Does Danish have voiced fricatives?*

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It is an open question whether Danish has voiced fricatives, whether at the phonetic level or the phonological level. The best candidates for being voiced fricatives are /v r/, which are sometimes described as being voiced fricatives at the phonological level, even though they are usually taken to be approximants at the phonetic level. In this article, we discuss the evidence for and against analysing /v r/ as voiced fricatives, including evidence from phonological processes, phonotactics, and language history. We also report the results from a pilot corpus study of the acoustics of /v r/, since we are not aware of any previous studies of the phonetics of /v r/. The phonological evidence consistently points to /v r/ being considered approximants, while the phonetic evidence suggests that (in simple onset position) /v/ is an approximant and /r/ is a variably voiced fricative. These results call for modelling within Boersma's BiPhon framework of the phonetics-phonology interface for /r/.

1 Introduction

Jørgen Rischel once described Danish as "second only to English in its post-medieval tradition of painstaking phonetic observation" (2000: 161). While this painstaking observation includes a great deal of instrumental phonetic research, it also includes a great deal of auditory observation, introspection, and proprioception, and there are still plenty of open questions about the Danish sound system. For instance, while Danish certainly has voiced continuants and certainly has fricatives, it is an open question whether it has voiced fricatives – either at the phonetic or the phonological level. This is important to consider for correctly

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evaluating the place of Danish in typologies of laryngeal contrasts, since the other class of obstruents, *viz.* stops, displays an aspiration contrast rather than a voicing contrast (Puggaard-Rode et al. 2022), leaving open the question whether voicing is a relevant parameter at all in Danish phonology. In the present study, we take a first stab at answering this question.

Among the Danish consonants, the strongest candidates for being voiced fricatives are /v r/, so we concentrate on those. The voiced continuant known as the 'soft d' is often transcribed using the symbol for a voiced dental fricative [ð], but it is already well-established that this is not phonetically a fricative (Brotherton & Block 2020), and while some earlier sources considered it to be underlyingly represented as a voiced fricative (Rischel 1970; Basbøll 1975), newer sources seem to have abandoned this analysis (unlike /v r/; e.g. Basbøll 2005: 215).

Following e.g. Jakobson et al. (1951), we will refer to Danish intervocalic medial and coda positions as 'weak', and stressed onset position as 'strong'. This is a very important distinction in Danish phonology, as proposed phonemes have very different realizations in strong and weak positions (see e.g. Horslund et al. 2021, 2022). According to this analysis, /v r/ are realized as [ʊ ʁ] in strong positions and [o̯ e̯] in weak positions. Phonetically, the strong realisations [ʊ ʁ], as in *hvem* [ʊɛmˀ] 'who' and *rem* [ʁæmˀ] 'strap', are usually described as approximants (Basbøll 2005: 62; Grønnum 2005: 138, 141, 2007: 109, 114–115; Petersen et al. 2021: 64, 69; Schachtenhaufen 2023: 53), and the weak realisations [o̯ e̯], as in *effektiv* [ˈɛfəkˌtʰio̯ˀ] 'efficient' and *natur* [næˈtʰue̯ˀ] 'nature', are usually described as semi-vowels or glides (Basbøll 2005: 63; Grønnum 2005: 63, 159, 2007: 116–177; Petersen et al. 2021: 69; Schachtenhaufen 2023: 61). However, Basbøll (2005: 62) and Schachtenhaufen (2023: 53) mention that [ʊ ʁ] can occur as voiced fricatives. Despite this widespread agreement, we are not familiar with any acoustic or articulatory studies on Danish [ʊ ʁ] and [o̯ e̯], so these phonetic classifications must be based only on auditory observation, introspection, or proprioception.

Neither the agreement nor the classification is mirrored in phonological analyses of /v r/. On the basis of phonotactics, Basbøll (2005: e.g. 147) classifies /v r/ as voiced obstruents at the phonological level, while Grønnum's (2005: 392) phonological classification, based on language history, differs between /v r/: she categorizes /v/ as an obstruent and /r/ as a sonorant.

In the rest of the paper, we discuss the various types of evidence bearing on the possible status of Danish /v r/ as fricatives. Our discussion deals with evidence relevant to the existing phonological analyses of /v r/ (i.e., Basbøll 2005; Grønnum 2005) as well as evidence that we consider relevant to the phonological status of /v r/. Following Boersma (e.g., 1998, 2009), we view phonological categories as a result of phonetic information (auditory and articulatory),

structural information (phonotactics), and morpho-lexical information (phonological processes). In our discussion of Basbøll and Grønnum's analyses, we evaluate the existing evidence in relation to both their own criteria and ours. For example, we disregard Grønnum's historical argument in relation to her own criteria due to lack of empirical support, and in relation to our criteria on the principal ground that diachronic observations are irrelevant for synchronic phonology (see further Horslund et al. 2022; Puggaard-Rode et al. 2024).

In Section 2, we discuss evidence from phonological processes, outlining the positional variants. In Section 4, we discuss phonetic evidence, presenting results from a small, preliminary corpus study. In the following two sections, we discuss the phonological classifications by Grønnum (Section 4) and Basbøll (Section 5) and the relevant evidence relating to their arguments based on language history and phonotactics, respectively. Finally, in Section 6, we conclude on how the question posed in the title of the paper can be answered in light of the presented evidence from phonological processes, phonetic measures and phonotactics. Our tentative answer is that phonologically, Danish has no voiced fricatives, while initial /r/ is phonetically best described as a variably voiced fricative. We acknowledge that the evidence presented here is insufficient to answer our question conclusively; we lack psycholinguistic evidence of how native speakers of Danish classify /v r/, and the phonetic evidence would benefit from controlled experimental elicitation and/or statistical confirmation. We expect to obtain such evidence in the future.

2 Phonological processes and positional variants

The phonological behaviour of /v r/ arguably supports analysing them as sonorants rather than as obstruents. The traditional analysis of Danish consonants (Rischel 1970; Basbøll 2005; Grønnum 2005) views consonant gradation as a synchronic phonological process, thus linking the voiceless unaspirated plosives [p t k] and semi-vowels [ɪ̯ ʊ̯ ɤ̯][1] as realizations of the underlying phonologically voiced obstruents /b d g/. We have previously argued that this analysis is problematic for several reasons (Horslund et al. 2021, 2022), and that the present-day alternation patterns must be accounted for diachronically and not synchronically (Puggaard-Rode et al. 2024). Our alternative analysis (Horslund et al. 2021, 2022) considers all instances of the semivowels [ʊ̯ ɪ̯] variants of /v j/, respectively. In our conception, /b d g/ are thus similar to the voiceless fricatives /f s/ in not having markedly different allophones in strong and weak positions. /v

[1] Following Schachtenhaufen (2023), we use the symbol [ɤ̯] for the so-called soft d, which is traditionally transcribed [ð] despite it being neither dental nor a fricative.

r/, however, have consonantal allophones in strong position, and vocalic allophones in weak positions. This is similar to the approximant /j/, which is realised as an approximant [j] in strong position and a semi-vowel [i̯] in weak position; compare *hjul* [ˈ**j**uːˀl] 'wheel', *tøj* [ˈtʰʌ**i̯**] 'clothes'. The only exception to this pattern is that /v/ is [ʊ] word-finally in complex codas, as in *ulv* [ˈulˀ**ʊ**] 'wolf'; there are very few such words. It is likely that /v/ is in fact realized as a fricative in these cases, even if it is not otherwise.

Support for linking [ʊ] and [ʊ̯] as allophones of the same phoneme /v/ and [ʁ] and [ʁ̞] as allophones of the same phoneme /r/ can be found in:

1. morphophonological alternations such as *effektiv* [ˈɛfəkˌtʰi**ʊ̯**ˀ] 'efficient' ~ *effektivisere* [ɛfɛktʰi**ʊ**iˈseːˀʌ] 'make efficicient', and *natur* [næˈtʰu**ʁ̞**ˀ] 'nature' ~ *naturist* [nætʰuˈ**ʁ**ɪst] 'naturist', although they are few.
2. stylistic alternations such as *leve* [ˈleː**ʊ**ə] ~ [ˈleː**ʊ̯**ə] ~ [ˈleː**ʊ**] 'live' and *bedre* [ˈpɛɣ̞**ʁ̞ə**] ~ [ˈpɛɣ̞**ʁ̞**] 'better'.
3. articulatory similarities between [ʊ] and [ʊ̯], i.e., both are labial continuants, and between [ʁ] and [ʁ̞], i.e., both are (supra-)pharyngeal continuants (see Sobkowiak 2018 for a review of proposals regarding the place of articulation in [ʁ]).

Due to laryngeal assimilation, /v r/ are often reported to devoice after aspirated plosives and voiceless fricatives, as in *kvik* [ˈkʰʊ̥ik] 'bright' and *kram* [ˈkʰʁ̥ɑmˀ] 'hug', similar to the approximants /l/ and /j/ as in *klar* [ˈkʰl̥ɑːˀ] 'clear' and *kjole* [ˈkʰj̊oːlə] 'dress'. This is a longstanding observation (e.g. Heger 1981; Grønnum 2005), which was tested empirically (in part) by Juul et al. (2019), who found evidence of partial devoicing of /l/ and substantial devoicing of /r/ after aspirated stops, but not after voiceless fricatives. Juul et al. (2019) also found evidence of /r/ devoicing after unaspirated stops, suggesting that /r/ devoicing is not caused by aspiration. They did not test whether /r/ devoices after voiceless fricatives.

Finally, /v/, unlike voiceless fricatives but similar to the sonorants /j l m n/, can be syllabic due to schwa assimilation (Brink & Lund 1975; Basbøll 2005; Schachtenhaufen 2010). In this process, an underlying schwa may elide, leading to adjacent consonants becoming syllabic. Some examples, where stylistic alternations without schwa assimilation are possible, are *sove* [ˈsɒːʊ̯ə] ~ [ˈsɒːʊ] 'sleep', *høje* [ˈhʌːi̯ə] ~ [ˈhʌːɪ] 'hills', *mule* [ˈmuːlə] ~ [ˈmuːl̩] 'muzzle', *dame* [ˈtæːmə] ~ [ˈtæːm̩] 'lady', and *krone* [ˈkʰʁ̥oːnə] ~ [ˈkʰʁ̥oːn̩] 'crown'. [ʁ̞] also occurs in a syllabic version [ʁ̩], which either stems from the historic fusion of inflectional and derivational /ər/ sequences, as in *danser* [ˈtænsʁ̩] 'dancer/dances', or from obligatory /r/-coloring of /ə/, whereby /ə/ is lowered by an adjacent /r/, as in *ændre* [ˈɛntʁ̩] 'change'. Syllabic [ʁ̩] can arguably also be the result of schwa assimilation, as in *bære* [ˈpæːʁ̩] 'to carry', which does not derive from a (morphophonological) /ər/-sequence. This is difficult to evaluate though, since

obligatory /r/-colouring rules out the possibility of stylistic alternations. Note that *bære* 'to carry' is homophonous with *bærer* 'carries/carrier', where [ɐ] *does* derive from a (morphophonological) /ər/-sequence. If an underlying schwa follows a stop or voiceless fricative preceded by a long vowel, schwa assimilation can skip the consonant and result in a short syllabic 'copy' of the preceding long vowel, as in *kåbe* [ˈkʰɔːpə ~ ˈkʰɔːɔp] 'gown' and *blæse* [ˈplɛːsə ~ ˈplɛːɛs] 'blow'. As we have seen above, such long-distance schwa assimilation is not found after /v r/, which may be taken as evidence that /v r/ do not behave like obstruents phonologically.

3 Phonetic evidence

We are not aware of any previous instrumental phonetic work investigating [ʊ ʁ]. As a first look, we present here the results of an exploratory study based on the Danish Phonetically Annotated Spontaneous Speech (DanPASS) corpus (Grønnum 2009). The recordings come from the DanPASS monologues, which constitute 171 minutes of unscripted speech from 18 speakers. The aim is to investigate to which extent the acoustics of [ʊ ʁ] supports them being (1) voiced, and (2) fricatives. We only investigate the strong realizations of /v r/, since we have every reason to expect they are realized as semivowels in weak positions.

Determining whether voicing is present or absent in a segment is relatively straightforward. We do this using the autocorrelation algorithm described by Boersma (1993): raw autocorrelation of the signal is calculated from Hanning-windowed sound segments, and these segments (frames) are considered voiced if the autocorrelation peak is higher than 0.45. Determining whether a segment is best classified as a voiced fricative or an approximant is much less straightforward. Following, e.g., Brotherton and Block (2020), we generally expect that the harmonics-to-noise ratio (HNR) is lower for fricatives than for approximants, so we compare [ʊ ʁ] with [j] (which is the only Danish phone consistently acknowledged to be an approximant). We cannot expect either result to give a straightforward answer to our research question, since there is likely to be by-token and by-speaker variation in the presence of voicing and the degree of aperture in both [ʊ ʁ]. Here, we only aim to get a first sense of the variability in the data. Since this is a preliminary exploratory study, we do not submit the results to inferential statistical analysis.

The analysis is carried out in R (R Core Team 2025). We found all syllables in DanPASS with [ʊ ʁ j] in simple onset position using the EMU Speech Database Management System (Winkelmann et al. 2017) for querying phonetic annotations. The token count is as follows: 1,537 instances of [ʊ] (of which 904 occur in stressed syllables), 335 instances of [ʁ] (of which 248 occur in stressed syllables), and 284 instances of [j] (of which 130 occur in stressed syllables).

Since the DanPASS annotations are only segmented at the syllable level, we implemented an automatic method for separating the onset from the rhyme based on fundamental frequency (f0) and root-mean-squared (RMS) amplitude. Both f0 and RMS amplitude are calculated with a frame shift of 1 ms using Praat (Boersma & Weenink 2024) with default settings.[2] If there is a lag between the syllable onset and the first valid f0 value, the vowel is assumed to start at the f0 onset; otherwise, the vowel is assumed to start at the first RMS amplitude frame which is 2 dB below the peak value in the syllable or higher. This value was determined to give the best results after comparing a few different values. While this segmentation is not perfect, we sampled a number of syllables and found that the results were quite good. Examples are given in Figure 1 below.

The presence or absence of voicing was determined using the raw autocorrelation-based f0 tracking algorithm in Praat with a frame shift of 1 ms and default settings otherwise. Tokens are reported as fully voiced if >90% of frames were voiced, fully voiceless if <10% of frames were voiced, and partially voiced otherwise. HNR was calculated in Praat using the cross-correlation algorithm with the silence threshold suppressed. In order to normalize for differences in local noise levels, we report the difference in HNR (in dB) between the midpoint of the onset consonant and the peak value of the syllable, referred to henceforth as ΔHNR. A ΔHNR value of 0 would correspond to a consonant that is exactly as harmonic as the most harmonic part of the following vowel; ΔHNR < 0 corresponds to a consonant that is noisier than the following vowel, which is by far the norm. It is worth noting that ΔHNR is likely highly correlated with the presence or absence of onset voicing. We stick with both measures, since ΔHNR is intended to probe manner of articulation (fricative *vs.* approximant), which we might in itself expect to correlate with the presence or absence of voicing.

[2] Praat's signal processing routines are accessed through the Parselmouth library for Python (Jadoul et al. 2018), using the `reticulate` library (Ushey et al. 2025) to facilitate communication between Python and R.

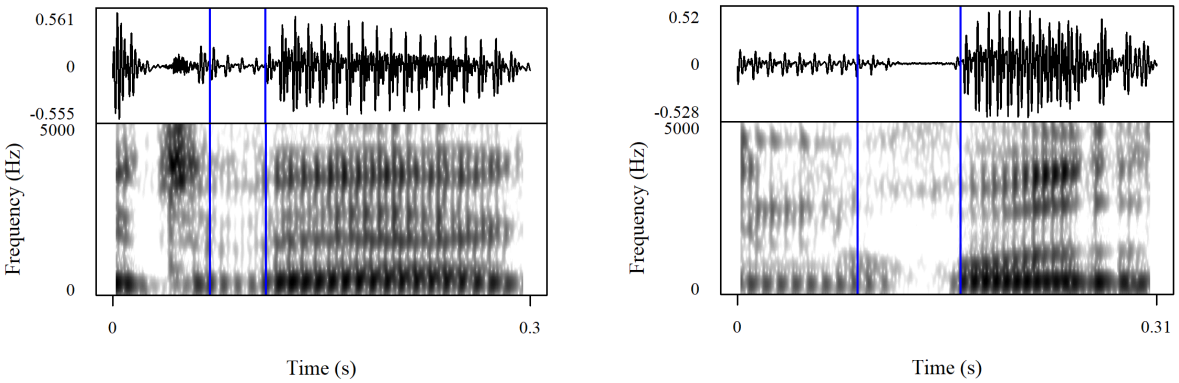


Figure 1: Examples of [ʊ] (left) and [ʁ] (right) with manually annotated onset and automatically annotated offset shown on the waveform and spectrogram.

Figure 2 shows the distribution of voicing in [ʊ ʁ] in stressed and unstressed syllables. In unstressed syllables, the majority of both [ʊ ʁ] tokens are fully voiced, although the proportion of fully voiced tokens is substantially higher for [ʊ]. In stressed syllables, however, there is actually a higher proportion of fully voiceless [ʁ] (39.7%) than fully voiced [ʁ] (37.2%). Meanwhile, the proportion of fully voiceless [ʊ] tokens in stressed syllables is quite marginal (7.1%), and the vast majority of tokens are fully voiced (81.4%).

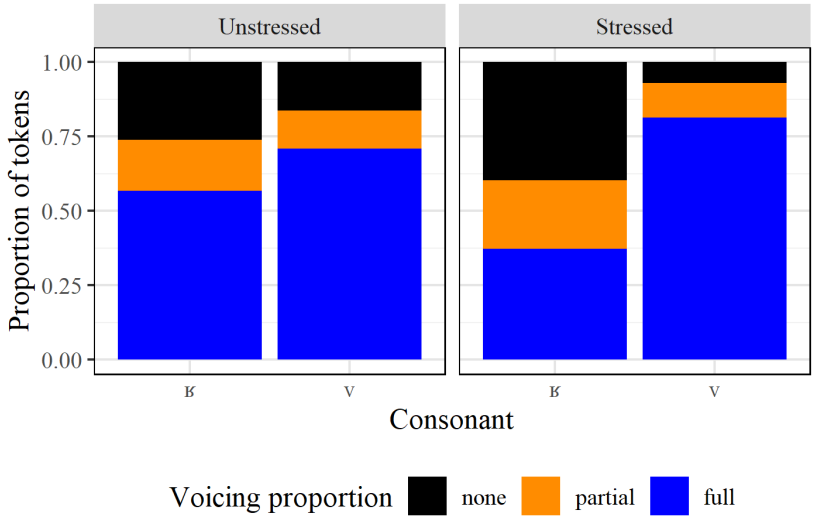


Figure 2: Distribution of voicing in [ʊ ʁ] in stressed and unstressed syllables.

Figure 3 shows the distribution of ΔHNR. While these values are quite variable, ΔHNR is on average similar for [j ʊ]. For [ʁ], the difference is somewhat larger in unstressed position, and larger yet in stressed position.

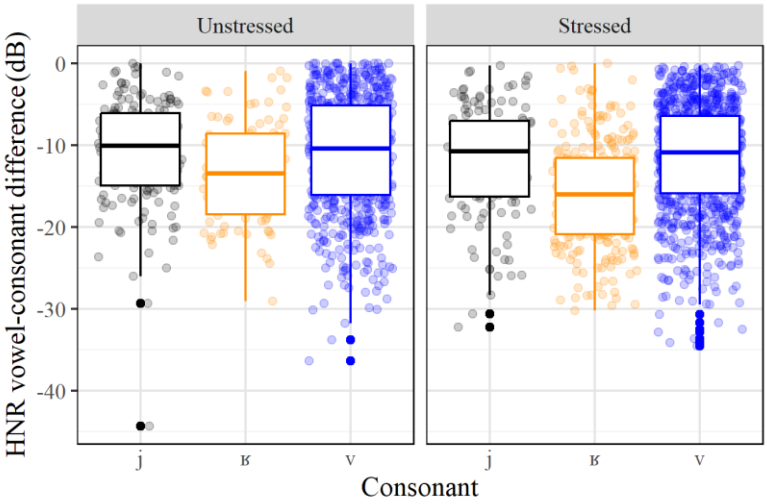


Figure 3: Distribution of ΔHNR in [j ʊ ʁ] in stressed and unstressed syllables.

If we assume that stressed positions better reflect the articulatory target of a consonant, and unstressed positions leave consonants more vulnerable to lenition or coarticulatory processes, the upshot is that voicing is targeted in [ʊ] but not necessarily in [ʁ]. An alternative explanation is that voicing is also targeted in [ʁ], but that the constriction achieved in stressed syllables counteracts voicing, which is not unlikely given a narrow pharyngeal constriction. The voicing status of [ʁ] is highly variable, likely due to latent variables such as speaker-specific patterns or phrasal position. In unstressed position, where lenition or coarticulation is more likely, the likelihood of [ʁ] being voiced is higher. Puggaard-Rode et al. (2022) report similar overall patterns for Danish /b d g/, although the likelihood of voicing in /b d g/ is overall substantially lower than in [ʁ]. There is evidence from e.g. Hutters (1985) that voicelessness is actively targeted in /b d g/. There is no such evidence for [ʁ], and the presence of voicing is near chance level in stressed position. Note, though, that the proportion of fully voiceless [ʁ] is a fair bit higher than the proportion of fully voiceless [v] in Dutch reported by Pinget and Quené (2023), despite the fact that Dutch /v/ is currently undergoing devoicing. Further research is needed to determine what triggers voicing or voicelessness in [ʁ]. For now, we will describe it as *variably voiced*. From a phonetic perspective, any sound can of course be considered variably voiced, and indeed we also see that [ʊ] is occasionally realized without voicing, but we assume that the *target* for [ʊ] is voicing, whereas we cannot determine the target either way for [ʁ] based on the data presented here.

The close similarity between ΔHNR of [j ʊ] suggests that [ʊ] is an approximant rather than a fricative, while the much greater ΔHNR of [ʁ] suggests that it is realized as a fricative. These results thus suggest that neither [ʊ ʁ] can straightforwardly be described as voiced fricatives at the level of phonetic

realization. Rather, [ʊ] appears to be targeted as a voiced approximant, whereas [ʁ] appears to be targeted as a (variably voiced) fricative.

4 Historical evidence

The argument behind Grønnum's (2005: 392) phonological classification of /v/ as an obstruent and /r/ as a sonorant is essentially historical. Grønnum (2005: 110) defines the class of approximants as phonological obstruents that are sonorants phonetically, i.e., voiced, frictionless, and resonant. Their phonological status as obstruents rests on the claim that they are the result of reduced historical obstruents (Grønnum 2005: 149). She distinguishes between approximants and semi-vowels, which she defines as a subset of the phonological sonorants, namely non-syllabic vocalic sounds. Grønnum thus classifies [ʊ] as an approximant (2005: 138) and argues that [ʊ̯] ought to be classified as an approximant according to her own definition, though she ends up classifying [ʊ̯] as a semi-vowel according to tradition (2005: 149). Without any explicit motivation, Grønnum classifies [ʁ] as a liquid, which is a type of sonorant in her classification (2005: 149), and [ʁ̯] as a semi-vowel, another type of sonorant, on the basis of its variable aperture and its phonological relationship to the sonorant [ʁ] (2005: 159).

From our perspective, Grønnum's historical argument is problematic as language users are not generally aware of language history (Linell 1979: 4) and must build their phonological representations from the language input *they* are exposed to and not the language input their ancestors were exposed to. We therefore adhere to making a clear distinction between synchronic and diachronic phonology (Horslund et al. 2022; Puggaard-Rode et al. 2024).

Grønnum's argument is also problematic in relation to her own criteria as her claim that [ʊ] and [ʊ̯] are the result of reduced historical obstruents is unsupported by research in historical linguistics. Middle Danish (spoken c. 1100–1500) is described as having both voiced and voiceless fricatives in weak positions. These voiced fricatives have various historical sources: some developed from voiceless fricatives in the transition from Proto-Nordic to Old Norse (Nielsen & Stoklund 2018), others developed from voiced stops (previously voiceless singleton stops) during the Middle Danish period. As outlined by Puggaard-Rode et al. (2024), these voiced fricatives gradually developed into semi-vowels, or full vowels in the context of schwa assimilation. In strong position, neither Middle Danish nor earlier stages of Danish had a voicing contrast in its fricatives. /v/ in strong position historically developed from an approximant /w/, which is still retained in several traditional dialects (Bennike & Kristensen 1898–1912). Meanwhile, /r/, whose historical origin Grønnum does not discuss, was historically an alveolar trill, with the change to a dorsal rhotic having presumably taken place in the Early Modern Danish period (Brink & Lund 2018).

As such, it is not the case that /v r/ have a long history of being realised as voiced fricatives in strong position, and recently (potentially) weakened to approximants; /v r/ have by all accounts been sonorants until a few hundred years ago, and they may not ever have been consistently realised as voiced obstruents.

5 Phonotactic evidence

In Basbøll's (1994, 2001, 2005) model of syllable structure, the Sonority Syllable Model, segments are divided into five natural classes defined by their sonority profile. More sonorous classes are always proper subsets of less sonorous classes, such that class I consists of all vocoids, class II consists of all sonorants (which includes all vocoids), class III consists of all voiced segments (which includes all sonorants), etc. These classes are argued to predict core syllable structure: the nucleus corresponds to a sonority peak, and sonority gradually increases in the onset and decreases in the coda. This is particularly relevant for our purposes, because voiced obstruents *de facto* form one of these classes (class III), and the only voiced obstruents in Basbøll's analysis of Danish are /v r/. As such, the status of /v r/ as voiced obstruents is predicted to affect their phonotactic behaviour. Eventually, Basbøll (2005: 207–208) concludes that only three classes are needed in the description of Danish, and that classes I–III can be collapsed to one class consisting of all voiced sounds. In other words, his analysis hinges on /v r/ being voiced, but it does not particularly hinge on them being obstruents.

In order to investigate to which extent the phonotactic distributions of /v r/ point towards these sounds being (1) voiced, and (2) fricatives/obstruents, we compare their phonotactic distributions to those of the voiceless fricatives /s f h/ and the voiced approximants /j l/.

Table 1: Phonotactics overview. C1, C2, and C3 refer to the first, the second, and the third consonant in a cluster. Marginal structures are enclosed by parentheses. See Tables 2–5 for examples and comments.

		ONSET				**CODA**			
		Simple	**Clusters**			**Simple**	**Clusters**		
			C1	**C2**	**C3**		**C1**	**C2**	**C3**
???	**v**	+	+	+		+	+	+	
	r	+		+	+	+	+		
Voiceless fricatives	**f**	+	+	(+)		+		+	
	s	+	+			+		+	+
	h	+							
Voiced approx.	**l**	+		+	+	+	+	+	
	j	+		+	+	+	+	(+)	

Judging from the overview presented in Table 1, the distribution of /r/ mirrors the distribution of the approximant /j/ almost perfectly, while the distribution of /v/ most clearly resembles the distribution of the fricative /f/ in onset and the distribution of the approximant /j/ in coda. Danish phonotactics, however, is more complex than Table 1 lets on, and the exact make-up of initial consonant clusters differs between /j r/ and between /f v/, as do the exact make-up of final consonant clusters between /j r/ and between /j v/, which we will see in Tables 2–5, in which many of the examples are taken from Grønnum (2007: 45–48).

Table 2 illustrates how the onset distribution of /v/ is more restricted than that of /f/ in C1 position, while the opposite pattern is detected in C2 position, thus providing evidence that /v/ has a higher sonority than /f/. Table 3 illustrates that the coda distribution of /v/ is more restricted than that of /j/ in C1 position, but since these restrictions are limited to the homorganic clusters /vm/ and /vp/, this has no bearing on the sonority of /v/. The fact that /v/ cannot precede /l n/ in onsets (if one discards the foreign sounding borrowed occurrences of /vl/), but can in codas, with /f/ showing the opposite pattern, suggests that /v/ has a higher sonority than /l n/. The fact that /v/ can precede /r/ in onsets, but not in codas, suggests that /v/ has a lower sonority than /r/.

Table 2: Examples of /f v/ in onset positions.

	/f/			**/v/**		
C1	*fnug*	[ˈfnuk]	‘flake’			
	flag	[ˈflæɪ̯ˀ]	‘flag’	*vlog**	[ˈʊlʌg]	‘vlog’
	fred	[ˈfʁɛɤ̯]	‘peace’	*vred*	[ˈʊʁɛɤ̯ˀ]	‘angry’
	fjord	[ˈfjoɐ̯ˀ]	‘fjord’			
C2	*sfære***	[ˈsfɛːʌ]	‘sphere’	*svær*	[ˈsʊɛɐ̯ˀ]	‘difficult’
				*bvadr****	[ˈpʊæɤ̯ˀʌ]	‘bleagh’
				tvivl	[ˈtʰʊiʊ̯ˀl]	‘doubt’
				dvale	[ˈtʊæːlə]	‘hibernation’
				kvik	[ˈkʰʊik]	‘bright’

* [ʊl] occurs only in this lexeme, which is a recent borrowing from English, and in borrowed proper names such as *Vladimir*, both of which sound distinctly foreign.
** [sf] occurs only in two lexemes, both from Greek and often pronounced [sʊ].
*** [pʊ] occurs only in this single lexeme, which is an interjection. The oddity of the cluster may stem from its homorganicity.

Table 3: Examples of /j v/ in coda positions.

	/j/			/v/		
C1				*flyvsk*	[ˈflyʊ̯ˀsk]	‘flighty’
	gejst	[ˈkɑɪ̯ˀsd]	‘spirit’	*provst*	[ˈpʰʁʌʊ̯ˀst]	‘provost’
	hegn	[ˈhɑɪ̯ˀn]	‘fence’	*havn*	[ˈhɑʊ̯ˀn]	‘port’
	Daim	[ˈtɑɪ̯ˀm]	brand name			
	tegl	[ˈtʰɑɪ̯ˀl]	‘brick’	*høvl*	[ˈhœʊ̯ˀl]	‘plane’
	tape	[ˈtʰɛɪ̯p]	‘tape’			
	fløjt	[ˈflʌɪ̯ˀt]	‘whistle’	smaragd	[smɑˈʁɑʊ̯ˀt]	‘emerald’
	strejf	[ˈstʁɑɪ̯ˀf]	‘trace’			
	rejs	[ˈʁɑɪ̯ˀs]	‘travel’	*sovs*	[ˈsʌʊ̯ˀs]	‘sauce’
	Heick	[ˈhɑɪ̯ˀk]	proper name	*tomahavk*	[tʰʌmæˈhɑʊ̯ˀk]	‘tomahawk’
C2				*djærv*	[ˈtjæɐ̯ˀʊ̯]	‘bold’
	*valg**	[ˈvalˀɪ̯]	‘choice’			
* [ɪ̯] is only realized in hyper-distinct speech.						

Table 4: Examples of /j r/ in onset positions.

	/j/			/r/		
C2	*pjat*	[ˈpʰjat]	‘nonsense’	*prik*	[ˈpʰʁɛk]	‘dot’
	bjælde	[ˈpjɛlə]	‘bell’	*brat*	[ˈpʁɑt]	‘sudden’
	tjener	[ˈtʰjɛːnʌ]	‘waiter’	*træt*	[ˈtʰʁɑt]	‘tired’
	djævel	[ˈtjɛːʊəl]	‘devil’	*drik*	[ˈtʁæk]	‘drink’
	kjole	[ˈkʰjoːlə]	‘dress’	*kram*	[ˈkʰʁɑm]	‘hug’
	gjord	[ˈkjoɐ̯ˀ]	‘girth’	*gro*	[ˈkʁoːˀ]	‘grow’
	sjov	[ˈɕʌʊ̯ˀ]	‘fun’	*Sri Lanka**	[sʁeˈlɑŋkʰæ]	proper name
				vred	[ˈʊʁɛɤˀ]	‘angry’
C3	*spjæt*	[ˈspjɛt]	‘jerk’	*spring*	[ˈspʁɛŋˀ]	‘jump’
	stjerne	[ˈstjæɐ̯nə]	‘star’	*straks*	[ˈstʁɑks]	‘right away’
	skjul	[ˈskjuːˀl]	‘hide’	*skrald*	[ˈskʁɑlˀ]	‘litter’
*[sʁ] occurs only in this single lexeme, which is a borrowed proper name						

Table 5: Examples of /j r/ in coda positions.

	/j/			**/r/**		
C1				*hersk*	[ˈhæɐ̯sk]	‘rule’
	gejst	[ˈkɑɪ̯ˀst]	‘spirit’	*børst*	[ˈpœɐ̯st]	‘brush’
	hegn	[ˈhɑɪ̯ˀn]	‘fence’	*bjørn*	[ˈpjœɐ̯ˀn]	‘bear’
	Daim	[ˈtɑɪ̯ˀm]	Brand name	*hørm*	[ˈhœɐ̯ˀm]	‘bad smell’
	tegl	[ˈtʰɑɪ̯ˀl]	‘brick’	*Karl*	[ˈkʰɑːˀl]	Proper name
	tape	[ˈtʰɛɪ̯p]	‘tape’	*svirp*	[ˈsʊiɐ̯ˀp]	‘flick’
	fløjt	[ˈflʌɪ̯ˀt]	‘whistle’	*vært*	[ˈʊæɐ̯t]	‘host’
	strejf	[ˈstʁɑɪ̯ˀf]	‘trace’	*verf*	[ˈʊæɐ̯f]	‘throw’
	rejs	[ˈʁɑɪ̯ˀs]	‘travel’	*vers*	[ˈʊæɐ̯s]	‘verse’
	Heick	[ˈhɑɪ̯ˀk]	Proper name	*værk*	[ˈʊæɐ̯k]	‘work’
	live	[ˈlɑːɪ̯ʊ]	‘live’	*djærv*	[ˈtjæɐ̯ˀʊ̯]	‘bold’

Table 4 illustrates how perfectly the onset distribution of /r/ mirrors that of /j/, and Table 5 illustrates the striking similarity between the coda distributions of /r j/. Both of these observations provide evidence that the sonority of /r/ is similar to that of /j/.

Taken together, the phonotactic distribution of /r v/ provides evidence that the sonority of /r/ is similar to that of /j/ and the sonority of /v/ is lower than that of /r/ but higher than the sonorants /l n/ and the obstruent /f/. This means that, phonotactically speaking, both /v r/ behave as sonorants, with /r/ being more sonorous than /v/, thus providing evidence against them being obstruents and for them being voiced. Our analysis thus supports Basbøll’s classification of them as voiced while challenging his classification of them as obstruents.

6 Conclusion

With the aim of answering the question ‘does Danish have voiced fricatives?’, we have considered four types of evidence bearing on the phonological status of /v r/. The various types of evidence point in different directions. We disregard Grønnum’s historical argument on the principal ground that diachronic observations are irrelevant for synchronic phonology. That leaves evidence from phonological processes, phonetics, and phonotactics. While evidence from both phonological processes and phonotactics suggests /v r/ behaving phonologically as sonorants, with /r/ more sonorous than /v/, and thus pointing towards a classification of /v r/ as voiced approximants similar to /j/, the phonetic evidence tells a different story. Our preliminary corpus study suggests that initial /v/ appears to be targeted as a voiced approximant, whereas initial /r/ appears to be

targeted as a (variably voiced) fricative. Our tentative conclusion is therefore that Danish has no phonologically voiced fricatives and /v r/ should be classified as approximants phonologically, but that phonetically [ʁ] is a fricative with variable voicing.

The finding that [ʁ] has the acoustic make-up of a fricative contradicts previous phonetic descriptions of [ʁ] as an approximant, based on auditory observation, introspection, and proprioception, which showcases the limitations of such methods and the necessity of instrumental phonetics.

In conjunction with our previous work (Puggaard-Rode et al. 2022) showing that Danish stops display an aspiration contrast rather than a voicing contrast, this study suggests that voicing is not a relevant parameter in Danish phonology. Even at the phonetic level, voicing (i.e., periodicity) is not contrastive, as the contrast between [ʁ] and the voiceless fricatives [f s] is more clearly signalled through auditory correlates of place of articulation.

In order to provide a more confident conclusion on the phonetics, we would like to extend our phonetic corpus study to a broader range of speakers and speaking situations, and to supplement the acoustic measures with physiological measures using e.g. electroglottography. Likewise, in order to get more direct evidence on how native Danish speakers classify /v r/, we would like to conduct a range of psycholinguistic experiments involving acceptability of nonsense words differing in phonotactic make-up, concept formation (Deese & Hulse 1967; Ohala 1983) and perceptual similarity measures (Neary 1981). In the future, we hope to extend our work on Danich /v r/ with respect to both phonetics and phonology and the phonetics–phonology interface.

While our results for /v/ lead to a closer connection between the phonetic observations and the phonological analysis than previously assumed, our results for /r/ lead to more discrepancy between the phonetic observations and the phonological analysis than previously assumed. This calls for modelling of the phonetics–phonology interface for the phonological category /r/ and its auditory cues within the framework of Boersma's (e.g. 2009) *Bidirectional Phonetics and Phonology Model* (BiPhon), something that we hope to be able to do in collaboration with him in the future.

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