Linguistic prominence and loudness: a systematic comparison between lexical word stress, sentence accent and vocal effort

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Or shorter:
Is there lexical stress without accent?

And if YES
Is this difference cued by loudness?
Evidence from German
Lexically stressed vs. unstressed

Stressed segments
/ɪleɪ/ in Lena

vs. unstressed
/ɪle/ in Lenor

- longer
- vowels more peripheral
- louder: more energy in the higher frequency regions (subglottal pressure)

also in deaccented position when sentence accent is neutralized???

- YES: Sluijter (Dutch)
- YES: Sluijter (Dutch)
  ????: Campbell (AmEngl)
  YES: Sluijter (Dutch)
  NO: Campbell (AmEngl)
  Fant (Swedish)

➡️ Very inconsistent
➡️ No data on German

Mooshammer & Harrington (IPDS Kiel)
BeST 2005
Three main questions concerning lexical stress without accent

1. Does this distinction cause a different tune-text alignment?
   analysis of f0-synchronisation

2. Are there supralaryngeal (non-tonal) differences?
   duration and formant analysis

3. Are there vocal effort differences?
   analysis of glottal pulses
**Corpus: Stress**

<table>
<thead>
<tr>
<th>/le/</th>
<th><strong>Stressed</strong> [+S]</th>
<th><strong>Unstressed</strong> [-S]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lena</td>
<td>/ˈleːna/</td>
<td>Lenor /ˈleːnər/</td>
</tr>
<tr>
<td></td>
<td>person’s name</td>
<td>washing powder</td>
</tr>
<tr>
<td>Sehnen</td>
<td>/ˈzeːnən/</td>
<td>Senat /ˈzeːnət/</td>
</tr>
<tr>
<td></td>
<td>sinews</td>
<td>senate</td>
</tr>
</tbody>
</table>
Corpus: Focus

Question-Answer paradigm

FOCUS [+F]

[+S]: Q: Wolltest Du Dir Friedas Buch ausleihen?
   A: Nein, ich wollte Lena's Buch ausleihen.

[-S]: Q: Kaufst Du Omo oder Lenor bei Schlecker?
   A: Ich kaufe Lenor bei Schlecker.

NON-FOCUS [-F]

[+S]: Q: Wie findest Du Lena?
   A: Ich hasse Lena und ihre Schusseligkeit.

[-S]: Q: Wäschst Du nicht gern mit Lenor und Omo?
   A: Ich hasse Lenor und Omo.
Corpus: vocal effort

Sentences with focused and stressed test sequences were spoken in 3 loudness conditions:
- comfortable
- loud: „speak loudly without shouting“
- soft: „speak softly without whispering“

All sentences were repeated 8 to 9 times
Recordings and analysis

- 5 speakers of Northern German, 1 speaker from Berlin (DP) (20 to 30, non-smokers, male)
- Glottal waveforms by Laryngograph processor
- Acoustical labelling in Praat
- Computation of f0 contours, RMS and formant tracks by EMU-tkassp from Kiel
- Speaker normalization for formants: Lobanov
- Prosodic labelling by using EMU/R
1. F0 contours

- Clear peaks in accented position
- Flat contour for deaccented words
- Similar f0 values for [-F] and [+F, -S]

Speaker-dependent variability:
- Speaker DP (Berlin) never deaccented *Lena*, but all *Lenor*
- Speaker SB very variable patterns
1. Alignment of L-

- Grice et al. (2000): L- after H* is aligned to the next strong syllable in falling rising contours in German

  LENA:
  ➔ steep slope during /ə/

  LENOR:
  ➔ shallower slope during /ə/
1. Alignment: F0 contour

Averaged contour for one speaker

Onset: begin of ø (hasse)
Offset: end of first syllable (Lena or Lenor)
Line-up point: end of ø (hasse)

/ˈhasəˌleːna/: strong condition

/ˈhasəˌleːnə:/: weak condition

⇒ No difference
2. Vowel quality: Formants

- F1 increases with greater global vocal effort and with lower degrees of prominence (sonority expansion)
- /e/ in unstressed syllables is centralized (= F2 lowering) but still distinct from /ɔ/ (6)
  (except for /e/ in Senat of speaker DP from Berlin)
2. Duration: vowels

- Shortening of unstressed vowels
- Differences are greater for /e/ in Sehnen vs. Senat
- No significant effects of accent
2. Duration: initial consonants

- Shortening of consonants in weak syllables

ACCENT:
- shorter /l/ in weak syllables for [+F]
- longer /z/ in weak syllables for [+F]  ➔ effect of devoicing
2. Devoicing of /z/ (voicing of /z/ is not distinctive in this position)

- Frequency of devoicing increases with decreasing vocal effort
  ➔ decreasing subglottal pressure (passive devoicing)

- More frequent devoicing of /z/ in Sehnen when unaccented

- Opposite pattern for Senat: more often devoicing in accented position
3. Intensity and glottal pulse

Intensity during vowel
- Clear decrease of intensity for global vocal effort changes

Unaccented condition
- /l/: little but significantly higher intensity for stressed than unstressed
- /z/: no difference
3. Glottal pulses: EGG

- Two periods taken from mid-vowel
- Time and amplitude normalized glottal periods
- Quicker closing of the folds than opening
- EGG: difficulty in determining the instance of glottal opening

➤ Not OQ and SQ was analysed but the shape of the glottal pulse
3. Glottal pulses: FDA

• Holistic analysis of the glottal pulse shape by using **Functional Data Analysis**
  = functional versions of time-variant digital data by computing splines
    (here: Fourier splines)

Advantage:
  – continuity
  – Tools: functional version of PCA

Principal Component Analysis: extraction of relevant factors for explaining the sources of the variance in the data
  Transformation of the raw data to a new coordination system \( \rightarrow \) factor scores
3. Glottal pulses: shape

**Positive:** longer closed phase, steeper rising
\(\approx\) loud speech

**Negative:** longer open phase, later peak
\(\approx\) soft/breathy

Analysis of resulting factor scores:
what items (e.g. loud) are similar to the extreme values?

- Significant differences between loud, normal and soft
- Significant differences between stressed and unstressed, independent of accent
3. Glottal pulse: individual speakers

Vocal effort:
sign. for all speakers

Prominence:
DP:
s > w and F = U

SB and GA:
only tendencies

BD, NU, GA:
wrong direction
Summary (1)

Independent of accent

• unstressed /e/ is
  - shorter
  - more centralized (lower F2 frequencies)

• unstressed consonants are
  - shorter (/l/ and /z/)
  - and more often devoiced (/z/)
Summary (2)

• Unstressed /e/ is not generally produced with a more symmetrical glottal pulse shape
  – indicating breathy or soft voice
  – contrary to
    • Sluijter et al. (1996): greater spectral tilt ➔ slower glottal closure
    • Ladefoged (1967, 2005): lower subglottal pressure in (accented) unstressed syllables
  – in agreement with
    • Campbell and Beckman (1997), Fant et al. (2000)

• No L- alignment effects
  – contrary to Grice et al. (2000)
    • different dialect?
    • not a falling-rising contour?
Discussion

• stress affects segmental features also in deaccented position
  – e.g. vowel and consonant durations, F2 in vowels, voicing for fricatives

• voicing of /z/:
  – unstressed /z/ was more often devoiced in accented (60%) than in deaccented position (30%)

  ↘ lower subglottal pressure (Ladefoged)
  ↘ glottal configuration (Sluijter et al.)
Discussion

→ more reduction/weakening in **accented** unstressed consonants (vs. **deaccented**)

**WHY?**

→ in order to enhance the syntagmatic contrast between initial unstressed and following stressed syllable (not important in deaccented position)

**IMPLIES**

→ active control of hypoarticulation

→ contrary to the assumption that reduction also means less effort
Conclusion

Initial question: Is there lexical stress without accent?

YES!!!

Stress is not just an abstract landing place for accents but segments differ phonetically in deaccented position.

In German stress in deaccented position affects only segmental features.

BUT NOT more global and longer-lasting properties such as subglottal pressure, voice quality, f0 contours or intensity.
Acknowledgements

Thanks to:

• Jennifer Schneeberg for help with labelling
• our technician Herbert Fuchs
• and to some of our speakers for deaccenting
2. Alignment: F0 contour (individual speakers)

All speakers:

Speakers BD, GA and SZ show no evidence for a steeper slope when followed by a strong syllable (black lines)

(speaker NU very variable)

⇒ L- is not foot-sensitive