Everything You Always Wanted to Know About VOT in Hungarian [*]

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1. Introduction

(1) In generative phonology, there has been considerable interest in what features are involved in laryngeal contrasts and what types of assimilations occur. Many claims in the literature have been based on impressionistic transcriptions or on vague descriptions, making it difficult to determine what the phonetic facts are. Careful acoustic studies often show that the data are very different from what might be expected, given discussions in the literature. For example,

- Lombardi (1999), among many others, claims that German word internal clusters may contain stops that disagree in voice. Yet as shown in Jessen & Ringen (2002), all such clusters are voiceless (either with or without aspiration of the second stop);
- Helgason & Ringen (2008) show that Central Standard Swedish has both prevoicing and aspiration, a type of laryngeal system that has been claimed not to exist by Lisker & Abramson (1964), among many others;
- van Alphen & Smits (2004) show that, in Dutch, prevoicing is only present in 75% of the word-initial lenis stops in productions of their subjects when reading a word list, a surprising result for a language which is supposed to contrast prevoiced stops with short-lag stops in word initial position.

(2) There has been no phonetic study of the two-way laryngeal contrast in Hungarian. Without such data, it is impossible begin to make cross-linguistic comparisons. For example,

- We might want to know whether it is usual for a language with a [voice] contrast (such as Dutch) rather than an aspiration contrast (as in German) to have prevoicing in only 75% of word-initial lenis stops.

In this paper we present the results of our investigation of voicing in Hungarian stops. We present data on stops in word-initial, intervocalic, and final position, and differences between men and women.

2. Background

2.1 *Laryngeal features*

(3) In the literature, there is often ambiguity about the phonetic nature of stops referred to as "voiced" and "voiceless". To avoid confusion, we use the terms ***fortis*** and ***lenis*** in this paper to indicate that there is a two-way contrast, without any suggestion as to the nature of the contrast.

(4) Until recently, it has been widely accepted that a two-way phonological distinction between the features [+voice] and [-voice] occurs *both* in

- languages such as Dutch, Russian, Hungarian, and French (henceforth 'true voice languages') which have prevoicing of utterance-initial lenis stops (and no aspiration of fortis stops), and in
- languages such as Icelandic, German, and English with aspirated stops in utterance-initial position (and no prevoicing of utterance initial lenis stops) (henceforth 'aspirating languages').
- Such a suggestion was thought to be plausible, in spite of the fact that there is no voicing in any initial stops in (most) aspirating languages, because aspirating languages (sometimes) have voicing of lenis stops in intervocalic position.

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(5) Recently, many phonologists and phoneticians have suggested that laryngeal features are privative, and that:
- the two-way contrast in aspirating languages such as English is between stops specified as [sg] and [∅] (Anderson & Ewen 1987, Beckman et al. 2009, Jessen 1989, 1996, 1998, Jessen & Ringen 2002, Iverson & Salmons 1995, Petrova et al. 2006, Rice 1994, Tsuchida et al. 2000 and many others), and
- the phonological distinction in true voice languages such as Hungarian is between stops that are specified as [voice] and [∅] (Beckman et al 2009, Jessen & Ringen 2002, Iverson & Salmons 1995).

2.2 *Passive voicing*

Q: What about the intervocalic voicing sometimes found in intervocalic lenis stops in aspirating languages?

A: This voicing is "passive" voicing, a result of a voiced context, not "active" as found in a true voice-language such as Hungarian. This explains why in studies of intervocalic voicing in German we find reports that speakers sometimes have fully or partially voiceless lenis stops in intervocalic position (see Jessen 1998, pp. 57-8). For example:
- Bothorel-Witz & Pétursson (1972) report that in intervocalic position before schwa, one third of the German lenis stops /d/ were voiceless for most of the closure duration.
- Fischer-Jørgensen (1976) reports that for about half of her subjects the lenis stops are sometimes almost voiceless in specific vowel contexts.

(6) Thus, it may be that a difference between languages that have *active* voicing of stops (as in Hungarian) and ones with *passive* voicing (as in German) is that intervocalic stops show significant variation in voicing (as in German) when the voicing is passive, and less or no variation when the voicing is active. Yet this is something that has not been systematically investigated.
- Since it is clear that Hungarian is a language with active voicing, one of the questions we wanted to determine was how much variation in voicing occurs in intervocalic lenis stops. We wanted to know whether there is a difference in the voicing of intervocalic lenis stops in Hungarian, a true voice language, and an aspirating language such as German.
- If such a systematic difference is found, it can be explained if the feature of contrast is [voice] in true voice languages and [sg] in aspirating languages, but such a difference is mysterious if [voice] of the feature of contrast in both types of languages.
- Hence, information about the voicing of intervocalic stops in Hungarian can provide evidence that bears on the issue of whether the feature of contrast in both aspirating and true voice languages is [voice] or whether the feature of contrast in aspirating languages is [sg].

2.3 *Hungarian*

(7) Hungarian has two types of stop consonants
- stops with early onset of voicing in which the beginning of voicing precedes the release of closure (prevoiced stops)
- stops with short lag VOT, where voicing starts shortly after the release of closure (short lag or voiceless unaspirated).
- both the prevoiced and voiceless unaspirated stops can occur in initial, mid or in final position of a word.

(8) Gósy (2001) studied VOT of fortis stops in Hungarian, but there is no comparable study for lenis stops in Hungarian, or of stops in other positions.
- Hence it is not known if virtually all utterance initial (and post-voiceless word-initial) stops in Hungarian are prevoiced (as in Swedish) or if a significant percentage are produced with no prevoicing (as in Dutch).

- Similarly, it is not known whether intervocalic lenis stops are often partially or completely voiceless, as has been reported in many studies of German (cf. Jessen, 1998, Jessen & Ringen, 2002) or fully voiced as in Swedish (Helgason & Ringen, 2002).

3. Subjects, method, materials

(9) Subjects

- Eighteen subjects, nine male and nine female, were paid for participating in the experiment:
- Ages of the speakers ranged from 19 to 37 (mean age of all subjects was 24.3; mean age for females was 24.6, for males 24.0).
- The subjects were all speakers of the Budapest variety of Hungarian, and had lived in Budapest for most or all of their lives.

(10) Materials

- The stimuli consisted of 82 items which contained both fortis and lenis stops and fillers in isolated words.
- The target words aimed at eliciting fortis stops and lenis stops in word-initial (post pausal) position, word-medial (intervocalic) position and word-final position. Three contrasting places of articulation for Hungarian stops were considered, bilabial, dental, and velar[1]
  - Initial stops: *bátor* ('brave'), *pápát* ('pope'+Acc.), *dékán* ('dean'), *tábor* ('camp'), *gégét* ('larynx'+Acc.), *kopár* ('treeless');
  - Intervocalic stops: *csibész* ('knave'), *kópé* ('imp'), *tudás* ('knowledge'), *réted* ('your meadow'), *béget* ('/he/ bleats'), *zsákot* ('sack+Acc.')
  - Final stops: *láb* ('foot'), *vád* (accusation'), *vág* ('carves').

(11) Procedure

- The subjects read a word-list. The aim was to obtain productions of words spoken in isolation, and therefore a carrier phrase was not used.
- Nonsense words were not used.
- Vowels were not systematically varied, but most vowels were mid or low since positive VOT is known to be longer before high vowels.
- Subjects were asked to pause briefly between words.

(12) Recordings

- Data were recorded in a sound-treated room at the phonetics laboratory of the Research Institute of Linguistics, Hungarian Academy of Sciences.
- The microphone (Sony, type ECM-MS 907) was placed directly in front of the speaker at a distance of approximately 25 cm.
- The durational analysis of the data was carried out using the Praat software package (version 5.4 version).
- The signal was recorded directly to hard disk at 44.1 kHz.

(13) Measurements

- The duration of utterance-initial stop voicing (prevoicing) was measured as the interval from voice onset to stop release. (see (14))
- Positive VOT was measured as the interval from stop release to the beginning of the second formant of the following vowel (see (15))
- Onset of the closure and onset of the second formant were determined visually from spectrograms and oscillograms.

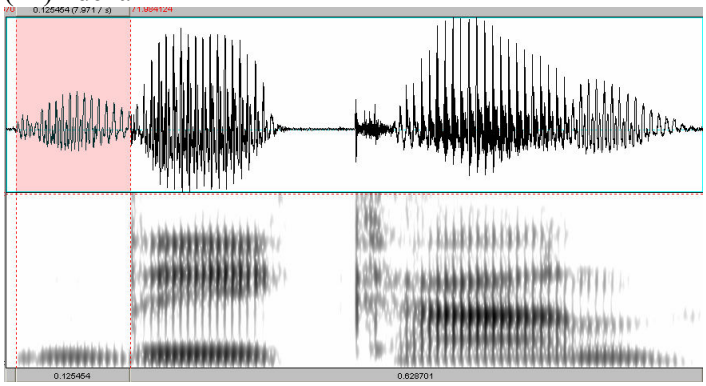
[1] The voiced and voiceless palatal stops were not included.

- Voicing duration in word-medial and final stops was measured as the interval between the end of the second formant of the vowel preceding the stop to the end of voicing during closure (see (16))

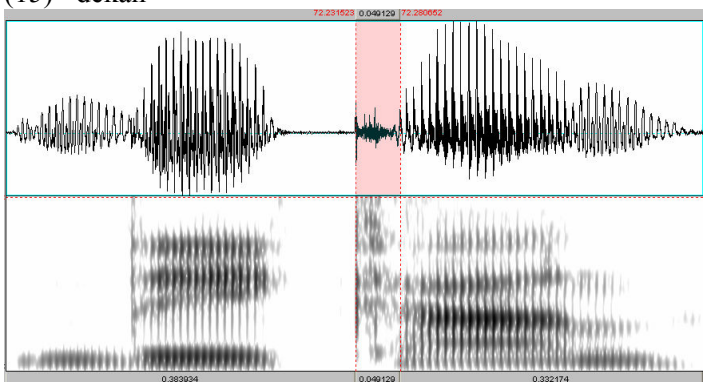
•Closure duration of a lenis stop was measured as the interval between the end of the second formant of the preceding vowel and the release of the stop

- Percentage of voicing was calculated by dividing the voicing duration by the closure duration (and multiplying by 100).

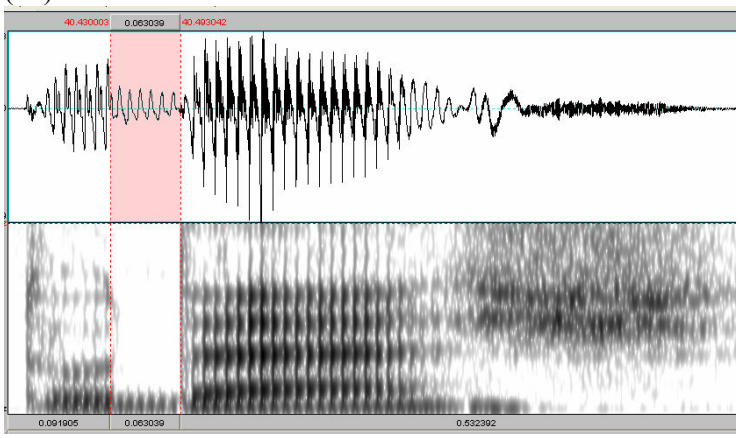
(14) dékán



(15) dékán



(16) tudás



- Statistical analysis of the data was carried out using analysis of variance (ANOVA) using SPSS statistical software, version 14.0). In all cases, the confidence level was set at the conventional 95%.

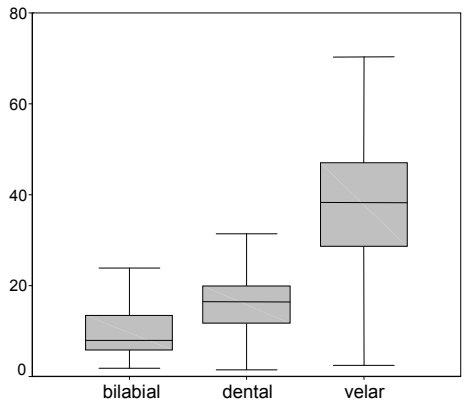
4. Results

4.1 *VOT in initial stops*

The VOT values for the fortis stops in initial position are given in (17). As expected the VOT values are short and positive in the case of fortis (voiceless) stops.

(17) VOT data for fortis stops in #CV position

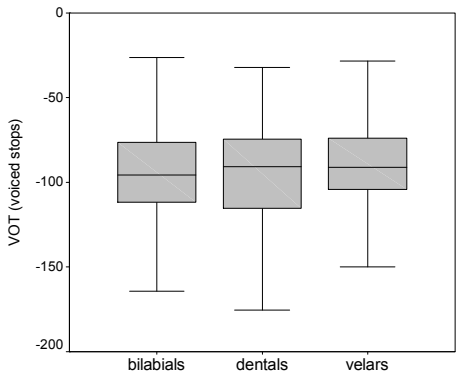
Fortis stops	Duration of VOT (ms)		
	Mean	range	SD
p	9.7	30.8	5.4
t	16.0	38.2	6.7
k	37.6	76.6	13.4



Values for initial lenis stops are given in (18). 100% of the initial lenis stops had prevoicing.

(18) VOT data for lenis stops in #CV position

Lenis Stops	Prevoicing (ms)		
	mean	range	SD
b	-94.6	178.4	28.1
d	-95.1	152.7	29.8
g	-89.6	134.0	30.1



These data for lenis stops allow us to answer one question: Does Hungarian exhibit prevoicing that is more like that found in Dutch, with many speakers failing to voice utterance initial stops or is the voicing in initial stops more like Swedish?

- Hungarian speakers had prevoicing in *all* word-initial stops. Hence, it is quite different from Dutch and more like Swedish.

- One explanation offered by van Alphen & Smits (2004) for the fact that only 75% of the utterance initial stops of their subjects had prevoicing is influence from another language.
- Some support for this explanation comes from a study of Fenno-Swedish. Fenno-Swedish, like Dutch and Hungarian, has a stop contrast between voiced and voiceless unaspirated stops. Ringen & Suomi (2009) found that the rate of voicing in word-initial stops in Fenno-Swedish was virtually identical to that reported for Dutch. In the case of Fenno-Swedish, there is a clear influence from another language which does not have prevoicing: All speakers of Fenno-Swedish also speak Finnish.

(19) Place effects: A one-way ANOVA indicated that there are significant differences in the VOT values for different places of articulation of the word-initial stops ($F(5, 1076) = 2059.667$, $p < 0.001$).

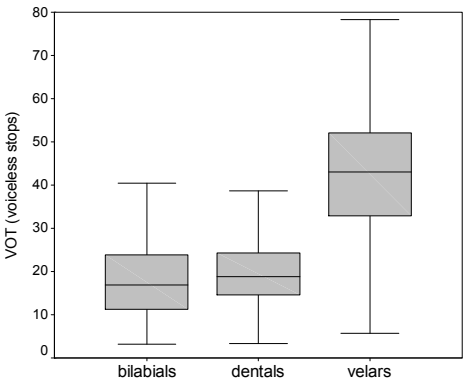
- A Tukey post hoc test indicated that place of articulation had a significant effect on VOT of the fortis stops: (between [p] and [t]: $p = 0.038$, while between [p] and [k] and [t] and [k]: $p < 0.001$). These results for the fortis stops are consistent with findings in other studies for fortis stops: VOT in k > t > p (Cho & Ladefoged 1999).
- However, place of articulation had no significant effect on VOT for initial lenis stops.

4.2 *Intervocalic Stops*

The VOT values for intervocalic fortis stops are shown in (20)

(20) VOT data for fortis stops in VCV position

fortis stops	Duration of VOT (ms)		
	mean	range	SD
p	18.4	66.7	10.3
t	20.0	87.6	8.7
k	42.7	72.5	13.8



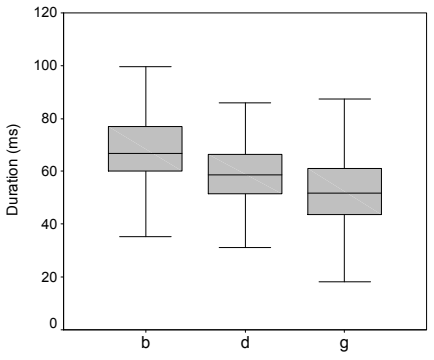
(21) Place effects: Statistical analysis showed that, again, that place of articulation had a significant effect on VOT values for fortis stops (one-way ANOVA: $F(5, 1501) = 3919{,}854$, $p < 0.001$).

- Post hoc Tukey test confirmed that place of articulation had a significant effect on VOT in fortis stops ($p < 0.001$) with one exception: there was no significant difference in VOT values of [p] and [t] in intervocalic position.
- The same result for place differences was found in the VOT values of fortis stops in an experiment that compared intervocalic fortis stops uttered by female subjects in isolated words and spontaneous speech (Gósy 2001). The actual values for isolated words, however, are shorter in the present material for our females subjects.

The duration of closure for intervocalic lenis stops is shown in (22)

(22) Duration data for lenis stops in VCV position

Intervocalic lenis stops	Duration of closure (ms)		
	mean	range	SD
b	68.6	84.6	14.4
d	59.4	79.2	13.1
g	52.9	86.8	13.8



- 95.5% of all the intervocalic stops were *fully voiced*. The percentages are given in (23).

(23) Voicing percentage of intervocalic stops

intervocalic stop	% voicing
b	98.1%
d	87.0%
g	89.4%

Hence, the intervocalic lenis stops are essentially fully voiced:

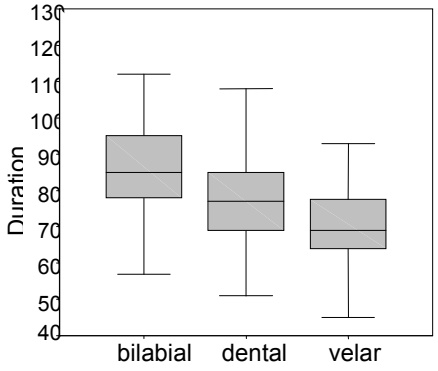
These data provide an answer to the question: "Is there variation of voicing of intervocalic lenis stops in Hungarian as has been found for German?"
• The answer is clearly "NO". This provides support for the position that the voicing in German intervocalic stops is the result of passive voicing and is different from the voicing found in Hungarian, which is attributable to active voicing.

4.3 *Final Stops*

The durations of the final lenis stops are given in (24) and the percentages of voicing for these final stops is given in (25). Again, there is substantial voicing during closure of the final stops.

(24) Closure duration of lenis stops in word-final position

Lenis stops	Closure duration of voicing (ms)	
	mean	SD
b	86.53	12.49
d	77.21	13.38
g	70.60	11.52



- The percentages are given in (25).

(25) Voicing percentage of word-final stops

word-final stop	% voicing
b	73.6%
d	71.8%
g	69.5%

5. Male-Female Differences

Males differed from females in voicing of lenis stops in initial position and intervocalic position, but not in final position (confirmed by one-way ANOVA: $F(1, 2578) = 5{,}915$, $p < 0.015$). Female subjects' prevoicing was *longer* than that of the males in all positions.

(26) Prevoicing in initial position

Stops	Prevoicing of lenis stops in initial position (ms)			
	females		males	
	mean	SD	mean	SD
b	-100.12	29.00	-88.28	25.70
d	-103.49	31.08	-86.19	25.96
g	-99.01	28.60	-78.44	28.35

Females also had longer voicing in intervocalic stops. As noted above, 95.5% of all subjects' intervocalic stops were fully voiced. However, the females' intervocalic lenis stops were longer than those of males' in intervocalic position (27) and the percentage of voicing of these lenis stops was greater for females that for males as illustrated in (28):

(27)

Stops	Duration of lenis stops in intervocalic position (ms)			
	females		males	
	mean	SD	mean	SD
b	72.7	14.2	64.5	13
d	63.2	13.7	55.7	11.3
g	56.3	14.1	48.9	12.2

(28)

Stop	Voicing in intervocalic stops (%)			
	females		males	
	Fully voiced (%)	Partially voiced (%)	Fully voiced (%)	Partially voiced (%)
b	100	0	96	4
d	96	4	96	4
g	92	8	93	7

In initial position females' VOT values for the bilabial and dental fortis stops were significantly shorter than those of the males, but the velars were not significantly different (confirmed by one-way ANOVA: $F(1, 2578) = 5{,}915$, $p < 0.015$).

(29) VOT values of fortis stops in initial position (non-significant differences are marked by italics)

Stops	VOT values of fortis stops in initial position (ms)			
	females		males	
	mean	SD	mean	SD
p	8.2	4.2	11.4	6.1
t	14.7	6.4	17.4	6.9
k	*36.71*	14.5	*38.6*	12.1

The females' VOT values for fortis stops in intervocalic positions were again shorter than those of males; however, the differences were not significant in either type of stops.

To summarize, we find no consistent difference between males' and females' fortis stops, but the female subjects had significantly more voicing in their lenis stops in both initial and intervocalic position. What can we make of this difference, given that it is often claimed that voicing in stops is easier for males than for females?

•In a recent paper, Morris et al. (2008) claim that when speakers' tempo is controlled for, there are no VOT differences between English- speaking males and females.

• It is well-known that as speech slows down, prevoicing increases in a true-voice language, but that there is little or no effect on the VOT of the short lag stops, whereas

• in an aspirating language (such as English), with a long-lag /short-lag contrast in stops, when speech gets slower, VOT increases in long-lag stops, but there is little or no change in the short-lag stops (Kessinger & Blumstein 1997; Volaitis & Miller 1992).

• Hence, it might appear that the differences we found with the speech of our males and females could be attributed to differences in the tempo of the males and females and is not really a male-female difference: the Hungarian men were speaking more rapidly than the women were. But:

Lingering questions:

• The study by Morris et al. (2008) did not study a true-voice language such as Hungarian and hence we do not know if their results can be generalized to a language with a different type of contrast. But even if they could be

• the fact that our subjects exhibited such differences could reflect the tendency, reported elsewhere, for females to exhibit more "clear speech" than males. Specifically, research, mainly on English, has shown that women often exhibit a tendency to produce clearer or more distinctive speech than do men (Bradlow et al. 1996, Byrd 1994, Hazen & Markam 2004, Kramer 1978, Henton 1992, 1983.). One consequence of slowing down is to increase prevoicing, which, in turn increases the contrast between the two stop types. But

• this cannot be the whole story; in Swedish, Helgason & Ringen (2008) found that prevoicing was robust. For all subjects pooled, 93% of the initial lenis stops had more than 10 ms. of prevoicing. Female subjects had significantly *shorter* prevoicing, not longer as in Hungarian, than did the male subjects. The female subjects had an average prevoicing duration of 66 ms as opposed to 109 ms for the males.

• For Dutch, van Alphen & Smits (2004) found that there was a significant difference between male and female subjects in the percentage of utterance initial stops that were prevoiced (86% vs 65%), but in contrast to the findings for Swedish, there was no significant difference in prevoicing duration of male subjects and female subjects (109 ms. vs 89 ms.).

• We are left with two questions: If the differences are attributable to tempo, why do Hungarian women speak more slowly than Hungarian men while Swedish and Dutch men are the ones with slower speech? And if the differences can be attributed to clear speech, why don't Swedish and Dutch women strive for clear speech?

6. Conclusions

This paper presents the results of an investigation of the Hungarian stops. Fortis stops are voiceless and unaspirated whereas lenis stops exhibit voicing in all positions.

- We have found evidence that supports the claim that there are differences between languages that have *active* voicing of stops (as in Hungarian) and ones with *passive* voicing (as in German). we found that there is virtually no variation in the voicing of lenis stops in intervocalic position in Hungarian. This is in stark contrast to what is reported for German where it is claimed that the voicing is *passive.*
- This difference can be explained if the feature of contrast is [voice] in true voice languages and [sg] in aspirating languages, but such a difference is mysterious if [voice] of the feature of contrast in both types of languages. Hence, this is evidence that supports the claim that the feature of contrast in true voice languages is [voice] but the feature of contrast in aspirating languages is [sg].
- We found that the prevoicing in initial stops is different from that found in Dutch and Fenno-Swedish. This difference could be explained by influence of other languages without prevoicing in the cases of Fenno-Swedish and Dutch.
- Finally, we found that the women in our study had longer prevoicing in their utterance- initial stops and longer voicing in intervocalic stops than did the men. It is not clear how we can understand this difference. In most other languages, it has been reported either that there is no difference in prevoicing of men and women or that men have longer prevoicing than do the women.

References

Anderson, John M. & Colin J. Ewen (1987). *Principles of Dependency Phonology*. Cambridge: Cambridge University Press.

Beckman, J., Jessen, M. & Ringen, C. (2009). German fricatives: Coda devoicing or positional faithfulness? *Phonology, 26,* 231–268

Bothorel-Witz, A & Pétursson, M. (1972). La nature des traits de tension, de sonorité et d'aspiration dans le système des occlusives de l'allemand et de l'islandais. *Travaux de l'Institut de Phonétique de Strasbourg 4*:277-356.

Bradlow. A., Toretta, G. A. & Pisoni, D. (1996). Intelligibility of normal speech I: Global and fine-grained acoustic-phonetic talker characteristics. *Speech Communication, 20*. 255-272.

Byrd, D. 1994. Relations of sex and dilaect to reduction. *Speech Communication 15*.39-54.

Cho, T., and Ladefoged, P. (1999). Variations and universals in VOT: Evidence from 18 languages.

Fischer-Jørgensen, E. (1976). Some data on North German stops and affricates. *Annual Report of the institute of Phonetics of the University of Copenhagen 10*: 149-200.

Gósy, M. (2001). The VOT of the Hungarian voiceless plosives in words and in spontaneous speech. *International Journal of Speech Technology 4,* 75-85.

Hazen, V. & Markham, D. (2004). Acoustic-phonetic correlates of talker intelligibility for adults and children. *Journal of the Acoustic Society of America 116*, 3109-3118.

Henton, C. 1983. Changes in the vowels of Received Pronunciation. *Journal of Phonetics 11*, 53-371.

Iverson, G. K., & Salmons, J. C. (1995). Aspiration and laryngeal representation in Germanic. *Phonology*, 12, 369–396.

Jessen, M. (1989). *Laryngale Mechanismen in der Phonetik und Phonologie des Deutschen. Auslautverhärtung, Stimmassimilation und Vokaleinsätze aus niversalgrammatischer Sicht.* Ms. Revised version of 1989 MA thesis, University of Bielefeld.

Jessen, M. (1996). The relevance of phonetic reality for underlying phonological representation: the case of tense versus lax obstruents in German. In U. Kleinhenz (Ed.), *Interfaces in phonology*. Berlin: Akademie-Verlag, pp. 294–328.

Jessen, M. (1998). *Phonetics and phonology of tense and lax obstruents in German*. Amsterdam: John Benjamins. Jessen, M., & Ringen, C. (2002). Laryngeal features in German. *Phonology*, 19, 189–218.Keating, P. (1984). Phonetic and phonological representation of stop consonant voicing. *Language*, *60.2*, 286–319.

Keating, P. (1990). Phonetic representations in a generative grammar. *Journal of Phonetics* 18, 321–334.

Kessinger, R., & Blumstein, S. (1997). Effects of speaking rate on voice-onset time in Thai, French, and English. *Journal of Phonetics, 25*, 143–168.

Kramer, C. (1978). Perceptions of female and male speech. *Language and Speech 20*.151-161.

Lisker, L., & Abramson, A. S. (1964). A cross-language study of voicing in initial stops: acoustical measurements. *Word, 20,* 384–422.

Morris, R. J., McCrea, C. R. & Herring, K. (2008). Voice onset time differences between males and females: Isolated syllables. *Journal of Phonetics 36*: 308-317.

Petrova, O., Plapp, R. Ringen, C. & Szentgyörgyi, S. (2000). Constraints on voice: an OT typology. Paper presented at the 74th Annual Meeting of the Linguistic Society of America, Chicago.

Petrova, O., Plapp, R. Ringen, C. & Szentgyörgyi, S. (2006). Voice and aspiration: evidence from Russian, Hungarian, German, Swedish, and Turkish. *The Linguistic Review 23*, 1-35.

Repp, B. H. (1979). Aspiration amplitude as a voicing cue for syllable-initial stop consonants presented monoaurally and in dichotic competition. Haskins Laboratories, Status Report on Speech Research, SR-57, 85–111.

Rice, K. (1994). Laryngeal features in Athapaskan languages. *Phonology 11,* 107–147.

Ringen, C. & Suomi, K. (2009). Fenno-Swedish VOT: In fluence from Finnish? *Proceedings Fonetik 2009.*

Tsuchida, A., Cohn, A. C. & Kumada, M. (2000). Sonorant devoicing and the phonetic realization of [spread glottis] in English. Working Papers of the Cornell Phonetics Laboratory, 13, 167–181.

Van Alphen, P. M., & Smits, R. (2004). Acoustical and perceptual analysis of the voicing distinction in Dutch initial plosives: The role of prevoicing. *Journal of Phonetics, 32,* 455–491.

Volaitis, L., & Miller, J. (1992). Phonetic prototypes: Influence of place of articulation and speaking rate on the internal structure of voicing categories. *Journal of the Acoustical Society of America, 92*, 723–735.