In comprehension, the language processor makes continuous predictions about upcoming material.

The predictions are based both on syntax and semantics.

Complete the following sentence
- **Yesterday, I saw Max’s _____ .**
- **Max’s sets up an expectation for a noun.**

Complete the following sentence
- **When the lights turned off, the room became _____ .**
- **This context sets up an expectation for a specific adjective, dark.**

When the predictions of the processor are not met, the brain reacts in robust ways.

Electrophysiological research on syntax has largely focused on mapping the time course of the brain’s reactions to different types of ungrammaticality/ill-formedness. Ungrammaticality is always surprising for the brain, since the brain never predicts ungrammaticality.
Violation paradigms

- The success of a process is manipulated, instead of its presence or computational demands.

- EEG measurement at *of* (i.e., *of* is the “target”):
  - *of can be integrated:*
    The scientist saw Max’s proof *of* the theorem.
    **VS.**
  - *of cannot be integrated:*
    The scientist saw Max’s *of proof the theorem.*

- The grammatical condition is considered the control condition and the ungrammatical the test condition.

- Effects are always reported in terms of increased amplitudes for the ungrammatical condition.

- So this manipulation does not measure the effort associated with successful processing. Instead it measures
  - the surprise response to ungrammaticality
  - and, often, subsequent effort associated with trying to fit the ill-formed element to the structure (nevertheless).
### Friederici model

- **Word category violation**
  - The scientist saw Max’s *of* proof the theorem.
  - Noun expected, preposition encountered

- **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

- **“Garden paths”**

  - The judge believed the defendant *was* lying.
  - *the defendant* has been analyzed as an object but *was* forces reanalyzing it as a subject.

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1. 150-200ms: ELAN (“early left anterior negativity”)
2. 300-500ms: LAN (“left anterior negativity”)
3. ~600ms: P600
**ELAN (150-200ms)**

*Hypothesized function: word category identification*

- Early Left Anterior Negativity.

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Das Baby wurde gefüttert

The baby was fed

Das Baby wurde im gefüttert

The baby was in the fed

---

Friederici, Pfeifer and Hahne (1993, 1996)
Other contrasts eliciting an ELAN

- **Neville, Nicol, Barss, Forster & Garrett, 1991:**
  - The scientist criticized Max’s *of* proof the theorem.
  - The scientist criticized Max’s proof *of* the theorem.
  - **Visual stimulus presentation**
  - **phrase structure violation elicited an N125 at left anterior electrodes**
ELAN is sensitive to prediction, not ungrammaticality (Lau et al., 2006, *Brain & Language*)

- Two ungrammatical sentences:
  
  (a) *Although the bridesmaid kissed Mary, she did not kiss Dana’s *of* the bride.
  
  (b) *Although Erica kissed Mary’s mother, she did not kiss Dana’s *of* the bride.

  - In (a), the ungrammatical *of* violates a prediction for a noun.
  - In (b), *of* is ungrammatical, but doesn’t violate a strong prediction (sentence would be fine if it ended at Dana’s).

![Enhanced ELAN for (a)](image)
How can word category be the first thing you recognize about a word?

- How can you know that *cat* is a noun before you access its meaning?
- Dikker, Rabagliati, & Pylkkänen (2009) MEG study:
  - You can recognize the syntactic category of a word before accessing its meaning only if the word’s category is somehow easily perceivable. Function morphemes are salient, easily perceivable, category markers.
  - Function morphemes are highly frequent and highly important for syntactic parsing. Behavioral work suggest they are recognized much earlier than open class items.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Expected Example sentence</th>
<th>Unexpected Example sentence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Preposition</td>
<td>The boys heard Joe's stories about Africa.</td>
<td>The boys heard Joe's about stories Africa.</td>
</tr>
<tr>
<td>Participle</td>
<td>The discovery was reported.</td>
<td>The discovery was in the reported.</td>
</tr>
<tr>
<td>Bare stem</td>
<td>The discovery was in the report.</td>
<td>The discovery was report.</td>
</tr>
</tbody>
</table>
LAN

_Hypothesized function: integration of morphosyntactic information_

- Left anterior negativity at 300-500ms.
LAN

*Hypothesized function: integration of morphosyntactic information*

- Osterhout & Mobley (1995)
  - **Visual stimulus presentation**
  - **LAN elicited by subject verb agreement violations:**
    - The elected officials *hope* to succeed.
    - The elected officials *hopes* to succeed.
  - **But not by number or gender violations between an antecedent and a reflexive pronoun:**
    - The hungry guests helped *themselves* to the food.
    - The hungry guests helped *himself* to the food.
    - The successful woman congratulated *herself* on the promotion.
    - The successful woman congratulated *himself* on the promotion.
LAN

*Hypothesized function: integration of morphosyntactic information*

- Gunter et al (2000): grammatical gender violation does result in a LAN

(1) Sie bereist das Land auf einem kräftigen Kamel.
   She travels the_{neuter} land_{neuter} on a strong Camel

(2) Sie bereist den Land auf einem kräftigen Kamel.
   She travels the_{masc} land_{neuter} on a strong Camel

- Visual stimulus presentation.
LAN

Hypothesized function: integration of morphosyntactic information

- Coulson et al. (2000):
  - LAN for pronoun case and verb agreement errors.
  - Visual.

  *Pronoun case*

  5a. The plane took *we* to paradise and back.
  5b. The plane took *us* to paradise and back.
  6a. Ray fell down and skinned *he* knee.
  6b. Ray fell down and skinned *his* knee.

  *Verb agreement*

  7a. Every Monday he *mow* the lawn.
  7b. Every Monday he mows the lawn.
  8a. They *suns* themselves on the beach.
  8b. They sun themselves on the beach.
P600

_hypothesized function: syntactic reanalysis and repair_

- Slow positive shift at 200-800ms.
- (E)LAN is generally followed by a P600.
Brain Potentials Elicited by Garden-Path Sentences: Evidence of the Application of Verb Information During Parsing

Lee Osterhout, Phillip J. Holcomb, and David A. Swinney

Event-related potentials were recorded from 13 scalp locations while participants read sentences containing a syntactic ambiguity. In Experiment 1, syntactically disambiguating words that were inconsistent with the "favored" syntactic analysis elicited a positive-going brain potential (P600). Experiment 2 examined whether syntactic ambiguities are resolved by application of a phrase-structure-based minimal attachment principle or by word-specific subcategorization information. P600 amplitude was a function of subcategorization biases rather than syntactic complexity. These findings indicate that such biases exist and can influence the paper under certain conditions and that P600 amplitude is a function of the perceived syntactic well-formedness of the sentence.
P600

hypothesized function: syntactic reanalysis and repair

- Garden path:
  - The judge charged the defendant was lying.

- Garden path can be avoided by inserting *that*, which leads to a sentential analysis of the object of believe:
  - The judge charged that the defendant was lying.
**P600**

*Hypothesized function: syntactic reanalysis and repair*

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**Figure 2.** Grand average event-related brain potentials (averaged over participants and items) to the final three words in unreduced and reduced sentences in Experiment 1 recorded over parietal (Pz) site. Onset of the postverbal noun (e.g., *defendant*) is at 0 ms (vertical calibration bar). Onsets of subsequent words are indicated with an arrow. Each mark on the horizontal axis represents 100 ms. Negative voltage is plotted up.
Does the P600 play any role in “normal” syntactic processing?

Kaan et al. 2000:

**Gap:**
Emily wondered *who* the performer in the concert had imitated _ for the audience’s amusement.

**No gap.**
Emily wondered whether the performer in the concert had imitated a pop star for the audience’s amusement.

- P600 for *imitated* in the gapped condition.
- Evidence that the P600 is not just violation related.
ERP experiments on syntactic violations have provided Abundance of data on the brain’s time course of detecting different types of grammatical errors.

In particular, they have provided evidence for a so-called “syntax-first” model, where a certain amount of structural computation is performed before word meanings are accessed (at the N400 stage).

However, we do not have psycholinguistic models for what happens in the mind/brain when we encounter ungrammatical expressions -- linguistic theories are theories of the computations that take place for well-formed structures.

Consequently, interpreting violation effects in terms of the brain’s computations is tricky at best.

- All we get to say is that a particular ERP effects is associated with a certain type of stimulus manipulation.