

## The acoustics of phonological contrast: Fortis and lenis stops in Danish and Dutch

In 1964, Lisker & Abramson popularized the notion that the acoustic cue of Voice Onset Time (VOT) is what distinguishes voiced, voiceless and aspirated stops. The paper was highly influential, and VOT remains an indispensable tool for many phoneticians and phonologists. For some languages with a laryngeal contrast in their stop consonants, VOT does indeed appear to be sufficient to consistently distinguish between them. On the other hand, it is also clear that Lisker and Abramson's three VOT-based stop categories cannot serve to explain all attested laryngeal stop contrasts. For example, in languages with a singleton-geminate contrast (e.g. Swiss German; Kraehenmann 2001), stop closure duration rather than VOT is the primary acoustic cue responsible for the contrast. The three categories also do not hold up to scrutiny when compared against a large set of typological data; in Cho and Ladefoged's (1999) comparison of 25 voiceless stops in 18 languages, the parameter of VOT seemed scalar rather than falling into the neat categories of voiceless unaspirated and aspirated.

For this presentation, we examined the distinction between fortis and lenis stops in the closely related Germanic languages, Danish and Dutch. The phonological feature responsible for the Danish distinction is generally taken to be [spread glottis] (e.g. Basbøll 2005); the lenis stop /b/ is thus voiceless, and the fortis /p/ is voiceless aspirated<sup>1</sup>. In Dutch, on the other hand, the phonological feature is generally taken to be [voice] (e.g. Booij 1995); lenis /b/ is pre-voiced, and fortis /p/ is voiceless. On the surface, it would seem that three VOT-based categories are sufficient to describe the acoustic differences between Danish and Dutch /b/ and /p/:

	pre-voiced	voiceless	aspirated
Danish		/b/	/p/
Dutch	/b/	/p/	

Using Praat (Boersma & Weenink 2016), we analyzed a range of acoustic features pertaining to the realization of the bilabial stops /b/ and /p/ to test whether VOT can tell the whole story. This was done through acoustic analysis of recordings of 10 young female native speakers of Danish and 7 young female native speakers of Dutch, recorded at Aarhus University and Leiden University, respectively. Following Pohl & Grijzenhout (2010), the speakers were recorded reading carrier phrases aloud with the stops in phrase-medial position. The carrier phrases were phonologically identical except for the consonants under scrutiny. In both Danish and Dutch, /b/ and /p/ were placed following schwa and preceding long [a]:

Danish: *den skønneste \_ark* [d̥ɛn s̥q̥ɔnəs̥d̥ə ' \_a:k]

Dutch: *de grote \_aan* [d̥ə χrout̥ə ' \_a:n]

The acoustic features that we analyzed include:

- the duration of the preceding schwa;
- the duration of stop closure;
- presence of voicing during the closure phase;
- time from stop explosion to the onset of voicing;

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<sup>1</sup> Note that /b/ and /p/ are simply used here as practical stand-ins for the fortis and lenis labial stops; they should not be taken as indicating phonological analyses.

- time from the onset of voicing until the onset of F2;
- the duration of the following vowel;
- the pitch level and movement in the following vowel

In fact, every one of the above-mentioned acoustic features are used either as an acoustic cue for the language-internal contrast, or as a consistent acoustic cue separating the two languages, or (often) both. Sometimes, the cues are even used for opposite purposes in the two languages. For example, in Danish, long closure duration is an acoustic cue signaling lenis /b/ while in Dutch it signals fortis /p/. Similarly, in Danish, long F2 lag after voicing onset is a strong acoustic cue for fortis /p/, while in Dutch it is a (comparatively weak) acoustic cue for lenis /b/.

This research serves to illustrate the complex and multifaceted phonetic underpinnings of two simple, seemingly very similar phonological contrasts. In this case, even though the two phonological contrasts originate from the same contrast in a not-so-distant parent language, the acoustic cues signaling the contrasts differ on every parameter we tested.

## References

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