

Stress patterns of German cardinal numbers

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Aim: To create an algorithm for assigning stress to German numbers

Introduction

- Motivation
- Structure of numbers in German
- Default stress and variability
- English stress: eurhythmy
- Wagner: prominence
- Varga: rhythmical variation in Hungarian
- Contrastive stress
- Outlook

Motivation

- Natural sounding synthesis
- Many applications for numbers in synthesis
- What is a number?
 - Part of speech?
- Variation

Structure of numbers in German

- Single lexical items up to 12

e.g. *vier, neun*

- 13–19: Lexical item plus *-zehn*

e.g. *vierzehn, achtzehn*

- Decades: Lexical item plus *-zig*

e.g. *vierzig, achtzig*

- 21–99: Unit “und” Decade

e.g. *achtundzwanzig, zweiundvierzig*

- Three digits: Unit “hundert” Unit “und” Decade

e.g. *dreihundertvierundsechszig*

- Grouping: in threes from right to left as in English

e.g. 438 676

Default stress

- Citation form
 - Phrase-like stress
 - * Primary stress: first syllable of the lexeme identifying the decade
 - * Secondary stress: first syllable of the lexeme identifying the unit
 - * “und” is unstressed

e.g.

Ich bin vierundZWANzig.

I am four and TWENTy.

I am twenty-four.

The Main Question

- Metrical well-formedness

Ich bin VIERundzwanzig JAHre alt.
I am FOUR and twenty YEARS old.
I am twenty-four years old.

- Contrastive stress

Ich bin VIERundzwanzig, nicht DREIundzwanzig.
I am FOUR and twenty, not THREE and twenty.
I am twenty-four, not twenty-three.

- What conditions the reversal?
- How reliable are the triggers?

Eurhythmy

- German has a preference for an alternating stress pattern (Jessen 1993)
- Rhythmic adjustment in English is to achieve a rhythmical target of eurhythmy (Hayes 1984)

Ideal eurhythmic metrical grid

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X                               X
X                               X
X      X      X      X      X      X
X  X  X  X  X  X  X  X  X  X  X
```

- Three rhythmical targets
 - Level of scansion: 4 syllables apart
 - A level dividing the level of scansion in half
 - A level higher giving the initial beat of the level of scansion precedence
- Language universal?

| | | | | | | | | | |
|------|---|---|---|---|---|---|---|---|---|
| ein | X | X | X | X | X | X | X | X | X |
| und | X | | | | | | | | |
| zwan | X | X | X | | | | | | |
| zig | X | | | | | | | | |
| Jah | X | X | X | | | | | | |
| re | X | | | | | | | | |
| | | → | | | | | | | |
| ein | X | X | X | | | | | | |
| und | X | | | | | | | | |
| zwan | X | X | | | | | | | |
| zig | X | | | | | | | | |
| Jah | X | X | X | | | | | | |
| re | X | | | | | | | | |

Prediction 1

- Reversal of stress:
 - When a number is followed by any word where primary stress precedes secondary stress.

Wagner: 2000

- Stress patterns depend on the strategy of the speaker to achieve eurhythmy
- Theory developed on German read data in terms of prominence
- Prominence defined as a measurement of the perceptual markedness in relation to the surrounding phonetic environment

Predictions 2: Wagner

- Reversal of stress:
 - When a number is immediately followed by a word with the same prominence value: numeral, noun or proper name, whose primary stress precedes any secondary stress
 - In syntactic terms:
 - * Reversal occurs if the leftmost constituent of the numeral's sister node is a noun, proper name or numeral and that is the head of the phrase in which the numeral occurs

21 Kinder

21 kleine Kinder

Varga: 1998

- Hungarian
 - Fixed primary stress on first syllable
 - Primary stress is cued by pitch-accent
- RV words
 - Double accented compound words
 - Phrase-like stress
 - Lexical process (limited scope)

| | | | |
|--------------|---|-------------|-------------|
| 'tizen'három | → | 'pont | tizen'három |
| thirteen | | exactly | thirteen |
| 'tizen'három | → | 'tizenhárom | 'pont |
| thirteen | | thirteen | points |

Varga: 1998

- Final Weakening

$* \rightarrow \emptyset / XP(PC(* -)PC \quad * \dots)XP$

- Where XP is a syntactic constituent starting with a double accented phrasal compound
- Postlexical rule
- Only applied if it leads to an interval of no more than four syllables between two consecutive primary stresses

Predictions 3: Varga

- If the lexeme identifying the unit has two syllables
 - Reversal of stress:
 - * If the following word belongs to the same syntactic phrase as the numeral and has a pitch accent on the first syllable
- If the lexeme identifying the unit has one syllable
 - Reversal of stress:
 - * If the following word belongs to the same syntactic phrase as the numeral and has a pitch accent on the first or second syllable

Contrastive stress

Ich bin VIERundzwanzig, nicht DREIundzwanzig.
I am FOUR and twenty, not THREE and twenty.
I am twenty-four, not twenty-three.

- Prominence for contrastive stress (Wagner 1999):
 - H*
 - Increase in duration
- Effects on numbers of the following environments and contrastive stress
- Interaction of focus and eurhythmy

Outlook

- Production experiment
 - Compare the predictions of well-formedness effects
 - Investigate their interactions with eurhythmy
- Preliminary results from pilot
 - F0 effects
- Phonetic measurement of stress
 - Backed up with perception experiment
- Result
 - Algorithm for assigning stress to German numbers