# Intrinsic Pitch in German: A Puzzle?

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### Background

Vowel intrinsic fundamental frequency (IF0): high vowels have a higher fundamental frequency than low vowels

Very robust phenomenon: 31 different languages (Whalen & Levitt 1995) babbling infants (Whalen et al. 1995) also found in tone languages (Torng et al. 2000)

- Biomechanical linkage between supralaryngeal and glottal activity: via the hvoid bone an upward movement of the tongue causes a rotation of the thyroid cartilage with respect to the cricoid cartilage → raising of FO
- BUT: As was found by Fischer-Jørgensen (1990) German tense-lax pairs are produced with a similar IF0 despite the lower tongue positions of lax vowels. For example Tongue height: /i:/>/e:/>// vs. F0: /i:/=/i/>/ei/
- She also found a better agreement between IF0 and jaw position than for tongue height

### Aims of this study

- Replication of Fischer-Jørgensen's study by using EMMA 0
- Examination of the jaw contribution on F0 by a bite-block condition 0

### Material

#### Corpus I: Speech rate corpus Six male German sneaker

- 0 0 EMMA
- Normal and fast speech rate
- CVC sequences with the symmetrical consonant contexts /p, t, k/
- Vowels:/i:, I, Y:, Y, e:, e, e:, ø:, œ, œ, a, o:, o, u:, u /
- Target words: /goCVCo/, e.g. getatte, gepaape, gepappe, getette
- Carrier phrase: "Ich habe gepaape gesagt" ("I said gepaape") Five repetitions

### Corpus II: Bite-block corpus

- 0 Three male German speakers
- EMMA and EPG
- Two conditions: with and without bite-block
- CVC sequences with initial voiced stops /b, g/ and final unvoiced stops /p, k/
- Vowels: /i:, I, y:, Y, et, e, øt, œ, at, a, ot, o, ut, u /
- Target words: /CVCə/, e.g. baape, bappe, gieke, gicke
- Carrier phrase: "Sage baape bitte" ("Say gepaape please")
- Ten repetitions

### Results



Figure 1: Tongue position (second sensor from the front) vs. jaw height in /p/ context for front vowels, averaged over all speaker of Corpus I

High lax vowels (e.g. /1/) are produced with a lower tongue position than the mid vowels (e.g. /ei/). The jaw height of high lax vowels (/I Y/) is between high and mid tense vowels (/i: v:/ and /e: ø:/).

Similar results for /t/ and /k/ context and for Corpus II

### Intrinsic Pitch

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- Both corpora: For most vowel pairs the lax types are produced with almost the same F0 as their tense counterparts (see Figure 2).
- □ In some cases F0 is actually higher in the lax vowels, despite lower jaw positions (also found in Corpus I).
- Range of IF0 increases for the bite-block condition.





Figure 2: IF0 for vowels of Corpus II, red: tense vowels, green: lax vowels.

## Relationship between tongue/jaw position and IF0

- Prediction for biomechanical coupling: positive correlations between F0 and articulator height parameters.
- To investigate the relationship between F0 and articulatory positions correlation coefficients were computed for each tense-lax vowel pair The percentage of significant positive and negative correlations and of non-significant correlations is given in Table I.
- Table I: Percentage of correlations between F0-rearmost sensor (TBackY), F0second rearmost sensor (TDorsY) and F0-Jawy (Corpus II), neg.=significant negative correlation, n.s. = non-significant, pos.=significant positive

	conclation.			
	N	neg. (%)	n.s. (%)	pos. (%)
TBackY	84	9.5	83.3	7.1
TDorsY	84	9.6	71.4	19.0
JawY	42	9.5	61.9	28.6

- Gamma Most of the correlation coefficients are not significant and some are even contradictory to the tongue height hypothesis, i.e. significant negative correlations are frequently found.
- There is a slight tendency for more frequent significant positive correlations between jaw and F0.

### Discussion

- The results of Fischer-Jørgensen can be confirmed: Lax vowels tend to have a higher fundamental frequency than would be predicted by their tongue or jaw height
- U We found a slightly better overall agreement between jaw height compared to tongue height with IF0.
- BUT: IF0 differences were even more pronounced when the jaw was arrested by a bite-block (see also Ohala & Eukel 1987) and negative correlations between F0 and jaw-height are by no means rare in the non-bite-block condition.

### Conclusions

- > IF0 seems to be a feature which makes tense-lax vowels more similar despite their prominent differences in duration and quality.
- → Results imply active laryngeal IF0 control for lax vowels???
- Future: EMG measurements of the cricothyroid for German speakers.
- > The influence of jaw position is unlikely to be the explanation for the similar F0 in tense and lax vowels.
- > Tense and lax vowels appear more similar with respect to F0 but do they also SOUND more similar?
- ➔ Perception tests (in progress)

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