Structure and Meaning

(Some) Recent Research in Syntax & ~Semantics
Hello!

My name is

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Please ask questions anytime

(there will also be lots of time at the end)
The slides will be shared with your instructor afterwards
Meaning

isn’t just understanding “the words on the page,” but is heavily influenced by context.
Intension

**bicycle**

/ˈbaɪsəkl/  

*noun*

noun: bicycle; plural noun: bicycles

1. a vehicle composed of two wheels held in a frame one behind the other, propelled by pedals and steered with handlebars attached to the front wheel.

*synonyms:* cycle, two-wheeler, pedal cycle;  More
Semantics vs Pragmatics

meaning out of context
Semantics vs Pragmatics

meaning within context

meaning out of context
Semantics vs Pragmatics
Structure

is connected to & intertwined with meaning.
Measuring Brain Waves

**EEG**
*electroencephalogram*

the **experiment/method** to record brain activity

yields raw data which we can “distill” for information on **ERPs**

**ERP**
*event-related potential*

“averaged” neural responses to events

interested in different spikes/dips - **components** in the data we get from an **EEG experiment**
EEG Setup
What is EEG Measuring?
What is EEG Measuring?

Adapted from the Institute for Learning & Brain Sciences at the University of Washington, here
Trials

- participant reads/listens to sentence
- we measure their **neural response** throughout
van Berkum et al. 2008, Fig. 3, p. 586

Kutas & Federmeier 2007, Fig. 23.1, p. 390
What Triggers ERP Responses?

- **everything!**
  - pictures, words, gestures, sounds,…
- **cognitive processes**
  - analysis, memory retrieval, etc.

what we are looking for:

**things that trigger a neural response that is substantially different from the others**

Kutas & Federmeier 2007
ERP Components have Names - The N400

- semantic anomalies
- less predictable/expected items within a structure/sentence

Kutas & Federmeier 2007

van Berkum et al. 2008

N400

negative voltage difference peaking around 400ms after stimulus onset
ERP Components have Names - The P600

- agreement violations, wrong inflection or phrase structure,...
- syntactic ambiguities, dispreferred syntactic structures, syntactically complex structures

Kutas & Federmeier 2007

B. Osterhout & Holcomb, 1992

Positive voltage difference peaking around 600ms after stimulus onset

Kuperberg 2007
Let’s look at some actual research
A Wild P600 Appeared!

The broker persuaded …

has (at least) two interpretations:
The P600 Makes Syntax Visible!

preferred/ expected

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

Osterhout & Holcomb 1992, Fig. 1, p. 787
The Broker Persuaded...

Osterhout & Holcomb, 1992

-2µV

Cz

1 sec

P600

The broker hoped to sell the stock.
The broker persuaded to sell the stock.

Kuperberg 2007
speakers/listeners know:

- what is more **common**
- what is more **expected/likely**

syntax is “in our heads”
Context can Override Semantics

When Peanuts Fall in Love: N400 Evidence for the Power of Discourse

Mante S. Nieuwland and Jos J. A. Van Berkum

Abstract

In linguistic theories of how sentences encode meaning, a distinction is often made between the context-free rule-based combination of lexical–semantic features of the words within a sentence ("semantics"), and the contributions made by wider context ("pragmatics"). In psycholinguistics, this distinction has led to the view that listeners initially compute a local, context-independent meaning of a phrase or sentence before relating it to the wider context. An important aspect of such a two-step perspective on interpretation is that local semantics cannot initially be overruled by global contextual factors. In two spoken-language event-related potential experiments, we found that the N400 effect, a sign of interpretive problems, was often absent when the anomalies were embedded in a supportive context (e.g., a girl talking to a clock about his depression), this N400 effect disappeared completely. Moreover, given a suitable discourse context (e.g., a story about an amorous peanut), animacy-violating predicates ("the peanut was in love") were actually processed more easily than canonical predicates ("the pea-
"The peanut was in love."

triggers an **N400**

however:

if embedded in a context where *peanut* is [+ANIMATE], the **N400** is *triggered by salted*!
Context can Override Semantics

A woman saw a dancing peanut who had a big smile on his face. The peanut was singing about a girl he had just met. And judging from the song, the peanut was totally crazy about her. The woman thought it was really cute to see the peanut singing and dancing like that. The peanut was salted/in love, and by the sound of it, this was definitely mutual. He was seeing a little almond.

salted
[dashed / N400]
in love
[solid / no N400]

Nieuwland & Van Berkum 2006, Fig. 6
Context can Override Semantics

context matters **immediately & can override the default semantic features** (like [+ANIMATE]) **of a word**

they matter in comprehension & **aren’t just “made up”**
**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.*

**morpho-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 anomaly:** 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.*

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).
The P600 is triggered by:
- syntactic errors produced by a native speaker

There is no P600 for:
- syntactic errors in foreign-accented speech
- native speech after exposure
The Listener’s Internal State: Political / Moral Views

Research Article

Right or Wrong?
The Brain’s Fast Response to Morally Objectionable Statements

Jos J.A. Van Berkum,1,2,3 Bregje Holleman,4 Mante Nieuwland,1,5 Marte Otten,1,6 and Jaap Murre1

1Department of Psychology, University of Amsterdam; 2Max Planck Institute for Psycholinguistics, Nijmegen, The Netherlands; 3Donders Institute, Centre for Cognitive Neuroimaging, Radboud University Nijmegen; 4Utrecht Institute for Linguistics/OTS, Utrecht University; 5Department of Psychology, Tufts University; and 6Department of Psychology, Harvard University

### The Listener’s Internal State: Political / Moral Views

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<th>~ liberal / progressive</th>
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Inferences about the Speaker

The Neural Integration of Speaker and Message

Jos J. A. Van Berkum\textsuperscript{1,2,3}, Danielle van den Brink\textsuperscript{3,4}, Cathelijne M. J. Y. Tesink\textsuperscript{3,4}, Miriam Kos\textsuperscript{3}, and Peter Hagoort\textsuperscript{1,3,5}

Abstract

When do listeners take into account who the speaker is? We asked people to listen to utterances whose content sometimes did not match inferences based on the identity of the speaker (e.g., “If only I looked like Britney Spears” in a male voice, or “I have a large tattoo on my back” spoken with an upper-class accent). Event-related brain responses revealed that the speaker’s identity is taken into account as early as 200–300 msec after the beginning of a spoken word, and is processed by the same early interpretation mechanism that constructs sentence meaning based on just the words. This finding is difficult to reconcile with standard “Gricean” models of sentence interpretation in which comprehenders initially compute a local, context-independent meaning for the sentence (“semantics”) before working out what it really means given the wider communicative context and the particular speaker (“pragmatics”). Because the observed brain response hinges on voice-based and usually stereotype-dependent inferences about the speaker, it also shows that listeners rapidly classify speakers on the basis of their voices and bring the associated social stereotypes to bear on what is being said. According to our event-related potential results, language comprehension takes very rapid account of the social context, and the construction of meaning based on language alone cannot be separated from the social aspects of language use. The linguistic brain relates the message to the speaker immediately.

Inferences about the Speaker

- **male/female**: "If only I looked like Britney Spears in her latest video"
- **upper-/lower-class**: "I have a large tattoo on my back"
- **young child/adult**: "Every evening I drink some wine before I go to sleep"

[Graph showing EEG waves labeled P3, Pz, and P4 over time]
<table>
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<tr>
<th>Authors</th>
<th>Topic/Example</th>
<th>Findings</th>
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<tr>
<td>Osterhout &amp; Holcomb 1992</td>
<td><em>The broker persuaded…</em>; dispreferred syntactic structures</td>
<td>dispreferred structures trigger <strong>P600</strong></td>
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<tr>
<td>Nieuwland &amp; van Berkum 2006</td>
<td>[+ANIMATE] peanuts</td>
<td>context can “override” semantics; <strong>N400</strong> for <em>salted</em></td>
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<td>Hanulíková et al. 2012</td>
<td>errors in native &amp; non-native speech</td>
<td>in accented speech, <strong>no P600</strong> in response to syntactic errors</td>
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<tr>
<td>Van Berkum et al. 2009</td>
<td>listener’s views &amp; morally objectionable statements</td>
<td><strong>N400</strong> for statements clashing with listener’s views</td>
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<td>Van Berkum et al. 2008</td>
<td>inferences about the speaker (gender, age,...)</td>
<td><strong>N400</strong> if statement doesn’t match attribute inferred about speaker</td>
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</table>
What does that mean...?

we can “see:”

- syntax & meaning
- preferred / dispreferred structures
- semantic/pragmatic mismatches

meaning:

- features & syntactic structures are not just made up / theoretical issues
people’s own moral / political views
what people infer about the speaker
■ gender, age, native speaker,...
for more, see e.g. Boland & Queen 2016, Havas et al. 2007, Van den Brink et al. 2010

very broadly:
world knowledge & context
■ immediately
■ gets updated with new/incoming information
for more, see e.g. Hagoort et al. 2004, Kamide et al. 2003, Sedivy et al. 1999, Tanenhaus et al. 1995, Traxler 2014
Disgust Sensitivity

(early results from current research at our lab)
... Disgust Sensitivity!? 

- the “emotional tag” of the *Behavioural Immune System*

- general cognition ➔ out-group stereotyping ➔ ~
  political/moral views

- shouldn’t it affect language comprehension too?
Pupillometry

- increase in pupil size: more
  - cognitive effort
  - mental workload
  - attention

- not mediated by conscious responses (like EEG)
- no task required (like EEG)

Gingras et al. 2015, Goldinger & Papesh 2012, Rondeel et al. 2015, Winn et al. 2018
Pupillometry: Disgust Sensitivity

I always wear hair bands to hold in my bangs.
Summary

you can “see” when a listener experiences something unexpected in ERP signatures / changes in pupil size

- error, clash, dispreferred structure,...
- e.g. features aren’t just made up or “theoretical”
Summary

the listener’s **internal state** is a factor in “how they understand”

- political views, (disgust sensitivity),...
meaning isn’t just “words on the page”

context is considered immediately

such as:

- inferences about the speaker (age, gender, native speaker status,...)
- changes to [+/-ANIMATE] for an entity
Thanks!

Any questions?

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