VARIATION AND DIALECTAL DIFFERENCES IN THE SEGMENTAL SCOPE OF PHONOLOGICALLY CONTRASTIVE LARYNGEALISATION

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ABSTRACT

Phonological contrasts in voice quality are assumed to be phonetically restricted to the segment(s) on which they are contrastive. However, in the suprasegmental stød (pronounced [støˀ]) in Danish, a contrastive laryngealisation akin to creaky voice, substantial variation occurs in the segmental span of non-modal phonation. In many cases it is continuously realised on the adjacent segment to the contrastive segment and may span up to four segments. This paper presents initial findings of this variation based on acoustic data from 21 native Danish speakers of the Copenhagen (10) and Aarhus dialect (11). It shows that variation in segmental span correlates significantly with the dialect of the speaker and the phonetic realisation of the contrast. Thus, this paper contributes novel findings on the possible quantitative scope of phonetic variation in phonological voice quality contrasts and the role of such variation in dialectal differences as well as individual speaker idiosyncrasy.

Keywords: Phonology, dialectal phonetic variation, creaky voice, Danish stød.

1. BACKGROUND

1.1. Segmental span of non-modal phonation

In languages that utilise non-modal phonation to create phonemic contrasts the change in voice quality is generally restricted to one segment, the vowel. Indeed, the span of non-modal phonation has even been found to be less than the full vowel, e.g. contrastive breathy voice spanning on average 43% of the vowel in Jalapa Mazatec [1]. This lack of full segmental span further persists when comparing languages with phonemic non-modal phonation (Mazatec, Chong, Mpi) and phonetic non-modal phonation (Tagalog) where only a few of the breathy vowels have phonation changes spanning their full duration [2]. Other non-modal phonation types such as contrastive laryngealisation, however, may span the full vowel [2], although percentages were not provided for this type. In a study on Yalálag Zapotec contrastive laryngealisation was realised in a model-nonmodal-modal pattern [3], again spanning only a portion of the vowel as seen with breathy voice in [1], [2]. The limiting factors on non-modal phonation segmental span are suggested to be (i) co-occurrence with other contrasts such as tone, making full vowel non-modal phonation shorter to allow for successive modal vibration that carries tonal information, (ii) possibly greater articulatory effort associated with the production of non-modal phonation and (iii) co-articulatory demands of surrounding segments such as plosives [2]. Whatever the phonological or phonetic limitations may be, however, it appears that a consistent pattern in the segmental span of contrastive non-modal phonation is restriction to one segment and most often less than the full segment. This paper provides data on the contrastive laryngealisation *stød* in Danish that seemingly defies this trend on a proportion of tokens. First some background is provided on the *stød* followed by an account of instances of post-segmental creaky voice and dialectal differences in the occurrence of these instances.

1.2. The Danish *stød*

The *stød* is a laryngealisation that characterises certain syllables which fulfil the phonetic requirement of primary or secondary stress and an adequate stretch of voiced segments called *stød basis* [4]. The *stød basis* is either a long vowel or a short vowel and an adjacent sonorant consonant. The *stød* is contrastive in minimal pairs like ‘ven’ [vɛn] *friend* vs ‘vend’ [vɛnˀ] *turn (imperative)* or can distinguish word classes in minimal pairs like ‘løber’ [ˈløːb̰ɐ] *(a) runner* vs ‘løber’ [ˈløːˀb̰ɐ] *(is) running*. However, not all words with *stød* have a non-*stød* minimal pair contrast and the rules for when a syllable with *stød basis* do not receive *stød* are complex and will not be elaborated here – see e.g. [5] for an overview.

The *stød* is an interesting phenomenon in relation to the segmental scope of phonological voice quality contrasts because it is classified as a syllabic prosody, [5] rather than a segmental contrast, indicating that its scope is the entire syllable, but the timing of the phonetic realisation of the *stød* has its onset roughly in the middle of the syllable [6] and is said to belong to a specific segment in syllables where the *stød basis* consists of more than one segment. Indeed, not just the presence of *stød* is contrastive but there are near-

minimal pairs that contrast based on which segment receives the *stød*. Compare 'lån' [ˈlɔːˀn] *loan* vs 'lund' [ˈlɔnˀ] *grove* where the long vowel in 'lån' receives the *stød* but in 'lund' the nasal receives the *stød*. Further, the phonetic realisation of this contrast varies between the dialects spoken in the two largest cities of Denmark, Copenhagen and Aarhus. Where the Copenhagen dialect realises both instances with laryngealisation akin to creaky voice, the dialect of Aarhus only laryngealises if the *stød* is received by the consonant as a general rule. If the *stød* falls on the vowel, it is instead realised as a long, falling tone, [lɔ̂ːn] instead of [ˈlɔːˀn], leading to what perceptually sounds like a rising-falling bi-tonal pattern [7]. This type of potential *stød* realisation will henceforth be referred to as tonal *stød*, given its phonetic realisation and perceptual properties in the Aarhus dialect, not because I claim that the *stød* is generally a laryngealisation caused by underlying tone as suggested by other scholars – a topic dealt with in [8]. The term tonal *stød* is thus used to characterise the *stød* that occurs in monosyllables with a long vowel and a sonorant consonant coda. Phonetically the tonal *stød* is laryngealised in Copenhagen but tonal in Aarhus.

2. METHODS

The data was not collected to investigate the segmental scope of laryngealisation during the *stød:* however, the presence of creaky voice after the *stød* was something I discovered during the annotation of the data in Praat [9] and decided to mark on a separate tier as it seemed surprisingly prevalent. Thus, this paper is an initial account of the phenomenon, henceforth referred to as post-*stød* creak, and provides a brief quantification of its occurrence. An in-depth phonetic, qualitative acoustic study is outside the scope of this short paper.

The data was collected as part of a PhD research project on phonetic variation in phonological voice quality contrasts and only the parts of the study setup relevant to the present paper are described here. The data consists of minimal pairs of two conditions: (i) no *stød* vs standard *stød* (25 pairs) and (ii) regular *stød* vs tonal *stød* (8 pairs). The pairs were embedded in full sentences read from a laptop screen presented and recorded in SpeechRecorder [10]. Many minimal *stød* pairs are homographs meaning context was needed for participants to know which word was prompted and for this reason carrier phrases were not a feasible option. Different sentences were used for each word instead and all sentences appeared three times in random order. The target word was never the ultimate or penultimate in a sentence to control for potential effects of utterance-final creaky voice to confound the presence of *stød*. Despite this, some tokens had to be discarded from final analysis due the presence of creaky voice on non-*stød* tokens or mispronunciations of the target word. Participants were recruited via social media and consisted of 10 Copenhagen speakers (5 male, 5 female) and 11 Aarhus speakers (6 male, 5 female) aged 21-43 (avg. 30.14). Criteria for inclusion were that the speaker had no vocal pathologies and had grown up in their respective dialect area and not lived outside of it for more than 2 years at the time of recording.

Post-*stød* creak, henceforth PSC, was marked in cases where creak was clearly audible and the waveform showed irregular vibrations, if relevant supported by visible vertical striations in the spectrogram, see Figure 1:

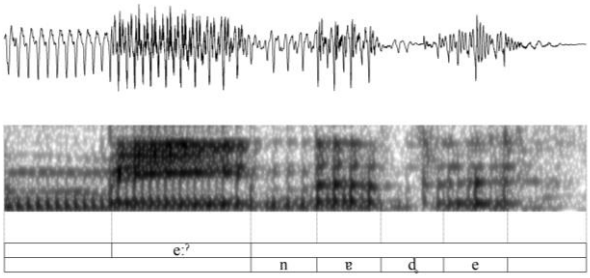

Figure 1: Praat picture of the utterance 'mener det', *(I) mean it*, spoken by a male Copenhagen speaker. The waveform is on top, the spectrogram just below, the stød segment is annotated on Tier 1 and the PSC segments are annotated on Tier 2.

Figure 1 also exemplifies the most extreme case of post-segmental PSC span found in the data. It is possible to produce laryngealisation without any irregular vibration or audible creaky voice [11] but for an initial account of the phenomenon, only segments with audible creak were included. It is possible that the amount of post-stød laryngealisation is larger if acoustic measurements are used to capture additional instances of non-creaky laryngealisation. For the analysis all non-*stød* tokens were excluded as only *stød* tokens are candidates for the presence of PSC. The final number of tokens for analysis of each type per dialect is given in Table 1 below.

3. PREVALENCE OF POST-STØD CREAK AND DIALECTAL DIFFERENCES

Table 1 provides an overview of the prevalence of PSC for each dialect and *stød* type calculated as a percentage of overall tokens of the respective types. As is evident the phenomenon is most prevalent in the Copenhagen dialect, in particular on tonal *stød* tokens

where more than half of the segments receiving *stød* are followed by PSC.

Dialect	PSC tokens regular stød	PSC tokens tonal stød
Copenhagen	194/893 **(21.7%)**	132/225 **(58.7%)**
Aarhus	41/1003 **(4.1%)**	13/249 **(5.2%)**

Table 1: Overview of the percentage of tokens with PSC out of total number of tokens with *stød* stratified by dialect and *stød* type.

There is, however, large inter-speaker variability with some speakers having no PSC and others having PSC on almost all tonal tokens, see Figure 2 and 3:

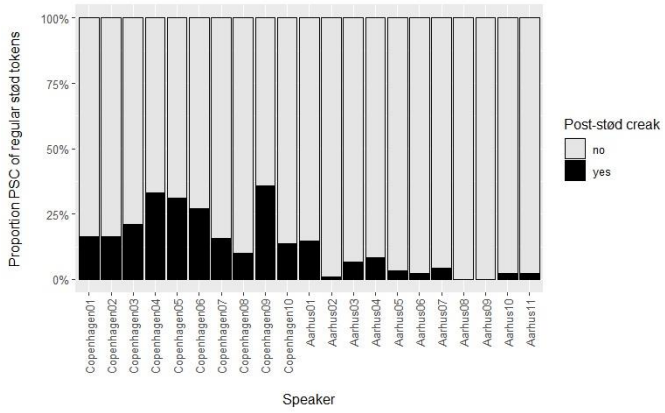

Figure 2: Bar graph showing the proportion of PSC tokens for each individual dialect speaker as a percentage of the total number of regular stød tokens.

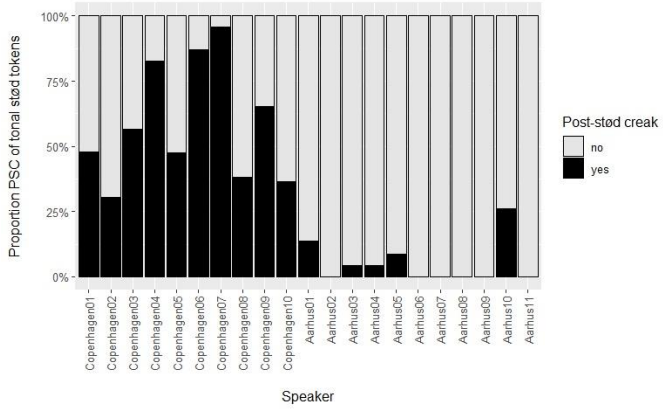

Figure 3: Bar graph showing the proportion of PSC tokens for each individual dialect speaker as a percentage of the total number of tonal stød tokens.

To test the significance of these observed differences a binomial logistic regression model (Generalised Linear Mixed Model, GLMM) was fitted in R [12] for two conditions: (i) the effect of dialect on PSC occurrence and (ii) the effect of *stød* type on PSC occurrence. For each condition a full GLMM was fitted which modelled PSC as a function of stød type + dialect, with speaker and word as random effects. The full model was compared to a reduced model excluding the fixed effect of interest, i.e. dialect for the first condition, *stød* type for the second condition. The effect of speaker dialect on PSC occurrence is significant (χ^2[1]=26.31, p=<0.05) which is to be expected based on the relatively large differences in prevalence observed in Table 1. The overall effect of *stød* type on PSC occurrence is also significant (χ^2[1]=9.52, p=0.002), an effect seemingly driven by the relatively large differences in occurrence between the two *stød* types in the Copenhagen dialect.

4. SEGMENTAL SCOPE

Having quantified the overall prevalence of PSC above the attention will now be turned to variation in the number of segments after the *stød* that are produced with PSC. As evident from the percentages in Table 2 below the overwhelming trend is that PSC occurs on the first segment after the *stød*, a phenomenon observed at least once in all but two speakers.

Dialect	PSC1	PSC2	PSC3	PSC4
Copenhagen	331/1118 **(29.6%)**	33/1118 **(3.0%)**	3/1118 **(0.3%)**	1/1118 **(0.09%)**
Aarhus	54/1252 **(4.3%)**	22/1252 **(1.8%)**	2/1252 **(0.2%)**	0/1252 **(0.0%)**

Table 2: Overview of tokens with PSC on segments 1-4 after the *stød* calculated as a percentage of the total number of tokens with *stød* stratified by dialect.

PSC on the second segment after the *stød* is much less prevalent and PSC on the third and fourth segment is very rare, the latter occurring only on one token in one Copenhagen speaker, see example in Figure 1. Further, the differences in prevalence between dialects decrease the further from the *stød* PSC occurs. It is difficult to make claims about conditioning factors for the production of PSC as the data was not elicited specifically to investigate the phenomenon and thus lack control for many factors that could influence its presence such as sentence

intonation, phonetic environment, stress placement, etc. No single word in the word list consistently has PSC so even though phonetic environment is likely to influence PSC there are clearly other factors to consider in future research. What can be concluded from the initial results here is that both dialect and type of *stød* correlate significantly with the presence of PSC, but with fairly large inter-speaker variability, suggesting that PSC has a degree of idiosyncrasy outside the realm of phonological contrast. The dialectal differences were most prevalent for PSC on the adjacent *stød* segment, much less so for when the segmental scope was larger than one adjacent segment. The fact that non-modal phonation was found to persist beyond the contrastive segment was a surprising finding defying the general trend in languages with this type of contrast and thus worth reporting on.

5. DISCUSSION

In phonetic terms there is nothing remarkable about laryngealisation being followed by creaky voice on the adjacent segment as an effect of coarticulation. However, as demonstrated here, the patterns of PSC suggest that this is more than an effect of co-articulation as it does not occur on all tokens and is significantly correlated with speaker dialect and type of *stød*. Further, it is cross-linguistically unusual for a phonologically contrastive laryngealisation to span more than (half of) one segment, the contrastive status seemingly restricting the segmental span to maximise the perception of the contrast. In regard to the Danish *stød* it is perhaps not unusual to find cases where the vowel receives *stød* and the sonorant consonant coda receives post-*stød* creaky voice considering that the *stød* is generally described as a syllabic prosody and the coda is part of the syllable. But recall that although the *stød* is a syllabic prosody in Danish phonology there are contrastive near-minimal pairs differing in segmental *stød* occurrence rather than syllabic *stød* occurrence, e.g. ‘lån’ [ˈlɔːˀn] *loan* vs ‘lund’ [ˈlɔnˀ] *grove*, conditioned by the length of the vowel. Given that these long vowel+sonorant consonant combinations are what produces the tonal *stød* condition and that the prevalence of PSC was statistically significant as a function of *stød* type it could be that the usual restrictive segmental scope of non-modal phonation observed in other languages is less restricted on these tokens because the vowel length already provides salient cues to the contrast, lessening some of the perceptual load from the *stød*. This, however, does not account for why PSC also occurs on regular *stød* tokens where the minimal pairs differ *only* in *stød* with no vowel length difference, e.g. ‘låner’ [ˈlɔːˌnɐ] *(a) borrower* vs ‘låner’ [ˈlɔːˀˌnɐ] *borrows*. The PSC here may just be a coarticulatory effect but as it does not occur very consistently on the same words across speakers coarticulation alone cannot sufficiently account for PSC.

A surprising finding was that PSC occurs on tonal *stød* tokens for the Aarhus speakers as these tokens have been found to be phonetically realised with a long, falling tone [7] rather than laryngealisation or creaky voice, meaning no PSC would be expected. It may be a few artifacts of the general effect observed with low tones where the vocal folds start to vibrate in more irregular cycles if the tone is particularly low, which would partly explain why this does not occur on all tonal tokens but only a few – these may have tones ending below a certain threshold where regular vocal fold vibration can no longer be sustained. It could also be an enhancement of the contrast where the tone is perceived as lower if it is produced with creaky voice on the adjacent segment. However, as creaky voice in the Standard Modern Danish dialect *is* the contrast, this seems less plausible. It is entirely possible that the presence of PSC is predicted by sociophonetic factors too, apart of course from the factor of dialect already found here, and given the individual variation evident in Figure 2 and 3, the idiosyncrasy of PSC occurrence could also be of interest to forensic phonetic research on Danish.

6. CONCLUSIONS

The aim of this paper was to provide an initial quantitative account for the phenomenon labelled post-*stød* creak occurring after the Danish laryngealisation *stød* as an example of how phonologically contrastive non-modal voice quality can span over more than one segment, an unexpected observation from research on other languages. Data were compared for two dialects, Copenhagen and Aarhus, and two types of *stød* conditions were included, regular *stød* and tonal *stød*. Post-*stød* creak prevalence was found to be significantly correlated with both dialect and *stød* type, being most prevalent on tonal *stød* tokens in the Copenhagen dialect. The segmental span of PSC was primarily the segment adjacent to the *stød* but could span up to four segments after the contrastive segment in one case. More research is necessary to determine the conditioning factors for PSC but this initial account shows that the Danish *stød* defies the general segmental restriction of contrastive laryngealisation and inspires more research into its conditioning factors, sociophonetic status and individual speaker idiosyncrasy relevant for forensic phonetic research on Danish and beyond.

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