Time for prediction?
The effect of presentation rate on predictive sentence comprehension during word-by-word reading

Edward W. Wlotko and Kara D. Federmeier

Presented by Tyler Klement
Introduction

- The brain and nervous system don’t compartmentalize like one might expect:
  - "The ability to learn and exploit regularities in the environment is a fundamental feature of the nervous system (Bar, 2011)."
  - It uses combination of signals from environment to learn
  - Results/"side-effects" evident in linguistic processing
Introduction

- When the brain detects **context** (in several possible manners) it can prepare for **incoming messages**

  - "The use of contextual cues in the language stream can allow the pre-activation of features of likely upcoming input at multiple levels and grains of representation (see, e.g., Kutas, DeLong, & Smith, 2011)."

- **ERP** studies are beneficial due to the **multitasking** nature of the brain

  - They provide insight to the background activities during language processing
Semantic Relatedness

- **Evidence** of this overlapping of *brain activity and resources* seen in effects of *semantic relatedness* on linguistic processing

- Two studies dealing with this:
  - Time for Prediction? (previously mentioned) 2015
  - A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing, by Kara D. Federmeier and Marta Kutas, 1999
    - Provided groundwork for the above study
Some quick terminology

• **Semantic relatedness:**
  - In other studies, this has meant associatively or thematically related
    • E.g. key and lock (associative), or umbrella and rain (thematic)
  - In the present two studies and still others, it’s taxonomic; items share feature information
    • E.g. chess and checkers, hammer and saw, helicopter and plane
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Introduction

• 1999 study by Kara D. Federmeier and Marta Kutas on:

  ▫ long-term memory’s **semantic structure** and effects on **incoming linguistic input**

  ▫ using EEG measurements of **ERPs**, focusing on the occurrence of **N400s**.

• Compared N400s of unexpected exemplars for **within-category** violations vs. **between-category** violations
Some quick terminology

- **Expected exemplar:** the expected word to complete a sentence
  - Average cloze probability was 0.74
  - Plausibility rating (in the 1999 study) of 95.6%

- **Within-category violation:** a word different from the expected word but still fitting to the context and semantically related to the expected word – “palms/pines”
  - Average cloze probability was 0.004
  - Plausibility rating (in the 1999 study) of 28.3%

- **Between-category violation:** a word different from the expected word but still fitting to the context, removed by at least one category in semantic relatedness – “palms/tulips”
  - Average cloze probability was 0.001
  - Plausibility rating (in the 1999 study) of 15.3%
Some quick terminology

• **Long-term memory**: memory encoded semantically

• **Short-term memory**: memory encoded acoustically (Baddeley 1966)

• **ERP**: Event Related Potential. Loosely termed, the unit of measurement for brain activity.

• **Cloze probability**: given a sentence fragment and a word to complete it, the proportion of people who would select that word (Taylor, 1953)
Refresher: What is the N400?

- **ERP** effect elicited by *each word* in a sentence

- Amplitude *reduces* as information is *added* (Van Petten & Kutas, 1990)

- **Amount** of reduction is correlated to *cloze probability*

- **Negative** going

- Peaks at around *400 ms* after stimulus onset

- Not sensitive to *negation* (Fischler et al. 1983)
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing
- Introduction

Constraints

Study also focused on effect of level of contextual constraints to best completion

- **High constraint** sentences had only one preferred ending; they were “efficient”, more easily completed
  - Expected exemplar average cloze probability of 0.896

- **Low constraint** sentences had a preferred ending with several close competitors, thus a wider scope for easier completion of less predictable items
  - Expected exemplar average cloze probability of 0.588
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing
- Method

Materials:
- 132 pairs of sentences ending with 3 possible, picturable, target words
  - Expected target exemplar
    - Highest cloze probability word
  - Within-category violation
    - Cloze probability < 0.05
  - Between-category violation
    - Close probability < 0.05

- First sentence gave context

- Second sentence, independent, was plausible for any of the 3 endings

- No lexical associations of any other words to target word in second sentence
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Method

Examples:

High constraint sentence pairs (single preferred expected exemplar):

- “Checkmate,” Rosaline announced with glee.
- She was getting to be really good at chess/monopoly/football.
- I guess his girlfriend really encouraged him to get it pierced.
- But his father sure blew up when he came home wearing that earring/necklace/lipstick.
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Method

Examples:

Low constraint sentence pairs (average expected exemplar cloze probability 0.588):

- Fred went to the pantry and got out the homemade jelly his grandmother had brought.
- Fifteen minutes later, however, he was still struggling to open the jar/box/zipper.
- Muffie, old Mrs. Smith’s pet, wears a bow on the puff of fur on its head.
- I don’t know how anyone could want to own a poodle/dalmatian/donkey.
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Method

Plausibility ratings

<table>
<thead>
<tr>
<th></th>
<th>High constraint</th>
<th>Low constraint</th>
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</thead>
<tbody>
<tr>
<td>Expected exemplars</td>
<td>97.7%</td>
<td>93.5%</td>
</tr>
<tr>
<td>Within-category violations</td>
<td>23.6%</td>
<td>30.2%</td>
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<tr>
<td>Between-category violations</td>
<td>11.9%</td>
<td>18.7%</td>
</tr>
</tbody>
</table>
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Method

Examples:

Items rotated roles between expected, within-category, and between-category:

- They wanted to make the hotel look more like a tropical resort.
- So along the driveway, they planted rows of palms/pines/tulips.
- The air smelled like a Christmas wreath and the ground was littered with needles.
- The land in this part of the country was just covered with pines/palms/roses.
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Method

Examples:

Items rotated roles between expected, within-category, and between-category:

- The gardener really impressed his wife on Valentine’s Day.
- To surprise her, he had secretly grown some roses/tulips/palms.
- The tourist in Holland stared in awe at the rows and rows of color.
- She wished she lived in a place where they grew tulips/roses/pines.
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Method

Participants:
18 students, mean age of 20

Procedure:
- The first context sentence was displayed on screen in full.
- Participant pressed button
- Second sentence came word-by-word
- Brain activity was measured using an EEG electro-cap
- Participants quizzed on their memory of the sentences in the end, to ensure they were paying attention
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Results
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Results
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Results

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*Expected Exemplars*

*Within Category Violations*

*Between Category Violations*
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Results

HIGH CONSTRAINT

LOW CONSTRAINT

--- Expected Exemplars

----- Within Category Violations

---------- Between Category Violations
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Results
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Results

• N400 responses were generated by unexpected exemplars
• Larger amplitudes were generated for these scenarios:
  ▫ Between-category violations (larger)
    • vs.
  ▫ Within-category violations (smaller)

and

• Within-category with low constraints (larger)
  • vs.
• Within-category with high constraints (smaller)
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing

- Discussion

This study revealed:

- Significant overlap between processing of context and semantic similarity

- **Semantic relatedness** apparently facilitates easier comprehension of within-category violations

- Plausibility and N400 don’t coincide as one might expect:
  - For expected and between-category violations:
    - No difference
  - For **within-category violations**:
    - **More** plausible violations in low constraint – larger N400
    - vs.
    - **Less** plausible violations in high constraints – smaller N400
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Discussion

Results from testing constraints tell us:

- **Plausibility** seems to lend less to comprehension than does **semantic relatedness**

- More **semantic** facilities are required for comprehending higher **constraining** contexts

- These thus aid in perceiving **semantically related violations**

- Due to the relation to long-term memory, this is argued to reflect **memory structure**.
A Rose by Any Other Name: Long-Term Memory Structure and Sentence Processing - Discussion

Conclusion:

Context and long-term memory structure are mutually dependent and contribute jointly to processing when reading
Time for prediction?

Introduction

• Used knowledge from previous study about semantic relatedness

• Focused on whether N400 patterns varied due to presentation rate and having less time for prediction

• Hypothesis: Faster pace will reduce semantic correlations and their effects on N400 reduction
Time for prediction?

Method

Subjects:
- 24 right-handed students
  - mean age of 19.2 years

Materials:
- 33 two-sentence mini-scenarios
  - Presumably extracted from the 132 scenarios in the 1999 study
Time for prediction?

Method

Procedure – similar to 1999 study:

• The first context sentence was displayed on screen in full.

• Participant pressed button

• Second sentence came word-by-word
Time for prediction?

Method

Procedure – similar to 1999 study:

- **Key difference:** in this study, the word-by-word sentences were separated into two blocks
  - **Block 1:** 200 ms per word and 300 ms between words, this is normal timing as with previous studies (2 words/sec)
  - **Block 2:** 200 ms per word and 50 ms between words (4 words/sec)

- **Brain activity** was measured using an EEG electro-cap

- Participants quizzed on their memory of the sentences in the end, to ensure they were paying attention
Time for prediction?

Results

Grand average ERPs

500ms SOA

— Expected

—-. Expected

--- Between-Category

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Time for prediction?
Results

Grand average ERPs

250ms SOA

--- Expected  --- Within-Category  --- Between-Category
Time for prediction?

Results

• When the fast rate was presented first, there was no similarity effect (no reduction of N400 amplitude from within-category violations)

• When normal rate was presented first, similarity effect held into the fast rate testing
Time for prediction?

Results

![Graph showing N400 semantic similarity effect (μV) for different time intervals and conditions.](image)
Time for prediction?
Discussion

• Results indicated that **timing** can affect **predictive comprehension**

• **Speeded** presentation rates seem to result in a shift to **non-predictive** mode of comprehension

• However, **prior experience** with prediction in the **same environment** may facilitate the ability to predict in **higher stress/speed** circumstances

• Therefore **predictive comprehension** mechanisms seem **malleable**
Time for prediction?

Conclusion

• Prediction important for processing, but not always present

• The discovery of the brain’s ability to adapt to such situations as those where it must predict from context, and those where it can more easily predict when primed, or otherwise switch to other comprehension methods, adds to the many other recent findings about the brain’s surprisingly agile and elastic nature
Thank you!
References


References


• Wlotko, E. W., & Federmeier, K. D., Time for prediction? The effect of presentation rate on predictive sentence comprehension during word-by-word reading, Cortex (2015), http://dx.doi.org/10.1016/j.cortex.2015.03.014