On the Meaning of Nuclear and Prenuclear Accents

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Outline

- Background: The status of nuclear and prenuclear accents
- Previous studies on the prominence and meaning of nuclear and prenuclear accents
- A production study on the relation between informativeness and nuclear and prenuclear accents in German
Nuclear and Prenuclear Accents

- West-Germanic languages: pitch accents serve to highlight information

JOHN and MAry went to a fanTASStic PARty last night.
Nuclear and Prenuclear Accents

- Which (phonetic) parameters bring about different levels of highlighting?

- Spectral characteristics (vowels)
  - reduced
  - full

- Intensity, Duration
  - unstressed
  - stressed
    - unaccented
    - accented

- Fundamental frequency (F0)
- Position in utterance
  - prenuclear
  - nuclear

(adapted from Terken & Hermes 2000)
Nuclear and Prenuclear Accents

- **Nuclear accent** = last pitch accent in an intonation unit (only obligatory accent)

- **Prenuclear accent** = pitch accent that occurs before the nucleus within the same intonation unit
  = strictly positional definition

JOHN and MARY went to a fantAStic PARty last night.

- prenuclear
- prenuclear
- prenuclear
- nuclear
Nuclear and Prenuclear Accents

More importantly: Difference in status

- **Nuclear accent** = structural head of an intonation unit
  
  $\rightarrow$ **prosodic hierarchy**

- Decisive for the interpretation (of the pragmatic meaning/information structure) of an utterance

- But not necessarily most prominent phonetically!
Nuclear and Prenuclear Accents

David only wears a bow tie when teaching.

a) David only wears a bow tie when TEAching. (Teaching is the only situation in which he wears a bow tie...)

b) David only wears a BOW tie when teaching. (He wears nothing but a bow tie...)

(Beaver & Clark 2008)
Nuclear and Prenuclear Accents

- Misinterpretations arising from wrong assumptions about prosody of written language

Sign in the London underground (Halliday 1970):

Two possible prosodic structures:

a) *Dogs must be CARRied.*

b) *DOGS must be carried.*

Two different interpretations:

a) If you have a dog, you have to carry it.

b) Everybody has to carry a dog.
Nuclear and Prenuclear Accents

- Position of nuclear accent indicates whether broad focus reading (focus projection) is possible

  [ I'm going to BerLIN tomorrow. ]F broad (accent on last argument)

  vs.

  I'm going to Berlin [ toMORrow. ]F narrow
Nuclear and Prenuclear Accents

- Position of nuclear accent indicates
  - whether all-new reading is possible in broad focus

John has an old COTTage.

a) Last summer he reconSTRUCted the shed.
   (shed = cottage) given information = coreference

b) Last summer he reconstructed the SHED.
   (shed ≠ cottage) new information = no coreference
Nuclear and Prenuclear Accents

- Status of **prenuclear accents** is unclear
- Previous studies draw inconsistent conclusions

1) Prenuclear accents are **optional** (Gussenhoven 2015) – or **ornamental** – on prefocal (= non F-marked) elements (Büring 2007)
   
   - Who did Gus vote for?
     
     GUS VOTED [for a friend of his neighbors from LITtleville]$_F$

Prenuclear accents may be used due to general principles of **rhythmic** organization and do not reliably mark information structural distinctions (Calhoun 2010)
Nuclear and Prenuclear Accents

2) **Lower inter-transcriber agreement** for prenuclear accents
   (Ladd 2008)

3) **Low listener sensitivity** (and longer RTs) of prenuclear accents: (acoustically identical) weak accents not perceived as accents in prenuclear but in nuclear position
   (Jagdfeld & Baumann 2011)

→ supports claim that prenuclear accents are perceived as less prominent
Prominence of Pitch Accents

- What do untrained (= theory-unbiased) listeners do when asked to annotate connected speech?

- Method: *Rapid Prosody Transcription* (RPT)

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Signal-based and expectation-based factors in the perception of prosodic prominence

JENNIFER COLE, YOONSOOK MO, MARK HASEGAWA-JOHNSON

*University of Illinois*

(2010)
Prominence of Pitch Accents

- 60 read German sentences from various databases (different focus structures and information status categories)

- 28 untrained native speakers of German

- Instruction on paper (translated): “your task is to underline all words you perceive as stressed/ highlighted / important on the transcript”
Prominence of Pitch Accents

- Only declaratives with a low boundary tone
Prominence of Accents: Position and Type

Accent Position

- no accent: 2%
- postnuclear: 7%
- prenuclear: 36%
- nuclear ip: 47%
- nuclear IP: 57%

Accent Type

- low: 25%
- falling: 40%
- high: 47%
- rising: 52%
Prominence of Accents: *Random Forests*

![Graph showing variable importance for prominence of accents using Random Forests.](image-url)
Prominence of Pitch Accents

- Importance of ACCENT POSITION confirms the structural prominence of the nucleus – also for untrained listeners

- However: Sometimes the ACCENT TYPE is more important for prominence perception
Prominence of Pitch Accents

prenuclear rising accent
Prominence of Pitch Accents

more prominent

less prominent

L+H*
L*+H
H*
H+L*
H+!H*

rising accents
falling accents

Baumann & Röhr (2015)
GToBI: Grice et al. (2005)

Summer School on Intonation and Word Order, University of Graz, 17-21 September 2018
Accent Type and Meaning: Information Status

- Pierrehumbert & Hirschberg (1990, Am. Engl.)
  - Meanings of starred tones are shared among different accent types (decreasing prominence):

  - new \( H^* \) \( \rightarrow \) accessible \( !H^* \) \( \rightarrow \) given \( L^* \)
**Accent Type and Meaning: Information Status**

- **Baumann & Riester (2013):** Corpus study, probab. distribution of ATs

<table>
<thead>
<tr>
<th>RefLex combinations</th>
<th>H*</th>
<th>!H*</th>
<th>H+!H*</th>
<th>L*</th>
<th>no pitch accent</th>
</tr>
</thead>
<tbody>
<tr>
<td>r-new / l-new</td>
<td>19</td>
<td>19</td>
<td>35</td>
<td>22</td>
<td>6</td>
</tr>
<tr>
<td>r-unused / l-new</td>
<td>43</td>
<td>8</td>
<td>5</td>
<td>40</td>
<td>5</td>
</tr>
<tr>
<td>r-generic / l-new</td>
<td>30</td>
<td>12</td>
<td>14</td>
<td>34</td>
<td>10</td>
</tr>
<tr>
<td>r-bridging / l-new</td>
<td>28</td>
<td>9</td>
<td>35</td>
<td>25</td>
<td>10</td>
</tr>
<tr>
<td>r-given / l-new</td>
<td>22</td>
<td>4</td>
<td>13</td>
<td>31</td>
<td>30</td>
</tr>
<tr>
<td>r-bridging / l-accessible</td>
<td>9</td>
<td>3</td>
<td>47</td>
<td>19</td>
<td>22</td>
</tr>
<tr>
<td>r-new / l-given</td>
<td>6</td>
<td>17</td>
<td>57</td>
<td>11</td>
<td>11</td>
</tr>
<tr>
<td>r-bridging / l-given</td>
<td>4</td>
<td>38</td>
<td>16</td>
<td>46</td>
<td>46</td>
</tr>
<tr>
<td>r-given / l-given</td>
<td>16</td>
<td>4</td>
<td>13</td>
<td>66</td>
<td>66</td>
</tr>
</tbody>
</table>

*Graph showing the distribution of accent types (%)*
Accent Type and Meaning: Information Status

- Similar result in perception study on German (Röhr & Baumann 2011): Task to judge an item’s degree of givenness

![Graph showing accent types on givenness scale (in %)]
## Accent Type and Meaning: Focus

### Production

<table>
<thead>
<tr>
<th>Questions:</th>
<th>Answers:</th>
<th>target word in:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Will Norbert Dr. Bahber treffen? Does Norbert want to meet Dr. Bahber?</td>
<td>Melanie will Dr. Bahber treffen.</td>
<td>background</td>
</tr>
<tr>
<td>2. Was gibt's Neues? What's new?</td>
<td></td>
<td>broad focus</td>
</tr>
<tr>
<td>3. Wen will Melanie treffen? Whom does Melanie want to meet?</td>
<td></td>
<td>narrow focus</td>
</tr>
<tr>
<td>4. Will Melanie Dr. Werner treffen? Does Melanie want to meet Dr. Werner?</td>
<td></td>
<td>contrastive focus</td>
</tr>
</tbody>
</table>

(lit.: Melanie wants Dr. Bahber to-meet)

Mücke & Grice (2014)
Accent Type and Meaning: Focus

- Production experiment with different sizes of focus domain in German (Mücke & Grice 2014)

(Falling vs. rising onglide)

(Krüger 2009, Ritter & Grice 2015)
Prenuclear Accents and Meaning

- Common opinion: Optionality of prenuclear accents in German and English: *ornamental* accents (Büring 2007)

- Some studies show that prenuclear accents are placed consistently, irrespective of information status
  - Textually given information in narrow focus contexts (Baumann et al. 2007, Féry & Kügler 2008)
  - Topics in topic-comment structures (Braun 2006)

- However, accents displayed subtle changes in peak scaling or peak alignment, which expressed meaning differences (Braun 2006, Féry & Kügler 2008)
Prenuclear Accents and Meaning

- Givenness slightly lowers prenuclear accents in comparison with accents on new information (Féry & Kügler 2008)
Prenuclear Accents and Meaning

E.g. higher and later F0 peaks in contrastive prenuclear accents vs. non-contrastive prenuclear accents (Braun 2006)

Contrastive:

[...] Die Georgier hingegen besitzen sogar eine eigene Schrift.

(‘The Georgians, however, even have their own writing system.’)

(‘In Armenia, the Latin alphabet is used’)
Prenuclear Accents and Meaning

Non-contrastive:

[...] Ungefähr 80% der Bevölkerung sind Christen.

(‘About 80% of the population are Christians.’)

(‘In Armenia, the Latin alphabet is used’)
New Production Study

- **Motivation**: Inconsistent results of (the few) previous studies on the relation between form and function of prenuclear accents in German – plus comparison with nuclear accents in the same setup

- **Testbed**: Find out whether differences in the information status of a sentence-initial argument (prenuclear) and a sentence-final argument (nuclear) influence their prosodic realisation

- **Hypothesis**: Positive correlation between informativeness and prosodic prominence
Method – Nuclear Accents

- 28 native German speakers (23f, 5m), aged 19-58

- Presentation of 20 different mini-stories on a computer screen (*PsychoPy*)

- Task: Read out the story at a natural but swift speech rate (‘tell the story to a friend’)

- After each story, subjects had to answer a content question
Method – Nuclear Accents

- Target words: Three-syllable nouns with stress on the first syllable, mostly sonorous material

  e.g. Mandelbaum, Regenwurm, Bauernhof, Wiegenlied
  ('almond tree', 'earthworm', 'farm', 'lullaby')

- Last argument (object) in the sentence
Method – Nuclear Accents

Nach dem langen Winter freuten sich alle auf ein paar sonnige Stunden im Freien.

Im Klostergarten blühten die ersten Pflanzen.

Die Nonne hat den Mandelbaum gegossen.
### Method – Nuclear Accents

<table>
<thead>
<tr>
<th>Context 1</th>
<th>Nach dem langen Winter freuten sich alle auf ein paar sonnige Stunden im Freien.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context 2a</td>
<td>Im Klostergarten blühte der erste <em>Mandelbaum</em>.</td>
</tr>
<tr>
<td>Context 2b</td>
<td>Im Klostergarten blühten die ersten <em>Pflanzen</em>.</td>
</tr>
<tr>
<td>Context 2c</td>
<td>Die Sonne schien schon den ganzen Tag und der Schnee war endlich geschmolzen.</td>
</tr>
<tr>
<td>Context 2d</td>
<td>Der Mönch hat einen <em>Brombeerstrauch</em> gegossen.</td>
</tr>
<tr>
<td><strong>Target</strong></td>
<td>Die Nonne hat den/einen <em>Mandelbaum</em> gegossen.</td>
</tr>
</tbody>
</table>
Method – Nuclear Accents

- Each participant (28) read only one condition per story (20), resulting in five realisations of each condition per speaker

  = 560 utterances in total

14 utterances (2.5%) excluded due to hesitations or creak in target word = 546 utterances entered the analysis
Method: Analysis

- Annotation: Accent types on target words

- Measurements:
  - \textsc{duration} of target words
  - \textsc{duration} of stressed syllables
  - RMS amplitude of stressed syllables (\textsc{intensity})
  - F0 \textsc{slope} (st/ms) and \textsc{range} (st) of accented target words
  - \textsc{tonal center of gravity} (alignment and scaling) (Barnes et al. 2012)
Hypothesis: Nuclear Accent Types

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Given</td>
<td>100</td>
</tr>
<tr>
<td>Accessible</td>
<td>50</td>
</tr>
<tr>
<td>New</td>
<td>75</td>
</tr>
<tr>
<td>Contrastive</td>
<td>25</td>
</tr>
</tbody>
</table>

IfL Phonetik Köln
Results – Accent Position

- Info status has highly significant influence on ACCENT POSITION
- More accents on given than expected - but prenuclear

![Diagram showing number of cases for given, accessible, new, and contrastive contexts with prenuclear (prenuc) and nuclear (nuc) accents]
Results – Nuclear Accent Type

- Surprisingly large number of falls on new and contrastive items
Results – Phonetic parameters

- Main effect of information structure on

- **Syllable Duration**

- **Word Duration**

- **Intensity**

  but *contrastive* significantly lower
Method – Prenuclear Accents

- Target words: Two-syllable nouns with stress on the first syllable, mostly sonorous material
  
  e.g. Nonne, Maler, Junge, Lehrer ('nun', 'painter', 'boy', 'teacher')

- First argument (subject) in the sentence
<table>
<thead>
<tr>
<th>Context 1</th>
<th>Nach dem langen Winter freuten sich alle auf ein paar sonnige Stunden im Freien.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Context 2a</td>
<td>Die <em>Nonne</em> kümmerte sich um den Klostergarten.</td>
</tr>
<tr>
<td><strong>given</strong></td>
<td></td>
</tr>
<tr>
<td>Context 2b</td>
<td>Im <em>Klostergarten</em> blühten die ersten Pflanzen.</td>
</tr>
<tr>
<td><strong>accessible</strong></td>
<td></td>
</tr>
<tr>
<td>Context 2c</td>
<td>Die Sonne schien schon den ganzen Tag und der Schnee war endlich geschmolzen.</td>
</tr>
<tr>
<td><strong>new</strong></td>
<td></td>
</tr>
<tr>
<td>Context 2d</td>
<td>Der <em>Mönch</em> hat einen Brombeerstrauch gegossen.</td>
</tr>
<tr>
<td><strong>contrastive</strong></td>
<td></td>
</tr>
<tr>
<td>Target</td>
<td>Die <em>Nonne</em> hat einen Mandelbaum gegossen.</td>
</tr>
</tbody>
</table>
Method – Prenuclear Accents

- 29 native German speakers (21f, 8m), aged 19-30
- 580 utterances in total

12 utterances (2.1%) excluded due to hesitations or creak in target word

75 utterance (12.9%) excluded due to phrase breaks after target word, turning prenuclear accents into nuclear accents

= **493 utterances** entered the analysis
### Hypothesis: Prenuclear Accent Types

<table>
<thead>
<tr>
<th></th>
<th>given</th>
<th>accessible</th>
<th>new</th>
<th>contrastive</th>
</tr>
</thead>
<tbody>
<tr>
<td>number of cases</td>
<td>100</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>0</td>
<td>low</td>
<td>high</td>
<td>rise</td>
<td>0</td>
</tr>
</tbody>
</table>

**IFL Phonetik Köln**
Results – Accent Type

- Info status has no influence on **ACCENT TYPE** (and **POSITION**)
- Hardly any cases of deaccentuation but 92% rises
Results – Range

- Main effect of info structure on RANGE (and SLOPE)
- Significant increase from *given* to *new* – vs. contrastive
Results – Phonetic parameters

- Main effect of information structure on
  - TCoG (SCALING) but contrastive significantly lower
  - WORD DURATION
  - INTENSITY but contrastive significantly lower
Conclusions

- Hypothesis „positive correlation between informativeness and prosodic prominence“ only partly confirmed:

- Informativeness strongly influences the prosody of final arguments
  - Increase of nuclear accents from given to contrastive (different distribution of ACCENT POSITION)
  - But less deaccentuations on given items than expected
  - Only subtle differences in ACCENT TYPE

= Speakers make systematic use of nuclear accents to express meaning differences
Conclusions

- Only subtle influence of informativeness on initial arguments
  - Consistent marking by rising prenuclear accents (no deaccentuations of given items)
  - For rhythmic reasons after all (Bolinger’s accent of power)?
  - But effects of RANGE and SLOPE: the newer an item the steeper the rise (= the higher its prosodic prominence)

= In this respect, prenuclear accents are not just ‘ornamental’
Conclusions

- Surprising but stable result for contrastive (double focus) structures:
  - Flat hat pattern = prosodically non-prominent prenuclear and nuclear accents
  - Possible reason: contrast already expressed by parallel syntactic structure
Outlook

- Typological comparison with prenuclear (and nuclear) accents in American English (J. Cole) and Spanish (J. Hualde)

- Furthermore: to what extent does the speaking style (neutral vs. lively) affect the prosodic marking?

Thank you for your attention!
Additional Slides
Prominence of Accent Types

- Perception experiment: Do German nuclear pitch accent types (plus deaccentuation) differ with respect to their perceived prominence?

- Three relevant tonal dimensions
  1. Direction of pitch movement (rises > falls)
  2. Degree of pitch excursion (steep > shallow)
  3. Height of the starred tone (H > !H > L)
Prominence of Accent Types: Stimuli

Baumann & Röhr (2015)
Prominence of Accent Types: Procedure

- 68 native German listeners
- Web-based questionnaire
- Task: Evaluate on a Visual Analogue Scale (0-100%)

“How highlighted does the name in the following utterance sound?”

*Sie hat mit der *Lana telefoniert.*

(‘She was on the phone with Lana.’)
Prominence of Accent Types: Results

Baumann & Röhr (2015)

Sie hat mit der Lana telefoniert. ('She was on the phone with Lana.')
Accent Type and Meaning: Information Status

- Schumacher & Baumann (2010): neurolinguistic perception study
- Cognitive processing of semantically accessible information (part-whole relation)
- Measurement of event-related potentials (ERPs) while listening to stimuli (24 subjects, 90 stimulus sets)

**Context:** Sabine repariert einen alten **Schuh.** (= holonym)

**Target Sentence:** Dabei zerschneidet sie **die Sohle.** (= meronym; accessible)

![Acoustic symbols: H*, H+L*, Ø]
Accent Type and Meaning: Information Status

- Significant three-way difference in processing effort:
  - N400: $\emptyset > H^* > H+L^*$

- Least integration costs for ‘secondary accent’ H+L* as marker of ‘secondarily given’ referents

![Waveforms and EEG plots showing N400 and P3 components at different locations (C3, CZ, C4, P3, PZ).]
Tonal Center of Gravity (TCoG)

- Holistic measure that incorporates contour shape and alignment or scaling of turning points (Barnes et al. 2012)

- Reflects either a temporal value (TCoG alignment) or a pitch level (TCoG scaling) within the sampled F0 region that represents the balancing point of the area under the curve
The same shape differences simultaneously affect the location of TCoG for timing and scaling.

Slides adopted from Barnes (2017) PaPE.
**TCoG in Two Dimensions**

- **Doomed rise**: Accents sound earlier and higher

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**TCoG (alignment)**

- **TCoG (scaling)**

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**Slides adopted from Barnes (2017) PaPE**
TCoG in Two Dimensions

- **Scooped rise**: Accents sound later and lower

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Slides adopted from Barnes (2017) PaPE
Results – TCoG (Scaling)

- Main effect of info structure on TCoG (SCALING)
- *Contrastive* significantly lower
Results – Intensity

- Main effect of info structure on INTENSITY
- *Contrastive* significantly lower
Results – Word Duration

- Main effect of info structure on **WORD DURATION**
- *Contrastive* significantly longer than *given*
Background: Prosodic Hierarchy

(from Krivokapić 2014)
Some References