1. Learning Russian phonotactics

For English learners of Russian, two aspects of initial consonant clusters must be learned:
1. The possible combinations, a superset of English onset clusters. Possible in Russian but not English:
2. The articulatory coordination patterns necessary to produce the sequences, which are different than those typically produced in English (Zsiga 2003, Davidson 2006)

**Articulatory differences in Russian & English**

- English: C1 release overlapped by C2 target. No audible release.
- Russian: C1 release is not overlapped and is audible.

**English speakers producing Russian clusters**

- An ultrasound study of obstruent-obstruent onset clusters by English speakers demonstrates that speakers often do not adequately overlap sequential gestures, giving rise to a period of open vocal tract: “gestural mistiming” (Davidson 2005)

**Main goal:** examine the longitudinal acquisition of stop-stop clusters by English learners of Russian.

- Do English learners achieve Russian-like articulatory patterns in a year of classroom learning?
- If not, what articulatory & acoustic patterns do they produce?

2. Methodology

- **Participants:** 4 native Russian speakers, 2 English learners in Elementary Russian at NYU, recorded at beginning & end of academic year
- **Stimuli:** 10 repetitions of each phrase for 3 sequence types: initial cluster (#CC), word-boundary (C/C), schwa (#C/C)
- **Ultrasound machine:** Sonosite Titan, 27.9fps scan rate, head and transducer stabilized

**Stimuli & data analysis**

- JPC stimuli corresponding to 10ms after onset of C1 closure to the release burst of C2 were extracted
- Tongue surfaces extracted from EdgeTrak & 10 repetitions of each set of tongue contours averaged
- Comparison of #CC-#C and #C#C:
  - Calculate the root mean square (RMS) difference for each frame, then average across all frames (very rough measure of articulatory differences)
  - The articulation of C#C is very different from #C, despite no schwa for either sequence.

3. Results

**Results from English learners in Elementary Russian**

- **HM acoustic results**
  - /gd/: Moderate decrease in schwa insertion from time 1 (T1) (83%) to T2 (60%)
  - /kt/: Big decrease in insertion from T1 (83%) to T2 (11%)
  - /tk/: No insertion at T1 or T2

- **HM articulatory results**
  - /gd/: Lower RMS for #CC-#C at T1, T2 similar to natives
  - /kt/: No differences between comparisons either at T1, T2
  - /tk/: From T1 to T2, decrease in gestural mistiming for velar-initial clusters.

- **JL acoustic results**
  - /gd/: High rates of insertion at both T1 (78%) and T2 (89%)
  - /kt/: Low rates of insertion at both T1 and T2 (10%)
  - /tk/: Big change in insertion from T1 (50%) to T2 (0%)

- **JL articulatory results**
  - /gd/: No substantial change in acoustics or articulation; pattern similar to natives
  - /tk/: By T2, #CC-#C is the smaller comparison; this leads to a successful acoustic output
  - /tk/: Could be due to implementation of #CC as C#C, or change in vowel production to differentiate #CC-#C

4. Discussion

When a learner’s acoustic output is similar to a native speaker’s, it may not be necessary that their articulation also matches

- Consistent with a many-to-one relationship between acoustics and articulation for cluster production (e.g. Ohala 1989, Espy-Wilson & Boyce 2000)

**Discussion points**

- Both voiceless clusters for JL and /tk/ for HM suggest that learners may not converge on the native speaker’s articulation.
- Are there undesirable ramifications for coarticulation with other sounds?
- Could there be another change toward the native Russian pattern later?