

An alternative, phonetically based phoneme analysis of the Danish consonant system

Camilla Søballe Horslund¹, Rasmus Puggaard² & Henrik Jørgensen³

¹Aarhus University and University of Amsterdam, ²Leiden University, ³Aarhus University

A showdown with the standard analysis

The standard analysis of the Danish consonant system links the unaspirated plosives [p-, t-, k-] with the semivowels [-ð̥, -ɹ̥, -ʊ̥] as realisations of the phonemes /b, d, g/ due to alternations like these:

- /b/ *kø[ʊ̥]e/kø[p]e – kø[p]te* (buy - bought)
- /d/ *meto[ð̥]e – meto[t]ik* (method - methodology)
- /g/ *ba[ɹ̥]e – ba[k]te – ba[ʊ̥]værk* (bake (inf.), past tense, baked goods)

Our argument: The standard analysis is outdated and impossible to learn from the language input

→ an alternative phoneme analysis of the Danish consonant system

- Based on phonetic facts
- Possible to learn from the language input

The Danish consonant inventory

	Labials	Alveolars	Palatals	Dorsals	Glottals	Labial-dorsals
Voiceless aspirated plosives	p^h-	t^s-		k^h-		
Voiceless unaspirated plosives	p	t		k		
Voiceless fricatives	f	s	ç-		h-	
Central approximants	ʋ-		j-	ɰ-		
Lateral approximants		l				
Semivowels		-ǿ̥	-ɹ̥	-ə̥		-ʊ̥
Nasals	m	n		-ŋ		

[**p^h, t^s, k^h, ç, h, ʋ, j, ɰ**] only occur in onset (strong position)

[**ǿ̥, ɹ̥, ʊ̥, ə̥, ŋ**] only occur in coda (weak position)

Phonemes and their phonetic realisations

Unproblematic phones

- [f-, s-, m-, n-, l-] and [-f, -s, -m, -n, -l] are realisations of /f, s, m, n, l/ respectively
- [h-] is the only realisation of the phoneme /h/

Problematic phones

- The link between [p^h-, t^s-, k^h-, p-, t-, k-, v-, j-, ʋ_ɹ-] and [-ð̥, -ɹ̥, -ʊ̥, -ɘ̥] is a central problem in Danish phonology
 - **The standard analysis has been the most dominant solution to this problem**
- The analyses of [-ŋ] and [ç-] constitute separate problems, which we won't discuss

The standard analysis

Phoneme	Onset realisation	Morphological alternations			
		Weak realisation		Strong realisation	
/p/	[p ^h]il (arrow)	galo[p] (gallop)	galo[p ^h]ere (to gallop)		
/t/	[t ^s]yv (thief)	va[t] (cotton wool)	va[t ^s]ere (to apply cotton wool)		
/k/	[k ^h]op (cup)	la[k] (laquer)	la[k ^h]ere (to laquer)		
/b/	[p]il (car)	plom[p]e (seal)	plom[p]ere (to seal)		
		kø[ʊ]!/kø[p]! (buy!)	kø[p]te (past tense)		
/d/	[t]ag (day)	meto[ð̥]e (method)	meto[t]ik (methodology)		
		sø[ð̥] (sweet)	sø[t] (neuter)		
/g/	[k]iv! (give!)	ba[ɪ]! (bake!)	ba[k]te (past tense)		
		ba[ʊ]værk (baked goods)			
		fonolo[∅] (phonologist)	fonolo[k]i (phonology)		
/v/	[ʊ]is! (show!)	effekti[ʊ] (efficient)	effekti[ʊ]isere (to make efficient)		
/j/	[j]ul (Christmas)	hø[ɪ] (high)	hø[ɪ]t (neuter)		
/r/	[ʁ]åd (advice)	natu[ɐ] (nature)	natu[ʁ]ist (naturist/nudist)		

[p^h-, -p] → /p/
 [t^s-, -t] → /t/
 [k^h-, -k] → /k/

[p-, -p/-ʊ] → /b/
 [t-, -ð̥, ∅] → /d/
 [k-, -ʊ, -ɪ, ∅] → /g/

[ʊ-, -ʊ] → /v/
 [j-, -ɪ] → /j/
 [ʁ-, -ɐ, ∅] → /r/

Different versions of the standard analysis

Uldall (1936)

- Phonetically different onset and coda phones can be linked to phonemes through **morphological alternations**

Rischel (1970)

- /p, t, k/ are always plosives. Aspirated in onset and unaspirated in coda.
- /d, g/ are realised as plosives in onset and as fricatives or semi-vowels in other positions
- The weak realisation of /b/, [ɸ] was not standard in 1970.
- *Soft g* [ɣ̟] was the standardised weak realisation of /g/, next to the unstandardized [ɣ̠, ɣ̡].

Grønnum (2005)

- Follows Rischel's analysis and adds two links: [v-, -ɸ] as realisations of /v/ and [ɸ-, -ɣ̠] as realisations of /r/

Basbøll (2005)

- 3 levels: morphophonemes – phonemes – phonetic realisations
- The plosive alternations are placed in the interface between morphophonemes and phonemes → /p, t, k/ only occur in onset while /ð/ only occurs in coda
- The alternations [v-, -ɸ], [j-, -ɣ̠] and [ɸ-, -ɣ̡] are placed in the interface between phonemes and phonetic realisations
- Phonemes can be deduced from morphophonemes, but the opposite is not possible

Overview over the 3 analyses

[p^h-, -p] → /p/

[t^s-, -t] → /t/

[k^h-, -k] → /k/

[p-, -p/-ᵇ] → /b/

[t-, -ᵈ, ∅] → /d/

[k-, -ᵑ, -ᵑ̥, ∅] → /g/

[v-, -ᵇ] → /v/

[j-, -ᵑ̥] → /j/

[ʁ-, -ʁ, ∅] → /r/

Rischel's analysis			Grønnum's analysis			Basbøll's analysis		
Phonemes	Phonemes in positions	Phonetic realizations	Phonemes	Phonemes in positions	Phonetic realizations	Morpho-phonemes	Phonemes in positions	Phonetic realizations
/p/	/p-/	[p ^h]	/p/	/p-/	[p ^h]	p	/p-/	[p ^h]
/b/	/-p/	[p]	/b/	/-p/	[p]	b	/-b/	[p]
/t/	/b-/	[p]	/b/	/b-/	[p]	t	/b-/	[p]
/d/	/-b/	[p]	/t/	/-b/	[p]	d	/-t/	[t ^s]
/k/	/t-/	[t ^s]	/t/	/t-/	[t ^s]	k	/-d/	[t]
/g/	/-t/	[t]	/d/	/-t/	[t]	g	/d-/	[t]
/v/	/d-/	[ᵈ]	/d/	/d-/	[ᵈ]	v	/-ᵈ/	[ᵈ]
(/j/)	/-d/	[ᵈ]	/k/	/-d/	[ᵈ]	k	/k-/	[k ^h]
(/r/)	/k-/	[k ^h]	/k/	/k-/	[k ^h]	g	/-g/	[k]
	/-k/	[k]	/g/	/-k/	[k]	v	/g-/	[k]
	/g-/	[k]	/g/	/g-/	[k]	j	/v-/	[v]
	/-g/	[ᵑ̥]	/v/	/-g/	[ᵑ̥]	j	/-v/	[ᵇ]
	/v-/	[v]	/j/	/v-/	[v]	r	/j-/	[j]
	/-v/	[ᵇ]	/j/	/-v/	[ᵇ]		/-j/	[ɹ]
	/j-/	[j]	/r/	/j-/	[j]		/r-/	[ʁ]
	/-j/	[ɹ]	/r/	/-j/	[ɹ]		/-r/	[ʁ]
	/r-/	[ʁ]		/r-/	[ʁ]			
	/-r/	[ʁ]		/-r/	[ʁ]			

Problems with the standard analysis

1. Neutralisations that cannot be dissolved
2. Lack of shared phonetic properties between different allophones of the same phoneme
3. Limited and problematic morphophonological evidence

→ **The proposed system cannot be learned from the input**

1. Neutralisations that cannot be dissolved

- A coda [ɣ] can represent 2 different phonemes or morphophonemes /g, j/
- A coda [ʁ] can represent 3 different phonemes or morphophonemes /b, g, v/
 - [ɣ] and [ʁ] can represent the same abstract category /g/

Dissolution (through alternations and vowel conditioning) are not possible for most words:

- [ɣ] in *kage* (cake), *mage* (mate), *lige* (equal) can represent either /g/ or /j/
- [ʁ] in *lov* (law), *krage* (crow), *krave* (collar) can represent either /g/ or /v/

→ A central problem for a phoneme analysis

It is a widespread assumption that speakers store phonemic forms in their lexicon (see e.g. Hayes 2009; Gussenhoven & Jacobs 2017)

→ A problem for language acquisition

Understanding the problem: Natural phonology

Terminology

Uniformity

- Max uniform: Only 1 phonetic realisation of each phoneme
- The more realisations, the lower the uniformity

Transparency

- Max transparent: Each phone represents a single phoneme
- The more phonemes a phone can represent, the lower the transparency

Biuniqueness

- Simultaneous uniformity and transparency
- A 1-to-1 relationship between phones and phonemes

(See Ács et al. 2008 and Galéas 2001)

The standard analysis

Uniformity

- 9 out of the 12 oral consonants have more than one realisation
- Most consonants have 1 strong and 1 weak realisation
- /r/ has 1 strong and 2 weak realisations [r̥, Ø]
- /g/ has 1 strong and 3 weak realisations [ɣ̥, ʁ̥, Ø]

Transparency

- Coda [ɣ̥] has 2 different sources /g, j/
- Coda [ʁ̥] has 3 different sources /b, g, v/

Biuniqueness

- Only /f, s, m, n, l, h/ have a biunique relation between phones and phonemes

The acquisition problem: The BiPhon model



- **A bidirectional model of phonetics and phonology** (e.g. Boersma 2011):
 - Comprehension and production make use of the same grammar
 - The child learns pairs of **[phonetic form]** and **'meaning'** and must construct all intermediary levels
- **Computer simulation study of French liaison** (Boersma & Leuwen 2017):
 - Most virtual learners established suppletive forms for masculine and feminine conjugations of the adjective *bon* (good) in order to generate the two phonetic forms [bɔ̃] and [bɔn]
 - We expect virtual learners of Danish to establish suppletive forms of the verb stem of *bage* (bake) in order to generate the three phonetic forms [pæ:ɪ̯], [pak] and [paɔ̯]

2. Lack of shared phonetic properties between different allophones of the same phoneme

A result of 2 sound changes:

1. **Loss of voicing in /b, d, g/** before the 1700s (Brink & Lund 2018)
→ The step from voiceless plosives to semi-vowels becomes very long
2. **Loss of soft g [ɣ]** for people born after approx. 1920 (Brink & Lund 2018)
→ lack of phonetic link between onset [k] and coda [ɪ, ʊ]

“It is possible during language change that two allophones drift too far apart to count anymore as variants of the same basic linguistic unit”

(Hayes 2009)

3. Limited and problematic morphophonological evidence

Evidence from alternations in:

- **Irregular verbs** of the *-te* type, e.g. *ba*[ɣ]*e* – *ba*[k]*te* (bake (inf.), past tense)
- **Loanwords** of Greaco-latin origin, e.g. *fonolo*[∅] – *fonolo*[k]*i* (phonologist – phonology)

Evidence suggests that these are learned too late to play a role in phonological acquisition:

- 75% of Danish children have acquired all consonant allophones by the age of 5.5 years (Heger 1979)
 - A more recent study by Clausen & Fox-Boyer (2017) show even earlier acquisition
- Irregular verbs of the *-te* type is not fully mastered at the age of 8 years (Bleses 2000)

It is implausible that:

- /b, d, g/-categories are built on alternations such as *hydrofo*[p] – *hydrofo*[p]*i*, *fonolo*[∅] – *fonolo*[k]*i*, *abbe*[-ð] – *abbe*[t]*isse*
- /p, t, k/- categories are built on alternations such as *mikrosko*[p] – *mikrosko*[p^h]*i*, *demokra*[t] – *demokra*[t^s]*i*, *patriar*[k] – *patriar*[k^h]*at*

A phonetically based alternative analysis

“We are not primarily interested in making all possible structural (‘significant’) generalizations about phonology (...) Instead, we are interested in those generalizations that a speaker-listener may reasonably make.”

(Linell 1975)

Inspiration: Ács & Jørgensen (2016)

- A different set of phonemes in onset and coda → Completely biunique, uniform and transparent
- Same phoneme analysis as Basbøll (2005) but with suppletive roots where Basbøll has morphophonemes

Our analysis

- Same set of phonemes in onset and coda
 - /b, g/ only occurs in onset as [p, k]
 - [ɹ̥] and [v̥] are considered realisations of the phonemes whose onset realisation they most closely match, i.e. /j/ and /v/. In cases which show clear alternations, we propose suppletive roots.
- Biunique from a positional perspective

Overview over the two phonetically based analyses

Ács & Jørgensen's analysis			Our analysis		
Phonemes	Phonemes in positions	Phonetic realizations	Phonemes	Phonemes in positions	Phonetic realizations
/p/	———— /p-/	———— [p ^h]	/p/	———— /p-/	———— [p ^h]
/b/	———— /b-/	———— [p]	/b/	———— /b-/	———— [p]
/t/	———— /t-/	———— [t ^s]	/t/	———— /t-/	———— [t ^s]
/d/	———— /d-/	———— [t]	/d/	———— /d-/	———— [t]
/ð/	———— /-ð/	———— [ð]	/d/	———— /-d/	———— [ð]
/k/	———— /k-/	———— [k ^h]	/k/	———— /k-/	———— [k ^h]
/g/	———— /g-/	———— [k]	/g/	———— /g-/	———— [k]
/v/	———— /v-/	———— [v]	/v/	———— /v-/	———— [v]
/v̥/	———— /-v̥/	———— [v̥]	/v/	———— /-v/	———— [v̥]
/j/	———— /j-/	———— [j]	/j/	———— /j-/	———— [j]
/j̥/	———— /-j̥/	———— [j̥]	/j/	———— /-j/	———— [j̥]
/r/	———— /r-/	———— [ʀ]	/r/	———— /r-/	———— [ʀ]
/r̥/	———— /-r̥/	———— [ʀ̥]	/r/	———— /-r/	———— [ʀ̥]

The phonetic basis for our analysis

Phoneme	Onset	Coda	Shared phonetic properties	Proposed coda lenition
/p/	[p ^h]	[p]	Voiceless bilabial plosives	Aspiration loss
/t/	[t ^s]	[t]	Voiceless alveolar plosives	Aspiration loss
/k/	[k ^h]	[k]	Voiceless velar plosives	Aspiration loss
/b/	[p]	-	-	Defectively distributed
/d/	[t]	[ð̥]	Alveolar oral consonants	Vocalisation
/g/	[k]	-	-	Defectively distributed
/v/	[v]	[v̥]	Labial voiced oral continuants	Vocalisation
/j/	[j]	[j̥]	Palatal voiced oral continuants	Vocalisation
/r/	[ʀ]	[ʀ̥]	Pharyngeal voiced oral continuants	Vocalisation

Suppletive forms account for alternations such as:

kø[v̥]*e*/*kø*[p]*e* – *kø*[p]*te*

(buy - bought)

ba[j̥]*e* – *ba*[k]*te* – *ba*[v̥]*værk*

(bake (inf.), past tense, baked goods)

Conclusion

The consonant system we propose is – contrary to the one proposed by the standard analysis – **possible to learn from the language input** because:

1. The system is **biunique from a positional perspective** → there is no neutralisation problem
2. The phonetic realisations of the same allophone **share at least one phonetic property** → the connection between them can be perceived in the input
3. The analysis **does not require children to build their phonetic system on the basis of alternations in irregular verbs and loanwords** they are unlikely to learn in early childhood

Since we propose less phonemes than Ács & Jørgensen, our system is **more economical**, all things considered

[maŋə t^sak]

[θæŋk juː]

Questions and comments

References

- Ács, Péter, Katalin Fenyvesi & Henrik Jørgensen. 2008. Dansk fonologi or morfologi set i lyset af de såkaldte naturlighedsteorier. *NyS – Nydanske Sprogstudier* 36: 10-37.
- Ács, Péter & Henrik Jørgensen. 2016. Hvorfor er dansk vanskeligt? Danske konsonantsegmenters to ansigter. *Skandinavistisk Füzetek* 10: 89-100.
- Basbøll, Hans (2005). *The phonology of Danish*. Oxford: Oxford University Press.
- Boersma, Paul. 2011. A programme for bidirectional phonology and phonetics and their acquisition and evolution. In Anton Benz & Jason Mattausch (Eds.), *Bidirectional Optimality Theory*, 33–72. Amsterdam: John Benjamins.
- Boersma, Paul & Jan-Willem Leussen. 2017. Efficient evaluation and learning in multilevel parallel constraint grammars. *Linguistic Inquiry* 48(3): 349-388.
- Bleses, Dorthe. 2000. Transparens og produktivitet i danske børns tilegnelse af verbers præteritum. *Nydanske Studier & Almen Kommunikationsteori* 26+27: 165-196.
- Brink, Lars & Jørn Lund. 2018. Yngre nydansk. In Ebba Hjort, Henrik Galberg Jacobsen, Bent Jørgensen, Birgitte Jacobsen, Merete Korvenius Jørgensen & Laurids Kristian Fahl (Eds.) *Dansk Sproghistorie 2: Ord for Ord*, 197-228. Aarhus: Aarhus Universitetsforlag.
- Clausen, Marit Carolin & Annette Fox-Boyer. Phonological development of Danish-speaking children: A normative cross-sectional study. *Clinical Linguistics & Phonetics* 31(6): 440–458
- Galéas, Grazia Crocco. 2001. Uniformity, Transparency of Encoding, and Bi-Uniqueness within the Model of Natural Morphology. *SILTA (Studi Italiani di Linguistica Teorica ed Applicata)* XXX/2: 397-405.
- Grønnum, Nina. 2005. *Fonetik og fonologi. Almen og dansk*. Copenhagen: Akademisk forlag. 3rd edition.
- Gussenhoven, Carlos & Haike Jacobs. 2017. *Understanding Phonology*. Oxon and New York: Routledge. 4th edition.
- Hayes, Bruce. 2009. *Introductory Phonology*. Malden, Massachusetts, Oxford and West Sussex: Wiley-Blackwell
- Linell, Per. 1975. *Psychological reality in phonology*. Cambridge University Press.
- Rischel, Jørgen. 1970. Consonant gradation: A problem in Danish phonology and morphology. In Benediktsson (Ed.), *The Nordic Languages and Modern Linguistics*, 460-480. Reykjavík: Vísindafélag Íslendinga.