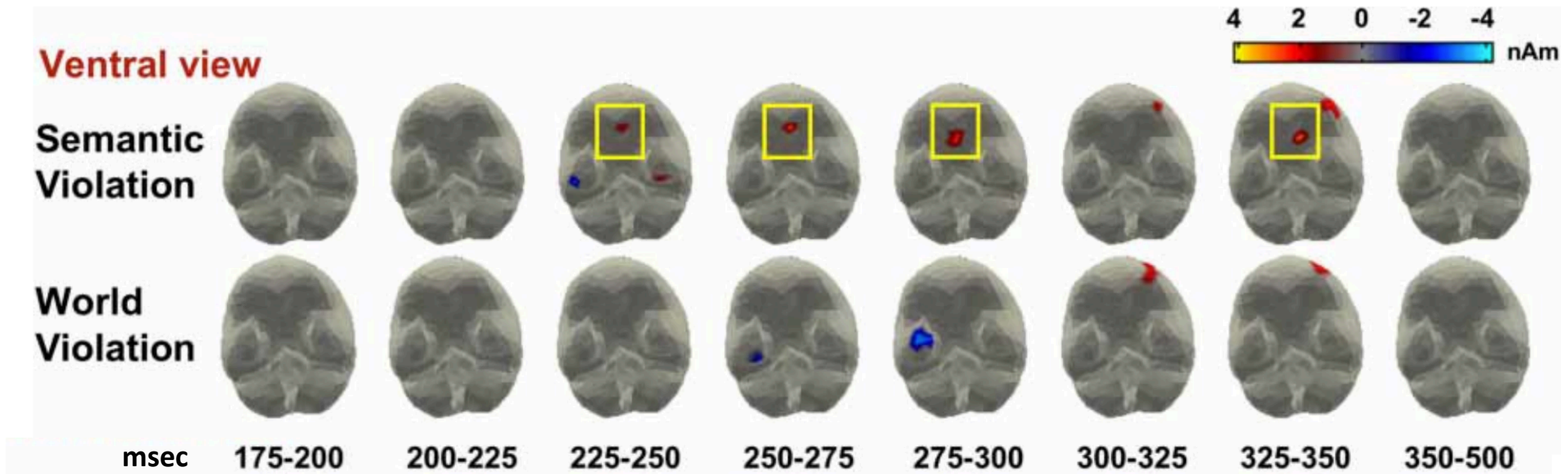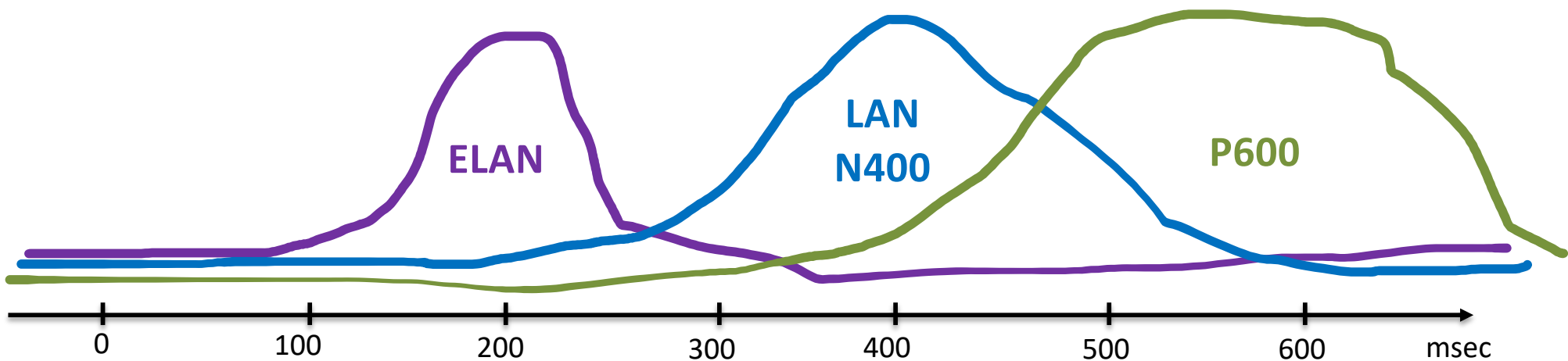
Semantics vs. world knowledge in prefrontal cortex

Liina Pylkkänen, Bridget Oliveri, and Andrew J. Smart

Department of Linguistics and Department of Psychology, New York University, NY, USA

ELAN

LAN
N400

P600

0   100   200   300   400   500   600   msec

SYNTACTIC
KNOWLEDGE

How syntactic
categories combine
("phrase structure")

Case and
agreement

Reanalysis

SEMANTIC
KNOWLEDGE?

250-300ms

WORLD
KNOWLEDGE

Plausibility

- ➤ Violation approach has been a popular way to study **the brain's sensitivity to different types of linguistic knowledge**.

- ➤ Can yield valuable information about **how serial/parallel processing is**.

- ➤ Large literature has investigated the **role of prediction** in violation effects.

  - o Does the effect reflect the ill-formedness of the expression or that you were strongly expecting something else?

  - o For example for the ELAN, we know that it largely goes away if the offending category does not also violate a prediction (Lau et al., 2006).

  - o N400 primarily reflects the predictability of the word (Nieuwland et al., 2020).

- ➤ Limitation: Violation effects **may not reflect** computations that occur during the the processing of **"normal" well-formed language**.

- ➤ To uncover the neural bases of syntax and semantics, we will **need to vary** syntactic and semantic **processing within well-formed expressions**.