

## The Danish voice quality contrast: F0 and HNR

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In this talk I examine the acoustic correlates of the Danish phonation contrast between modal voice and ‘stød,’ a non-modal voice quality related to creaky voice and often denoted with the superscript [ʔ]. Previous research finds that syllables with stød are realized with high fundamental frequency (F0) and phonetically modal phonation at the beginning of the rhyme followed by a dip in F0, intensity, and oftentimes increased aperiodicity and the percept of creaky phonation in the latter portion of the rhyme (Fischer-Jørgensen, 1897). In contrast, phonologically modal stressed syllables are typically produced with a short fall or fall-rise F0 contour and relatively stable, high intensity throughout the syllable (Thorsen, 1982). However, little research has focused on how stød is differentiated from modal phonation using other acoustic measures, including measures of aperiodicity (or noise) in the acoustic signal such as the harmonics-to-noise ratio (HNR) and cepstral peak prominence (CPP), which have been shown to successfully voice quality contrasts in other languages (Garellek, 2012; Kuang, 2013). Here, I present the results of a production study examining the acoustic correlates of the Danish phonation contrast produced by 38 speakers in the ‘common stød’ region of Denmark, focusing primarily on F0 and HNR measures.

The results of two linear discriminant analyses (LDAs) (Venables WN & Ripley BD, 2002) revealed that measures of aperiodicity in the acoustic signal are the most important acoustic correlates to the phonation contrast throughout both the vowel and coda sonorant in CVS syllables (C = consonant, V = vowel, S = sonorant). In particular, the mid-frequency range noise measure  $HNR < 1500$  Hz (dB) ranked amongst the top three acoustic correlates to the contrast during both the vowel and coda. A series of linear regression models (Baayen et al., 2008; Bates et al., 2015) confirmed these results, finding that syllables with stød are produced with greater aperiodic noise (lower HNR) compared to modal syllables, similar to what has been found in other languages (Garellek, 2019). However, in contrast to previous findings, F0 did not consistently differentiate modal and stød syllables and did not rank amongst the top three acoustic correlates to the contrast in the LDA (Fischer-Jørgensen, 1897; Grønnum, 2022). Further analyses revealed that this is because both modal and stød syllables were produced with a mix of falling, rising, and flat F0 contours. In particular, approximately 30% of all syllables with stød were produced with a rising F0 contours. Further investigations suggest that rising contours in stød syllables are produced more frequently in monosyllabic words than disyllabic words. Furthermore, although rising contours were produced proportionally more often by speakers from outside the greater Copenhagen metropolitan area than by speakers from within the region (56.57% vs 42.9%), three of the four speakers with the most rising contours were from the greater Copenhagen metropolitan area.

Overall, these results indicate that the phonation contrast between stød and modal phonation is best characterized by increased aperiodic noise in the acoustic signal for stød syllables across speakers. Furthermore, a complex interplay between regional and speaker-specific factors may be at play in the production of stød, particularly with respect to the F0 contour. Finally, this study shows that stød may be produced with a rising pitch contour, a novel finding for speakers from the greater Copenhagen metropolitan area.

## References

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