

# A Phonetic Faithfulness Analysis of Sonorant Devoicing in Icelandic

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## ABSTRACT

This study analyzes sonorant devoicing in Icelandic, conditioned by underlyingly aspirated stops (e.g., /vant<sup>h</sup>a/ → [vaŋta]). This process exemplifies overapplication opacity: the sonorant surfaces as voiceless even though the triggering aspiration is neutralized. I propose that this opaque interaction arises from the preservation of subphonemic coarticulatory detail. The analysis is developed within the Phonetic Faithfulness model, wherein phonology operates on a phonetically detailed source representation that grammatically encodes anticipatory devoicing. This account derives Icelandic overapplication opacity by appealing to the grammar's sensitivity to finer-grained phonetic detail, supporting the view that complex phonological patterns can be shaped by phonetic considerations.

**Keywords:** Icelandic, voiceless sonorant, opacity, aspiration, phonetically based phonology

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## 1. Introduction

The existence of a phonemic contrast between voiced and voiceless sonorants is typologically marked, attested in only a small fraction of the world's languages (e.g., Maddieson, 1984; Moran & McCloy, 2019). Icelandic is one such language, maintaining a clear contrast in word-initial position, as evidenced by minimal pairs like *hné* [ŋjɛ:] 'knee' vs. *né* [njɛ:] 'nor'. Furthermore, this language also provides a rare instance of phonological alternations that derive devoiced sonorants. Specifically, a sonorant preceding an underlyingly aspirated stop is systematically devoiced, as seen in words like *vanta* /vant<sup>h</sup>a/ → [vaŋta] 'to need' and *lampa* /lamp<sup>h</sup>a/ → [laŋpa] 'lamp (sg. acc.)'. This process, which affects all sonorants, is

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the central focus of this paper.<sup>1)</sup>

This sonorant devoicing before aspirated stops in Icelandic is theoretically intriguing because it presents a classic case of phonological opacity. Specifically, it exemplifies overapplication opacity: the sonorant devoicing is conditioned by an aspirated stop, yet this trigger is absent from the surface form. The resulting phonetic output, such as [va<sup>h</sup>pta], contains a voiceless sonorant without an apparent motivation, thereby obscuring the conditioning environment for the process. This type of opacity is particularly problematic for classic Optimality Theory (Prince & Smolensky, 1993/2004), where the absence of the surface trigger makes it difficult to motivate the alternation via conventional markedness constraints.

This paper argues that this opaque alternation is best explained not by abstract feature manipulation but by the phonological grammar's direct preservation of sub-phonemic phonetic detail. The core proposal is that the grammar is sensitive to fine-grained coarticulatory effects. In the Icelandic case, the opaque result can be rooted in a language-specific laryngeal coarticulation, where the glottal opening gesture of an underlyingly aspirated stop begins early, overlapping with the preceding sonorant. If the language's phonological grammar can access this coarticulatory event via a phonetically enriched representation that encodes such detail, it can select a surface outcome faithful to that phonetic substance, yielding a categorical voiceless sonorant even without an apparent surface trigger for devoicing. This analysis, formulated within a unified grammar of phonetics and phonology (Flemming, 2008; Kim, 2024, in press), lends direct support to the Phonetic Faithfulness account of phonological opacity (Kim 2024), bridging the gap between phonetic implementation and its phonological consequences.

The remainder of this paper is organized as follows. Section 2 provides an overview of the phonological patterns and phonetic details of Icelandic sonorant— aspirated stop (henceforth RT<sup>h</sup>) sequences. Based on this discussion, Section 3 highlights the central theoretical challenge and demonstrates its difficulties for some alternative analyses. Section 4 then develops the main proposal of this paper: an analysis grounded in the framework of Phonetic Faithfulness. Section 5 offers

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1) While low-level, partial phonetic devoicing of sonorants adjacent to aspirated consonants is a widespread and largely predictable coarticulatory phenomenon (e.g., *plea* [p<sup>h</sup>li:] in English, see Tsuchida et al., 2000; Blevins, 2018), cases of phonological neutralization of sonorant voicing are distinctively rarer. The case of Icelandic is particularly noteworthy in this regard, as this neutralization process is found in one of the few languages that maintain a phonemic contrast between voiced and voiceless sonorants, offering a rare window into the nature of such processes.

concluding remarks.

## 2. Illustrations of the Icelandic Sonorant Devoicing Process

### 2.1. Phonological patterns

The consonant inventory of Icelandic is presented in Table 1. For the purposes of this paper, the most crucial aspects of the inventory are the contrast between aspirated and unaspirated stops and the rich set of voiceless sonorants.

**Table 1.** The Icelandic consonant inventory (largely based on Heimisdóttir 2015)

	Labial	Dental	Alveolar	Palatal	Velar	Glottal
Stop	p p <sup>h</sup>		t t <sup>h</sup>	(c) (c <sup>h</sup> )	k k <sup>h</sup>	
Nasal	m (m)		n ɲ	(ɲ) (ɲ̥)	(ŋ) (ŋ̥)	
Fricative	f	θ	s		(x)	h
Approximant <sup>2)</sup>	v	ð		j (ç)	ɣ	
Lateral			l ɭ			
Rhotic			r ɾ			

While the precise phonemic status of all voiceless sonorants is a matter of ongoing debate (in the table, the sounds in parentheses represent phones whose phonemic status is uncertain or clearly allophonic), this paper focuses on the phonological processes they participate in, rather than resolving their status in the inventory. Thus, this study proceeds from the position that the language has a phonemic voicing contrast, at least among the coronal sonorants.

The existence of a synchronic voicing contrast is most clearly demonstrated by word-initial minimal pairs, as shown in (1). As the examples illustrate, all sonorants, with the exception of the labial nasal, show a clear contrast in this position.<sup>3)</sup> The

2) While the language seems to have a voicing contrast between fricatives at first glance, voiced fricatives such as /v ð ɣ/ are more frequently realized as approximants like [v̥, ð̥, u̥], without frication (Helgason, 1993; Másdóttir et al., 2024; Stefansdóttir et al., 2021). Thus, it is also possible to say that the contrast observed here is mainly between true fricatives and approximants, rather than being the laryngeal contrast.

3) [ɲ ɲ̥] and their voiceless counterparts [ɲ̥ ɲ̥̥] are present only in some limited contexts such

examples below and those that follow are primarily from the entries listed in *Íslensk Nútímamálsorðabók* (Dictionary of Modern Icelandic; Jónsdóttir & Úlfarsdóttir, 2020), unless otherwise specified.

(1) The voicing contrast between coronal sonorants in word-initial position

a. <i>né</i>	[n̥jɛ:]	‘nor’	<i>hné</i>	[n̥jɛ:]	‘knee’
b. <i>lið</i>	[l̥i:ð]	‘people, folk’	<i>hlið</i>	[l̥i:ð]	‘side’
c. <i>rár</i>	[r̥au:r]	‘crossbar (sg. gen.)’	<i>hrár</i>	[r̥au:r]	‘raw’
d. <i>maður</i>	[m̥aðʏr]	‘person, man’	-	-	-

These minimal pairs provide strong evidence for a phonemic voicing contrast, at least for coronal sonorants. While historical origins (from *h*+sonorant clusters) or positional restrictions have sometimes been used to argue for an allophonic status (e.g., Heimisdóttir, 2015), such arguments are insufficient to dismiss this synchronic contrast without further evidence justifying an underlying abstract cluster.

Outside of this contrastive word-initial position, the distribution of voiceless sonorants is highly restricted. They appear almost exclusively in one context: preceding an underlyingly aspirated stop, in both medial and final clusters. This specific context, i.e., before an aspirated stop, is the environment where the voicing contrast is systematically neutralized in favor of the voiceless member.

(2) Devoicing in medial clusters (Árnason, 2011; Rögnvaldsson, 2020)

a. <i>hempa</i>	/hɛmp <sup>h</sup> a/	[hɛmp̥a]	‘robe’
b. <i>vanta</i>	/vant <sup>h</sup> a/	[vant̥a]	‘need’
c. <i>banki</i>	/paunk <sup>h</sup> i/	[pauŋ̥ci]	‘bank’
d. <i>banka</i>	/paunk <sup>h</sup> a/	[pauŋ̥ka]	‘knock’
e. <i>hjálpa</i>	/hjaulp <sup>h</sup> a/	[çauŋ̥pa]	‘help’
f. <i>harpa</i>	/harp <sup>h</sup> a/	[har̥pa]	‘harp’

The examples in (2) illustrate the devoicing of sonorants in medial clusters. When sonorants are followed by an underlying aspirated stop in this context, they are devoiced (Heimisdóttir, 2015; Rögnvaldsson, 2020; Thráinsson, 1994).<sup>4</sup> It is worth

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as before palatal and velar stops. It is therefore straightforward to define them as allophonic variants of [n] and [ŋ] (Árnason 2011:109). I will not discuss them separately in detail.

4) Since this devoicing process occurs only before an underlying aspirated stop, voiced

noting that the devoicing process described here is opaque: the sonorant is devoiced by the following aspirated stop, but this conditioning trigger is itself altered, losing its aspiration and merging with the plain voiceless stop series. This creates a surface form like [hæmp̥pa] or [vaŋta] where the motivation for the voiceless sonorant is no longer overt.<sup>5)</sup>

The other context where voiceless sonorants are attested is also where a sonorant is followed by an aspirated stop, but in the final position. The examples are given in (3).

(3) Sonorant devoicing in final clusters

a. <i>pomp</i>	/p <sup>h</sup> ɔmp <sup>h</sup> /	[p <sup>h</sup> ɔmp̥ <sup>(h)</sup> ]	‘ceremony’
b. <i>hreint</i>	/r̥eint <sup>h</sup> /	[r̥eint̥ <sup>(h)</sup> ]	‘clean (neut. nom.)’
c. <i>hönk</i>	/høyŋk <sup>h</sup> /	[høyŋk̥ <sup>(h)</sup> ]	‘hank’
d. <i>dælt</i>	/taiɫt <sup>h</sup> /	[taiɫt̥ <sup>(h)</sup> ]	‘friendly (neut. nom.)’
e. <i>ekkert</i>	/ɛk <sup>h</sup> k̥ <sup>h</sup> ɛrt <sup>h</sup> /	[ɛk̥ɛrt̥ <sup>(h)</sup> ]	‘nothing’

The pattern in word-final clusters illustrated above presents a point of comparison. While sonorant devoicing is conditioned by the same environment (i.e., before an aspirated stop), the realization of the triggering stop differs between the medial and final contexts. Contrary to many previous descriptions that assume uniform deaspiration in both contexts (e.g., Árnason, 2011; Ringen, 1999:138; Rögnvaldsson,

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sonorants appear when there is no following aspirated stop. For instance, *vona* [vɔ:na] ‘to hope’ (Rögnvaldsson, 2020:18), *landi* [lant̥i] ‘land (sg. dat.)’ and *vakna* [vahkna] ‘wake up’ (Thráinsson, 1994:150).

5) Given that the devoicing seems to be always accompanied by deaspiration of the triggering stop in this context, it is difficult to say that there is an apparent complementary distribution between voiced and voiceless sonorants here, as both voiced and voiceless stops occur before an unaspirated stop on the surface: *henta* [hɛnta] ‘to be appropriate’ vs. *henda* [hɛnta] ‘to throw’ (Jessen & Petursson, 1998:44). Thus, in theory, it is possible to suggest that even phonemic contrast holds between voiced and voiceless sonorants within medial sonorant-stop clusters, as carefully proposed by Jessen & Petursson (1998). In this paper, however, I assume the underlying presence of the aspirated stops in this context, following most of the previous literature (Thráinsson, 1978, 1994; Árnason, 2011; Heimisdóttir, 2015; Rögnvaldsson, 2020). Indirect evidence for this argument can be suggested by a variant of Icelandic spoken in North-Eastern Iceland (in particular, in Eyjafjarðarsýsla and Þingeyjarsýsla counties). In this variant of the language, an aspirated stop is realized without deaspiration, although sonorant devoicing is sometimes attested as a variation (Heimisdóttir, 2015). For instance, *henta* [hɛnt<sup>h</sup>a] ‘to be appropriate’ vs. *henda* [hɛnta] (Rögnvaldsson, 2020; Hilmisdóttir & Svavarsdóttir, 2023).

2020; Thráinsson, 1994:151), the aspiration of the final stop often appears to be maintained, at least when words are produced in isolation. This positional variation will be further discussed in Section 2.2.

While the patterns described above hold robustly in Icelandic, several exceptions should be noted. First, the devoicing process is not attested in the North-Eastern variant of the language (Árnason, 2011; Rögnvaldsson, 2020; see also fn. 5). Second, an RT<sup>h</sup> cluster derived by certain types of derivation, including compounding, does not show devoicing. For instance, *ein-tala* [eint<sup>h</sup>a:la] ‘singular’ or *sum-part* [symp<sup>h</sup>art<sup>h</sup>] ‘partly’ (Árnason, 2011:261; Fortuna, 2016). Third, besides the contexts discussed above, an utterance-final devoicing process may target the liquid consonants [l, r]. In pre-pausal position, these consonants can be devoiced into [l̥, r̥], respectively (Árnason, 2011:237-8; Dehé 2014). To the best of my knowledge, nasals do not undergo the same postlexical process in this specific context.

## 2.2. Phonetic details

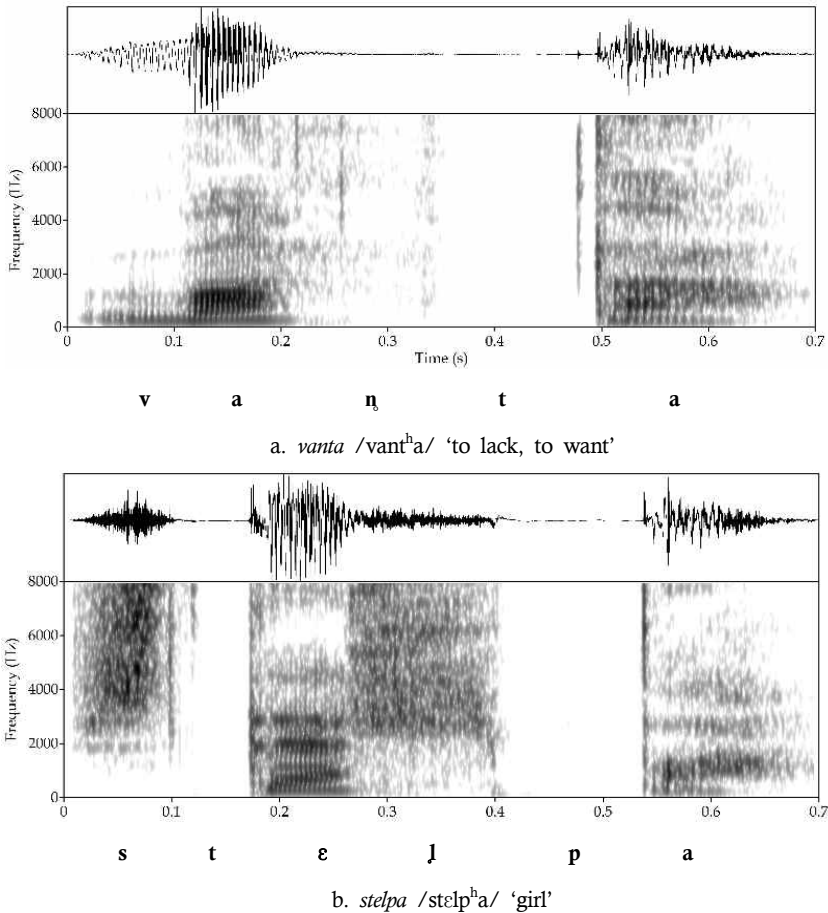
Cross-linguistically, voiceless sonorants exhibit a consistent set of phonetic characteristics: no voicing during most of their articulation, an obscured formant structure, longer duration than their voiced counterparts, and varying degrees of breathiness or frication noise. These properties often make them acoustically similar to voiceless fricatives (e.g., Blevins, 2018; Ladefoged & Maddieson, 1996; Lotven et al. 2020; Maddieson & Emmorey, 1984).

Icelandic voiceless sonorants are no exception, sharing these general acoustic properties. Previous studies have shown that they typically lack a voicing bar and clear formant structures, are longer in duration than their voiced counterparts, and are likely to be accompanied by noticeable aperiodic noise (Bombien, 2006; Flego & Berkson, 2020; Hoole & Bombien, 2010). In particular, the intensity of the aperiodic noise reportedly varies by manner and position, being strongest in rhotics and weakest in nasals, and more apparent medially than initially (Bombien, 2006).

Figures 1 and 2 illustrate the realization of RT<sup>h</sup> clusters in medial and final positions, respectively. The spectrograms given in those figures are sourced from *Íslensk Nútímamálsorðabók* (Jónsdóttir & Úlfarsdóttir, 2020), which provides sound files for its headwords produced by a single native speaker (Guðfinna Rúnarsdóttir, b. 1963).

These spectrograms show that, in both medial and final contexts, a nasal is significantly devoiced before an underlying aspirated stop. Nasals in both contexts

lack a voicing bar throughout their closure, and are sometimes accompanied by weak, high-frequency breathy noise. In the most extreme cases, a nasal consonant may have no internal acoustic cues to its presence at all, acoustically resembling a devoiced and unreleased stop. For laterals and rhotics, devoicing is realized with more apparent aperiodic noise, making them acoustically similar to fricatives rather than typical sonorants. While no voicing is present in these liquids, some vague formant structures may be visible. To sum up, the general acoustic characteristics observed in these spectrograms are consistent with previous literature on Icelandic devoiced sonorants.



**Figure 1.** Spectrograms of the Icelandic voiceless sonorants in medial positions.

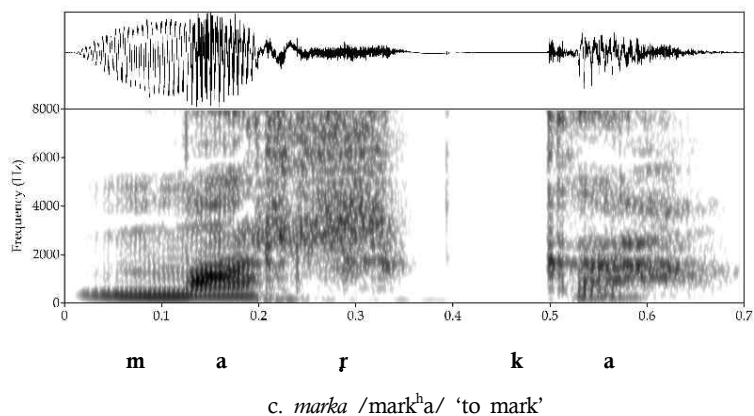


Figure 1. Continued

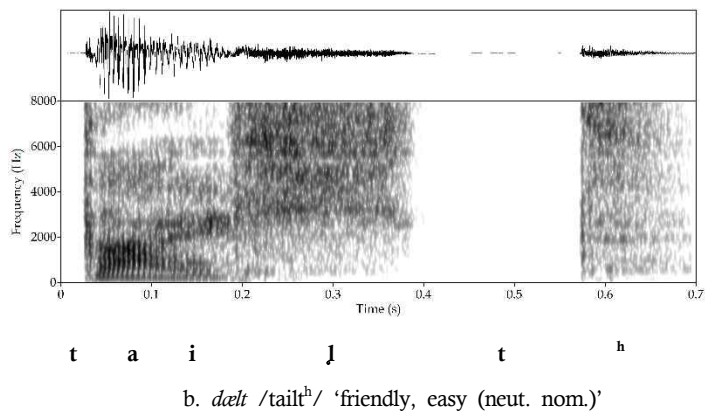
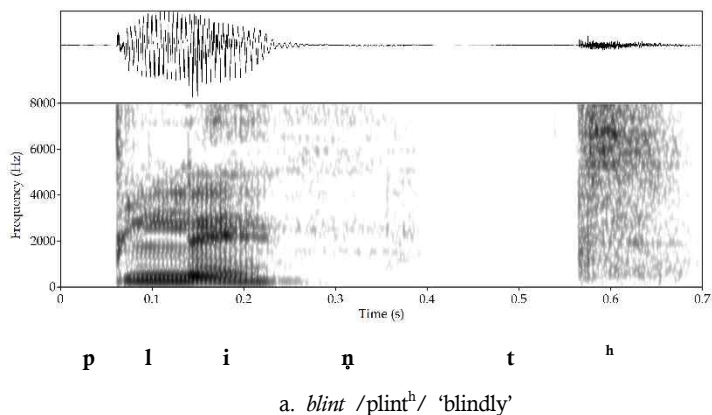
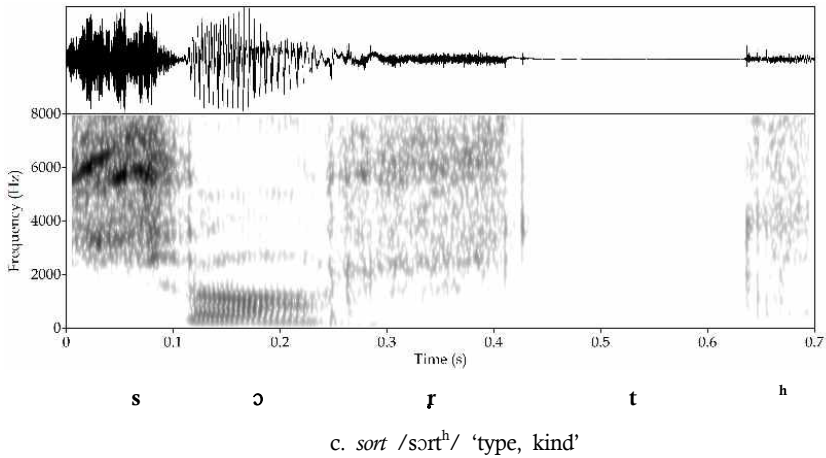


Figure 2. Spectrograms of the Icelandic voiceless sonorants in final positions.



**Figure 2.** Continued

While the overall acoustic characteristics of voiceless sonorants are similar in medial and final contexts, a phonetic difference between the two environments is observable in their following stops: the realization of the stop's aspiration. In medial position (Figure 1), the devoicing pattern is straightforwardly opaque: the underlying  $RT^h$  cluster is realized as a voiceless sonorant and a plain unaspirated stop ( $RT$ ). The deaspiration is generally consistent, with no significant aperiodic interval following the stop release. In contrast, in the final position (Figure 2), the underlying aspirated stop appears to retain its aspiration. The spectrograms clearly show a significant interval of aspiration noise following the stop release, creating a surface cluster of a voiceless sonorant and an aspirated stop ( $RT^h$ ). This observation does not fully align with conventional descriptive accounts that often assume uniform deaspiration in both medial and final environments (e.g., Árnason, 2011; Ringen, 1999; Thráinsson, 1994).

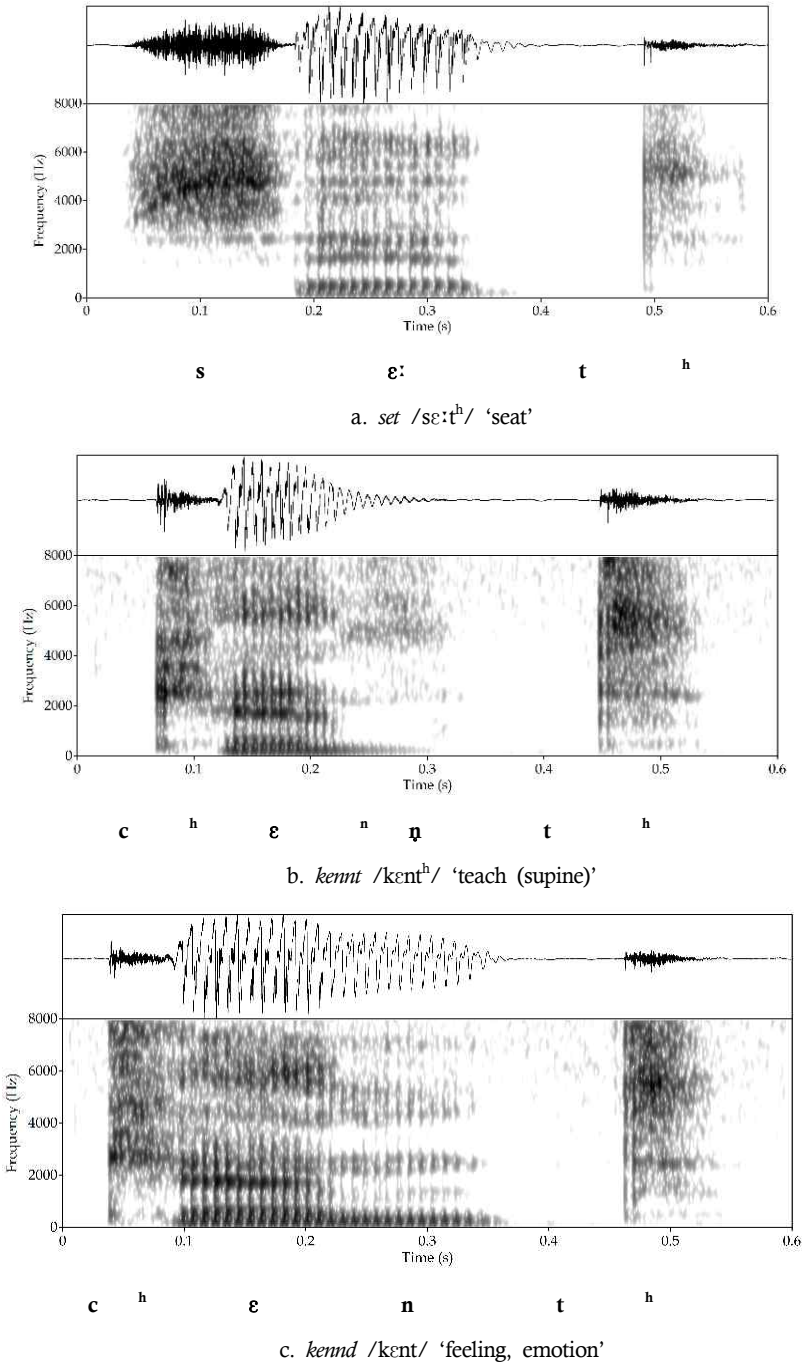
Although whether post-release aspiration is consistently present in Icelandic does not function as a key element in the theoretical discussions that follow, some brief additional observations are provided below for interested readers and as a basis for potential future research.

**Table 2.** Aspiration duration (in ms) of word-final stops following sonorants from tokens in *Íslensk Nútímamálsorðabók* (Jónsdóttir & Úlfarsdóttir, 2020)

Cluster type	Duration of aspiration (ms)	N (tokens)	Cluster types	Duration of aspiration (ms)	N (tokens)
nt_#	54	4	ɳt_#	109	10
mp_#	86	2	ɱp_#	79	4
ŋk_#	69	2	ŋk_#	103	2
lt_#	81	4	ɭt_#	115	5
rt_#	-	-	ɾt_#	124	11
Overall mean	71	12	Overall mean	96	32

Table 2 presents the aspiration duration of word-final stops following sonorants, measured from tokens in *Íslensk Nútímamálsorðabók*. The observed data suggest that both underlyingly aspirated stops (mean: 96 ms) and their unaspirated counterparts (mean: 71 ms) are characterized by a significant aspiration phase, showing that substantial post-release aspiration is a shared characteristic in this position, albeit with a slight difference in their duration.

Note that this tendency does not appear to be an idiolectal pattern. Data from the UCLA Phonetics Lab Archive (UCLA Phonetics Lab, 2007) show a similar robust tendency across multiple speakers. For example, one male speaker's productions recorded in 1986 show a mean aspiration duration of 107 ms in final [ɳt<sup>h</sup>] sequences (5 tokens), which is comparable to the 101 ms average duration in word-final /t<sup>h</sup>/ with no preceding sonorant (30 tokens). The spectrograms in Figure 3 visualize this comparison, with the words *set* [se:t<sup>h</sup>] 'seat', *kennt* [c<sup>h</sup>ɛɳt<sup>h</sup>] 'teach (supine)', and *kennd* [c<sup>h</sup>ɛnt] 'feeling, emotion'.



**Figure 3.** Spectrograms of the words *set* [se:t<sup>h</sup>], *kent* [c<sup>h</sup>ɛnt<sup>h</sup>] and *kemd* [c<sup>h</sup>ɛnt].

As the spectrograms illustrate, the aspiration following the devoiced sonorant in *kennt* [c<sup>h</sup>ɛnt<sup>h</sup>] is comparable in duration to that in *set* [sɛ:t<sup>h</sup>]. Also, similar to the speaker from *Íslensk Nútímamálsorðabók*, this male speaker produces the underlyingly unaspirated stop in *kennd* [c<sup>h</sup>ɛnt] with significant aspiration. This pattern suggests that, at least among the speakers observed here, the laryngeal contrast is neutralized in the final context not by deaspirating an aspirated stop, but rather by aspirating an unaspirated one — a point that warrants further investigation. Nevertheless, the central observation remains consistent: unlike in the medial position, underlying final aspirated stops appear to preserve their aspiration.<sup>6)</sup>

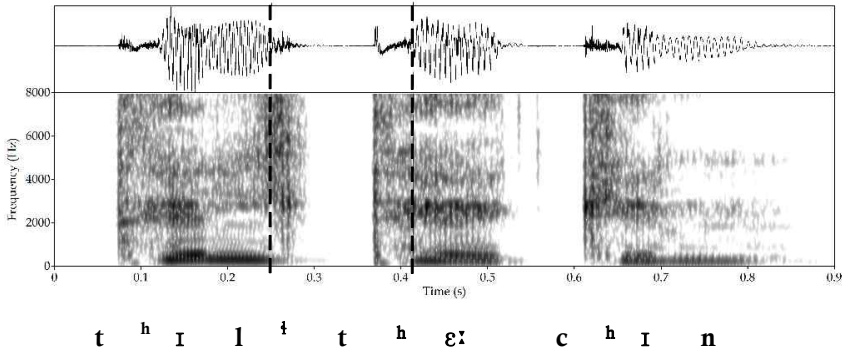
As discussed, the current findings suggest that a portion of Icelandic speakers may systematically preserve aspiration in the final context. However, aside from the fact that this final aspiration is not the main focus of this paper, I refrain from proposing this as a robust generalization for two primary reasons. First, the data discussed so far are drawn exclusively from citation forms produced by a limited number of speakers, not from a broader, controlled study of connected speech. Second, the observed aspiration may not be a consistent word-level phenomenon but rather a consequence of utterance-final strengthening, which should be discussed in a different context. The tentative conclusion, therefore, is not a definitive statement that aspiration is preserved consistently in word-final positions but the demonstration that this transparent interaction is possible. Further corpus and experimental studies are needed to ascertain its precise distribution and systematicity in Icelandic.

Next, it is worth noting that, phonetically, the devoicing process can be partial, while the dominant patterns appear to result in categorical neutralization. For instance, as can be seen in tokens like *kennt* (Figure 3b), the devoiced nasal exhibits both breathy noise and voicing throughout a considerable portion of its closure. In addition to this kind of incomplete devoicing, sub-phonemic application of the process can also be found in contexts where it is considered phonologically blocked. For instance, in the compound word *tiltekinn* ‘specific, particular’ (formed from *til*

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6) This phonetic evidence suggests there would be another opaque pattern involving sonorants and stops. If both unaspirated and aspirated stops are aspirated in final positions as the phonetic data observed so far show, then speakers who have such patterns underapply the devoicing process: while the process transparently applies due to the presence of the aspiration for the underlying aspirated stop, it opaquely does not apply before the underlying unaspirated stop, which has a significant amount of aspiration after the release. Given that surface phonological contrast cannot easily be made between these two stops, accounting for this underapplication thus requires reference to the underlying contrast.

+ *tekinn*), devoicing should not apply across the morpheme boundary (Árnason, 2011:261; Fortuna, 2016). However, in some instances, like the one illustrated in Figure 4 (from *Íslensk Nútímamálsorðabók*), the glottal opening gesture expands bidirectionally from the stop closure, not only causing post-release aspiration but also fricativizing a part of the preceding voiced lateral.



**Figure 4.** Spectrogram of the Icelandic word *tiltekinn* (*til+tekinn*) ‘specific’.

This, combined with the cases of incomplete devoicing illustrated in Figure 3, implies that the underlying laryngeal controls—such as the precise timing and degree of glottal opening—may be variable and not perfectly categorical.

Finally, it is necessary to note that the distinct aspiration evident in Figure 4 indicates two concurrent facts regarding NT<sup>h</sup> clusters in morphological derivatives: the categorical application of sonorant devoicing is inhibited, and stop aspiration is systematically preserved. While the blocking of sonorant devoicing in such environments has been previously documented (e.g., Árnason, 2011; Fortuna, 2016), these descriptions do not explicitly report a corresponding inhibition of deaspiration. This observation is further substantiated by the evidence from the Talrómur 3 corpus (Sigurgeirsson et al., 2021). An examination of utterances of a derivative such as *samtal* ‘conversation’ (/sam-/ ‘con-’ +/t<sup>h</sup>al/ ‘speech’) from seven native speakers (4 females and 3 males) shows not only that the /m/ undergoes minimal to no devoicing but also that the following /t/ maintains robust aspiration, with Voice Onset Time (VOT) values averaging around 40 ms (see Appendix for representative spectrograms and further details). Collectively, these findings suggest that in these morphological contexts, neither sonorant devoicing nor deaspiration applies in a phonologically categorical manner.

### 2.3. Summary

Icelandic exhibits a phonemic voicing contrast in sonorants, as evidenced by word-initial minimal pairs. However, this contrast is systematically neutralized in clusters where a sonorant is followed by an underlyingly aspirated stop. This devoicing process presents two key characteristics that form the basis of our discussion. Phonetically, the resulting devoiced sonorants are characterized by an absence of voicing and an accompanying aperiodic noise. This acoustic profile suggests that the primary mechanism for this devoicing is the addition of a glottal opening gesture to the sonorant’s articulation. Phonologically, the process is opaque, particularly in medial contexts. Here, the conditioning environment is absent from the surface form, as the triggering aspirated stop is itself devoiced. In addition to this, several contextual variations have been noted with some phonetic observations.

### 3. Challenges Surrounding the Icelandic Overapplication Opacity

The sonorant devoicing process in Icelandic presents a classic case of phonological opacity. In a rule-based framework, this can be straightforwardly captured as a counterbleeding interaction: a sonorant devoicing rule applies first, and its conditioning environment is then removed by a subsequent deaspiration rule, as formalized in (4).

(4) Counterbleeding opacity where deaspiration opacifies sonorant devoicing

UR	/vant <sup>h</sup> a/	/har <sup>h</sup> a/
Sonorant devoicing (R → R̥ / __T <sup>h</sup> )	ɲ	ʃ
Deaspiration (T <sup>h</sup> → T / C__V)	t	p
SR	[vaɲta]	[haʃpa]

This type of derivational solution, however, is unavailable in classic Optimality Theory (OT; Prince & Smolensky, 1993/2004), which relies on a strictly parallel evaluation of candidates. Within classic OT, this process is fatally problematic due to harmonic bounding. This point is illustrated in tableau (5), where the opaque candidate (5d) can never be optimal. Given that voiceless sonorants involve a glottal opening gesture, resulting in breathiness or frication, the process of sonorant devoicing here is formalized in terms of an assimilation to the [+spread glottis] status

of its adjacent aspirated stop, following a long line of research considering a devoiced sonorant as [+sonorant, +spread glottis] (Halle & Stevens, 1971; Lombardi, 1994; Blevins, 2018, among others).

(5) *vanta* /vant<sup>h</sup>a/

/vant <sup>h</sup> a/	*T <sup>h</sup> /C_V	AGREE [s. g.]	IDENT [s. g.]
a. [vant <sup>h</sup> a]	*	*	
b. [vanta]			*
c. [vant <sup>h</sup> a]	*		*
d. [vaŋta]		*	**

Note that, in the tableau, the opaque candidate [vaŋta] (5d) violates IDENT [spread glottis] twice (for both the sonorant and the stop). This candidate is harmonically bound by the transparent candidate [vanta] (5b), which violates the same constraint only once. Because the opaque candidate will always be worse on faithfulness than the transparent candidate, without satisfying any markedness constraint that its transparent counterpart violates, there is no ranking that can make it optimal (a problem of *gratuitous faithfulness violation*, Baković 2007).

### 3.1. Output-Output faithfulness

As discussed above, the opacity observed in Icelandic sonorant devoicing is problematic for classic OT due to harmonic bounding. One potential way to resolve this is to introduce constraints that expand evaluation beyond the input-output mapping of a single word. Output-Output (OO) Faithfulness theories (Benua, 1997; Steriade, 2000; Kenstowicz, 1996, 2002, among others) offer such a mechanism.

The core logic of this transderivational approach to opacity is that an opaque candidate, despite being harmonically bound, can be saved if it is more faithful to a separate, morphologically related base form than its transparent competitor is. If a high-ranking IDENT-OO constraint demands identity with the laryngeal features of this base, the opaque candidate can emerge as optimal.

For this strategy to work in Icelandic, a paradigm must contain at least one form where the voiceless sonorant is derived transparently. This could occur in word-final positions where, as discussed in Section 2, the triggering aspiration could be preserved, at least for some speakers of the language. The paradigm of *banki* [pauf<sup>h</sup>ci]

‘knocking (sg. dat.)’ provides a suitable illustration. Here, the nominative singular form *bank* [paʊŋk<sup>h</sup>] may serve as a transparent base; it is morphologically simple (i.e., unsuffixed) and lacks phonological opacity, unlike derivatives such as *bank-i* ‘knocking (sg. dat.)’ or *bank-s* ‘knocking (sg. gen.)’ (see also Benua 1997:28). As the paradigmatic base, it has to be derived without reference to other surface forms, as shown in the tableau in (6). In the tableau, AGREE [spread glottis] forces sonorant devoicing, while the stop’s aspiration is preserved as the \*T<sup>h</sup>/C\_\_# constraint is bottom-ranked. Therefore, the optimal output is [paʊŋk<sup>h</sup>] (6c), where sonorant devoicing is transparently applied.

(6) A Base-Derivative analysis of *bank* /paʊŋk<sup>h</sup>/

/paʊŋk <sup>h</sup> / Base: none	*T <sup>h</sup> /C__V	IDENT-OO [s. g.]	AGREE [s. g.]	IDENT [s. g.] OBS	*T <sup>h</sup> /C__#
a. [paʊŋk <sup>h</sup> ]			*!		*
b. [paʊŋk]				*!	
c. [paʊŋk <sup>h</sup> ]					*
d. [paʊŋk]			*!	*	

This transparently derived output [paʊŋk<sup>h</sup>] can then serve as the base for inflected forms like the dative singular /paʊŋk<sup>h</sup>ɪ/. As illustrated in (7), the analysis of the inflected form requires a higher-ranked \*T<sup>h</sup>/C\_\_V to force deaspiration of the medial stop. In a classic OT analysis, this would lead to the transparent candidate \*[paʊŋcɪ] (7b) winning. However, with the introduction of the IDENT-OO [spread glottis] constraint and by ranking it over AGREE [spread glottis], the grammar can now prioritize faithfulness to the base’s voiceless sonorant. This constraint decisively rules out the competitive transparent candidate (7b), allowing the opaque candidate [paʊŋcɪ] (7d) to emerge as optimal.

(7) A Base-Derivative analysis of *banki* /paʊŋk<sup>h</sup>ɪ/

/paʊŋk <sup>h</sup> ɪ/ Base: [paʊŋk <sup>h</sup> ]	*T <sup>h</sup> /C__V	IDENT-OO [s. g.]	AGREE [s. g.]	IDENT [s. g.] OBS	*T <sup>h</sup> /C__#
a. [paʊŋc <sup>h</sup> ɪ]	*!	*	*		
b. [paʊŋcɪ]		**!		*	
c. [paʊŋc <sup>h</sup> ɪ]	*!				
d. [paʊŋcɪ]		*	*	*	

However, this transderivational strategy fails as a general solution to the Icelandic case because not all paradigms contain a transparently derivable base, even with the assumption that the transparent derivation in the final context is systematic and thus reliable in the language. The paradigm for the noun *hempa* ‘robe’, shown in Table 3, provides a crucial counterexample.

**Table 3.** Declension of the noun *hempa* ‘robe’

	Singular		Plural	
	Indefinite	Definite	Indefinite	Definite
Nominative	he[mp]a	he[mp]an	he[mp]ur	he[mp]urnar
Accusative	he[mp]u	he[mp]una	he[mp]ur	he[mp]urnar
Dative	he[mp]u	he[mp]unni	he[mp]um	he[mp]unum
Genitive	he[mp]u	he[mp]unnar	he[mp]a	he[mp]anna

As the paradigm shows, the /mp<sup>h</sup>/ cluster in *hempa* is always followed by a vowel, meaning deaspiration is active in all forms. Consequently, it is impossible to derive a transparent output like \*[hɛmp<sup>h</sup>a] that could serve as a base for the other forms. The analysis runs into a dead end: to derive opacity via OO-Faithfulness, a transparent base is required, but for some paradigms, no such form exists. Therefore, while OO-Faithfulness may account for some selected cases, it cannot be a general solution to the Icelandic overapplication.

### 3.2. Stratal OT

Another potential solution to phonological opacity is to abandon the strict parallelism of classic OT and adopt a derivational model. Stratal OT (Kiparsky, 2000 et seq.) is a prominent framework in this line, reintroducing derivation by positing distinct phonological sub-grammars, or strata, which are interleaved with the morphological component. For Icelandic, this approach could in principle resolve the opacity by ordering the two key processes at different strata: sonorant devoicing could apply at an early stratum, and deaspiration at a later one (cf. the rule-based derivation in (4)). The central task, then, is to determine the specific strata at which these two processes apply.

Let us first consider the placement of sonorant devoicing. If we assume it applies at the Word Level, then to create opacity, deaspiration must apply at the subsequent

Postlexical Level. This scenario, however, is highly implausible. Deaspiration in Icelandic is a pervasive word-internal process, conditioned by various segmental contexts within a word (e.g., after sibilants as in /t<sup>h</sup>ask<sup>h</sup>a/ → [t<sup>h</sup>aska] ‘bag’, between a consonant and a vowel as in /maðk<sup>h</sup>a/ → [maθka] ‘maggot (gen. pl.)’ and /ulp<sup>h</sup>a/ → [ulpa] ‘parka’, between a vowel and a sonorant, /fir<sup>h</sup>na/ → [fihtna] ‘to get fat’ and /t<sup>h</sup>it<sup>h</sup>ra/ → [t<sup>h</sup>ɪ:tra] ‘to tremble’, and even between vowels, /kat<sup>h</sup>a/ → [ka:ta] ‘road’; Heimisdóttir, 2015). Classifying it as a phrasal postlexical rule would incorrectly predict it to be overly pervasive, deaspirating almost all non-phrase-initial aspirated stops since almost all word-final segments seem to provide a derived environment for an automatic application of the process, targeting any word-initial aspirated stop. Furthermore, there is direct evidence against devoicing being a Word Level process: the process is systematically blocked in compounds and certain derivatives, such as *sam-tal* [sam<sup>h</sup>tal] ‘conversation’, *ein-tala* [eint<sup>h</sup>a:la] ‘singular’ or *sum-part* [symp<sup>h</sup>art<sup>h</sup>] ‘partly’ (Árnason, 2011; Fortuna, 2016; see also Figure 4). If devoicing were active at this stratum, it would be expected to apply to these forms, contrary to fact.

These considerations thus point conclusively to sonorant devoicing being a process of the Stem Level. Given that a Postlexical locus for the deaspiration process is untenable, the only remaining plausible scenario for a stratal analysis is locating deaspiration at the Word Level. This division of labor appears, at first glance, to successfully derive the opaque surface form for /vant<sup>h</sup>a/, for instance. The derivation in (8) illustrates this: at the Stem Level, AGREE [spread glottis] forces devoicing, and at the Word Level, \*T<sup>h</sup>/C\_\_V forces deaspiration, yielding the correct opaque output [vanta].

(8) A stratal analysis of Icelandic sonorant devoicing

a. Stem Level

vant <sup>h</sup> a		AGREE [s. g.]	IDENT [s. g.] OBS	*T <sup>h</sup> /C__V	IDENT [s. g.] SON
a.	vant <sup>h</sup> a	*!		*	
b.	vanta		*!		
c.	☞ vant <sup>h</sup> a			*	*
d.	vanta	*!	*		*

b. Word Level

vant <sup>h</sup> a		*T <sup>h</sup> /C__V	IDENT [s. g.] SON	AGREE [s. g.]	IDENT [s. g.] OBS
a.	vant <sup>h</sup> a	*!	*	*	
b.	vanta		*!		*
c.	vant <sup>h</sup> a	*!			
d.	ᵛᵛ vanta			*	*

However, this seemingly successful analysis faces a ranking paradox when confronted with the full set of facts. The crucial problem lies in the grammar of the Word Level. As discussed, a derivative like *sam-tal* [sam<sup>h</sup>al] ‘conversation’ (formed by attaching a derivational affix /sam-/ ‘con-’ to the base /t<sup>h</sup>al/ [t<sup>h</sup>al] ‘speech’), needs to be formed at this level, while faithfully preserving the stop’s aspiration. To derive this outcome, the Word Level grammar must crucially rank the faithfulness constraint IDENT [spread glottis] OBS above the markedness constraint \*T<sup>h</sup>/C\_\_V, as shown in (9).

(9) Word Level ranking required for derivatives like /sam-t<sup>h</sup>al/

sam-t <sup>h</sup> al		IDENT [s. g.] OBS	IDENT [s. g.] SON	*T <sup>h</sup> /C__V	AGREE [s. g.]
a.	ᵛᵛ sam-t <sup>h</sup> al			*	*
b.	samtal	*!			
c.	sam-t <sup>h</sup> al		*!	*	
d.	samtal	*!	*		*

This creates an unresolvable contradiction. The grammar at the Word Level requires one ranking condition (IDENT [spread glottis] OBS >> \*T<sup>h</sup>/C\_\_V) to correctly produce certain derivatives and compounds. Yet, it requires the exact opposite ranking condition (\*T<sup>h</sup>/C\_\_V >> IDENT [spread glottis] OBS) to derive the deaspiration in [vanta], as was necessary in (8b). A single, consistent constraint ranking cannot satisfy both requirements at the same stratum. This paradox demonstrates that a standard Stratal OT analysis with the three universal strata, despite its derivational power, is ultimately unable to provide a coherent account of the Icelandic data.<sup>7)</sup>

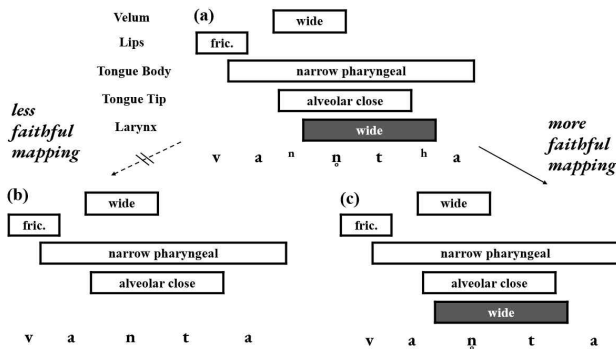
## 4. Phonetic Faithfulness Analysis

### 4.1. The core proposal: Opacity as faithfulness to phonetic details

The preceding section demonstrated that major alternative frameworks, such as Output-Output Faithfulness and Stratal OT, face challenges in accounting for the Icelandic sonorant devoicing case. This section develops a novel analysis that resolves the opacity problem by grounding it in phonetic substance. The core proposal is that this opaque alternation is not the result of abstract binary feature manipulation or complex derivational ordering but is rather an emergent property of the phonological grammar's direct sensitivity to, and preservation of, fine-grained, sub-phonemic detail.

This analysis is formulated within a framework that posits a unified grammar of phonetics and phonology, largely built upon the Realized Input model of phonology (Flemming, 2008). More specifically, the framework adopted here is a simplified version in which crucial evaluations for phonetics and phonology are carried out in parallel (Kim, 2024, in press). More detailed discussion and a non-parallel version of this approach can be found in Kim (2024, Ch. 2).

To illustrate the core idea intuitively, consider the schematic illustration in Figure 5.



**Figure 5.** A schematic illustration of the Phonetic Faithfulness principle using articulatory gestures

7) One could argue for a non-standard model with additional lexical strata (e.g., Kiparsky, 2015), to resolve this type of paradox. However, while increasing the number of strata offers greater analytical flexibility, it also potentially risks significant overgeneration and requires strong independent morphological evidence to justify each additional level, which may not be available for Icelandic.

In Figure 5, (a) represents a hypothetical, phonetically detailed form of /vant<sup>h</sup>a/. In this form, natural laryngeal coarticulation is present: the ‘wide’ glottal gesture associated with aspiration begins during the preceding alveolar closure and extends beyond the stop’s release. The central premise of Phonetic Faithfulness is that a language’s phonology can prefer an output that best preserves the details of such a phonetically rich input. Consequently, the mapping from the detailed input (a) to the opaque output [vanta] (c) is considered more faithful than the mapping to the transparent output [vanta] (b). This is because (c), which retains the glottal gesture on the sonorant, involves less overall change from the gestural coordination in (a) than (b) does. In other words, the opaque outcome can emerge as optimal because it is more faithful to the phonetically detailed input than the transparent outcome is.

While this concept is illustrated with articulatory gestures for clarity, the framework employed here assumes that such phonetic details are encoded by auditory features (Flemming, 2002 et seq.), not articulatory gestures directly.<sup>8)</sup> The relevant auditory dimension for the sonorant voicing contrast will be modeled using a multi-valued feature, [noise duration], which quantifies the duration of aperiodic noise within a segment. This aperiodic noise can manifest as a fully realized aspiration following a stop, or as breathy/fricative noise during a sonorant.

A simplified scale of this feature is presented in (10). It provides a way to formally quantify different degrees of voicing and voicelessness. These degrees are treated as a function of the duration of aperiodic noise, which itself is a phonetic consequence of the glottal opening gesture. Note that the diacritic for breathy voice [◌<sup>Q</sup>] indicates a sonorant where formants are partially obscured by the aperiodic noise. The value of [noise duration] for each sound is subscripted.

(10) The scale of [noise duration] with regard to a sonorant

<b>[noise duration] = 0</b>	m <sub>0</sub>	n <sub>0</sub>	l <sub>0</sub>	r <sub>0</sub>	T <sub>0</sub>
<b>[noise duration] = 1</b>	m <sup>m</sup> <sub>1</sub>	n <sup>n</sup> <sub>1</sub>	l <sup>l</sup> <sub>1</sub>	r <sup>r</sup> <sub>1</sub>	
<b>[noise duration] = 2</b>	<sup>m</sup> m <sub>2</sub>	<sup>n</sup> n <sub>2</sub>	<sup>l</sup> l <sub>2</sub>	<sup>r</sup> r <sub>2</sub>	T <sup>h</sup> <sub>2</sub>
<b>[noise duration] = 3</b>	m <sub>3</sub>	n <sub>3</sub>	l <sub>3</sub>	r <sub>3</sub>	h <sub>3</sub>

8) This approach rests on the assumption that articulatory gestures are manipulated to achieve acoustic and auditory goals, and that even inherently articulatory markedness requirements, such as those concerning articulatory difficulties, are enforced in the grammar via their associated auditory specifications (e.g., Flemming, 2001). Although auditory features are adopted here for expository convenience under this premise, there is no principled reason why the phonetically detailed representations or the features utilized in the grammar could not directly specify entities like articulatory gestures.

The divisions on this scale reflect a relative difference in [noise duration] between the sounds, rather than being a direct translation of the quantified acoustic measurements. While not a direct mapping, the divisions are phonetically grounded, and it is helpful to consider how they relate to observed acoustic intervals. As Heimisdóttir's (2015) experimental data show, the duration of post-release aspiration is approximately 70-80 ms, and the length of a devoiced sonorant is approximately 110-120 ms in Icelandic. Although a direct, systematic translation is not assumed, each step on the scale roughly corresponds to a 30-40 ms interval in these experimental measurements.<sup>9)</sup>

Before constructing the full, formal derivation in section 4.2, it is useful to first illustrate the core logic of the analysis with a simplified sketch. Let us assume that the grammar has access to a phonetically enriched input like [va<sup>n</sup>ŋ<sub>2</sub>t<sup>h</sup><sub>2</sub>a]. In this representation, the sonorant /n/ has already coarticulated with the following aspirated stop in terms of its laryngeal status. The following tableau demonstrates how, given this enriched input as a base for faithfulness, the grammar selects the opaque output over other candidates.

(11) A sketch analysis of the opaque devoicing process

[va <sup>n</sup> ŋ <sub>2</sub> t <sup>h</sup> <sub>2</sub> a]	*T <sup>h</sup> /C__V	*BREATHYVOICING	FAITH-[noise dur.]
a. [va <sup>n</sup> ŋ <sub>2</sub> t <sup>h</sup> <sub>2</sub> a]	*!	*	
b. [van <sub>0</sub> t <sub>0</sub> a]			**!***
c. [van <sup>n</sup> <sub>1</sub> t <sub>0</sub> a]		*!	***
d. [va <sup>n</sup> ŋ <sub>2</sub> t <sub>0</sub> a]		*!	**
e. <sup>ES</sup> [van <sub>3</sub> t <sub>0</sub> a]			*

The sketch analysis in (11) shows that while candidate (11a) is perfectly faithful, it violates the higher-ranked markedness constraint against aspirated stops in this context. Candidates with breathy-voiced sonorants (i.e., partially devoiced sonorants

9) An anonymous reviewer noted that this scale could appear arbitrary or constructed ad hoc for the current analysis. The scale, however, is an extension of the VOT dimension proposed by Flemming (2002:41), with values informed by empirical data (e.g., Heimisdóttir, 2015). Analytically, the crucial factor is the relative distance between these values, as evaluated by the correspondence constraint, not the absolute numbers themselves. A scale of 0, 15, 30, 45, for instance, would thus be equally viable. Ideally, of course, the model would be quantitatively fitted to actual acoustic measurements from the language, replacing the abstract discrete values assumed here (cf. Flemming, 2001).

with aperiodic noise) are also ruled out by the \*BREATHYVOICING constraint. Among the remaining candidates, the opaque output [va<sub>3</sub>t<sub>0</sub>a] (11e) is selected over the transparent one [va<sub>0</sub>t<sub>0</sub>a] (11b). This is because the total [noise duration] of the opaque form is closer to that of the phonetically enriched input, thus incurring fewer faithfulness violations, successfully implementing the principle of Phonetic Faithfulness illustrated in Figure 5.

This sketch, however, hinges on the crucial assumption that a phonetically detailed representation like [va<sup>n</sup>ɲ<sub>2</sub>t<sup>h</sup>a] is available to the grammar as if it were simply given, without discussing how such a detailed phonetic representation can be provided to the grammar. The central task for the following subsection, therefore, is to provide a complete and formal analysis that replaces this temporary assumption. I will detail the grammatical mechanism that first generates this enriched representation from the abstract input /vant<sup>h</sup>a/ and then demonstrate how this representation systematically leads to the selection of the opaque surface form.

#### 4.2. Formal analysis of the Icelandic opacity

This section presents the Phonetic Faithfulness analysis of Icelandic sonorant devoicing. The core of the analysis is a two-stage process designed to model how fine-grained phonetic detail informs the selection of a phonological output, although these processes can technically be done in parallel, as in McCarthy's (1999) Sympathy Theory.

##### (12) Two-step evaluations within a parallel grammar

###### a. **Stage 1:** Deriving the Designated Candidate

In the first stage, the grammar generates a phonetically enriched but non-contrastive representation of the input, termed the Designated Candidate (D). This is achieved through the interaction of a specific subset of constraints known as Phonetic Realization (PR) constraints.

###### b. **Stage 2:** Selecting the optimal output

In the second stage, the full constraint set evaluates surface candidates. Crucially, faithfulness is not evaluated against the abstract input, but against the Designated Candidate (D) derived in Stage 1.

Let us examine how these two stages can work together within a single stratum of grammar. First, for the full analysis, the Designated Candidate should be

identified. The Designated Candidate represents an ideal phonetic implementation of the input, incorporating natural coarticulatory effects or contextual durational adjustments without resulting in categorical phonological change (e.g., neutralization, deletion, or insertion). Its selection is governed exclusively by Phonetic Realization (PR) constraints. Following Kim (2024, Ch. 2), these PR constraints fall into two subtypes:

(13) Two types of Phonetic Realization constraints

a. **Contextual Articulatory Markedness:**

Constraints that regulate phonetically natural processes like coarticulation, gestural timing, and contextual duration adjustments.

b. **Cue Realization:**

Constraints that demand the preservation of a segment's inherent auditory-acoustic cues to maintain its perceptual characteristics.

For the present study, the key interaction is between a markedness constraint driving laryngeal coarticulation and a cue constraint preserving sonorant voicing.

(14) \*[R: noise duration] < 3 / \_\_T<sup>h</sup> (abbr. \*R<sub>[n.d. < 3]</sub>T<sup>h</sup>)

Before an aspirated stop, assign  $n$  violation marks when the value of [noise duration] for a sonorant is  $n$  less than 3.

(*informally*: fully devoice a sonorant before an aspirated stop)

(15) Realize [R: noise duration] = 0 (abbr. [R: n.d.] = 0)

Assign  $n$  violation marks when the value of [noise duration] for a sonorant is  $n$  less than or greater than its specified target value.

(*informally*: fully preserve sonorant voicing and clear formant structures)

The markedness constraint in (14) models the strong laryngeal coarticulatory pressure to devoice a sonorant before an aspirated stop.<sup>10)</sup> The cue realization constraint in (15) penalizes alternations to a sonorant's inherent voicing.

The selection of the Designated Candidate is determined by the ranking of these

---

10) Cross-linguistically, although categorical and phonemic devoicing of sonorants is less common, low-level partial phonetic devoicing adjacent to voiceless obstruents is a more widespread and largely predictable coarticulatory phenomenon (Blevins, 2018; Tsuchida et al., 2000). The introduction of a phonetic markedness constraint governing such a process is thus well-motivated.

PR constraints. As tableau (16) illustrates, ranking the articulatory markedness constraint (14) over the cue realization constraint (15) results in a partially devoiced sonorant as the optimal phonetic plan for the given input.

(16) The selection of the Designated Candidate

/vant <sup>h</sup> a/	*R <sub>x</sub>	*T <sup>h</sup> /C__V	*R <sub>[n.d. &lt; 3]T<sup>h</sup></sub> PR	ID [n.d.]	[R: n.d.] = 0 <sup>PR</sup>
a. [van <sub>0</sub> <sup>h</sup> <sub>2</sub> a]			**!*		
b. <b>D</b> [va <sup>n</sup> <sub>2</sub> <sup>h</sup> <sub>2</sub> a]			*		**
c. [van <sub>3</sub> <sup>h</sup> <sub>2</sub> a]					
d. [van <sub>0</sub> t <sub>0</sub> a]					
e. [va <sup>n</sup> <sub>2</sub> t <sub>0</sub> a]					
f. [van <sub>3</sub> t <sub>0</sub> a]					

Tableau (16) illustrates how this selection is made. As assumed within the framework, the evaluation at this stage is governed exclusively by the PR constraints; other general markedness and faithfulness constraints are inactive, as indicated by the shading in the tableau. A crucial aspect of this stage is the nature of the candidate set. Following Flemming (2008) and Kim (2024, in press), a Designated Candidate must be a phonetically enriched representation that does not entail contrastive phonological consequences. This means that the grammar selects a Designated Candidate from a pool of candidates that reflect only minor, sub-phonetic adjustments to the input string, given the language-specific phonetic requirements. Candidates involving categorical changes, such as complete neutralization, deletion, or insertion, are not eligible for the Designated Candidate selection. In the context of tableau (16), this restricts the competition to candidates like (16a) and (16b), while excluding (16c), which represents a full neutralization of the sonorant’s voicing.

The competition between the eligible candidates is then resolved by the ranking of the PR constraints. The tableau shows that the choice boils down to candidate (16a), which is fully faithful to the sonorant’s underlying voicing, and candidate (16b), which incorporates partial, coarticulatory devoicing. The decision is made by the crucial ranking \*R<sub>[n.d. < 3]T<sup>h</sup></sub> >> [R: n.d.] = 0. Candidate (16a) is ruled out as it fatally incurs more violations of the higher-ranked articulatory markedness constraint. Candidate (16b), while incurring a violation of the lower-ranked cue realization constraint, better satisfies the overriding demand for coarticulation. It

therefore emerges as the winning candidate. The resulting candidate, [va<sup>n</sup>ŋ<sub>2</sub>t<sup>h</sup>₂a], can thus be understood as the grammar's ideal phonetic implementation of the input /vant<sup>h</sup>a/. It is a phonetically detailed plan that balances the pressure to enact natural phonetic processes (coarticulation) against the need to preserve auditory cues, without resorting to categorical modification at this stage.

With the Designated Candidate [va<sup>n</sup>ŋ<sub>2</sub>t<sup>h</sup>₂a] established, the full grammar evaluates potential surface outputs. The crucial mechanism at this stage is a correspondence constraint that demands faithfulness to the phonetic specification of the Designated Candidate. Note that this constraint refers to the Designated Candidate, rather than the abstract input form (cf. Jun, 2002; McCarthy, 1999).

(17) IDENT [noise duration] (abbr. ID [n.d.])

Assign *n* violation marks when the [noise duration] value for a surface output is *n* greater or less than the [noise duration] value for the corresponding Designated Candidate.

This faithfulness constraint competes with other general markedness constraints active in Icelandic. Two such high-ranking constraints are crucial for the analysis. The first is \*T<sup>h</sup>/C\_\_V, which penalizes an aspirated stop appearing between a consonant and a vowel. While the phonetic motivation for this constraint is not as direct as for a PR constraint, its activity in Icelandic grammar is independently supported by the deaspiration process observed in other contexts, such as in forms like /maðk<sup>h</sup>ur/ → [maθk<sub>YR</sub>] 'maggot'. The second is \*BREATHYVOICING (abbr. \*R), a segment-internal markedness constraint against segments that possess both voicing and breathy phonation simultaneously. This penalizes phonetically complex segments like [ʰŋ₂], much like constraints against voiced obstruents (e.g., \*[-son, +voi]).

Tableau (18) presents the final evaluation, where these constraints interact to select the optimal output.

(18) *vanta* /vant<sup>h</sup>a/ → [van<sub>3</sub>t<sub>0</sub>a]

/vant <sup>h</sup> a/	*R	*T <sup>h</sup> /C_V	*R <sub>[n.d. &lt; 3]T<sup>h</sup></sub> PR	ID [n.d.]	[R: n.d.] = 0 PR
a. [van <sub>0</sub> t <sup>h</sup> <sub>2</sub> a]		*!	***	** (4 → 2)	
b. <b>D</b> [va <sup>n</sup> <sub>2</sub> t <sup>h</sup> <sub>2</sub> a]	*!	*	*		**
c. [van <sub>3</sub> t <sup>h</sup> <sub>2</sub> a]		*!		* (4 → 5)	***
d. [van <sub>0</sub> t <sub>0</sub> a]				**!* (4 → 0)	
e. [va <sup>n</sup> <sub>2</sub> t <sub>0</sub> a]	*!			** (4 → 2)	**
f. <sup>☞</sup> [van <sub>3</sub> t <sub>0</sub> a]				* (4 → 3)	***

The evaluation in tableau (18) proceeds as follows. First, the higher-ranked markedness constraints act as a filter. \*T<sup>h</sup>/C\_V rules out any candidate that retains the post-stop aspiration in this context, such as (18a) and (18c). The \*BREATHYVOICING (i.e., \*R) constraint, also ranked highly, penalizes any candidate with a partially devoiced sonorant, including the Designated Candidate (18b) itself.

This initial filtering leaves the crucial comparison between the transparent candidate [van<sub>0</sub>t<sub>0</sub>a] (18d) and the opaque candidate [van<sub>3</sub>t<sub>0</sub>a] (18f). The decision between them is rendered by their faithfulness to the Designated Candidate, as measured by ID [n.d.]. Recall that the total [noise duration] of the Designated Candidate is 4 (from <sup>n</sup>η<sub>2</sub> and t<sup>h</sup><sub>2</sub>a). The transparent candidate (18d) has a total [noise duration] of 0, a difference of 4 steps from the Designated Candidate. In contrast, the opaque candidate (18f) has a total [noise duration] of 3 (from η<sub>3</sub>), which is only 1 step away. Because it minimizes the faithfulness violation against the detailed phonetic plan embodied by the Designated Candidate, the opaque candidate [van<sub>3</sub>t<sub>0</sub>a] is correctly selected as the optimal output. This outcome requires the crucial ranking {\*R, \*T<sup>h</sup>/C\_V} >> ID [n.d.] >> [R: n.d.] = 0, prioritizing the phonetic faithfulness to the Designated Candidate over the inherent cue realization.<sup>11)</sup>

11) The use of an intermediate representation like the Designated Candidate utilized in the presented analysis naturally raises two questions. The first inquiry concerns its apparent reversal of the canonical phonology-phonetics interface. Unlike structurally analogous representations in earlier parallel frameworks such as Sympathy Theory (McCarthy 1999), the Designated Candidate is crucially specified with phonetic details determined by a part of the grammar. This seems to entail that phonetic decisions precede phonological ones, a stance at odds with the conventional architecture in which phonology feeds phonetics. However, in line with perspectives that advocate for the influence of phonetic factors on phonological

### 4.3. Extensions

The Phonetic Faithfulness approach developed above not only models the core opacity problem but also provides a principled account for a broader set of related patterns illustrated in Section 2. This section demonstrates the analysis’s empirical coverage by addressing transparent devoicing, blocking effects in derived words, and gradient phonetic realizations.

First, the grammar that captures overapplication opacity also straightforwardly accounts for transparent patterns, such as devoicing of a sonorant before a word-final aspirated stop. Unlike in the medial context, the  $*T^h/C\_V$  constraint is inactive word-finally, allowing the triggering aspiration to surface. Tableau (19) illustrates this with the analysis of  $/reint^h/ \rightarrow [rein_3t^h_2]$ .

(19) *hreint* /reint<sup>h</sup>/ → [rein<sub>3</sub>t<sup>h</sup><sub>2</sub>]

/reint <sup>h</sup> /	*R	*T <sup>h</sup> /C_V	*R <sub>[n.d. &lt; 3]PR</sub> T <sup>h</sup>	ID [n.d.]	[R: n.d.] = 0 <sub>PR</sub>	[T <sup>h</sup> : n.d.] = 2 <sub>PR</sub>
a. [rein <sub>0</sub> t <sup>h</sup> <sub>2</sub> ]			*! **	** (4 → 2)		
b. <b>D</b> [rei <sup>n</sup> η <sub>2</sub> t <sup>h</sup> <sub>2</sub> ]	*!		*		**	
c. <b>ES</b> [rein <sub>3</sub> t <sup>h</sup> <sub>2</sub> ]				* (4 → 5)	***	
d. [rein <sub>0</sub> t <sub>0</sub> ]				**! ** (4 → 0)		**
e. [rei <sup>n</sup> η <sub>2</sub> t <sub>0</sub> ]	*!			** (4 → 2)	**	**
f. [rein <sub>3</sub> t <sub>0</sub> ]				* (4 → 3)	***	**!

The analytic procedure for this transparent pattern is not different from that of the core analysis: after the Designated Candidate [rei<sup>n</sup>η<sub>2</sub>t<sup>h</sup><sub>2</sub>] is established, the final outputs are evaluated. Since  $*T^h/C\_V$  does not apply in this word-final context, the choice is adjudicated by faithfulness constraints. The winning candidate (19c) [rein<sub>3</sub>t<sup>h</sup><sub>2</sub>] is selected because it is more faithful to the Designated Candidate’s total


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patterning (e.g., Flemming, 2008; Jun, 2002; Kim, 2024, among others), I contend that a phonetically enriched intermediate representation is not merely a theoretical possibility but a grammatical necessity (see Flemming, 2008 and Kim, 2024 for detailed theoretical discussion). The second inquiry pertains to the learnability of such representations. While an exhaustive treatment of this issue is not provided here, recent computational simulations by Kim (2024) confirm that these phonetically rich representations are robustly learnable within the proposed model. While further experimental evidence is warranted, this result shows that such representations are, at the very least, not unlearnable.

[noise duration] than competitors like [ɾein<sub>0</sub>t<sub>0</sub>] (total [n. d.] = 0) are. While candidate (19f) is as faithful as the winner on the correspondence in [noise duration], it is ruled out by the low-ranked cue realization constraint Realize [<sup>h</sup>T: noise duration] = 2 (abbr. [<sup>h</sup>T: n.d.] = 2), which favors the preservation of the stop's aspiration. The presence of such low-ranked cue realization constraints thus serves a tie-breaking function without disrupting the overall grammar.<sup>12)</sup>

Next, the analysis extends to cases where devoicing is blocked, for instance, in derivatives like *sam-tal* ‘conversation’ (from *sam-* ‘con-’ + *tal* ‘talk, speech’). This requires the inclusion of a high-ranking Output-Output faithfulness constraint demanding that a derivative preserve specific phonetic properties of its base. While such Base-Derivative (BD) faithfulness constraints (Benua 1997) were shown to be insufficient to account for the opacity itself (see Section 3.1), they can be effectively utilized within this framework to model morphologically-conditioned blocking effects, as illustrated in (20).

(20) *samtal* /sam-t<sup>h</sup>al/ → [sam<sub>0</sub>t<sup>h</sup><sub>2</sub>al]

/sam-t <sup>h</sup> al/ Base: [t <sup>h</sup> <sub>2</sub> al]	ID-BD [n.d.]	* <sub>R</sub>	* <sup>T<sup>h</sup></sup> /C_V	* <sub>R</sub> [n.d. < 3] <sup>T<sup>h</sup></sup> PR	ID [n.d.]
a.  [sam <sub>0</sub> t <sup>h</sup> <sub>2</sub> al]			*	***	** (4 → 2)
b. <b>D</b> [sa <sup>m</sup> m <sub>2</sub> t <sup>h</sup> <sub>2</sub> al]	*!* (2 → 4)	*	*	*	
c. [sam <sub>3</sub> t <sup>h</sup> <sub>2</sub> al]	*!*** (2 → 5)		*		* (4 → 5)
d. [sam <sub>0</sub> t <sub>0</sub> al]	*!* (2 → 0)				**** (4 → 0)
e. [sa <sup>m</sup> m <sub>2</sub> t <sub>0</sub> al]		*!			** (4 → 2)
f. [sam <sub>3</sub> t <sub>0</sub> al]	*! (2 → 3)				* (4 → 3)

As the tableau shows, most changes to the sonorant in the derivative would alter the word's total [noise duration] from that of the base [t<sup>h</sup><sub>2</sub>al] (total [n.d.] = 2), thus fatally violating the top-ranked ID-BD [n.d.]. The top-ranked ID-BD [n.d.] constraint thus rules out any candidate whose total [noise duration] does not match that of the base, leaving only two primary candidates, i.e., (20a) and (20e). The choice

12) If aspiration in this context were not retained and thus resulted in opacity, contrary to the observations in Section 2 but in line with some previous literature, this phenomenon could be readily accounted for by the same analysis applied to the medial overapplication case. This, however, would require that a constraint such as \*<sup>T<sup>h</sup></sup>/C\_#, which was effectively disregarded in the analysis in (19), be ranked sufficiently high to motivate deaspiration.

between them is resolved in favor of (20a) by the high-ranking  $*R$  constraint, which penalizes the partially devoiced sonorant in (20e). This observation motivates the ranking condition where  $*R$  is ranked over the other markedness constraints along with ID-BD [n.d.], since the opposite ranking would wrongly predict candidate (20e) to be optimal instead of candidate (20a).

A further potential advantage of this framework is its ability to model gradient, non-contrastive phonetic patterns, or incomplete neutralization. The variation, potentially grammatical, observed in Figure 3, where sonorants are only partially devoiced in final contexts, can be generated by a simple re-ranking of constraints.<sup>13</sup> If ID [n.d] is ranked above the markedness constraint  $*R$ , the grammar will prefer an output that is maximally faithful to the Designated Candidate, yielding an output with a partially devoiced sonorant like [ʰn̥₂]. This is illustrated in (21). Such flexibility in accounting for both categorical and gradient patterns is a benefit not readily available to purely abstract models.

(21) *hreit* /reitʰ/ → [reiⁿn̥₂tʰ₂]

/reitʰ/	ID [n.d.]	$*R$	$*T^h$ /C_V	$*R_{[n.d. < 3]PR} T^h$	[R: n.d.] = 0 <sub>PR</sub>
a. [reiⁿ₀tʰ₂]	*!* (4 → 2)			***	
b. <b>D</b> $\in \mathbb{F}$ [reiⁿn̥₂tʰ₂]		*		*	**
c. [reiⁿ₃tʰ₂]	*! (4 → 5)				***
d. [reiⁿ₀t₀]	*!*** (4 → 0)				
e. [reiⁿn̥₂t₀]	*!* (4 → 2)	*			**

As demonstrated, a key advantage of the present analysis is its provision of a unified framework for phonetically gradient processes (e.g., incomplete neutralization) and phonological opacity, which have traditionally been treated in separate contexts. This merit is particularly evident in cases where the boundary between a phonetically gradient application and a categorical phonological phenomenon is blurred, as illustrated by the example discussed above (see Kim, 2024 for the relevant details).

13) While such a partial devoicing observable in Figure 3 is assumed here as a speaker's systematic production which requires a different constraint ranking, it might be a case of speaker-internal sub-phonemic variation. In such a case, the grammar presented in the analysis would be implemented within a stochastic grammar, such as Maximum Entropy (MaxEnt) grammar (Goldwater & Johnson, 2003; Hayes & Wilson, 2008) or Noisy Harmonic Grammar (Boersma & Pater, 2016), to model such a variation.

## 5. Concluding Summary

In this study, I have shown that the overapplication opacity involving a devoiced sonorant in Icelandic can be properly analyzed with the concept of Phonetic Faithfulness, couched within the unified grammar of phonetics and phonology (Flemming, 2008; Kim 2024, in press). The main proposal was that the language's grammar first assigns detailed phonetic properties to the given input, considering how much laryngeal coarticulation is preferred over keeping the full voicing of a sonorant. As long as this preference is reflected in the source representation, to which the grammar can refer, the phonological grammar can choose to preserve the phonetic bias shaped in the source representation as closely as possible, resulting in surface opacity. This result aids the claim that phonologically problematic patterns, including opacity, may have their roots in phonetic substance (Kim 2024, in press).

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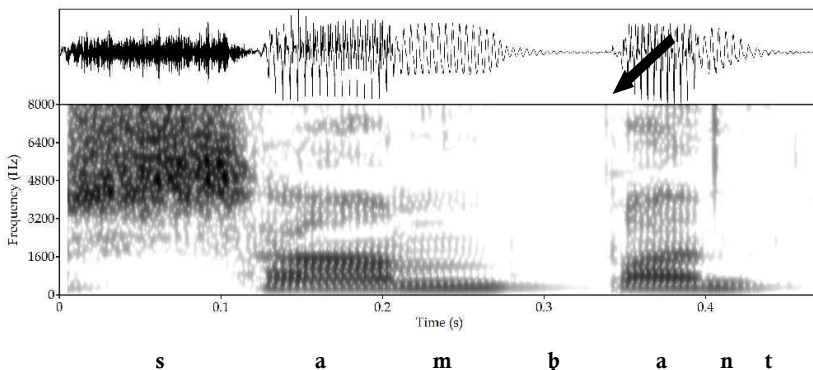
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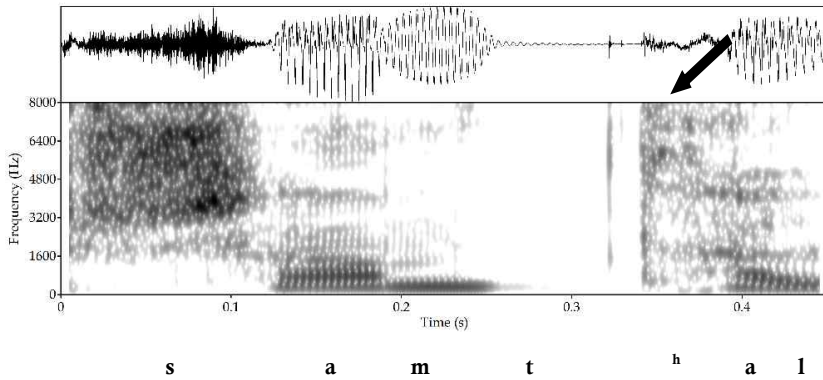
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## Appendix

While it has been documented that sonorant devoicing is blocked in certain derivational contexts in Icelandic (Árnason, 2011; Fortuna, 2016), the concurrent blocking of deaspiration in the same environment has not previously been noted. While finding examples that satisfy this specific condition is difficult given the limited phonetic data available, the Talrómur 3 corpus (Sigurgeirsson et al., 2021), which features recordings of four female and three male native speakers producing diverse sentences in various emotional states, provides evidence that speakers do not apply either sonorant devoicing or deaspiration, at least to an extent that would produce a categorical consequence. This is illustrated by the morphologically derived word *samtal* /sam-t<sup>h</sup>al/ ('conversation', from *sam-* 'con-' + *tal* 'speech'), produced by seven speakers. The tokens were extracted from sentence #118, uttered in neutral emotional condition ("Ég vil ráðleggja þér að hafa **samband** við skólann og fá **samtal** við skólastjórnendur, þeir geta farið yfir þetta með þér." [I want to advise you to get in touch with the school and have a conversation with the school administrators; they can go over this with you.]). The mean Voice Onset Time (VOT) for the stop /t<sup>h</sup>/ following the morpheme boundary was 40 ms, in contrast to the average VOT of 14 ms for unaspirated /p/ in *samband* /sam-pant/ ('contact, relation', from *sam-* 'con-' + *band* 'string') from the same sentence. This duration difference suggests that the aspiration of the base word's initial stop is not phonetically neutralized, a finding consistent across speakers. The following two spectrograms illustrate two words *samband* /sam-pant/ (with an unaspirated stop) and *samtal* /sam-t<sup>h</sup>al/ (with an aspirated stop), produced by the same speaker (id: F02).



**Figure A.** Spectrogram of the Icelandic word *samband* (*sam+band*) 'contact'.



**Figure B.** Spectrogram of the Icelandic word *samtal* (*sam+tal*) 'conversation'.