Prosody and the brain I: Sentence comprehension and reference

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Overview

Introduction EEG and ERPs
  Why use EEG to study prosody?
Prosody & sentence comprehension
  ERPs show importance of prosodic phrasing
  Prosodic boundaries and pitch accents
  Superfluous vs. missing boundaries
Prosody & reference
  Pitch accents in referential contexts
  Superfluous vs. missing accents

Session II: turn-taking (not all brain-imaging)
This afternoon: practical issues, methods, analysis
Introduction: EEG

Electro-encephalography

• Summation of synchronous activity of many neurons with similar spatial orientation
• Raw EEG not very informative: artifacts (e.g., eye blinks), ‘brain waves’ (e.g., alpha), sleep stages
Introduction: ERPs

Event-related potentials

• Time-locked to ‘event of interest’
• Averaging: cancels out noise
Introduction: ERPs

Example: N400
I take my coffee with cream and... sugar ———
dog ———

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5 uV

400 ms

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Unexpected words

Expected words

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e.g., Kutas & Hillyard (1980); Federmeier & Laszlo (2009)
Introduction: ERPs

Example: P600

- syntactic violations
- difficult sentences
- locally ambiguous sentences
- ...

e.g., Osterhout & Holcomb (1992)
Why study prosody with ERPs?

• Difficult to measure on-line comprehension in the auditory modality
  – eye-tracking needs visual display
• EEG/ERPs: no additional task necessary
  – But: task is often used!
• Allows studying the processing of prosodic phenomena themselves
Prosody & Sentence Comprehension
Prosodic phrasing

Research on sentence comprehension mainly based on reading-data: easy to control

But: spoken language contains prosody

Can prosody help sentence comprehension?
- Prosodic phrasing: defines separate parts of sentences
- Helpful for (locally) ambiguous sentences: structure unclear
ERP research on prosody

German locally ambiguous sentences:

Peter verspricht Anna zu arbeiten # und das Büro zu putzen.
Peter verspricht # Anna zu entlasten # und das Büro zu putzen.
Peter verspricht # Anna zu arbeiten # und das Büro zu putzen.

Results

1. ERP component related to prosodic phrasing
2. Processing difficulties for prosodic mismatch

Steinhauer, Alter, & Friederici (1999)
Closure Positive Shift

Peter verspricht Anna zu arbeiten # und das Büro zu putzen.

Peter verspricht # Anna zu entlasten # und das Büro zu putzen.

Closure Positive Shift (CPS) at prosodic boundaries

Steinhauer, Alter, & Friederici (1999)
Prosodic phrasing helps

Peter verspricht Anna zu arbeiten # und das Büro zu putzen.
Peter verspricht # Anna zu entlasten # und das Büro zu putzen.
Peter verspricht # Anna zu arbeiten # und das Büro zu putzen.

Biphasic N400/P600 effect at verb
Prosody-induced processing difficulty
But: no control

Steinhauer, Alter, & Friederici (1999)
Dutch follow-up

Dutch locally ambiguous sentences:

De leerling bekende de leraar te hebben gespiekt...

*The pupil confessed the teacher to have cheated...*

“The pupil confessed to the teacher to have cheated...”

De leerling bekende de leraar te hebben opgesloten...

*The pupil confessed the teacher to have locked up...*

“The pupil confessed to have locked up the teacher...”

**Subject-control:** *The pupil* (subject of *confessed*) is always understood subject of second verb: *the pupil cheats* and *the pupil locks up*
Dutch follow-up

Dutch locally ambiguous sentences:
De chirurg adviseerde de vrouw te slapen...
The surgeon advised the woman to sleep ...
“The surgeon advised the woman to sleep...”

De chirurg adviseerde de vrouw te ondersteunen...
The surgeon advised the woman to support ...
“The surgeon advised [someone] to support the woman...”

Object- control: Object of advised is understood subject of second verb:
– the woman sleeps
– [someone] is object of advised and supports the woman

Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs (2010)
Prosodic phrasing

EEG experiment: 4 conditions (controlled)
De chirurg adviseerde de vrouw te slapen...
De chirurg adviseerde de vrouw te ondersteunen...
De chirurg adviseerde # de vrouw te slapen..
De chirurg adviseerde # de vrouw te ondersteunen...

Separate analyses for subject- and object-control

Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs (2010)
Results subject-control

- N400 effect for prosody mismatch
- same result without boundary

Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs (2010)
Results object-control

De chirurg adviseerde de vrouw te slapen...
De chirurg adviseerde de vrouw te ondersteunen...
De chirurg adviseerde # de vrouw te slapen...
De chirurg adviseerde # de vrouw te ondersteunen...

- No difference without boundary
- N400 for boundary mismatch

=> prosodic boundary affects parsing

Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs (2010)
Phrasing and accents

Grouping by pitch accents

Q1: Who died?
Q2: What happened?

A: JOHNson died. (see Gussenhoven, 1999; cf. Selkirk, 1984)

• Pitch accent on Johnson can project focus to died because
  - words are adjacent
  - noun is argument (e.g. subject or object) of verb

• Hypothesis: if broad focus assumed
  - accented noun projects focus to adjacent unaccented verb
  - noun has to be an internal argument of that verb

Bögels, Schriefers, Vonk, & Chwilla (2011c)
Results accent subject-control

De leerling bekende de leraar te hebben gespiekt...
De leerling bekende de leraar te hebben opgesloten...
De leerling bekende # de LERAAR te hebben gespiekt...
De leerling bekende # de LERAAR te hebben opgesloten...

- Broad focus (isolated sentences)
- *Teacher* accented, *lock up* deaccented
- *Teacher* projects focus to *lock up*
- *Teacher* should be interpreted as argument of *lock up*

Bögels, Schriefers, Vonk, & Chwilla (2011c)
Results accent subject-control

- same N400 effect without boundary
- N400 & positivity for mismatching prosody

=> stronger effect: accent strengthens grouping

Bögels, Schriefers, Vonk, & Chwilla (2011c)
Results accent object-control

De chirurg adviseerde de vrouw te slapen...
De chirurg adviseerde de vrouw te ondersteunen...
De chirurg adviseerde # de VROUW te slapen...
De chirurg adviseerde # de VROUW te ondersteunen...

- No significant effects
  => good-enough semantics?
  VROUW is understood subject of slapen

Bögels, Schriefers, Vonk, & Chwilla (2011c)
Missing vs. superfluous boundary

Shown that boundary affects parsing

What about absence of a boundary?

Boundary Deletion Hypothesis (Pauker et al., 2011)

• mentally deleting a boundary is costly
• mentally inserting one less so
Missing vs. superfluous boundary

When a bear is approaching the people # the dogs come running.

When a bear is approaching the people # the dogs come running. ——

=> mental deletion: larger effect

Prosodic disambiguation

When a bear is approaching the people come running. ——

When a bear is approaching the people come running. —

=> mental insertion: smaller effect

Lexical disambiguation

Is it necessarily a ‘prosodic revision’?

(Pauker, Itzhak, Baum, & Steinhauer 2011)
The traveler followed the carrier and the guide through the area.

The traveler followed the carrier # and the guide through the area. (SUPERFLUOUS)

The traveler followed the carrier # and the guide talked about the area.

The traveler followed the carrier and the guide talked about the area. (MISSING)

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Bögels, Schriefers, Vonk, Chwilla, & Kerkhofs (2013)
Summary Prosody & Sentence Comprehension

• ERP research shows that prosodic phrasing can affect listeners’ sentence comprehension
  – effects depend on the specific structure
  – pitch accent can strengthen the effect
  – prosody & good-enough semantics can overrule syntax

• Superfluous boundaries lead to stronger processing difficulties than missing ones

Review: Bögels, Schriefers, Vonk, & Chwilla (2011b)
Closure Positive Shift

Replicated for:

- Numerous languages (e.g., Bögels et al., 2010; Pauker et al., 2011)
- Pause removed (Steinhauer et al., 1999)
- No linguistic info: hummed sentences (Pannekamp et al., 2005)
- Children from about 3 years (Männel & Friederici, 2009, 2011)
- Commas in reading (e.g., Drury et al., 2016, but see Kerkhofs et al., 2008)
- Music? (e.g., Knösche et al., 2005)

What does it reflect?

- purely prosodic processing
- all aspects of prosodic phrasing: lengthening, intonation
- sometimes preceded by negativity (e.g., Pauker et al., 2011)
Use of CPS

CPS used to investigate prosody in sentence processing

Dutch locally ambiguous sentences:
The sheriff protected the farmer and the farm hand in front of the shed.
The sheriff protected the farmer # and the farm hand defended the ranch.

Use of CPS

CPS used to investigate prosody in sentence processing

1. Neutral context
2. Biasing context: When they heard that the farmer was robbed, the sheriff and the farm hand ran to the farm.

The sheriff protected the farmer and the farm hand defended the ranch.

⇒ prosodic boundary affects sentence processing immediately when encountered

Prosody & Reference
Pitch accents

- Pitch accents indicate focused information
  - given information is deaccented

ERP-study with sentences (Magne et al., 2005)

Q: Did he give a ring or a bracelet to his wife?
A1: He gave a RING to his wife.
A2: He gave a ring to his WIFE.

- Incorrect accent middle (ring) => P300 like effect
- Incorrect accent end (wife) => N400 like negativity
Pitch accents

Divergent results

• Types of accents yielding processing problems
  – missing and superfluous accents (e.g., Magne et al., 2005)
  – only missing accents (e.g., Hruska & Alter, 2004; Toepel et al., 2007)

• ERP signatures
  – positivities (P300, P600), negativities (N400, frontal negativity)
Pitch accents: reference

Color contrastive

context

“The red ball”

exp. trial

✓ “The YELLOW ball”
✗ “The yellow BALL”
✓ “The yellow ball”

Object contrastive

context

“The yellow hat”

exp. trial

✗ “The YELLOW ball”
✓ “The yellow BALL”
✓ “The yellow ball”

Display disappeared before spoken utterance
Task: Which side was the referred to object? (20%)
Pitch accents: reference

Color contrastive
context: the yellow ball
the RED ball
the red BALL
the red ball

Negativity for missing accent (red)
No effect for superfluous accent (BALL)

Object contrastive
context: the red tent
the RED ball
the red BALL
the red ball

No effect for superfluous accent (RED)
Immediate negativity for missing accent (ball)

Bögels, Schriefers, Vonk, & Chwilla (2011a)
Pitch accents: reference

**Color contrastive**
context: *the yellow ball*
- *the RED ball*
- *the red BALL*
- *the red ball*

Neutral: like matching condition
=> neutral accent on *red* sounds contrastive in this context

**Object contrastive**
context: *the red tent*
- *the RED ball*
- *the red BALL*
- *the red ball*

Neutral: like mismatching condition
=> downstepped accent on *ball*

Bögels, Schriefers, Vonk, & Chwilla (2011a)
Only missing accent leads to processing difficulty (N400?)

- accent helps integration of new information (cf. Wang et al., 2011)
- no accent: more difficult integration

Divergence with other studies (e.g., Magne et al., 2005)

- Task? Prosody judgment or not (but see Dimitrova et al., 2012)
- Stimuli: new vs. contrastive information; identical referent? (see e.g., Baumann & Schumacher, 2012)
Summary

• EEG/ERP is useful for studying on-line prosodic processing and effects of prosody on comprehension

• Sentence processing: prosodic breaks and pitch accents affect sentence comprehension
  – even overrule syntax combined with good-enough semantics

• CPS is ERP component specific for prosody

• Missing accents lead to processing difficulty
Some future directions

• Role of missing vs. superfluous prosodic phenomena

• Relative importance of prosodic cues
  – Prosodic boundaries vs. pitch accents
  – Relative strength of prosodic boundaries

• Interplay of production & comprehension
  – How consistent is production?
  – How do listeners deal with variability?
References (1)


References (2)


Thank you!

Questions?