Becoming sonorant

Master Thesis

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1 Introduction

1.1 Sonority

Among the observations on the influence of sonority one generalization is that more sonorous sounds are more likely to be clustered with less sonorous sounds, with a rule making sure there is a minimal distance in sonority between them (Parker, 2011). There has been quite some debate on the definition of this minimal distance and how this can be empirically measured. This question alone can have many answers, not in the least because up to 98 acoustic correlates have been ascribed to sonority (Parker, 2002). A prevalent definition has been given by Ladefoged (1975): “The sonority of a sound is its loudness relative to that of other sounds with the same length, stress, and pitch”.

Finding acoustic correlates to correspond to this definition has led to a description of the hierarchy of the sonority of sounds with the relative sound level compared to an utterance initial vowel as the only acoustic correlate (Parker, 2008). Furthermore, Parker notes that the matchup between sound level measurements and syllable structure constraints (minimal distance) points to a phonological mechanism that is not accidental in nature.

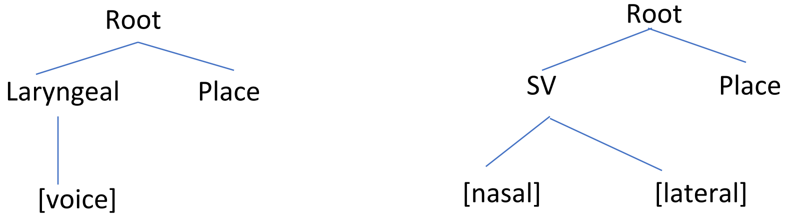
Phonologists have had their equivalent of sonority in the feature [sonorant] since Chomsky & Halle published The Sound Pattern of English in 1968. However, the presence of rules in a language, and the need for these rules to have to have their building blocks, has not yet led to a clear unification of phonetic sonority and phonological sonorants. The most sonorous of sounds (vowels) do not necessarily have the feature [sonorant], and although this feature is used to describe the phonological class of sonorant sounds, the question remains if this is just for a lack of a better description?

1.2 The usage of [sonorant]

The major class binary feature [sonorant] even provides more complications in combination with the other major class feature [consonantal]: together they define the three sound classes (vowels [+sonorant, -consonantal], resonants [+sonorant, +consonantal] and obstruents [-sonorant, +consonantal), but the combination [-sonorant, -consonantal] is problematic (Botma, 2011). Although the laryngeal sounds /h/, /ɦ/, and /ʔ/ can be seen as proponents of this final feature description, it is important to note that the use of major class features is not necessary for to express the contrast with other sounds. The contrast between the three sound classes, in which /h/, /ɦ/, and /ʔ/ are included (resonants and obstruents), might just as well be expressed by one feature being either positive, negative or absent. A case against the use of the [consonantal] feature has been made by Harris (1996), followed up by an argument against sonority in 2006.

An argument against sonority does not immediately herald the exit of the feature [sonorant], although proposals have been made to demote it from being a major class feature to a non-major class feature (Harris, 1996). The Sonorant Voice (SV) theory (Avery & Rice, 1989; Rice, 1993) has attempted to provide insight into what makes the obstruents with their contrastive voicing different from sonorants with spontaneous voice. In this theory, there are two types of phonological voicing correlating to the contrastive and spontaneous voice types. The contrastive voice is realized through a laryngeal node dominating a [voice] feature (1a), the spontaneous, or sonorant, voice is realized through the SV node dominating [nasal] or [lateral] features (1b).

1.

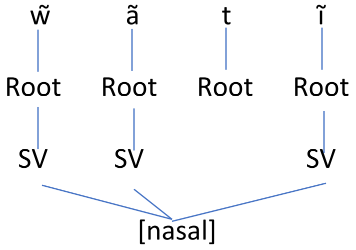


a. Obstruent voicing

b. Sonorant voicing

The advantage of this approach is that instead of treating [sonorant] as a descriptive feature the SV node in the SV theory makes it possible to phonologically explain the application of rules like post-nasal voicing assimilation as being governed by a sonority-based feature. The nasal harmony pattern in Southern Barasano has been analyzed along these lines (2); all targets for nasal harmony are specified for SV, thus providing a landing site for the [nasal] feature (Piggott, 1992).

2.



1.3 Influence of sonority

The triggering of a phonological rule by a sonority related feature might provide insight into the phonological process behind the input and output of a phonological rule. Is a sonority-based feature possibly a key factor in the change towards sonorant sounds in a language?

One of the ways of finding a possible influence of sonority would be to look at sounds that change from being phonologically [-sonorant] to [+sonorant], and analyzing whether this change can be attributed to the presence of a sonorous sound as described above for the SV theory. Or if this change might be better explained by other phonological theories like Element Theory, or by looking at different phonological processes like lenition? Thus, main question becomes: what causes segments to become sonorant?

1.4 Structure

This paper will attempt to find the cause of the change to a sonorant segment by looking into a database of languages and their phonological rules. In section 2 a general descriptive database study will be presented. Section 3 will look into more specific observations from this dataset by presenting case studies. The analysis of these changes within phonological theories will be given in section 4. Finally, it will be discussed if a general observation on the cause of sonorization can be made, and if this has implications on the necessity of a phonological feature based on sonority in section 5, leading to the conclusion in section 6.

2 Database study

2.1 Introduction

To find out what causes segments to become sonorant, it must first be made clear what type of segments undergo this change. Secondly, the type of segment that is the output of a change towards a sonorant segment is of importance. And finally, the context in which this change happens could be of influence on how and why an input segment becomes a specific output segment.

In this section, all three of the above categories will be descriptively analyzed with data from a large phonological database and their respective significance to the cause of the change towards a sonorant segment will be accounted for.

2.2 Method

The database that has been chosen for this research is P-Base (Mielke, 2003-2017). This database contains 629 languages and 7318 patterns from these languages. P-Base was searched for occurrences of the input segment being [-sonorant] and the output segment being [+sonorant]. A total of 255 phonological rules leading to this change were found. These results were analyzed for the type of rule (regressive, progressive, both),

The results were also analyzed for type of change the rule induced (e.g. plosive → approximant), and the specifics of the context in which this change takes place. Fourteen results from the search were discarded for a lack of information in either of the three mentioned criteria, leading to a dataset of 241 phonological rules, spread over 136 different languages (including different dialects). A summary of the changes is given below in table 2 and total overview of all languages and the number of phonological rules can be found in appendix A.

2.3 Results

2.3.1 Global Results

Before looking into why, and in which context, plosives and fricatives become sonorant, there is something else that stands out. Some of the plosives remain plosive when a rule is applied (n = 14, 3a), some of the plosives become fricatives (n = 20, 3b), some fricatives remain fricatives (n = 17, 3c), and furthermore there are two rules that turn a fricative segment into a plosive (3d).

3. a. /k/ → [ʔ] / __X

b. /k/ → [h] / __X

c. /f/ → [h] / __X

d. /s/ → [ʔ] / __X

When looking further into which segments these plosives and fricatives are changed, it becomes clear that P-Base has defined /ʔ/ and /h/ as being [+sonorant]. The relevance of the change will be further discussed below in section 4.3. For the current analyses, the non-sonorant segments have been removed from the further analyses, leaving a total of 191 phonological rules available. The counterparts of the tables in this section, with the above-mentioned plosive and fricative outputs included can be found in appendix B.

Out of the 191 phonological rules 32 were classified as progressive, 88 as regressive, and 61 rules were classified as 'inter' as they are active with context specified on both sides of the target segment, with 41 of these being intervocalic. The remaining ten rules were classified as 'other' as they are not dependent on certain segments in the context but rather on suprasegmental features (table 1). The distribution between these categories is not predictable as shown by a χ^2 test: χ^2 (3) = 72,664; p < 0,001.

Table 1. *Number or phonological rules per rule type. Insert corrected numbers.*

Progressive	32
Regressive	88
Inter	61
- **Intervocalic**	41
Other	10
Total	**191**

Looking at the two [-sonorant] groups, plosive and fricative, the plosives are the largest group to undergo changes. A total of 151 rules govern a change in a plosive segment, with most changes towards nasals (n = 47) and approximants (n = 40). A smaller number of rules apply to fricatives, 40 in total. Out of these most changes are towards approximants (n = 24) and nasals (n = 7). For a summary see table 2 and for a full overview see appendix C. The changes as described in table 2 do not happen in a predictable fashion for fricatives (χ^2(5) = 57,2; p < 0,001) and for plosives (χ^2(6) = 78,887; p < 0,001).

Table 2. *Number of rules per original segment (first column) leading to the target segment (first row).*

	Approximant	**Assimilation**	**Liquid**	**Nasal**	**Tap**	**Trill**	**Vowel**	**Total**
Fricative	24	2	0	7	1	3	3	**40**
Plosive	40	10	10	47	25	18	1	**151**
Total	**64**	**12**	**10**	**54**	**26**	**21**	**4**	**191**

For the total of 241 phonological rules there are 82 different contexts in which a change occurs. For the plosive input group 59 different contexts are present and for the fricative input group 33 different contexts. Although minor differences in the contexts for the rules lead to these large numbers, there are major groups discernable from this, namely 54 rules act on a context with a syllable or word boundary, 45 rules act on an intervocalic context, and 43 rules have a nasal in their context (table 3).

Table 3. *Largest context groups (first row) per input type (first column).*

	Nasal	**Intervocalic**	**Boundary**	**Other**	**Total**
Fricative	11	5	21	3	**40**
Plosive	32	40	33	46	**151**
Total	**43**	**45**	**54**	**49**	**191**

2.3.2 Becoming Sonorant

Segments undergoing a change to become a nasal are generally (79,6%, n = 43) influenced by a nasal segment, either a nasal consonant (4a) or a nasalized vowel, in the context (4b). In the other cases, the changes occur when a word boundary (4c) or voiced plosive (4d) is present immediately after the segment under the influence of the phonological rule. Plosives are much more liable to change to nasals (87%, n = 47) than fricatives (13%, n = 7).

4. a. /t/ → [n] / __{m, n, ŋ}

   b. /t/ → [n] / __{Ṽ}

   c. /k/ → [ŋ] / __{#}

   d. /k/ → [ŋ] / __{b,d,g}

Plosives are also more subject to change under the influence of phonological rules to taps (96%, n = 25) than fricatives are. Taps are mostly the result of an intervocalic context (70%, n = 18) (5a), with the remaining cases being the result of a context with a directly adjacent word boundary (20%, n = 5) (5b), or a plosive on its right side (5c).

5. a. /t/ → [ɾ] / V__V

b. /t/ → [ɾ] / __#

c. /t/ → [ɾ] / __p

For trills the same pattern occurs, the context of the change is mostly intervocalic (62%, n = 13) (6a), with the remainder of the contexts made up of word boundary related (24%, n = 5) (6b) and other individual circumstances. Fricatives are slightly more likely to change to a trill (14%, n = 3) in comparison to the taps, but the majority of the changes from an obstruent to a trill originate from the plosives (86%, n = 18).

6. a. /d/ → [r] / V__V

b. /d/ → [r] / __#

Only plosives undergo a change to becoming a liquid segment, the majority under the influence of a liquid (40%, n = 4) (7a) or intervocalic context (20%, n = 2) (7b). The remaining rules act on a context with either a word boundary or a nasal segment, or a combination of both.

7. a. /t/ → [l] / __l

b. /t/ → [l] / V__V

A much less clear image presents itself when looking at approximants (excluding the above-mentioned categories; nasals, taps, trills, and liquids), fricatives are also much more likely to be subject to this type of change (37,5%, n = 24) in comparison to the other cases. The contexts in which the changes occur are much more numerous than with the changes to the other categories, nine different contexts for a total of 64 phonological rules. However, when generalizing these contexts to the closest common denominator two major context groups arise. Vowel-based contexts make up 42,2% (n = 27) (8a), and boundary-based contexts account for 26,6% (n = 17) (8b).

8. a. /t/ → [j] / {V}__{V}

b. /p/ → [w] / __#

The largest groups of contexts leading to the changes are nasals, vowel-based or boundary related, with additional contexts differing per target segment. The largest groups are summarized in table 4 below.

Table 4. *Percentage of contexts (first row) leading to the target segments (first colomn).*

	Vowel-based	**Nasal**	**Liquid**	**Boundary-related**	**Other**
Nasal	-	79,6%	1,9%	14,8%	3,7%
Tap	70%	-	-	20%	10%
Trill	62%	-	6%	24%	8%
Liquid	20%	20%	40%	20%	-
Approximant	42,2%	1,5%	4,6%	26,6%	25,1%

The significance of the context related to the changes has been calculated for all contexts per target segment as can be seen below in table 5. All changes but the liquids show no association between the context groups.

Table 5. *Values of χ^2 test for the change of obstruents to the target segments.*

	Nasals	**Taps**	**Trills**	**Liquids**	**Approximants**
Obstruents	$\chi^2(4) = 84{,}657$; $p < 0{,}001$	$\chi^2(3) = 26{,}462$; $p < 0{,}001$	$\chi^2(5) = 29{,}857$; $p < 0{,}001$	$\chi^2(3) = 0{,}6$; $p = 0{,}8964$	$\chi^2(8) = 93{,}711$; $p < 0{,}001$

2.4 Discussion & Conclusion

Three patterns emerge from the data discussed above. First of all, segments that change to a liquid or nasal have respectively a liquid or a nasal in the context of the phonological rule. Secondly, with the exception of the two previously mentioned segments – liquids and nasals – the context that stands out the most is the intervocalic or vowel-based context. And finally, boundaries seem to have a prominent effect on the sonorization of segments (table 6).

Table 6. *Largest context groups leading to sonorant segments.*

Nasal	**Vowel-based**	**Boundary-related**	**Other**
22,7%	33,9%	23,1%	20,3%

The first pattern seems to point to spreading of nasality and liquidity, by respectively nasal and liquid segments. For the nasal target segments the nasal context is a significant contributor, but as described in table 4, the same cannot be said for the liquid target segments. Although the majority of the changes (40%) stems from a liquid context, there simply is no significant difference between the other possible contexts (intervocalic, nasal, boundary). This can partly be explained by the lack of rules describing this change in the dataset; ten phonological rules are not enough to draw conclusions from.

The nasal target segments however are the result of a larger number of rules (n = 54), with the largest context group (n = 43) being nasal segments. The gaining of sonority by the obstruent segments is likely to come from these segments in the context, but the exact working of this should be looked into in more detail as there are multiple possible paths on the road to sonority.

The second pattern that stands out is that a segment in intervocalic or vowel-based context is likely to become sonorant. Analogous to the spreading of sonority in a nasal context, the gaining of sonority by obstruent segments in this context is likely to come from the vowels in the context. The difference however is that a nasal context leads to nasal target segments in 91,8% of the cases, but there is no clear target segment type following from the vowel-based context as can be seen in table 7. There is no clear association between these groups as shown by a χ^2 test; $\chi^2(4) = 44{,}743$; $p < 0{,}001$. Thus, the only conclusion so far is that it is necessary to further investigate the outcome of a phonological rule with a vowel-based context.

Table 7. *Percentages of sonorant target segments (top row) from a vowel-based context.*

Nasal	**Tap**	**Trill**	**Liquid**	**Approximant**
0%	29,5%	19,8%	3,4%	47,3%

As for the third pattern noticeable from the results, the effect of boundaries is noticeable on the sonorization of the target segments. The difference between the first and second pattern however is that there is no clear sonorant segment to point to as a cause for the gaining of sonority.

To return to the main question; what causes segments to become sonorant? From table 6 it might be concluded that being in the context of a nasal or vowel influences the change to a sonorant segment. However, boundary related contexts also lead to a large part of the changes, and this is problematic when assuming the spreading of sonority. A possible explanation would be assuming the opposite: instead of gaining [+sonority] the phonological rule could lead to the loss of [-sonority]. A similar process is seen in word final devoicing as well. This rule does not add [-voice], but rather some information is lost. Word final devoicing is better explained as the loss of [+voice], viewing the phonological rule implementing this change as a process of lenition.

The prevalence of boundaries in sonorization, and the possibility of a lenition-based analysis, will be looked into further in section 3, together with the case studies on the gaining of sonority from nasal and vowel based contexts. In section 4 the processes as described in section 3 will be matched against Element Theory and Feature Geometry to identify the best fit for the description of sounds becoming sonorant.

3 Case studies

3.1 Introduction

It has become clear from section 2 that there are three major context groups (table 6) and four groups of target segments within which we can see significant differences between these context groups (table 5). However, as we have seen from table 7, one context does not lead to one type of target. The entire phonological process from input, to context, to output is deserving of further analysis to be able to paint a clear(er) picture. Furthermore, languages themselves might differ in their phoneme inventory or phonological constraints and therefore might necessitate the de-generalization of the context or target segment groups made in section 2 altogether.

If all the different variations in input, output and context can still be grouped together after looking into the more specific workings of the phonological rules, the answer to the main question should become more apparent. Should this section lead to the conclusion that we cannot generalize across multiple languages and multiple types of rules, it will be more difficult to exactly assess what causes a segment to become sonorant. However, if generalization is possible, the processes described in this section can further analyzed to ascertain the cause of sonorization in different phonological theories.

3.2 Analysis

3.2.1 Nasal target segments

Obstruents become nasal segments largely under the influence of other nasal segments (see section 2.3.2), the rules governing this change can be further classified along the lines of table 1: the largest group being the regressive rules (n = 41), followed by progressive rules (n = 11) and ‘inter’ rules (n = 2). The different types of rules will be discussed along these lines, further split by the context types.

A typical regressive rule with a nasal context (9a) comes from Kanuri, a Nilo-Saharan language spoken in Nigeria. In this rule, the voiceless plosives change to nasals before the /n/. Kanuri does have voiced plosives in its phoneme inventory as well as voiced and voiceless fricatives (Cyffer, 1998). The voiceless segments are not a special group undergoing a change in a regressive environment (n = 13), voiced segments (n = 14; Mising, 9b) and a mix of both voiced and voiceless segments (n = 14; Catalan, 9c) are just as likely to undergo this change ($\chi^2(2) = 0{,}05$; $p = 0{,}98$). Mising, a Sino-Tibetan language from India, has a phoneme inventory also containing the voiceless counterparts (Prasad, 1991) of the segments undergoing the change in 8b, thus the voiced segments are the intended target in this language, just as the voiceless segments are the intended target in Kanuri. Both Mising and Catalan are also indicative for their respective groups, as is the case for all phonological rules given below, unless mentioned otherwise.

9. a. /p,t,k/ → [m,n,ŋ] / __n

b. /b,d,g/ → [m,n,ŋ] / __{m,n,ɲ,ŋ}

c. /p,b,t̪,d̪/ → [m,n̪] / __{m,n}

Amongst the regressive rules another of the largest context groups, boundary-related contexts, is present in two ways, either together with a nasal segment or alone. In the first case (Orma, 10a), a morpheme boundary is present between the target segment and the nasal segment. Although this combination occurs less (n = 10) than the nasalization happening because of just a nasal segment (n = 23), the presence of a boundary does not seem to block the exchange of nasality. Furthermore, the presence of just a boundary (Central Yupik, 10b) can be enough to change an obstruent to a nasal (n = 5).

10. a. /p’,t,d,ɗ,k,g,k’/ → [m,n,ŋ] / __+n

b. /k,q/ → [ŋ,ɴ] / __#

The progressive rules do not have a single boundary leading to a nasal segment, however the plosives present in the phoneme inventory of Kapampangan (Forman, 1971), an Austronesian language from the Philippines, do change to nasal segments with a morpheme boundary present (11a), embodying the reverse of the rule in 10a. In Bisu, a Sino-Tibetan language spoken in China and Thailand, the alveolo-palatal fricative nasalizes after a nasal segment (11b). Although five other progressive rules behave in this same way, nothing can be said about significant differences between voiced or voiceless segments as could be done for the regressive rules, because of the small number of rules.

11. a. /p,b,t,d,k,g/ → [m,n,ŋ] / m+__

b. /ʑ/ → [ɲ] / {m,mʲ,n,ŋ}__

Both the ‘inter’ rules combine boundaries and nasal vowels in their contexts. In Bribri (12a), a Chibchan language from Costa Rica, word final nasalization takes place. And in Cubeo, from the Tucanoan language family, word initial or internasal-vocalic nasalization takes place (12b).

12. a. /d̪/ → [n̪] / ĩ,ũ,ẽ,õ,ã__#

b. /b,d/ → [m,n] / {#/ ĩ,ɨ̃,ũ,ẽ,ɑ̃,õ}__ĩ,ɨ̃,ũ,ẽ,ɑ̃,õ

3.2.2 Tap target segments

Taps are generally the results of an intervocalic context (section 2.3.2), with the remainder being split between regressive rules (n = 3), progressive rules (n = 4) and one rule being a combination of any vowel from the phoneme inventory on one side or a boundary on the other side (Maithili; Ramawatar, 1996; 13), thus being both progressive and regressive.

13. /ɖʰ/ → [ɽʰ] / V__, __#

The regressive rules behave similarly in that a coronal plosive changes to a tap, but the exact place remains when the rule is applied. In the Lower Grand Valley dialect of Dani, an Austronesian language from Indonesia, the voiceless alveolar stop changes to an alveolar tap (14a), while in Pengo, a Dravidian language spoken in India, the retroflex stops change to retroflex taps (14b).

14. a. /t/ → [ɾ] / __{k,kʷ,w,j}

b. /ʈ,ɖ/ → [ɽ] / __{t̪,d̪}

For the progressive rules the same principle applies, in Tamil, a Dravidian language mainly in use in India, the voiceless alveolar stop changes to an alveolar tap (15a), while in Senoufo (Supyire dialect), a member of the Niger-Congo language family spoken in Mali, the alveolar obstruents change to alveolar taps, but the velar stop changes to a uvular trill in unstressed syllables (15b).

15. a. /t/ → [ɾ] / {m,n,ɳ}__

b. /d,s,g/ → [ɾ,ɾ,ʀ] / +__

The segments undergoing intervocalic change are mostly voiced (n = 15), some are voiceless (n = 4), but none of the rules have a mix of both amongst the input segments. This significant difference ($\chi^2(2) = 19,05$; $p < 0,001$) leads to the further specification of these rules based on the voiced or voiceless input.

In Tagalog, an Austronesian language from the Philippines, a voiced plosive changes to a tap in between any vowel from the Tagalog (Ramos, 1971) vowel inventory (16a). The change for the voiceless plosive does not differ from this; in Martuthunira, a Pama-Nyungan language spoken in Australia, the retroflex plosive changes to a retroflex tap (16b).

16. a. /d/ → [ɾ] / V__V

b. /ʈ/ → [ɽ] / V__V

3.2.3 Trill target segments

Intervocalic contexts also make up the majority of the contexts for the rules governing the change to trills. Most changes are from a voiced alveolar plosive (n = 11), but two rules have a change from a voiceless alveolar plosive to a trill. In Pileni, an Austronesian language from the Solomon Islands, this is the case (17a), in Dieri, the voiced alveolar plosive changes to a trill (17b).

17. a. /t/ → [r] / V__V

b. /d/ → [r] / V__V

For the rules with boundary-related contexts, there are three progressive rules and two combinations with a vowel on the opposite side of the context, one with the boundary word-initial, the other with the boundary word-final. The progressive rules behave like the rule in 15b from Senoufo, where the alveolar segments are tapped, but the velar segment becomes a uvular trill. The two combinations with a boundary and vowel are both from Selepet, a Trans-New Guinea language spoken in Papua New Guinea. Voiceless plosives undergo a change word-initially (18a) and voiced plosives undergo a change word-finally (18b)

18. a. /p,t̪,k/ → [w,r,h] / #__V

b. /b,d̪,g/ → [w,r,h] / V__#

3.2.4 Approximant target segments

The largest group of target segments, the approximants, have two of the large context groups present in their phonological rules; the intervocalic and boundary based group. Next to these two groups a number of combinations between vowels and boundaries make up the contexts for the approximant target segments.

The intervocalic contexts all lead to the change to approximant in the same way; the place of articulation remains the same with the exception of one rule. In Kanuri (also seen in 8a) the velar plosives change to a labial approximant (19a). The other changes are predictable and follow the process as in Agarabi (19b), a Trans-New Guinea language spoken in Papua New Guinea.

19. a. /k,g/ → [w] / {u,o}__V

b. /b, d/ → [w, j] / V__V

The overlap between vowel-based contexts and boundary based contexts has already been described in 18a and 18b. The phonological rule that changes the alveolar plosive to a trill also changes the labial plosive to an approximant. Koiari (Dutton, 1996), a Trans-New Guinea language spoken in Papua New Guinea, also shows a word initial change to an approximant, but only with a subset of the vowel inventory of the language (20a). Furthermore, morpheme boundaries may also be crossed as in Tauya, also a Trans-New Guinea language spoken in Papua New Guinea (20b).

20. a. /β/ → [w] / #__{u,o}

b. /v,ʒ/ → [w,j] / V__+a

Phonological rules with boundary-related contexts only occur regressively in the dataset. Word final changes to approximants are present in Tirmaga, a Nilo-Saharan language spoken in Ethiopia and Sudan (21a). Word boundaries and consonants appear in the same distribution in Lele, an Afro-Asiatic language from Chad (21b).

21. a. /c,ɟ/ → [j] / __#

b. /g/ → [j] / __{#,C}

3.3 Discussion & Conclusion

From sections 2.3.2 and 3.2.1 it has become clear that nasal target segments generally are the outcome of a rule with a nasal context, albeit a nasal consonant or nasal vowel. The exception being rules where word finally the obstruent nasalizes, as seen in 10b. Word final nasalization has been described for vowels in Tashlhiyt as a word boundary marker (Willms, 1972), and as mentioned in Barnes (2006) a phrase final position may lend itself to nasalization. Neither of these two descriptions match the rule in in Central Yupik (9b). However, the phoneme inventory provides more insight into why the nasalization may happen; the language does not have any tap or trill in the inventory (St. Clair, 1974) so a change analogous to the rule in Maithili (12) is not possible. Central Yupik does have approximants in its inventory, but unlike in Tirmaga (20a) the language doesn't change the word final obstruent to an approximant.

Nasalization is not bound to obstruents with a specific place of articulation, for every place an obstruent occurs a nasal segment can be pronounced with the same place of articulation. The same cannot be said for the taps and trills, no labial segments change to a tap and velar segments change in two cases to a uvular trill. The change to a tap or trill is heavily place bound, or in other words; to have a tap or trill as the output of a rule the place of the input segment is of the utmost importance.

Approximants do not share this restriction on the input segments, but it must be noted that for every place of articulation of the input segments a corresponding approximant is available. The 'decision' on when an input segment becomes a tap, trill or approximant is not yet clear. The phonological rules from Argobba (22a) and Agarabi further illustrate this; both languages change the labial plosive to a labial approximant, but in Argobba changes the coronal plosive to a coronal tap while in Agarabi the coronal plosive changes to a coronal approximant (22b).

22. a. /b,d̪/ → [w,ɾ̪] / __#

b. /b,d/ → [w,j] / V__V

A possible explanation would be the lack of a coronal tap or trill in Agarabi, but this language has the segment /r/ in its inventory (Bee, Luff, & Goddard, 1973). So why does Agarabi not make use of this option? The context in the rules of both languages is different, but an intervocalic context does not exclude trills as seen in table 3.

The difference may be found in the characteristics of the input segment: possible evidence that the properties of the input define the potential output can be found amongst the taps and trills as output segments. The taps and trills have significantly more voiced segments then voiceless segments or both voiced and voiceless segments serving as the input for the phonological rules governing these changes ($\chi^2(2) = 24,05$; $p < 0,001$). The languages that have voiceless inputs change to taps – Martuthunira (Dench, 1995), Western Shoshoni (Crum & Dayley, 1993), Pileni (Næss, 2000) and Siona (Wheeler & Wheeler, 1962) – do not have the voiced counterpart in their inventory, while the languages that have the voiced input segment do have the voiceless counterpart in their inventory. Although the same does not apply to the segments changing to trills, the type of segment that can be the output of a rule does seem to be bound by properties of the input segment; in this case a marking for voicedness may define the possible change, with the four languages lacking the voiced obstruent having this marking on the voiceless obstruent.

Not all input segments are then to be treated as equals, and not all contexts lead to the same output segments, but languages do have similar systems per category discussed in this section. Therefore a shared cause for sonorization across languages is viable, however a closer look into the phonological processes behind these rules is needed to provide insight into why a coronal may become a tap, a trill or an approximant, or why a word boundary may lead to word-final nasalization or word-final approximants.

In section 4 the rules discussed in this section will be given a closer look to further pin down what causes segments to become sonorant.

4 Theoretical comparison

4.1 Global summary

In section 2 the distribution of the phonological rules has been reported; nasal target segments are largely the result of nasal contexts. Taps, trills and approximants have vowel-based and boundary-related context groups as significant surroundings in the phonological rules. From section 3 it has become clear that although there are differences between context groups, the input segments of the rules have an influence on the outcome of the rule.

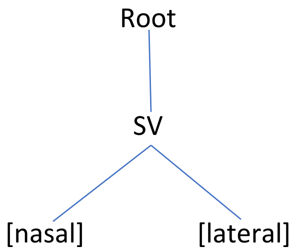
The question that remains is how do the inputs and contexts lead to the output as described in sections 2 & 3? Is there a structure to be found when these rules are analyzed along the lines of phonological theories, and is one theory better at describing or explaining the processes at play when obstruents become sonorants? Furthermore, and perhaps more importantly, does the analysis lead to a directly demonstrable cause for sonority?

4.2 Application to Feature Geometry

Feature Geometry as proposed by Clements (1985) and further updated by McCarthy (1988) has enabled researchers to describe many phonological processes in a clear manner. Although many proposals for additions and changes have been made through the years, the one of importance to this research is that by Rice (1993). The addition of a Sonorant Voice (SV) node in the geometry enables the spreading of sonority, or sonorant features, to be described. Before the introduction of this node in the geometrical structure, sonority, because of its major class status, could not be subject to spreading within this structure.

The ability to use the SV node for the spreading of sonority, together with the inherent implications of the structure of Feature Geometry (23, cf. Avery & Rice, 1989), the phonological rules from section 3 can be modeled to fit within this structure.

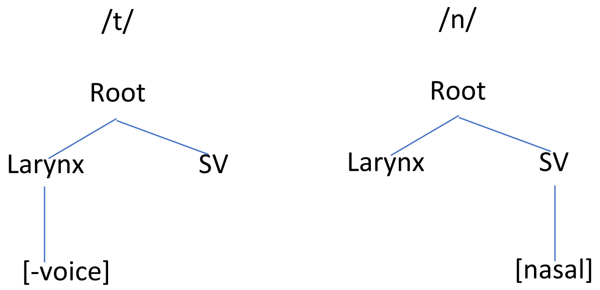
23.



4.2.1 Nasal target segments

The first rule discussed in section 3 (9a) describes the change of voiceless plosives to nasals when these plosives are on the left side of an alveolar nasal. The place of articulation does not change, nor does the major class feature [consonantal]. The change that does happen is that the laryngeal voice specification is lost in favor of an SV node [nasal] feature (24). As is common with Feature Geometry only the changes will be denoted in the examples.

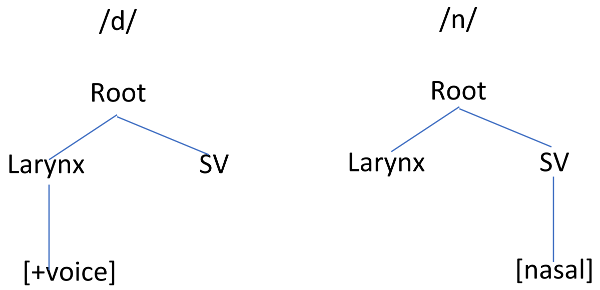
24.



As in SV theory the laryngeal node is reserved for obstruents, the loss of the [-voice] feature implies the loss of obstruency. Furthermore, the application of the [nasal] feature to the previously empty SV node supplies the segment with its voicing and nasality, thus completing the change to a nasal segment.

This same transfer of features applies to the rule in 9b. The laryngeal voicing is lost, and sonorancy is gained through the application of the [nasal] feature on the SV node (25).

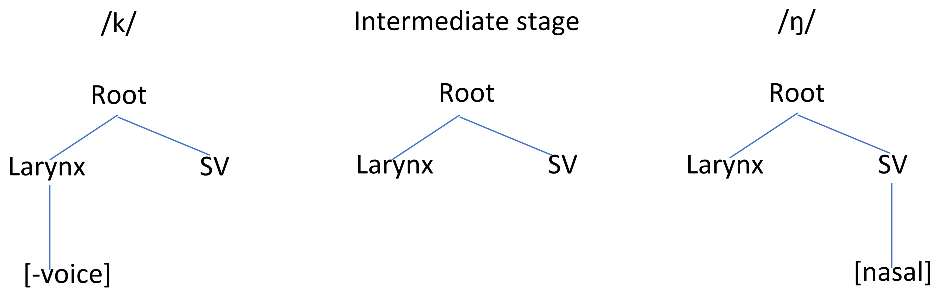
25.



In both of the above described cases the nasality is able to spread from the segment on the right side of the plosive, thus providing nasality and with that also sonority. This fairly straightforward analysis is not possible when observing the phonological rule from 10b. A dorsal plosives changes to a dorsal nasal when in word-final position. Nasality cannot be spread from a boundary, so where does nasality come from in this language?

One explanation would be that a word final position is a weak position in this language, and so, along the lines of word final devoicing, the [voice] feature is lost on this segment. Word final devoicing is present in Central Yupik for the voiced dorsal plosive (St. Clair, 1974), making a strong case that the word final position is a weak position for dorsal segments. As both the laryngeal and SV node now have no specification it comes down to how this language treats underspecified nodes. If Central Yupik interprets the underspecification of both nodes as leading to a default specification of the SV node as [nasal] (c.f. Rice & Avery, 1991) the change in 26 is explained.

26.

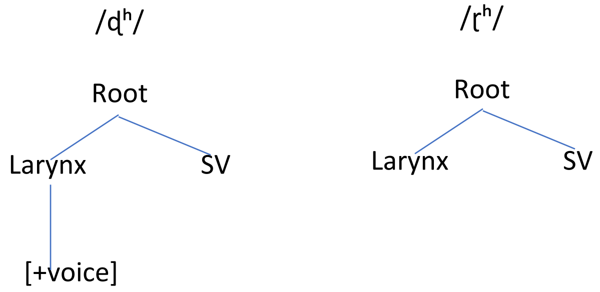


Although the insertion of the [nasal] feature allows for a description of the process, it does not make the change fully predictable. However, the following descriptions in the paragraphs below on the changes to the other target segments do point to a common and predictable lenition-like process being at play, viz. further sections in 4.2 and section 4.4.

4.2.2 Tap target segments

The tap target segments are all derived from coronal input segments, no change of place is present in the phonological rules. The first rule from section 3.2.2 (13) describes the change of a retroflex voiced aspirated plosive to a retroflex aspirated tap, either post-vocalically or word-final (27).

27.



As described in the previous section, the delinking of the [voice] feature from the laryngeal node denotes the loss of obstruency. The difference however is that no nasality is inserted on the SV node, therefore a similar process to 24 would be expected, leading to a change from /ɖʰ/ to /ɳʰ/. As this is not the case the languages behaving like Maithili do not have a default rule leading to the insertion of a nasal segment, contradicting the assumption of Rice & Avery (1991) as described in the previous section. But, with both the SV node and the laryngeal node underspecified, the SV node must take precedence as the lack of [voice] specification on the laryngeal node does not lead to an underspecified [-voice] or [+voice] interpretation, resulting in an obstruent target segment. An empty SV node may therefore lead to the presence of sonority, while at the same time not necessitating the insertion of a [nasal] or [lateral] feature. This will be further discussed in section 5.

The process of changing to a tap is therefore best described as the loss [voice] specification and the lack of feature spreading; however, the other phonological rules must adhere to the same specifications as in 27 for this assumption to hold.

In the phonological rule from Tamil (15a) a voiceless alveolar plosive changes to an alveolar tap post-nasally. Analyzing this rule as in section 4.2.1 would lead to the nasalization of this segment (see 11a, 11b, 24) instead of resulting in a tap. A lexical phonological change to a tap instead of a nasal, hereby excluding the [nasal] feature from linking under the SV node does lead to the expected behavior as seen in 25.

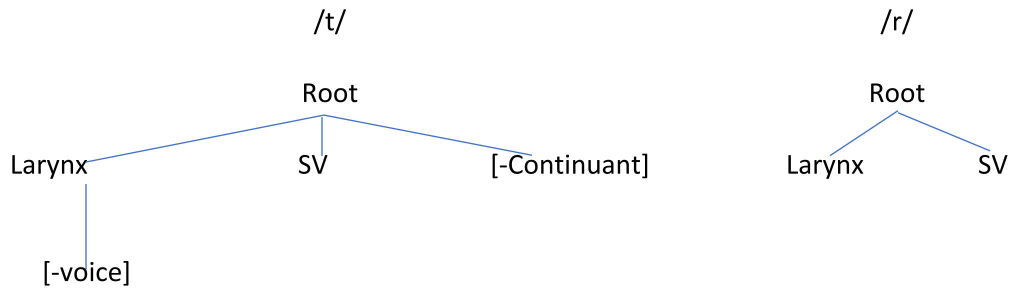
Intervocalic tapping is the most common process leading to the tap target segments. As the vowel segments are not specified for anything on the SV node, nothing can spread to this node, leading to the expected empty node as described in 25, the lenition-like characteristics of the analysis in the previous section remain the same.

4.2.3 Trill target segments

The trill target segments differ from the taps in one single but important way, the manner of pronunciation changes from [-continuant] to [+continuant]. When simply delinking features from the input segment and linking features from the context segments to create the target segment, the expectation from the phonological rules in section 3.2.3 is that this feature must spread from the vowels. But why would vowels be specified for [+continuant]? This feature is inherently present in vowels and the expectation would therefore be that by using underspecification this feature is not actually present in a vowel's feature geometry.

Although it seems that this would be a major problem in the analysis of changes to trill segments, a look at the inventories of the languages this considers provides a possible outcome. None of these languages have a tap in their inventory, therefore, when delinking of the [voice] feature from the laryngeal node is applied, the subsequent feature geometry would imply a tap as target segment. However, a lexical phonological rule leading explicitly to trills allows for the analysis in these languages to ignore the specification for [continuant] (28), leading to the pronunciation of trill where along the lines of the analysis in the previous segment a tap would be expected.

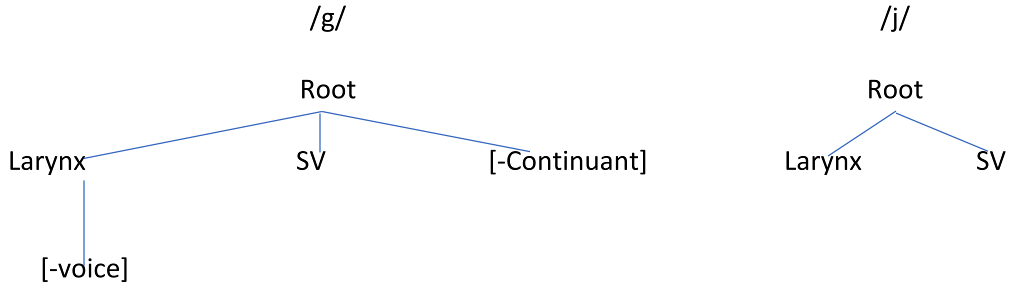
28.



4.2.4 Approximant target segments

The description of nasals as target segments is by delinking the [voice] feature and the insertion of the [nasal] feature, while the descriptions of taps and trills as target segments are purely the delinking of the [voice] feature. The description of the change to approximant target segments is likely to follow along these lines. The word final reduction to an approximant in 21a & 21b can be described the same way as the change to a trill segment in 28, for no tap, nor trill exists for the place of articulation of /c/, /ɟ/ and /g/. For the analysis as proposed in the previous sections to be applied to this change as well, the empty SV node would have to lead to approximants in non-alveolar positions. In 29 this change is illustrated for a dorsal segment, analogous to the analysis in section 4.2.3 the [continuant] specification will have to delink as well as the [voice] specification on the laryngeal node.

29.



The phonological rules in 20a & 20b can be explained in the same way, but 19a & 19b are in need of further investigation. In 19a, the place of articulation does change, but under the influence of back rounded vowels the target place of articulation becomes labial. Although both a labial trill and labiodental tap can be pronounced, both are not in the phoneme inventory of the languages with such a rule. Thus, the description of the change in 29 holds, with the addition of the change in place.

In Agarabi (18b) the voiced alveolar plosive changes to an approximant, although for this place of articulation both a tap and a trill can be pronounced. The alveolar trill is also present in the inventory of this language, and with this availability possibly complicating the analysis given up to this point. But Agarabi not only lacks a tap in its inventory, the voiced velar plosive is also missing (30).

30. Agarabi Consonants (Bee, Luff, & Goddard, 1973): p, t, k, ʔ
b, d
m, n, r

As the voiceless plosives /p, t, k/ are present and the voiced counterparts /b, d/ are down by one, it could be that the place specification for /d/ is not present as alveolar. If the /d/ in Agarabi has an underlying representation such as [-labial] it would not lead to confusion with any other voiced segments. Therefore, if the /r/ in Agarabi has a specification for place of articulation not matching the /d/, this would lead to the language defaulting to the pronunciation of the then closest segment that matches in its specification of place: /j/. With this interpretation, the lenition-like process as described in 27, and the preceding sections in 4.2, still holds true for approximants.

A second option explaining why Agarabi does not follow the process as seen from section 4.2.3 is that the same rule is applied twice, first leniting to the /r/ and secondly leniting to the /j/. However, it must be noted that both analyses of Agarabi possibly explaining why it does not behave as is to be expected from the preceding sections deserves further discussion, which will be given in section 5.

4.3 Application to Element Theory

Element Theory (Harris & Lindsey, 1995) has slightly more recently been developed than Feature Geometry and is stooled upon a different basic interpretation of phonology. Rather than using abstracted phonological features and placing these in geometrical structures, Element Theory proposes phonological elements that map onto information- bearing patterns in the speech signal, as described by Backley (2011).

The process leading to the taps, trills and approximants in section 4.2 leads to a lenition based interpretation of the changes described in section 3. This process of lenition has been suggested for intervocalic processes by Botma & Van ‘t Veer (2013) along the lines of Element Theory. Viewing the described changes from plosives and fricatives to sonorant segments as lenition also provides a possible explanation for the anomaly found in the first paragraph of section 2.3.1. When viewing the sound /p/ along the lines of Element Theory, it becomes clear that this segment has multiple paths of lenition (31a-c).

31. a. /p/ |U, ʔ, H| → /f/ |U, H| → /w/ |U|

b. /p/ |U, ʔ, H| → /f/ |U, H| → /h/ |H|

c. /p/ |U, ʔ, H| → /ʔ/ |ʔ|

The loss of elements intuitively describes lenition at work: each step in the process of lenition corresponds with the loss of an element. Furthermore, the segments from 3a-d follow from the process described in 31b & 31c. In combination with the processes seen in section 4.2, and the assumption that sonority is incorporated in the carrier signal (Traunmüller, 1994) on which the elements are imposed, Element Theory should be able to give a good description of the phonological rules in section 3.

4.3.1 Nasal target segments

Describing the change from an obstruent to a nasal segment in Element Theory shares a basic insight with the description in Feature Geometry from section 4.2.1. The process consists of two parts: first the loss of obstruency and second the gaining of nasality. The difference however lies in what constitutes this loss. While in Feature Geometry the lack of [voice] specification gives way to a possible sonorant interpretation of the segment, in Element Theory the loss of elements denoting a stop |ʔ| or frication |H| leaves no other possible interpretation than a sonorant segment.

Analyzing the phonological rule in 9a along these lines shows a loss of the plosive element and the transfer of a low-frequency energy element |L| (32). The element denoting place |A| remains the same.

32. /t/ → /n/

|A, ʔ| |A, L|

The voiced segments changing from an obstruent to a nasal segment (as in 9b) illustrate the same process that has been seen in the Feature Geometry analysis; for a segment to become sonorant, the voicing feature, or in this case the element |L̲|, is lost (33).

33. /d/ → /n/

|A, ʔ, L̲| |A, L|

While the loss of segments and the insertion of the |L| element in the target segment shows the change of an obstruent under the influence of a nasal segment; the case of word-final nasalization (10b) should also be addressed. Although a default nasal insertion rule might explain the description given in 26, Element Theory allows for a different interpretation. The element denoting plosives |ʔ| is linked to a sustained drop in acoustic energy and as described above, the |L| element denotes low-frequency energy. If, instead of interpreting lenition as a segment layer process, lenition may also be active on the element layer of phonology, word-final nasalization might be described as the lenition of the more excessive drop in energy |ʔ| to a less excessive presence in energy |L| (34). Further possibilities and the viability of this interpretation will be discussed in section 5.

34. /k/ → /ŋ/

|U, ʔ| |U, L|

4.3.2 Tap target segments

In Element Theory a tap, trill or approximant only consists of a place marker, with no further modifications like low-frequency energy |L|. In Maithili however there is an aspirated tap, while at the same time the unaspirated version is also present in the language (Yadav, 1996). A contrast between these two pronunciations in the phonological representation should be possible for a full description in Element Theory of these processes to be possible.

Aspiration is denoted by |H̲|, high-frequency energy, in Element Theory. This element therefore needs to be present in both the plosive and the tap (35). However, due to the nature of the |H̲| element, it also describes aspirated fricatives in Element Theory. The notation of |A̲, H̲| in 35 could therefore also be interpreted as /ʂʰ/, but the /ʂ/ itself is not in the inventory of Maithili, only the dental /s̪/ is present. This segment has a different place element (|I| versus |A̲|), thereby confirming the notation below as sufficient in describing the change to a tap.

35. /ɖʰ/ → /ɽʰ/

|A̲, ʔ, H̲, L̲| |A̲, H̲|

A change to an unaspirated tap like in Tamil (15a) can easily be described as a loss of the |ʔ| element, the remaining place element |I| automatically denotes the tap in Element Theory. What does stand out is that the place element is different for this alveolar segment, then for the previously described changes. In Element Theory both the |A| and |I| elements can describe the alveolar segments, however when both dental and alveolar segments are present in a language |I| denotes the dentals and |A| denotes the alveolars. As Tamil has no dental segments in its inventory (Schiffman, 1999), it allows for the description of /t/ as having place |I|, and by losing the |ʔ| element change to the tap. Describing the /t/ as having place |A| would lead to target segment /r/, a trill instead of a tap, when losing |ʔ|.

36. /t/ → /ɾ/

|I, ʔ| |I|

The change to tap segments in intervocalic context (cf. 16a & 16b) is not problematic in an Element Theory analysis, as seen above in 36, the loss of the |ʔ| element, and if present the voicing |L̲| element, automatically leads to a tap target segment.

4.3.3 Trill target segments

Unlike the description in Feature Geometry of the change between taps and trills – the differentiation between [+continuant] and [-continuant] – in Element Theory the difference is simply denoted by a different place element. A more complex explanation for why a [continuant] feature is therefore unnecessary, but the ability to correctly ascribe the place element of the segments undergoing the change is all the more needed.

The changes in phonological rules 17a & 17b allow for exactly the correct place analysis with the /r/ as target segment. The /t/ and /d/ segments lose their plosive |ʔ| element and the voicing |L̲| element, leaving only the correct place element |A| describing /r/ (37).

37. /d/ → /r/

|A, ʔ, L̲| |A|

In the rules from Selepet this description is more difficult; the segments changing to a trill are dentalized, and as described above, these segments have a different place element |I|. This element on its own should result in a tap target segment. However, Selepet does not have a contrasting alveolar plosive to the dental plosives, and furthermore, Selepet also lacks an alveolar tap in its inventory. The analysis of this change could therefore go two ways; either the dental plosives may be described as having place element |A| (38a), or the trill may be described as having place element |I| (38b).

38. a. /t̪/ → /r/

|A, ʔ| |A|

b. /t̪/ → /r/

|I, ʔ| |I|

4.3.4 Approximant target segments

Up until this point two place elements have been mentioned that can denote a single segment by being present on its own. These place descriptions have resulted in the taps and trills described in the two above sections. Segments with other place notations lead to approximant segments in Element Theory.

The first phonological rule from section 3.2.4 (19a) contains not only a change of an obstruent to an approximant, but at first sight also a change of place. Unlike the description given in section 4.2.4 there is no necessity in Element Theory to denote this change, it follows from the loss of the |ʔ| element. However, the /w/ is by default denoted as |U̲| in Element Theory, contrasting with |U| which denotes /ɰ/. Kanuri, the language in which this rule is active, does not have this segment in its inventory allowing for a simple lenition analysis of this phonological rule (39).

39. /k/ → /w/

|U, ʔ| |U|

The second phonological rule from section 3.2.4 (19b) is seemingly harder to describe in Element Theory. The first change in 19b, from a voiced labial plosive to an approximant is a simple loss of the |ʔ| and |L̲| elements as seen before. The analysis of the change from a voiced alveolar plosive to an approximant is harder to justify. As shown in section 4.3.3 alveolar segments may be described with both |I| and |A| elements, since Agarabi has no dental-alveolar contrasting segments in its phoneme inventory. But as seen in 36, a single |I| element denotes an alveolar tap by default. However, this segment is not present in the inventory of Agarabi (Bee, Luff, & Goddard, 1973), therefore allowing defaulting to the other segment with this place notation, /j/, analogous to the change described in 40.

40. a. /b/ → /w/

|U̲, ʔ, L̲| |U̲|

b. /d/ → /j/

|I,ʔ,L̲| → |I|

The rules in 20a, 20b & 21a follow the same lenition path as described above, however the change in 21b is requires a more in-depth look. A voiced velar plosive changes to a palatal approximant, following the exact definitions of Element Theory, this would necessitate a change of place (41a), without the context (a boundary) providing this place element. A solution would be analyzing /g/ as having |I̲| as its place element (41b), however this does require that no other segment in this language could also have a claim to this specification.

41. a. /g/ → /j/

|U, ʔ, L̲| |I̲|

b. |I̲, ʔ, L̲| |I̲|

The segments with which /g/ contrasts in Lele (Frajzyngier, 2001) are listed below (42), together with their Element Theory descriptions. Viewing the voiced plosives as the default plosive together with the absence of aspiration allows the description of voiceless plosives to be done with the |H̲| element, and the prenasalized plosives to be described with the |L̲| element. There are five places of articulation below, none fully palatal, allowing the description of the palatal element |I̲| to be applied to /g/ without this causing a problem for the description of any of the other elements in the language. Therefore, assuming that /g/ underlyingly has place |I̲| in Lele, attributes to the viability of the lenition analysis in 41b.

42.	p	t	tʃ	k	k͡p
	|U̲, ʔ, H̲|	|A, ʔ, H̲|	|A, I, ʔ, H̲|	|I̲, ʔ, H̲|	|U, U̲, ʔ, H̲|
	b	d	dʒ	g	g͡b
	|U̲, ʔ|	|A, ʔ|	|A, I, ʔ|	|I̲, ʔ|	|U, U̲, ʔ|
	ɓ	ɗ	ⁿd	ⁿdʒ	s
	|U̲, ʔ̲|	|A, ʔ̲|	|A, ʔ, L̲|	|A, I, ʔ, L̲|	|A, H|

4.4 Discussion & Conclusion

Both theories used for the descriptions succeed in explaining why this loss results in the segments specified by the phonological rules from section 3. However, there are differences in how intuitive these theories provide an answer to why the specific output segments are the results of the processes described in the sections above.

Feature Geometry is able to provide an adequate description of the process, but needs to fall back on a default insertion rule when the presence of nasality cannot be derived from the bare geometrical structure (10b, 26). This makes a default analysis grouping all languages together difficult as a priori knowledge of the presence of certain default insertion rules is needed to predict the outcome of a phonological rule.

Element Theory provides a framework for a lenition based analysis which spans across languages with more ease than Feature Geometry. Almost all rules can be fit into one process of lenition: the deletion of the |ʔ|, |H| and, if present, |L̲| elements. This process of lenition might best be described as the loss of the elements that have the most energy associated with them, or, in other words, changing a segment to a lower energy level. Although this view provides an explanation for word-final nasalization in a more intuitive way than a default insertion rule, a language will have to be analyzed for segments present in its phoneme inventory (42) to be sure that the lenition based process holds true.

The advantage that Element Theory has in the description of the phonological rules from a perspective of lenition is further illustrated by the distinction between taps, trills, and approximants. In Feature Geometry this is signaled by a [continuant] feature, necessitating the loss of this feature when a change from a plosive to an approximant takes place. Element Theory on the other hand has the advantage of encapsulating this distinction within its elements, thereby grouping taps, trills, and approximants all together as segments that only have an element for place in its description.

Although the differences between the theories have become clear from this section, the overlap between the theories is more poignant. In both cases the change of obstruents to sonorants is best described as the loss of obstruency, rather than the gain of sonorancy. A process of lenition causes the input segments to lose their laryngeal feature or obstruent element to make way for the sonorant interpretation of the segment. Therefore, sonority is not a property of a segment that is spread to or from another segment, and as such sonorization, or the gaining of sonority, is not an adequate description of the processes described in this section.

5 Discussion

The changes described in sections 2 & 3 have led to an analysis based on a lenition-like process for both Sonorant Voice Theory and Element Theory. And as concluded in section 4.4 the shared lenition base points to a loss of obstruency as the cause for the sonority of a segment. However, the two different theories do not provide a simple out-of-the-box solution to the described phonological rules.

SV Theory has, as stated in section 4.2.1, the need for a default interpretation or insertion of [nasal] to fully represent word final nasalization. Applying this default interpretation cross-linguistically on an empty SV node becomes problematic in section 4.2.2 as this would lead to nasal segments as the output of the phonological rules described in that section. The tap segments that are the output instead of the nasal segments point to at least a language specific configuration for the presence of a default nasal insertion. If the analyses proposed in section 4.2 are to hold true as a general process for obstruents becoming sonorants the presence of language specific constraints requires additional knowledge on nasal insertion before the process can be applied. Furthermore, as seen in section 4.2.4, assumptions have to be made on the underlying representation of segments, further occluding the picture of what output will be present from the combination of the input segment and the context.

While Element Theory also requires knowledge on the underlying representation of segments in a language (see section 4.3.4), the process from input to output remains fully predictable across all types of changes described in section 4.3. The process of lenition that is applied when using this theory can have broader implications for the predictability of these types of changes in languages. Viewing the phonological structure leading to a speech signal as elements imposed on a carrier signal (Traunmüller, 1994) allows for the prediction of when this process will take place. The amount of modulation of the carrier signal (Ohala, 1992; Traunmüller, 2005), represented by the number of elements, and the position in the word (Bouavichith & Davidson, 2013) could provide constraints leading to the processes seen in the previous sections.

The possibility of providing a prediction on the changes to sonorant segments will be discussed further below, first the relevance of the differences described in sections 2 & 3 in light of Element Theory will be discussed. To start with, the different contexts in section 2 that were believed to lead to a sonorant segment actually provide the context for the loss of obstruency. As an obstruent has either of two elements, |ʔ| or |H|, defining it as an obstruent, the context in which it gets lost must impose a limitation on the presence of these elements. As Element Theory groups taps, trills and approximants together it is logical to view the context groups as described in section 2 along these same lines (table 8).

Table 8. *Percentages of changes to target segments (first column) following from context groups (top row).*

	Vowel-based	**Nasal**	**Boundary-related**	**Other**
Nasal	0%	79,6%	14,8%	5,6%
Other	51,3%	1,8%	23,9%	23%

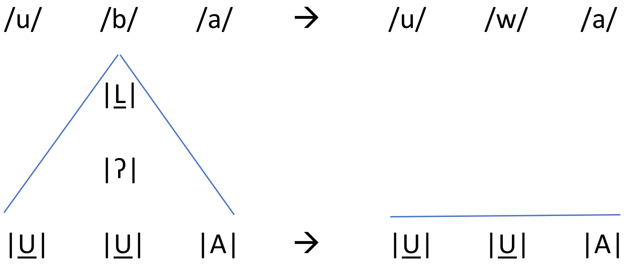
For the target segments other than nasals there is a significant difference between the four context groups ($\chi^2(3) = 55{,}96$; $p < 0{,}001$). Input segments to a phonological rule are therefore more likely to lose their obstruency when adjacent to a vowel, then when adjacent to a boundary or other segment. As vowel are only specified for place in Element Theory, and the target segments other than nasals also only specified for place, the utterance that is the result of this change is more homogenous in its energy distribution.

For nasal target segments has already been stated that there is a significant difference in the distribution of the context groups leading to this segment type. From section 4 followed that word-final nasalization can be seen as a lowering in the energy state of the segment, analogous to the lowering of the energy in the other target segments. For languages with word-final nasalization the nasal target segment can be seen as the half way point in the process of lenition, but for the almost 80 percent of the cases where a nasal context is the cause for a change, two interpretations are possible. First, the nasal output could be viewed as the result of full lenition being applied to an obstruent segment as an intermediate stage, with an element for nasality spreading after the lenition, leading to a nasal target segment. Secondly, the nasal output could be the result of a lowering in energy, but as the nasal context has a higher energy level the input segment does not have to undergo full lenition. This would lead to an interpretation where an input segment is only lenited to the energy level of the surrounding context. As this same view can be applied to every segment undergoing lenition, this has the preference over the first interpretation.

From sections 2 & 3 it has become clear that the majority of the phonological rules act regressively. However, from the point of view of the input segment it adjusts itself progressively to the following segment, reaching an equilibrium in its energy level together with the context segment. For intervocalic, or any intersegmental change for that matter, the input segment has two context segments to comply with. Although this could be problematic when viewing a change in the target segment as the result of the spreading of a feature or element – where does it spread from; left or right, and when it spreads from one side, why is the other side needed? – for a lenition based view this is simply seen as reaching the same energy level (40a&b). These types of changes have been presented in detail by Harris (2003; 2004) and Harris & Urua (2001).

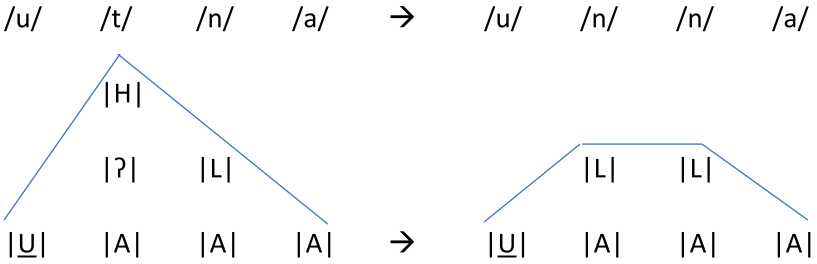
43. a. /b/ → [w] / V__V

/akubar/ → /akuwar/



b. /t/ → [n] / __n

/utna/ → /unna/



Although three major contexts have been discussed throughout sections 3 & 4, the significantly smaller contexts also impose the same process of lenition as seen in the previous section and directly above. However, just as this process and some of the context groups might span across languages, individual languages may have their own definitions on word-final nasalization (Central Yupik, 10b), or lack of post-nasal nasalization (Tamil, 15a), or even on how certain segments are underlyingly defined (Lele, 42). Therefore, it stands to reason that not only the degree of lenition the language applies in certain contexts, but also the contexts in which lenition may be active can be language specific, leading to the 5,6% and 23% of the contexts for respectively nasal and non-nasal target segments being classified as 'other'.

The how of what causes segments to become sonorant has been covered by the previous sections, the why however, is still unclear. It is one thing to assume that the phonological rules are simply a given, but discussing only the segments that undergo a change may well describe the change but not lead to its cause. To fully answer the question on what causes segments to become sonorant a broader view on this part of linguistic structure is needed.

To make a prediction on the change that takes place two variables are needed; the input segment and its context. However, as the direct contexts given in sections 2 & 3 do provide information on whether the output will be a nasal segment or not, it does not signify when or where in an utterance the change takes place. It is likely that these changes take place in weak positions as articulatory gestures are less extreme in these positions (Pierrehumbert & Talkin, 1992; De Jong, 1998). Since the elements of Element Theory have a direct correlation to the phonetic characteristics of a segment (Backley, 2011), the less extreme a gesture is, fewer elements will be representing this gesture phonologically. The presence of fewer elements is exactly what has been described in section 4.3, leading to the view that the contexts in which the changes happen are at least language specifically weak, causing the weakening of the segment and hereby facilitating the change from obstruent to sonorant.

Further evidence that weakening and weak position indeed are present in the phonological rules that have been described comes from Backley & Nasukawa (2009); the typical weakening positions – intervocalic and word-final – match with two of the major context groups mentioned in section 2.3 (tables 3 & 6). The third major context group – nasals – is not a typical weakening position, but it is also not a member of the group of typically strong positions (Backley & Nasukawa, 2006; Vaux & Samuels, 2005). As the lenition of a segment involves some loss of its defining properties (for an overview see Gurevich, 2004), parallels can be drawn between lenition in weak positions and lenition in not-strong positions. The lenition in the typical weakening positions leads to the loss of all defining properties but one, as described in sections 4.3.2-4.3.4 (see also 43a). The lenition in a not-strong position never fully reduces to just one element, although there is a loss of energy the lenition itself is not the goal of the process, but rather reaching an equilibrium in energy level (see 43b).

6 Conclusion

The assertions made in section 5 not only necessitate looking at changes in languages from a general point of view to ascertain which processes are at play, but also make clear that differences between individual languages may at first sight lead to the assumption that they do not follow a generalized system. However, using Element Theory for the analysis of the weakening of segments from obstruents to sonorants allows a cross-language process to be recognized. This leads to the conclusion that segments do not become sonorant, they do however become non-obstruent, giving way for sonorancy in the pronunciation.

For further research, a look into weak positions across languages may shed more light on the broader process at play. As has become clear, not only the properties of the input segment and the context matter for the process to be predictable, language specific (underlying) specifications must be taken in account before a full prediction on the why, the what and the when can be made. With more language specific information available the proposed lenition analysis may become fully predictable cross-linguistically.

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Appendix A

Language	Number of rules
Afar	2
Afrikaans	2
Agarabi	1
Akan	1
Amele	1
Anywa (aka Anuak)	1
Arbore	9
Argobba	3
Axininca Campa (Asháninca)	2
Batibo Moghamo (Meta')	2
Bisu	1
Bribri	5
Burmese	1
Cabécar	4
Capanahua	1
Catalan	5
Cherokee (Oklahoma dialect)	2
Cubeo	2
Cuna (San Blas Cuna)	2
Dahalo	1
Dani, Lower Grand Valley	1
Degema	1
Dhivehi (Maldivian)	1
Dieri (Diyari)	1
Efik	2
Estonian	4
Evenki	1
Finnish	4
Garawa (Bundjil/Wandji)	1
Georgian	1
German, Michigan	1
Gooniyandi	3
Gugu-Bujun	1
Hausa	1
Hixkaryana	1
Hungarian	1
Ilocano	1
Indonesian	1
Inupiaq, Barrow (North Alaskan Inupiatun)	1
Irish (Irish Gaelic)	2
Irish (Irish Gaelic) (certain Donegal dialects)	1
Jukun (Jukun Takum)	1
Kalenjin	1
Kalenjin, Nandi	1
Kanakuru	9
Kanuri	4
Kapampangan	3
Kashaya	7
Khmer	1
Kinyarwanda (Rwanda)	1
Kiowa	2
Kirghiz	1
Koiari	1
Korean	1
Koromfé	2
Korowai	2
Kumiái (Jamul Tiipay dialect)	1
Larike	2
Lele	1
Lithuanian	2
Lorma	1
Lumasaaba (Masaba)	1
Maale	1
Macuxi (Macushi)	1
Maithili	2
Marathi (Cochin)	1
Marathi (Kosti)	2
Martuthunira	1
Maya (Yucatan)	2
Maya, Chontal (Tabasco Chontal)	6
Maya, Itzaj (Itzá)	2
Mende	1
Mikasuki	1
Mikir	1
Mising	1
Mixe, Midland (Jaltepec variety)	1

Mixe, North Highland (Totontepec Mixe)	2
Mundari	1
Muruwari	1
Nahual, Michoacán (Michoacán Nahuatl)	2
Nahuatl, Huasteca	1
Nahuatl, North Puebla	1
Nahuatl, Tetelcingo	1
Nalik	1
Nangikurrunggurr/Ngankikurung kurr	1
Noon	3
Nuer	2
Nuuchahnulth (Tsishaath Nootka)	4
Orma	1
Oromo, Boraana (Borana-Arsi-Guji Oromo)	2
Oromo, Harar (Eastern Oromo)	1
Oromo, Waata (Sanye)	3
Pech (Paya)	1
Pengo	1
Pero	2
Pero (Gwandum dialect)	4
Pileni	3
Popoluca, Sayula	1
Runyoro-Rutooro (Nyoro/Tooro)	1
Sawai	1
Sekani	1
Selepet	2
Senoufo, Supyire	2
Sentani	1
Serbo-Croatian (Cres Čakavian)	1
Shilluk	1
Shoshoni, Western	1
Siona	1
Slavey, North (Bearlake variety)	2
Slavey, North (Hare variety)	2
Slavey, South (Slavey)	2
Slovene	6
So (Soo)	1
Somali	1
Sri Lanka Creole Portuguese (Indo-Portuguese)	1
Tagalog	1
Tamil	1
Tauya	2
Telugu	1
Tepehuan, Southeastern	3
Teribe	3
Tirmaga	1
Tokelauan	1
Totonac, Misantla (San Marcos variety)	1
Tsakhur	1
Tsimshian, Coast	1
Turkish	1
Tyvan (Tuvin)	1
Tzotzil	1
Tzutujil (Western Tzutujil)	1
Wambaya	2
Wolaytta	1
Xakas (Khakas)	1
Yaqui, Sonora	1
Yavapai	1
Yupik, Central	1

Appendix B

Counterpart to table 1. *Number or phonological rules per rule type.*

Progressive	36
Regressive	126
Inter	69
- **Intervocalic**	45 -
Other	10
Total	**241**

Counterpart to table 2. *Number of rules per original segment (first column) leading to the target segment (first row).*

	Approximant	**Assimilation**	**Fricative**	**Liquid**	**Nasal**	**Plosive**	**Tap**	**Trill**	**Vowel**	**Total**
Fricative	24	2	14	0	7	2	1	3	3	**56**
Plosive	40	10	20	10	47	14	25	18	1	**185**
Total	**64**	**12**	**34**	**10**	**54**	**16**	**26**	**21**	**4**	**241**

Counterpart to table 3. *Largest context groups (first row) per input type (first column).*

	Nasal	**Intervocalic**	**Boundary**	**Other**	**Total**
Fricative	11	12	26	7	**56**
Plosive	33	45	44	63	**185**
Total	**44**	**57**	**70**	**70**	**241**

Appendix C

Overview of all output from rules applied to plosives. When multiple output types are specified on one line (e.g. approximant/tap), both these types follow from one rule.

Output Type	Number of Rules
approximant	34
approximant/tap	1
approximant/trill	2
approximant/trill/fricative	1
assimilation	10
fricative	19
fricative/approximant	1
liquid	7
nasal	42
nasal/liquid	3
nasalized tap	1
plosive	12
plosive/fricative	1
plosive/nasal	1
preglottalized nasal	3
tap	20
tap/trill	3
trill	13
vowel	1
Total	**179**

Overview of all output from rules applied to fricatives.

Output Type	Number of Rules
approximant	22
assimilation	2
ejective approximant	2
fricative	16
fricative/null	1
nasal	9
plosive	2
tap/trill	1
trill	2
vowel	3
Total	**60**