# Voice Onset Time in Russian*

Catherine Ringen & Vladimir Kulikov
University of Iowa

## Introduction.

ꕥ There have been numerous recent studies of voicing and aspiration in a variety of languages, including Dutch, Swedish, German, Korean (van Alphen & Smits 2004; Helgason & Ringen 2008; Jessen & Ringen 2002; Beckman, Jessen & Ringen 2009; Cho & Ladefoged 2002).

- ♦ What are the features of contrast in various languages?
- ♦ One issue is whether, in languages such as German & English, the feature of contrast is [spread glottis] or [voice], the feature usually assumed to be contrastive in languages such as Russian, Dutch, French & Hungarian.
  - German & English: *aspirating languages*
  - Russian, Dutch, French & Hungarian: *true voice languages*

ꕥ There have been few studies of voicing in true voice languages. This is problematic because without data about voicing in stops in true voice languages such as Russian, it is impossible to determine whether there is a difference between aspirating languages and true voice languages with respect to voicing during closure in initial, intervocalic and final positions.

In this paper we present the results of our investigation of VOT in Russian initial and intervocalic stops.

## Background.

ꕥ *Voice onset time*. Lisker & Abramson (1964) studied the Voice Onset Time of stops in initial position in eleven languages.

- Voice Onset Time, or VOT, refers to the timing of the beginning of voicing (usually in the following vowel) relative to the release of a stop closure.
- Release of the stop closure is considered to be time 0.

ꕥ Lisker and Abramson found two types of languages with two-way laryngeal contrasts:[1]

- ♦ First type
  - Voicing begins *during the stop closure* in one series of stops;
    - ✧ this means that VOT is a negative number because voicing begins *before* the stop is released.
    - ✧ Stops with negative VOT: are known as *prevoiced stops* or *stops with voicing lead.*
  - In the other stop series voicing begins almost immediately after the stop is released.
    - ✧ VOT is a (relatively) small positive number for these stops.
    - ✧ Such stops are referred to as having *short-lag VOT* or as *voiceless, unaspirated stops*.

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[1] Helgason & Ringen (2008) show that Swedish has a type of two-way contrast not discussed by Lisker & Abramson: Swedish contrasts prevoiced stops with aspirated stops.

- Dutch and Hungarian are two of the languages in which Lisker & Abramson found one series of stops with negative VOT and the other with short-lag VOT.
- Dutch and Hungarian are both true voice languages.

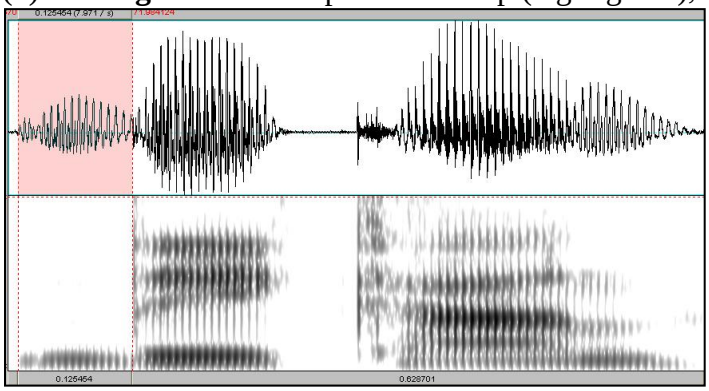
☙ The VOTs for stops in these languages are given in (1) (1 speaker of Dutch, 2 speakers of Hungarian).

(1) Mean VOTs (in ms.) for Dutch and Hungarian from Lisker & Abramson (1964)

| | Dutch[2] | Hungarian |
|---|---|---|
| /b/ | -85 | -90 |
| /d/ | -80 | -87 |
| /g/ | | -58 |
| /p/ | 10 | 10 |
| /t/ | 15 | 16 |
| /k/ | 25 | 29 |

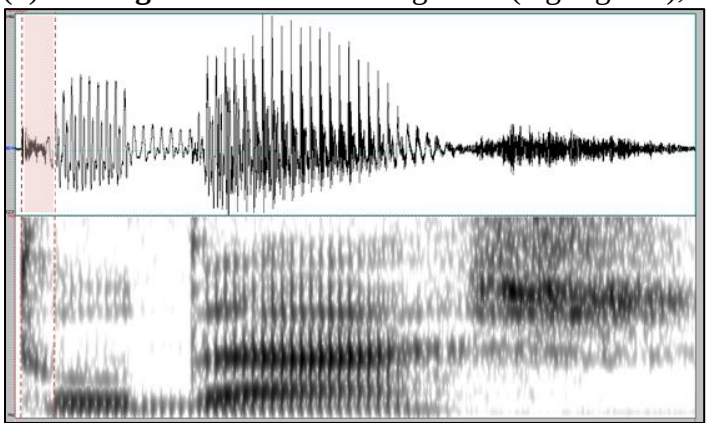
☙ An example of a Hungarian prevoiced stop in initial position is given in (2)

(2) **Hungarian**[3] initial prevoiced stop (highlighted), *dékán* 'dean'




An example of a Hungarian stop with short-lag VOT in initial position is given in (3)

(3) **Hungarian** initial short-lag VOT (highlighted), *tudás* 'knowledge'



[2] Dutch has no laryngeal contrast in velar stops.
[3] Hungarian spectrograms from Gósy & Ringen (2009).

- ♦ In the second type of language with a two-way contrast studied by L & A,
  - • in one series of stops, voicing begins a (relatively) long time after the stop closure is released.
    - ✧ VOT is a (relatively) large positive number for these stops.
    - ✧ Such stops are known as *long-lag VOT* or (voiceless) *aspirated stops*
  - • The other stop series has short-lag VOT (voiceless, unaspirated stops)

➢ English[4] and Cantonese are the languages in which Lisker & Abramson found one series of stops long-lag VOT and the other with short-lag VOT.

➢ English & Cantonese are both aspirating languages.

ꕤ Mean VOTs (in ms.) for Cantonese from Lisker & Abramson (1964) are given in (4)

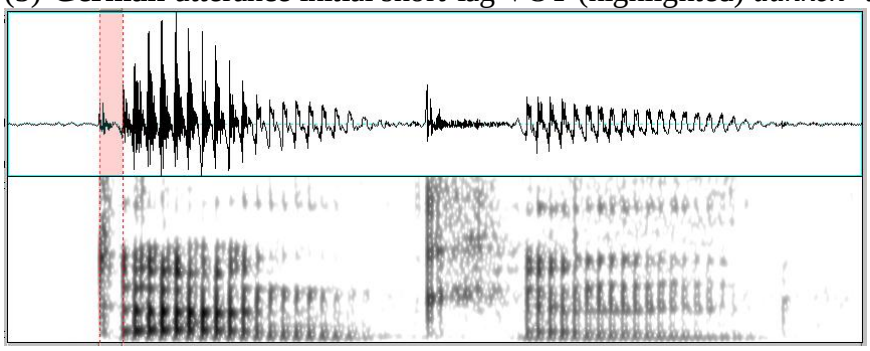
(4) Cantonese (1 speaker)

| | |
|---|---|
| /p/ | 9 |
| /t/ | 14 |
| /k/ | 34 |
| /$p^h$/ | 77 |
| /$t^h$/ | 75 |
| /$k^h$/ | 87 |

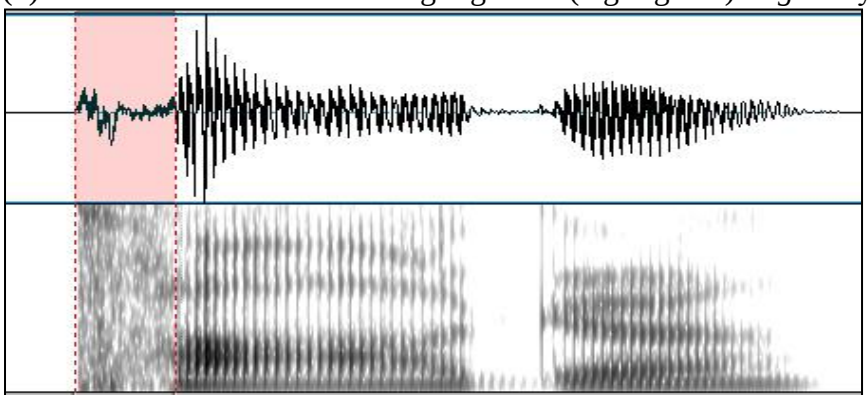
ꕤ German[5] is another language, like English and Cantonese, with a contrast between aspirated stops and voiceless, unaspirated stops in initial position.

ꕤ An example of a German stop with short-lag VOT is given in (5) and an example of a German stop with long-lag VOT (aspirated) is given in (6).

(5) **German** utterance initial short-lag VOT (highlighted) *danken* ‘to thank’



(6) **German** utterance-initial long-lag VOT (highlighted) *Tage* ‘day PL’



[4] Some English speakers produce prevoiced stops (Lisker & Abramson, 1964).
[5] Some German speakers produce prevoiced stops (Jessen, 1998).

ꕥ Summarizing at this point: Lisker and Abramson studied two types of languages with two-way laryngeal contrasts:

True voice languages

| |
|---|
| negative VOT in initial position (prevoiced or voicing lead) |
| short-lag VOT in initial position (voiceless, unaspirated stops) |

Aspirating languages

| |
|---|
| long-lag VOT in initial position (voiceless, aspirated stops) |
| short-lag VOT in initial position (voiceless, unaspirated stops) |

ꕥ *Sensitivity of VOT*. There is evidence that speakers are very sensitive to the VOTs that they are exposed to.

- Speakers of American English produced significantly longer VOTs in aspirated bilabial stops after they were asked to imitate speech with lengthened VOTs in aspirated bilabial stops (Nielsen 2006).
- Not only did speakers generalize the increased aspiration to aspirated bilabials in new words, they also generalized the increased aspiration to velar stops.

- Positive VOTs in the speech of a speaker of Brazilian Portuguese were longer after an extended stay in the United States and shorter after an extended stay in Brazil (Sancier & Fowler 1997)
- The authors explain these results as the influence of the English stops with long-lag VOT on the amount of positive VOT in the speaker's native Brazilian Portuguese.

- VOTs in a native language are sensitive to those in a language being studied; the stops of English speakers learning Korean showed influence from Korean in as little as one week. Chang (2010).

ꕥ *True voice languages vs. aspirating languages*

- One confusing aspect of descriptions of various languages is that stops in true voice languages and in aspirating languages are referred to simply as "voiced" and "voiceless," despite the differences in the pronunciation.
- This means that it is often difficult or impossible to determine what the exact phonetic nature of the stops in question is because sometimes the series that is referred to as "voiced" has prevoicing in utterance-initial position and sometimes it does not. Sometimes the series that is described as voiceless is aspirated (as in German), whereas sometimes it is not (as in Russian).
- We will use the terms *fortis* and *lenis* to refer to the two types of stops without implying what the phonological or phonetic nature of the stop contrast is: hence, if
  - ✧ contrast between short-lag VOT and prevoiced stops:
    fortis series has short-lag VOT
    lenis series has voicing lead,
  - ✧ contrast between long-lag VOT and short-lag series,
    fortis series has long-lag VOT
    lenis series has short-lag VOT.
  - ✧ The fortis series always has more positive VOT than the lenis series.

**Motivation for study.**

ꕥ *Variation in prevoicing in initial lenis stops in true voice languages.* Recent studies of languages with prevoicing have found that speakers do not always prevoice initial stops.

- van Alphen & Smits (2004) found that prevoicing was only present in 75% of the productions of lenis stops by their subjects when reading a wordlist.
  - ✧Surprising result for a language which is supposed to contrast prevoiced stops with short-lag VOT stops in word initial position
  - ✧ Prevoicing was less likely in words that begin with an obstruent-sonorant cluster; excluding words without the clusters, 86% of the initial lenis stops had prevoicing.
- Same result is reported by Ringen & Suomi (2010) for Fenno-Swedish, a language which also contrasts prevoiced stops with voiceless, unaspirated stops:
  - ✧ 87% of the Fenno-Swedish word-initial lenis obstruents had prevoicing (excluding those in clusters).
- Caramazza & Yeni-Komshian (1974) observed even more overlap between the VOT distributions of lenis and fortis stops in Canadian French:
  - ✧ 58% of the lenis tokens were produced without prevoicing; all fortis stops were produced without aspiration.

ꕥ In all these cases, the authors suggest that the explanation for the overlap between the fortis and lenis stops is that there is influence from another language.

ꕥ Without data from speakers who are not influenced by another language, it is not possible to know whether the overlap exhibited by Dutch, Fenno-Swedish, and Canadian French is typical of speakers of true voice languages.

| Hence, one motivation for our study was to determine whether speakers of Russian also exhibit overlap in lenis and fortis stops in initial position. |
|---|

ꕥ *Variation in voicing in intervocalic lenis stops in aspirating languages.* It has seemed reasonable (to some) to assume that the feature of contrast for aspirating languages is [voice] because, although in initial position lenis stops are not (usually) voiced, they are voiced in intervocalic position.

- However, intervocalic lenis stops in aspirating languages are not always fully voiced.
- Iverson & Salmons (1995), Jessen & Ringen (2002) suggest that the intervocalic voicing of lenis stops in aspirating languages is *passive* and that languages with *active* voicing will not exhibit such variation.
  - ➢ *Passive voicing* is voicing that occurs because stops are in a voiced environment, and does not reflect any active voicing on the part of speakers.
  - ➢ *Active voicing*, in contrast, is voicing that is the result of active voicing gestures on the part of speakers.
- Beckman et al. (2010) report that, in study of German, only 55.5% of intervocalic lenis stop tokens had voicing of over 90% of the closure.

ꕥ Again, without data about languages with active voicing, we cannot determine whether the German intervocalic voicing of lenis stops is different from voicing of intervocalic lenis stops in a language with active voicing.

| Since it is clear that Russian is a language with active voicing, another motivation for our study was to determine whether Russian speakers have full voicing in intervocalic lenis stops. |
|---|

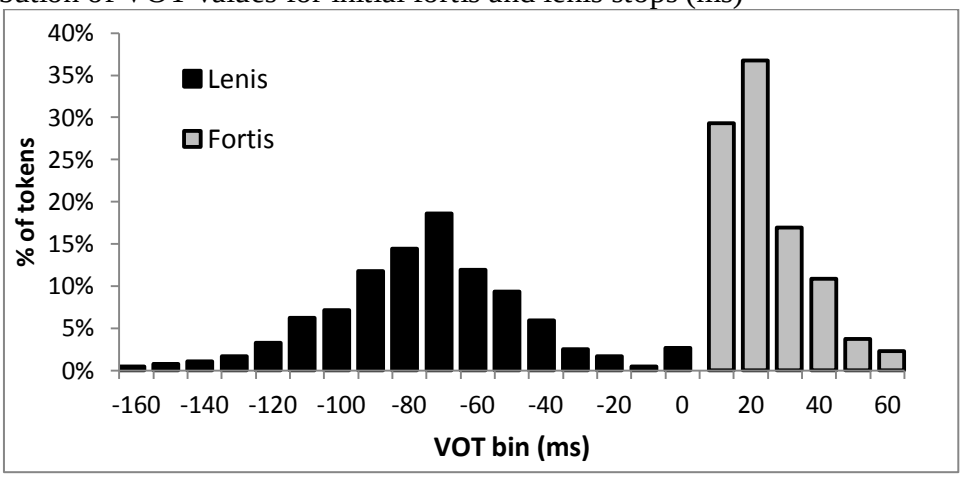
**Study.**

- We recorded 14 speakers of Russian at St. Petersburg State University.
  - monolingual speakers of Standard Russian
  - 8 males and 6 females
  - no students of linguistics or English language majors[6]
  - mean age was 19.1 years.
- The speakers read a list of words twice.
  - words with fortis and lenis stops in word-initial and intervocalic positions
  - no control for place of articulation
  - no control for co-occurrence of fortis and lenis stops in the same word
  - initial fortis (n=20), initial lenis (n=23),
  - intervocalic fortis (n=26), intervocalic lenis (n=26) stops.
  - total number of tokens: 95x2x14=2660 tokens.

**Results**

☙ *Initial.* The distribution of VOT values for initial stops is given in (7).

(7) Distribution of VOT values for initial fortis and lenis stops (ms)




☙ Mean VOTs and standard deviations for initial fortis and lenis stops are shown in (8).

(8)

| | Bilabial (ms) | Dental (ms) | Velar (ms) |
|---|---|---|---|
| Fortis | 18 (8) | 20 (6) | 38 (12)* |
| Lenis | -70 (29) | -75 (29) | -78 (26) |

* Significantly different from bilabial and dental fortis stops ($F(2,24)=150.4$, $p < 0.001$)

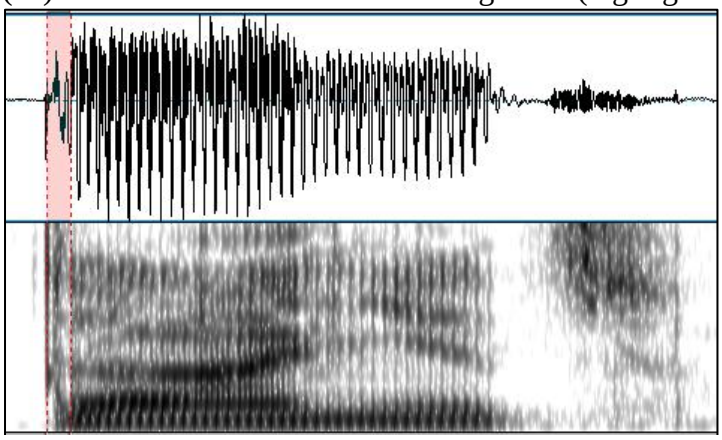
- As expected, fortis stops were pronounced as voiceless, unaspirated and had positive VOT values averaging 18 ms. for bilabials, 20 ms. for dentals, and 38 ms. for velars.
- Lenis stops were pronounced with robust prevoicing, with negative mean VOT values -70 (bilabial), -75 (dental), and -78 (velar) ms.
- Consistent with the pattern for contrast between prevoiced and voiceless unaspirated stops in L & A.
- Importantly, 97.4% of the Russian initial lenis stops were prevoiced.[7]

[6] We did not record speakers who were English language majors because, as noted earlier, it has been found that exposure to a language with different laryngeal contrasts affects speakers' VOTs in their native language.

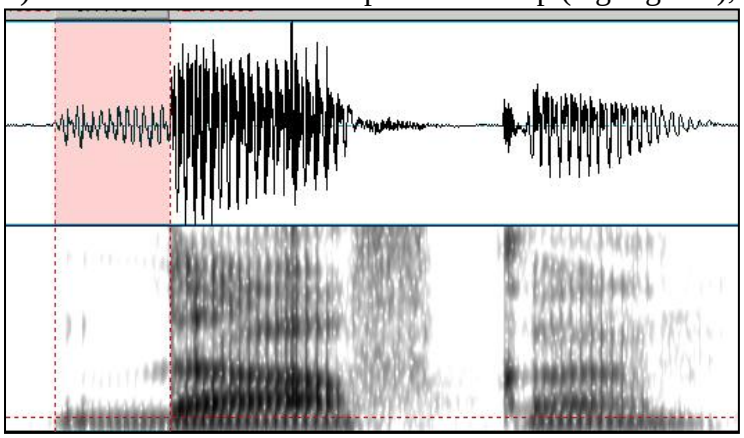
[7] Those initial lenis stops that were produced as voiceless, unaspirated were due to two male speakers (S5 and S6), who pronounced 12 and 26 % of all initial lenis stops without prevoicing.

ᔓ Examples of typical fortis and lenis stops are given in (9).

(9a) Russian utterance-initial short-lag VOT (highlighted), *tanec* ‘dance’



(9b) Russian utterance initial prevoiced stop (highlighted), *davka* ‘a crush’



ᔓ *Intervocalic*. The results for intervocalic stops are shown in (10).

- Except for a short voicing tail into closure (M=22.5 ms., SD=11.1), the intervocalic fortis stops were completely voiceless
- Voicing Ratio averaging 23.7%. (SD=12.8). (Voicing ratio tells what percentage of the entire closure is voiced.)
- The majority of intervocalic lenis stops (98.1%) were pronounced with voicing during the entire closure.
- Production of lenis stops with incomplete voicing was due to six speakers: three males (S7, S9, S13) and three females (S2, S3, S8). Most of these stops (83%) were velars.
- Male and female speakers did not exhibit any differences in voicing or VOT in fortis and lenis stops.

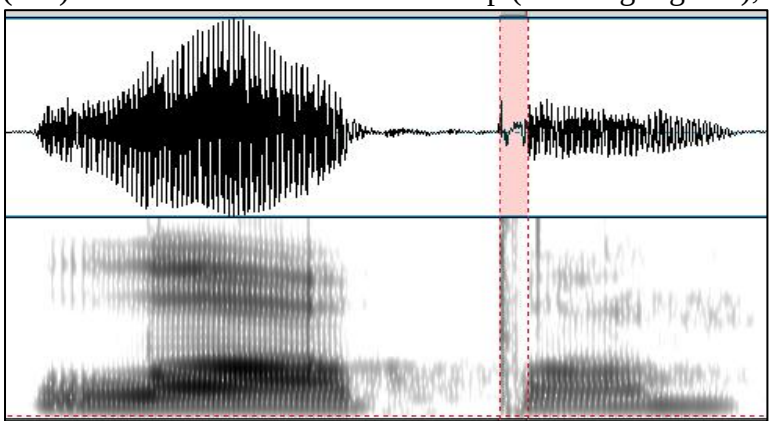
(10) Mean VOT values and closure duration (ms) with standard deviations (in brackets) of intervocalic fortis and lenis stops

| | **Fortis** | | **Lenis** | | |
|---|---|---|---|---|---|
| | Closure | VOT | Closure | Voice | % voiced |
| Bilabial | 103 (21) | 18 (7) | 78 (13) | 78 (13)** | 99.5% |
| Dental | 96 (22) | 18 (6) | 62 (13) | 62 (13) | 99.1% |
| Velar | 92 (20) | 35 (10)* | 69 (15) | 68 (16) | 96.4% |

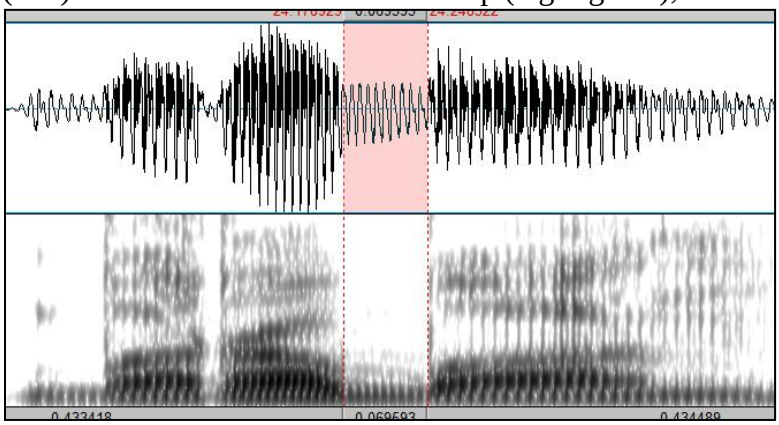
* Significantly different from bilabial and dental fortis stops ($F(2,24)=86.7$, $p < 0.001$)
** Significantly different from dental and velar fortis stops ($F(2,24)=40.0$, $p < 0.001$)

ꕤExamples of typical intervocalic fortis and lenis stops are given in (11a) and (11b).

(11a) **Russian** intervocalic fortis stop (VOT highlighted), *lapa* ‘paw’



(11b) **Russian** intervocalic lenis stop (highlighted), *baraban* ‘drum’ 100% voiced



**Conclusion.**

ꕤ Over 97% of the Russian initial lenis stops were prevoiced. This result is similar to what was reported for initial stops in Hungarian; in a study of VOT in Hungarian, it was found that 100% of the Hungarian initial stops were prevoiced (Gósy & Ringen 2009).

- This contrasts with the lower numbers reported for Dutch (86%), Fenno-Swedish (87%) and Canadian French (58%).

Q: Why these differences?

A: In all these cases with percentages of prevoiced stops that are lower than those we found in Russian, the authors suggest that the explanation is that there is influence from another language: in the case of Dutch the authors suggest the influence comes from English in the media and at school, in the case of Fenno-Swedish, all speakers are bilingual in Finnish, a language which has no prevoiced stops, and in the case of Canadian French, the authors suggest the influence comes from English.

- An even more striking case is Japanese, also a true voice language. Kong (2009) reports that only about 20% of lenis tokens exhibit prevoicing. According to Kong Japanese is undergoing a change.

- In all the true voice languages we know of, where speakers do not (essentially) always prevoice utterance initial lenis stops, the languages are claimed to be either undergoing a change or to be influenced by a language with a different VOT system, or both.

ꝏ We also found that over 98% of the Russian intervocalic lenis stops were fully voiced.

- This is considerably different from the voicing in intervocalic German stops reported by Beckman et al. (2010): only 55.5% of intervocalic lenis tokens in German had voicing of over 90% of the closure.
- We suggest that the voicing we find in Russian intervocalic lenis stops is definitely different from that in German. When speakers are actively aiming to voice intervocalic stops, little or no variation occurs. Our results support the claim that the voicing in intervocalic position in aspirating languages such as German is passive, not active as in it is in true voice languages.

**References**

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

Beckman, J., Jessen, M. and Ringen, C. (2010). "German intervocalic stops differ from stops in true voice languages: Empirical evidence." Presented at the Berkeley Germanic Linguistics Roundtable.

Caramazza, A. and Yeni-Komshian, G. H. (1974). "Voice onset time in two French dialects." *Journal of Phonetics*, 2, 239-245.

Chang, Charles B. (2010). *First language phonetic drift during second language acquisition*. Ph.D. dissertation, University of California, Berkeley, CA.

Cho, T., Jun, S.-A. and Ladefoged, P. (2002). "Acoustic and aerodynamic correlates of Korean stops and fricatives." *Journal of Phonetics, 30,* 193-228.

Gósy, M. and Ringen, C. (2009). "Everything you always wanted to know about voicing in Hungarian," presented at the International Conference on the Structure of Hungarian 9, Debrecen, Hungary.

Helgason, P. and Ringen, C. (2008). "Voicing and aspiration in Swedish stops." *Journal of Phonetics, 36,* 607-628.

Jessen, M. (1997). "Tense vs. lax obstruents in German," Arbeitspapiere des Instituts für Maschinelle Sprachverarbeitung (AIMS), Universität Stuttgart, Vol 3, No.1.

Jessen, M. and Ringen, C. (2002). "Laryngeal features in German." *Phonology*, 19, 189-218.

Kong (2009). *The development of phonation-type contrasts in plosives: Cross-linguistic perspectives.* Ph.D. dissertation, Ohio State University. Columbus, OH.

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

Nielsen, K. (2006). "Specificity and generalizability of spontaneous phonetic imitation." In *Proceedings of the ninth international conference on spoken language processing (Interspeech)* (paper 1326), Pittsburgh, USA.

Ringen, C. and Suomi, K.(2010). "On voicing in Fenno-Swedish stops." Presented at the XXVI meeting of Finnish Phoneticians, The University of Eastern Finland.

Sancier, M.L. and Fowler, C.A. (1997). "Gestural drift in a bilingual speaker of Brazilian Portuguese and English." *Journal of Phonetics, 25,* 421-436.

Van Alphen, A., and 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.

catherine-ringen@uiowa.edu
vladimir-kulikov@uiowa.edu