Version 2: August, 2008

Russian voicing assimilation, final devoicing, and the problem of *v*

S.-Y. Kuroda,

Preface October, 2013

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I have let this languish amidst numerous moves. Noah Girgis and I (see below) looked for a place to publish Yuki's last paper , and several people suggested this forum, so I am belatedly uploading it here; obviously, Yuki is no longer here to revise it, so it will have to stand as is as his final work. I hope there will be some who find it interesting.

Foreword (September, 2010)

Noah Girgis and Susan Fischer

S.-Y. Kuroda was working on this paper up until only two days before his death in February, 2009. What we have attempted to do with the text as Kuroda left it is to clean up the formatting, do a minimal amount of reorganization, and fix a few grammatical and stylistic infelicities. Fischer had made editorial suggestions on Kuroda's syntax and semantics papers for many years, and Girgis had been working on this paper with Kuroda in the same capacity for several months, so we are confident that Kuroda would have approved the changes that we have made. What we would like to do in this foreword is place the paper in a larger context of phonological theory as well as to highlight the contributions made by this paper to the analysis of Russian phonology in particular.

With regard to phonological theory, one major contribution made by this paper is Kuroda's articulatory based feature geometry, which is grounded in earlier work by, e.g., Clements (1985) and Sagey (1986) among others. The current work is an advance over Kuroda's own earlier proposals in that underlying representations are more abstract; phonological features are filled in later in the derivation in accordance with a markedness hierarchy.

The other contribution to phonological theory here is the notion that *v* functions as a sonorant. The idea is not new, having been previously proposed by Coats & Harshenin (1971) in order to account for the fact that *v* behaves differently from other obstruents with regard to voicing assimilation; *v* can act as a target in the process but not as a trigger. The sonorant status of v has been challenged by Barkaï & Horvath (1978) on the grounds that intrinsic rule ordering is necessary if such a proposal is accepted, something which can be avoided by reordering *v* in the sonority hierarchy (Jespersen 1897-1899; Zwicky 1969). A sonority hierarchy employs an implicational scale such that segments above or below a given point in the hierarchy will predictably participate in a phonological process in a particular language. Vowels are considered the most sonorous and obstruents the least sonorous, with the divisions between the two extremes typically separated into liquids, nasals, glides, fricatives, and stops. For example, among acceptable syllable nuclei, a language X may permit a nasal (e.g.,[n̩] in English "cotton") or a liquid (e.g., [l̩] in English "idol") to act as a nucleus, but never an oral stop. This could be used to justify separating the liquids and nasals from the oral stops in a sonority hierarchy. Barkaï & Horvath (1978) use examples from Hungarian and Hebrew, both

languages unrelated to Russian, to show that *v* (in these languages as well as in Russian) falls into a unique position in the sonority hierarchy. They argue that *v* is more sonorous than other obstruents but at the same time less sonorous than nasals, liquids, or glides. Padgett (2002) offers an in-depth account specific to Russian *v* using OT with special attention to the unique phonetic properties of *v*. He highlights the differences not only between *v* and the obstruents, but also those between *v* and the sonorants. Kuroda's proposal, however, is able to account for the voicing assimilation process without leaving *v* isolated from either the sonorant or obstruent class.

The behavior of Russian *v* has posed a puzzle for phonologists for decades. Kuroda claims that sonorants behave as obstruents in some contexts and as vowels in others; by proposing that *v* is a sonorant, he is able to account elegantly for its behavior in Russian phonology using an innovative version of feature geometry. His approach thus offers a major contribution to the overall phonological analysis of Russian.

Part I

1. Introduction

In a series of recent papers I have presented a new model of feature geometry, Aerodynamic Feature Geometry (ADFG). The idea originally grew out of the treatment of a particular problem in Japanese phonology, voicing assimilation (Kuroda 2002/2008). ADFG has been further developed through application to the description of Korean sonorant assimilation (Kuroda 2003/2004) as well as through improving the description of Japanese voicing assimilation and coda nasalization (Kuroda 2006).

This new geometry has been progressing but is not yet stable or complete. Not only have many important aspects of phonological phenomena (e.g. secondary articulation) still been put aside and not yet incorporated in the theory, but the theory has also already undergone some substantial changes. The original idea was to build a geometry grounded in the aerodynamic-articulatory mechanism of human sounds. This idea is still fundamental; however, the concept of phonetic and phonological "features" in this geometry has gone through radical changes, and the relationship between the aerodynamic-articulatory mechanism and the structure of the geometry has become less direct and more subtle.

Originally, the structurally organized features in the geometry were assumed to be phonetic features grounded in phonology and phonetics. The nodes were assumed to be *class nodes* representing classes of such features, a common, if not universally accepted, conception in contemporary phonology (Clements 1985, Sagey 1986). This conception of features has now been put out of the geometry, and is replaced by one according to which the geometry is only a structure built on abstract nodes. These abstract nodes represent the degree of markedness with regard to three different parameters, which correspond to three independent aerodynamic-articulatory dimensions in speech production. The

phonology determined by this abstract geometry is then assumed to be related to non-mental physical reality by means of a set of interface conditions.

Due to this emphasis shift from *features* to *abstract* markedness relations, the name originally given to the geometry, Aerodynamic *Feature* Geometry (ADFG), no longer accurately describes the theoretical content or the spirit of the idea. Therefore, I introduce a new name, Aerodynamic *Phonological* Geometry (ADPG). I retain the old name, ADFG, only to refer to its older stage or to remind the reader of its historical and etymological origins.

In the present paper I would like to apply this new geometry to the problem of Russian voicing assimilation and the sound that corresponds to *v* in Russian orthography, a well-known issue in Russian phonology much discussed in recent literature in phonological theory. The purpose of this paper, however, is not so much to provide a new description of a phonological phenomenon in Russian as it is to show how this new geometry works and what potential it might have. For this purpose, I have examined the analysis that Hayes (1984) worked out in the framework of classical generative phonology and I have developed an analysis in terms of the new geometry.

I draw the Russian data exclusively from Hayes (1984) and Kiparsky (1985). I have not extended the empirical basis of the study beyond this limit, nor have I engaged myself in resolving factual questions where those sources left them open, either by fieldwork or corpus work on Russian. Some questions might be raised about the data on which Hayes's analysis depends concerning possible dialectal or idiolectal biases and performance-related perturbations (cf. Padgett 2002). An e-language that emerges from a piece of the Russian grammar (i-language) described by the analysis in the present paper may not exactly match what is normally taken as standard Russian, nor, for that matter, any dialect or idiolect of Russian. But then, can any such e-language be precisely identified in reality? An e-language that is theoretically generated by a description of an i-language could be nothing more than a phantom (but, in a certain theoretical sense, real) *Ur*-e-language, on the basis of which we can hopefully account for dialectal or idiolectal biases as well as performance-related perturbations that confront us in reality, by means of minor theoretical amendments.

2. Aerodynamic Phonological Geometry (ADPG) 1: Node geometry.

2.1. *Aerodynamic phonological geometry*

Underlying the idea of feature geometry is the assumption that the set of phonological segments is structured to account for some important aspects of the functions of phonological segments. Underlying ADPG is the assumption that this structure is dependent, to a significant degree, on the aerodynamic design of the articulatory organ. The articulatory organ is schematized in the figure below. The schema consists of a main air passage (the oral cavity), a bypass (the nasal cavity), a bypass cover (the uvula) and a movable shutter (the lips, teeth or tongue).

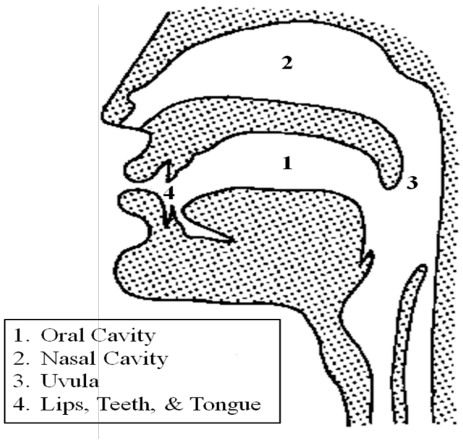


Figure 1. Articulatory organ schema (Université de Lausanne)

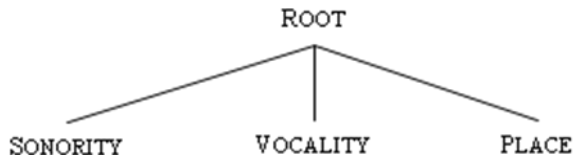
There are three relevant parameters in this design

(1) ADPG design parameters:

- The states of the entry to the main air passage and of the bypass cover.
  - This parameter aerodynamically determines the quality of the Air Source and phonologically determines the *voice quality*, or VOCALITY.[1]
- The degree and manner in which the shutter is opened or closed.
  - This parameter aerodynamically determines the quality of Air Movement and phonologically determines the degree of SONORITY.
- The positioning of the shutter.
  - This aerodynamically determines the quality of the Wave Pattern and phonologically determines the PLACE of articulation.

ADPG incorporates the design of these independent parameters at the top level of its structure:

(2) The top level of the ADPG node tree:



As I mentioned earlier, in ADFG, the original version of ADPG, these nodes and those that they dominated were class nodes representing classes of phonetic features. I will label this earlier version of ADPG c-geometry (c- for classificatory, classical...). The present version of ADPG, which now replaces c-geometry, will be called a-geometry (a- for abstract, advanced,...). The crucial difference between the two geometries is that in a-geometry nodes are not assumed to be class-nodes; they are not directly interpreted extensionally as a class of phonetic features that they dominate. Instead, the physio-

[1] I put technical or semi-technical terms used in ADPG in small capitals.

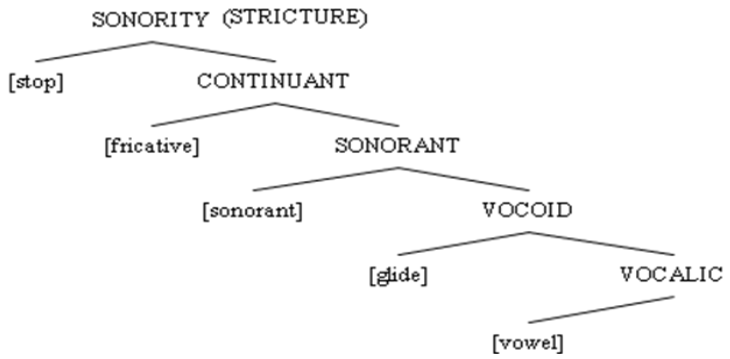
phonetic implementations of nodes are determined by phonology-phonetics interface conditions. Interface conditions may be context-sensitive, inter-segmentally or intra-segmentally, as will be illustrated below. This general principle does not of course exclude the possibility that interface conditions for some nodes are context-free; in such a case a node could happen to be interpretable as representing a class of phonetic features. This situation should be taken, in principle, as incidental for the geometry. However, context-free situations might predominate in the demonstration of the basic part of the phonology of a language.

In the next section I will demonstrate an implementation of ADPG by c-geometry in terms of phonetic features in order to introduce the original basic intention of ADPG. However, this implementation is now technically overridden by a-geometry, and the rest of the paper does not formally depend on the following further explanation of c-geometry. Hence, the reader familiar with my earlier work may wish to skip this section and proceed directly to section 2.3.

2.2. *c-geometry* (Kuroda 2002/2008, Kuroda 2003/2004)

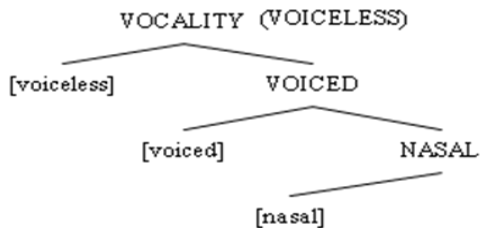
The tree in (3) below represents the dominance relation under SONORITY. The levels under SONORITY may be considered to correspond to degree of sonority, higher in the tree being less sonorous. The top node of the sonority branch is also referred to as STRICTURE and directly dominates the feature [stop], the most unmarked realization of SONORITY. The most marked option under SONORITY is VOCALIC, which actualizes phonetically as the feature [vowel].

(3) The SONORITY branch (c-geometry)



The VOCALITY branch is assumed to have the structure described by (4) below. The top node (the most unmarked) may also be called VOICELESS; it can be actualized as the feature [voiceless].

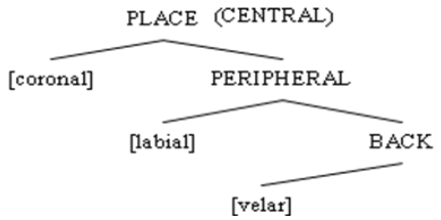
(4) The VOCALITY branch (c- geometry)



This tree specifies that [nasal] is the most marked value, and [voiceless] the least marked and default value of VOCALITY. Note that in this geometry the fact that nasal sounds are acoustically voiced was not captured by making the feature [voiced] a redundant feature of nasal sounds. The dependence of nasality on voicing was incorporated in the design of the geometry.[2] The phonetic feature called [voiced] represents *non-nasal* voiced sounds, thus indicating vocal fold vibration without the nasal bypass open. The phonetic substance of the feature commonly called [voiced] was assigned to the node VOICED, rather than to the phonetic feature here labeled [voiced].

The PLACE branch corresponds to the place of articulation. I assume, as generally agreed, that coronal is the least marked specification of this parameter. I here assume without further argument that labial is less marked than velar. The PLACE branch then can be given as follows:

(5) The PLACE branch (c-geometry)



2.3. *a-geometry* (Kuroda 2006)

In this section I will present ADPG as it is now conceived, which I call a-geometry, in contrast with c-geometry described above. To repeat, in a-geometry, nodes are abstract entities that are to be connected to phonetic reality indirectly by means of interface conditions.

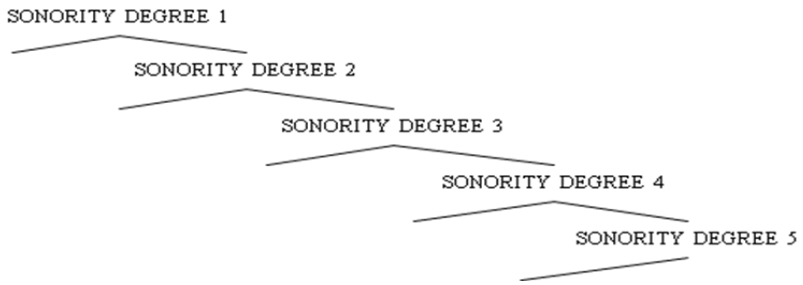
Nodes in a-geometry are assumed to represent degrees of markedness: those dominating are interpreted as less marked than those being dominated. We agree to label nodes with the branch name followed by DEGREE 1, DEGREE 2, …, DEGREE N, from the top node. For example, SONORITY DEGREE 1, etc. (we may elide DEGREE and simply write SONORITY 1, etc.). DEGREE 1 is the least marked (the default) node of the branch. The

[2] Note that this geometry cannot account for languages with underlying distinctive voiceless nasals. Some Southeast Asian and American languages present a problem for such a geometry. For example, Jalapa Mazatec (Silverman et al, 1995) has a three-way laryngeal contrast among voiced, voiceless, and creaky nasals. Burmese also has distinctive voiceless nasals (Ladefoged and Maddieson 1996)

number of degrees for each branch is language-dependent, but I am not concerned with that issue in this paper. As shown in the following examples, the terminal branches of a node-tree of a-geometry are dangling lines, not terminated by feature symbols. Feature symbols are provided by interface conditions.

I present the following pair of a node tree and a list of context-free interface conditions as a STANDARD model of the SONORITY branch of a-geometry.

(6) The SONORITY branch (a-geometry)



(7) The interface conditions for SONORITY for the STANDARD model

SONORITY DEGREE 1	=>	[stop]
SONORITY DEGREE 2	=>	[fricative]
SONORITY DEGREE 3	=>	[sonorant]
SONORITY DEGREE 4	=>	[glide]
SONORITY DEGREE 5	=>	[vowel]

These STANDARD conditions, however, may not be sufficient for a particular language. Take, for example, Japanese, where the phoneme /t/ is phonetically actualized by the affricates [tʃ] before /i/ and [ts] before /u/. Hence, the STANDARD conditions must be amended by context-sensitive conditions, here informally formulated, to the following effects:

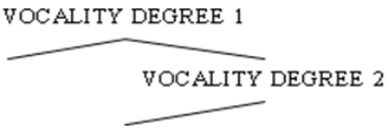
(8) Interface conditions for SONORITY for Standard Japanese

SONORITY DEGREE 1	=>	[tʃ]	in env. __/i/
	=>	[ts]	__/u/

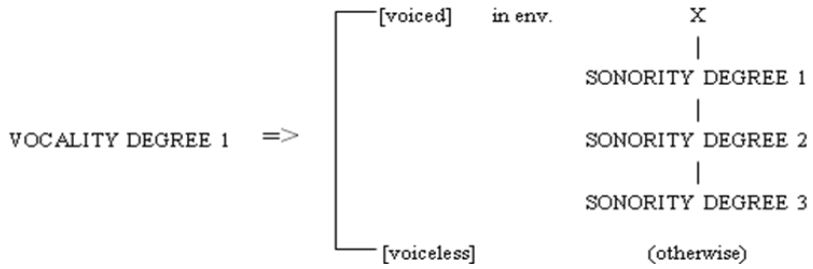
These conditions must override, and thus must precede, the first line of the list given in (7).

For the VOCALITY branch I propose the following as the STANDARD model.

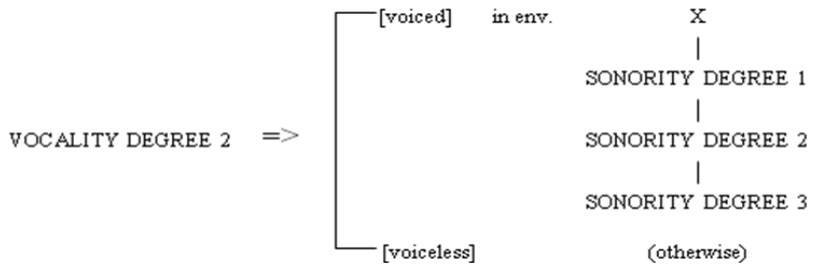
(9) The VOCALITY branch (a-geometry)



(10) The interface conditions for VOCALITY DEGREE 1



(11) The interface conditions for VOCALITY DEGREE 2



Note that the non-branching trees X given above in (10) and (11) terminate in SONORITY DEGREE 3 without a dangling bar. We agree to understand that (10), for example, specifies the condition that is met by segments whose SONORITY DEGREE is equal to or greater than 3, namely, segments of which the SONORITY branch is compatible with X, in other words, can be obtained by extending the tree X. This is obviously a natural convention for interpreting a condition represented by a non-terminating tree.

The idea behind the interface conditions (10)-(11) is this. The VOCALITY phonetically translates into [voiceless], [voiced] or [nasal]. However, each SONORITY DEGREE can entertain only a binary, not a three-way, opposition, and how the binary opposition is interpreted phonetically depends on the SONORITY DEGREE. It is interpreted as the opposition [voiceless] vs. [voiced] for SONORITY DEGREES down to DEGREE 2 (for stops and fricatives) and further down (for sonorants, glides and vowels) as the opposition [voiced] vs. [nasal]. We are thus assuming that as far as normal cases are concerned, obstruents are capable of binary opposition in terms of [voiceless] vs. [voiced], and sonorants in terms of [voiced] vs. [nasal]. We are also assuming, perhaps somewhat controversially, that nasal glides or vowels can contrast phonologically with non-nasal glides and vowels in terms of nasality; voiceless glides or voiceless vowels are taken as a matter of phonetic realization and not of phonological contrast.

The unmarked vs. marked contrast in VOCALITY is coded by the [unvoiced] vs. [voiced] opposition at the SONOTIRTY DEGREE 2 level, but the same contrast must be coded by the [voiced] vs. [nasal] opposition at the next level of SONORITY. Empirical support can be found from sporadic historical changes in Japanese exemplified by the following pair. The pair of the earliest forms *kapa* 'river' and *keburi* 'smoke' evidences the phonemic contrast of obstruents in terms of voicing. This pair underwent a historical change through which obstruents softened to sonorants. The contrast is now actualized in terms of the opposition [voiced] vs. [nasal]: *kapa* > *kafa* > *kaʃa* ~ *kawa* 'river' vs. *keburi*

> keʃ*uri* > *kemuri* 'smoke'.

It is important to note that this conception of a-geometry, which separates the insertion of concrete phonetic features from the geometry of node-trees, makes the SONORITY branch and the VOCALITY branch orthogonal to each other and removes the necessity of introducing redundancy rules such as

(12) [nasal] => [sonorant].

At this point, let me introduce two examples of *NON-STANDARD* interface conditions for VOCALITY. First, in some dialects of Japanese, notably the standard dialect, the voiced velar stop is nasalized word-internally. We have *gengo* [genŋo] 'language' and *gengo-gaku* [genŋo-ŋaku] 'linguistics'. Thus, we have the following conditions.

(13) VOCALITY interface conditions for Standard Japanese

in env. [SONORITY DEGREE 1, PLACE DEGREE 3]

VOCALITY DEGREE 2	=>	[voiced]	in env. #___
		[nasal]	elsewhere

Secondly, in some dialects of Japanese (notably Tohoku dialects), stops of unmarked VOCALITY are voiceless word-initially and voiced word-internally, while stops of marked VOCALITY are voiced word-internally and pre-nasalized word-internally. This distribution of stops can be described by the following conditions:

(14) VOCALITY interface conditions for some Tohoku dialects of Japanese

in env. [SONORITY DEGREE 1]

VOCALITY DEGREE 1	=>	[voiceless]	in env. #___
		[voiced]	in env. V__V
VOCALITY DEGREE 2	=>	[voiced]	in env. #___
		[pre-nasalized]	in env. V__V

The PLACE branch specifies the place of articulation. It is common to take [coronal] as the default, least marked, place of articulation. It contrasts with the peripheral places of articulation [labial] and [velar]. I assume here without argument that [labial] is less marked than [velar]. We have then the following node tree and STANDARD PF interface conditions for the PLACE branch:

(15) The PLACE branch (a-geometry)

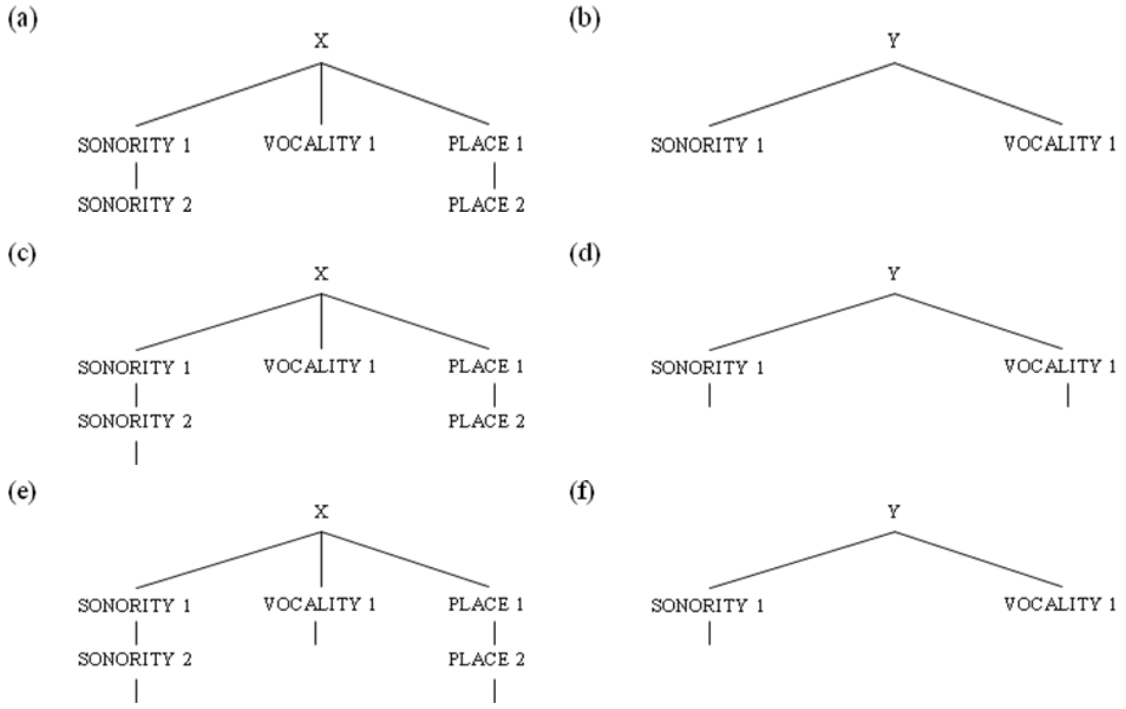
(16) The interface conditions for PLACE (context free)

PLACE 1 (CENTRAL)	=>	[coronal]
PLACE 2 (PERIPHERAL)	=>	[labial]
PLACE 3 (BACK)	=>	[velar]

2.4. *Segment trees* in a-geometry

The COMPLETE NODE TREE of a-geometry is obtained by grafting trees (6), (9) and (15) to base tree (2). A sub-tree of the COMPLETE NODE TREE THAT IS NON-BRANCHING EXCEPT AT ROOT is by definition a SEGMENT TREE, or, simply, a SEGMENT. The ROOTS of a segment tree will generally be denoted by capital letters X, Y, Z etc., which may also be used to name them. A segment tree may not have three branches. A dangling bar | may or may not be attached to the terminal node of a branch of a segment tree.

(17) Examples of SEGMENT TREES



If no branch of a segment tree ends in a dangling bar, it is called a PHONOLOGICAL SEGMENT; (17)(a) and (b) are PHONOLOGICAL SEGMENTS. If a segment tree has three

branches and all branches end in a dangling bar, it is called a PHONETIC SEGMENT; (17)(e) is a PHONETIC SEGMENT and the others are not.

We may indicate a PHONETIC SEGMENT by putting X in brackets:

(18) Notation: Phonetic segment
A phonetic segment may be indicated by a symbol for the segment put in brackets.

For example, X in (17)(e) may be bracketed: [X]. In fact, we have [X] = [f].

The root by itself, with or without a dangling bar, is also a segment:

(19) The root as a segment

For the sake of typographical convenience, we may represent a segment tree, except for the root as a segment tree, by the names of its last nodes enclosed in brackets. If the last node of a branch has a dangling bar |, the name of the branch is underlined. The segments in (17) are represented as follows according to this convention:

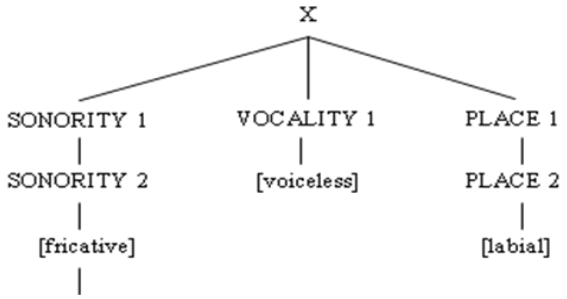
(20) (a) [SONORITY 2, VOCALITY 1, PLACE 2]
(b) [SONORITY 1, VOCALITY 1]
(c) [SONORITY 2, VOCALITY 1, PLACE 2]
(d) [SONORITY 1, VOCALITY 1]
(e) [SONORITY 2, VOCALITY 1, PLACE 2]
(f) [SONORITY 1, VOCALITY 1]

Segments are put to use in two different ways: (i) as a component of a phonological representation of some linguistic form like a lexical item, a word or a phrase; or (ii) as a component of a structural description of a rule, constraint, convention etc. We will agree to interpret the dangling bar | differently in these two cases. In both cases, a branch with a dangling bar | is *terminated* in some sense, but not quite in the same sense.

In case (i), we will agree to understand that branches with dangling bars are terminated in the sense of phrase structure grammar, even though we do not see any nodes labeled with a terminal symbol at the end of |.

In particular, if a segment is a PHONETIC SEGMENT, given the interface phonetic conditions and given sufficient information about relevant environments, terminal nodes in the form of phonetic features can be supplied and attached to dangling bars. Thus, X with dangling bars and X with phonetic features as terminal nodes are considered to be equivalent provided that there is adequate environmental information. They are merely notational variants, with or without phonetic features explicitly expressed. For example, given the STANDARD interface conditions, the tree in (21) is equivalent to (17)(e) above in this sense:

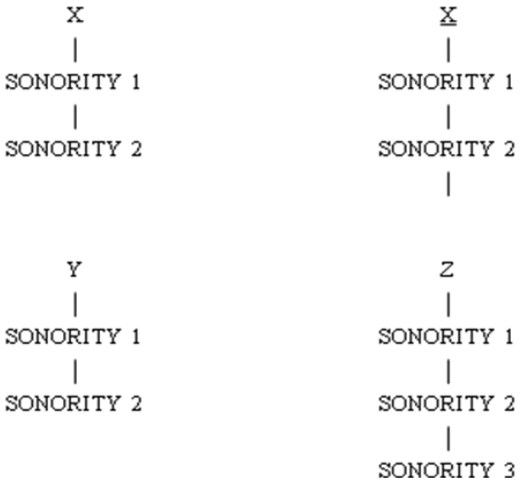
(21)



(17)(e) with dangling bars may be considered as input and (21)as output to the phonetics, respectively, though both represent the same segment.

In contrast, in case (ii), X constitutes part of the conditions to be met by a segment Y to which the rule, constraint or convention applies. Y must be a segment that is compatible with X. For this case, we will agree to understand a dangling bar as follows: if a branch B (for example, the SONORITY branch) of X ends with a dangling bar |, Y can meet the condition X only if Y's B-branch is exactly the same as that of X; Y's B-branch may not extend it. For example, consider the following trees:

(22)



Y = [SONORITY 2] meets both conditions X and $\underline{X}$. Z = [SONORITY 3] can meet only condition X, not $\underline{X}$. Condition $\underline{X}$ in effect selects fricatives, excluding sonorants, under the STANDARD interface conditions, but it may select different phones under different conditions.

If X is the root by itself, without specification of any of the branches, we have the following two cases, with or without a dangling bar:

(23)

(a) is the condition that can be satisfied by any segment. On the other hand, (b) would be a condition that is not satisfied by any segment, since no phonological segment can consist only of X. Rather than taking it as ill-formed, however, let us agree to have the following interpretation:

(24) Representation of a break
X represents a break (silence).
|

Note that at this stage of the presentation, the condition can be met with any segment [SONORITY 1, VOCALITY 1, PLACE 1] and must be equivalent to [X]. In the next section, however, I will introduce the concept of projection reversal, and the nodes dominated directly by the root X may not necessarily be SONORITY 1, VOCALITY 1, or PLACE 1. Hence, [SONORITY 1, VOCALITY 1, PLACE 1] will not be equivalent to [X]. Depending on what the root directly dominates we have different kinds of sites: consonantal, sonorant, vocalic, etc. Let us agree to resolve this ambiguity, for example, by using R-[SONORITY 1, VOCALITY 1] to indicate that the root directly dominates SONORITY 1 and VOCALITY 1 and R-[SONORITY 1, VOCALITY 2] to indicate that the root directly dominates SONORITY 1 and VOCALITY 2. We will see below that the former characterizes the consonantal site and the latter the sonorant site. R-[SONORITY 5, VOCALITY 1] on the other hand characterizes the vocalic site, provided that SONORITY 5 is the highest degree of sonority.

Let me summarize the roles of dangling bars:

(25) The convention for a dangling bar attached to branch B of X
(a) For X as part of a structural description:
For a segment Y to satisfy X, Y's branch B must terminate at the same node as the one to which the bar is attached.
(b) For X as a segment in a phonological representation:
Branch B is sent to phonetics and has become invisible to phonology.
(c) A bar attached to root X indicates that X is a break.

At this point, let us also recall that phonological segments in a-geometry are abstract node-trees with or without a dangling bar but without terminating phonetic features; phonetic features are supplied by interface PF conditions post-phonologically. Interface conditions may be context-sensitive. Hence, a segment may not be taken as representing a phone. For example, using the notational convention for the sake of typographical convenience introduced above, in some dialects of Japanese, [SONORITY 1, VOCALITY 1, PLACE 1] is phonetically implemented by [t] word-initially and [d] word-internally. Conversely, [d] implements [SONORITY 1, VOCALITY 2, PLACE 1] word-internally, but [sonority 1, vocality 1, place 1] word-initially. Nonetheless, in order to facilitate understanding, not to mention typographical convenience (even though there is some danger of misunderstanding), let us agree to represent phonological segments with capital letters in Roman or Greek letters, or IPA symbols. Generally, the letter or symbol used to represent a phonological segment X is a phonetic symbol in capitals of a sound *most plausibly associated with it*, usually a phonetic symbol for the sound that would be implemented by the STANDARD interface conditions. When appropriate I enclose letters

and symbols used for this purpose with angular brackets.

For example, the phonological segment [SONORITY 1, VOCALITY 1, PLACE 1] can be represented by <T> and [SONORITY 1, VOCALITY 2, PLACE 1] by <D>. [SONORITY 3, VOCALITY 2, PLACE 1] can be represented by <N> and [SONORITY 3, VOCALITY 2, PLACE 2] may be represented by <□>, where □ is a phonetic symbol for a labial approximant, etc.

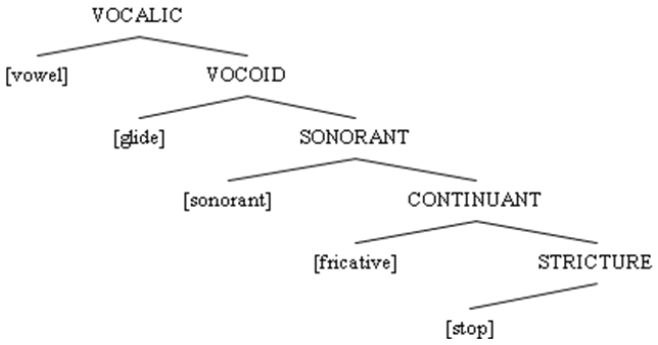
3. Aerodynamic Phonological Geometry 2: Projection reversal

3.1. *Projection reversal of sonority*

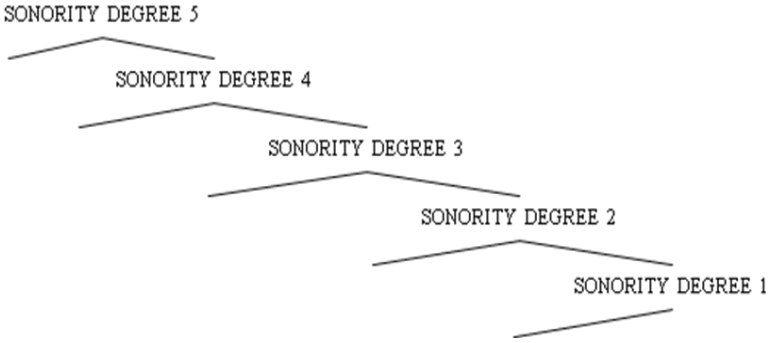
Feature geometry usually distinguishes consonants and vowels by introducing [consonantal] or [vocalic] as features attached to the root node, and likewise for the feature [sonorant]. (Clements & Hume 1995:292; Halle 1995:2) Such features that are attached to the root node are not justified in the aerodynamic design of geometry in ADFG. The distinction between consonants and vowels is a matter of sonority degrees, which is structurally mirrored in the SONORITY BRANCH. Sounds with a lesser degree of sonority are consonantal, and those with a greater degree are vocalic. This fact is reflected in (3) and (6). However, a problem with this line of thought, of course, is that vowels are located down at the bottom of the SONORITY BRANCH and would count as the least consonantal consonants. This implies that they would be affected by rules that apply to consonants in general.

When we decided to represent SONORITY degrees as in tree (3) or (6), we made an arbitrary decision. Sonority is a scalar measure. When we combine this measure with an entailment relation encoded in the form of a tree, there is no intrinsic reason to choose the direction of the entailment. Let x and y be SONORITY degrees and let $x < y$. If we gloss the sonority scale in terms of "at least as sonorous as" and define E_x as "being at least as sonorous as x," then E_y entails E_x. In contrast, if we gloss the sonority scale in terms of "at most as sonorous as" and define E_x as "being at most as sonorous as x," then E_x entails E_y. The former perspective gives the geometric structure given in (3) and (6). We can envision the geometric structure for the latter perspective if we imagine these trees as if they were mobiles and if we imagine holding them at the other end. The result would be the trees in (27) and (28). The entailment relation encoded in these trees in terms of the domination relation among nodes is "at most as sonorous as."

(26) PROJECTION REVERSAL: SONORITY in the VOCALIC PROJECTION (c-geometry)



(27) PROJECTION REVERSAL: SONORITY in the VOCALIC PROJECTION (a-geometry)



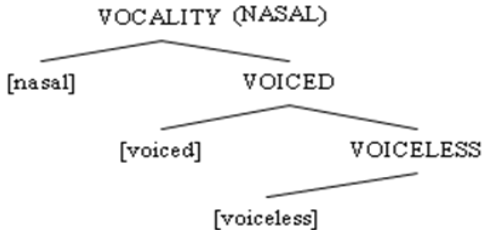
To summarize, we have the geometry of the sonority structure projected in two different perspectives: the CONSONANTAL PERSPECTIVE, (3) or (6), and the VOCALIC PERSPECTIVE, (26) or (27). The opposition of consonantal versus vocalic is not determined by properties of segments formalized in terms of features like [consonantal] or [vocalic]; rather, it inheres in the sites that segments occupy. Each site is designated CONSONANTAL or VOCALIC. At CONSONANTAL SITES, the SONORITY BRANCH is projected in the CONSONANTAL PERSPECTIVE as given in (3) or (6), while at VOCALIC SITES, it is projected in the VOCALIC PERSPECTIVE as given in (26) or (27). The entailment relation determined in one projection does not apply in the other projection; a general rule that applies to consonants does not apply to vowels at VOCALIC SITES, since vowels at VOCALIC SITES are represented by trees planted upside down from the consonantal perspective, and structural descriptions written to conform to the CONSONANTAL PERSPECTIVE would not be met by any tree at a VOCALIC SITE. In the default case, syllable peripheries (onsets or codas) would be CONSONANTAL SITES, and syllable nuclei would be VOCALIC SITES. Fricatives are less likely to be syllable nuclei than sonorants, and stops are almost never allowed in nuclei. Glides are less likely to count as codas than sonorants, and vowels are almost never allowed as codas.

3.2. *Projection reversal of vocality*

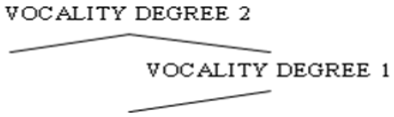
I also assume that the projection of VOCALITY BRANCH may be reversed at a site with the SONORITY DEGREE 3, i.e., the SONORITY DEGREE that is phonetically implemented by sonorants. Sonorants can usually be classified as stops and fricatives, but in some environments they display unique behavior as sounds on the border between consonants and vowels. I assume that in such environments the projection of the VOCALITY BRANCH reverses. Approximants are therefore unmarked sonorants as consonants, but nasals are unmarked sonorants as sonorants. A SITE where the VOCALITY BRANCH reverses is by definition a SONORANT SITE.

The VOCALITY BRANCH at such a site takes the following form:

(28) The VOCALITY BRANCH (c- geometry)



(29) The VOCALITY BRANCH (a-geometry)



In earlier works (Kuroda 2002/2008, 2006) I assumed that a sonorant is at a SONORANT SITE in Korean if and only if it is adjacent to another sonorant, and in Japanese if and only if it is a coda followed by a voiceless obstruent onset. These stipulations account for sonorant assimilation in Korean and coda nasalization in Japanese. In this work I will assume that in Russian, sonorants are in general at SONORANT SITES, with an exception I will specify below.

These might appear to be totally ad hoc stipulations, but they may in fact be phonetically/phonologically justified at least partially on the grounds of a general theory of projection reversal. For example, the specification we will propose to introduce in Russian phonology according to which sonorants generally occupy SONORANT SITES may be a characteristic of a *consonant-dominant* phonology like Russian. In such a phonology sonorants would have to behave less like consonants and more like glides or vowels, to help form viable syllable nuclei. In contrast, one might expect that in a vowel-dominant phonology where open syllables predominate, like Japanese, sonorants are generally at onset position and behave like consonants. In Japanese, sonorants may also appear in coda position if they are nasal. This proviso may well be phonetically motivated and may not be altogether ad hoc.

3.3. *Projection reversal of sonority*

Sonorants are sometimes "syllabified" and constitute syllable nuclei. Syllabified sonorants function like vowels in this respect. I propose that such sonorants occupy SYLLABIC SITES, where both the SONORITY and the VOCALITY BRANCH are projected upside down, i.e., reversed. In our analysis of Russian phonology we will make use of this possibility.

Part II. Russian voicing assimilation

4. Russian voicing assimilation and final devoicing

4.1. *Facts*

The sound represented by the letter *v* in Roman transcription of Russian orthography interacts in an intricate way with voicing assimilation, which could otherwise be taken as a fairly simple process. We can put aside the problem of *v* for now as we discuss the process of assimilation without considering the problem of *v* in this section. The following data are reproduced from Hayes (1984) and Kiparsky (1985).[3]

(30) Obstruents

1. Final devoicing: obstruents *devoice* in word-final position[4]

sad+a	[sada]	gen. sg.	vs.	sad [sat] nom. sg.	'garden'	[K:(46)]

2. Voicing assimilation.

2.1. Obstruents *trigger* assimilation

2.1.1. *Devoiced* final obstruents also *trigger* assimilation

2.2. Obstruents are *targeted* by assimilation:

gorod+k+a	goro[tk]a	'little town'	[K:(47)]
mcensk#by	mcen[zgb]y	'if Mcensk..'	
mcensk#byl	mcen[zgb]yl	'it was Mcensk..'	
mozg	mo[sk]	'brain'	[K:(48)]

(31) Sonorants/vocoids

1. Sonorants/vocoids do *not devoice* at word-final position:

mysl'	'thought'	[H:321]

2. Voicing assimilation

2.1 Sonorants/vocoids do *not trigger* assimilation:

o[t n]auki	(*od nauki)	'from science'	[K:(51)]

2.2. Sonorants are *not targeted* by assimilation

rta	'mouth gen. sing'	[H:321]

2.3. Sonorants are *optionally transparent to* assimilation:

iz# mcensk+a	i[s mc]enska	~	i[z mc]enska	'from Mcensk'	[K:(49) (71)]
ot#mzd+y	o[d mzd]y	~	o[t mzd]y	'from the bribe'	[K:(49) (71)]

According to Padgett (2002: 5), "this [transparency] has always been a controversial claim; some sources, such as Shapiro (1993) deny it altogether...." He doubts that there is any "phonological voicing assimilation in [*ot mzdy*] etc." and wonders "then why do some sources, most notably Jakobson, claim there is?" He does not rule out different

[3] I draw most data from Hayes (1984) and Kiparsky (1985). I will refer to these works as H and K, respectively. Kiparsky (1985) summarized Hayes's analysis and developed from it an analysis of his own in the framework of his theory of lexical phonology. The analysis presented in this paper may be taken as a reanalysis of Hayes's. I will liberally quote directly from Kiparsky in my exposition of Hayes's analysis but such quotes should perhaps be taken as Kiparsky's exposition of Hayes's analysis and may not necessarily reflect more advanced aspects of his own analysis.

[4] Final devoicing applies between a preposition and a following major category, but not between a major category and a following clitic, though voicing assimilation does. I will not be concerned formally with how a word-boundary is inserted in a way consistent with the phenomenon of voicing assimilation and final devoicing.

dialects, but opts for "optional, gradient assimilation in fast or casual speech." In contrast, Hayes refers to an optional rule "which syllabifies sonorant liquids and nasals that are not adjacent to a vowel" and which bleeds Voicing Assimilation [H:327, note1]. In what follows I will consider both possibilities as a dialectal difference. I refer to the option following Hayes/Kiparsky as the strong version/dialect (Assimilation has more force and more segments targeted by assimilation) and the other, following Padgett, as the weak version/dialect (less segments targeted) of assimilation.

4.2. *The analysis of obstruent voicing assimilation and final devoicing*

4.2.1. *Understanding the phonological significance of Russian voicing assimilation*

The impression given by the relevant phonological phenomena could be that Russian voicing assimilation is not to be analyzed as markedness linking, since both voicing and voicelessness assimilate. It might also appear that voicing assimilation is a process independent of final devoicing. However, I would take the position that the two phenomena, final devoicing and voicing assimilation, are but two aspects of one underlying phonological design: neutralize the voicing contrast for obstruents at non-onset-release sites. Voicing assimilation is a euphonic adjustment to this neutralization.

Let us confirm that this neutralization does not take place before a sonorant. Before sonorants, voiceless and voiced obstruents contrast:

(32) *klub* 'club' vs. *glum* 'joke'; krup 'croup' vs. *gruppa* 'group' ;
smena 'change vs. *zmeja* 'serpent'; *kniga* 'book' vs. *gnida* 'nit' etc.

With the above understanding, we may describe the phenomenon of assimilation in informal terms as follows:

(33) An informal description of the analysis of voicing assimilation

Rule 1 - Voicing Neutralization:

Unmark marked obstruents to the left of an obstruent in a consonant cluster or of silence.

Rule 2 - Voicing Assimilation

Mark an unmarked obstruent in a consonant cluster to the left of a marked obstruent.

We may interpret the phrase "consonant cluster" in two different ways. The weak version takes the consonant cluster as a sequence of obstruents only, and the strong version as a sequence of obstruents possibly with intervening sonorants.

Recall that in the strong dialect, assimilation is *optionally* blocked by a sonorant between two obstruents. Cf: (31) 2.3. Hayes and Kiparsky attribute this blocking to optional syllabification of the intervening sonorant that bleeds Assimilation [K: 107]. It is not clear to me how general this rule is, but for now I formulate it in the strongest form:

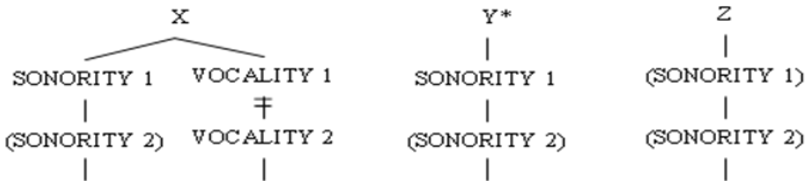
(34) Optional syllabification that bleeds Assimilation

Rule 3 - Make a sonorant syllabic between two obstruents.

The attentive reader will have noticed that if this syllabification rule is *obligatory*, we get the same effect as the weak version of assimilation, provided that the environment for syllabification is as general as given in this rule.[5]

4.2.2. *The analysis formulated in terms of ADPG (a-geometry)*
Assuming certain conventions about how to interpret segment representations, we can formulate the above informal analysis in a-geometry as follows.

(35) Voicing Neutralization--the weak form



By the common convention about parentheses, the first branch of X is understood to be an abbreviation of the disjunction of the following two branches:

(36)

A dangling | implies that only trees whose SONORITY branch ends in SONORITY 1 or 2 satisfy X. This condition excludes sonorants from satisfying X. The same obtains for Y and Z. Superscript * attached to Y means "any number of," including zero.

The rightmost term Z of (35) is an abbreviation of the disjunction of two trees of the same forms as in (36) and the following:

(37)

By convention, the root Z with a dangling | is interpreted as representing a break (silence), cf: (24).

The formulation (35) is ambiguous as to whether the rule applies globally or iteratively. Consider, for example, *nadstroj* 'superstructure'. We may delink VOCALITY 2 from *d* either by interpreting X = *d*, Y* = *s*, and Z = *t* or by interpreting X = *d*, Y* = 0 and Z = *s*. We could remove such ambiguity by complicating the formulation of the rule with an additional specification of the environment so that Z might be the rightmost element of an obstruent cluster. We can, however, achieve the same effect by introducing a general maximality convention for interpreting a structural description:

[5] Hayes (1984: 327, note 1) intimates a rule of syllabification as general as given here, while Kiparsky's rule [K: (57)] does otherwise.

(38) *The maximality convention for structural description*
A rule applies to the maximal string that fits the structural description.

According to this convention the sequence XY*Z is interpreted as a maximal sequence satisfying the structural description of the rule. In the above example with *nadstroj* we apply the rule with X = *d,* Y* = *s*, and Z = *t*.

It is generally easier and more convenient, for typographical reasons, to reformulate rules in somewhat informal, phrasal form.

(39) Voicing Neutralization--the weak form (in phrase)

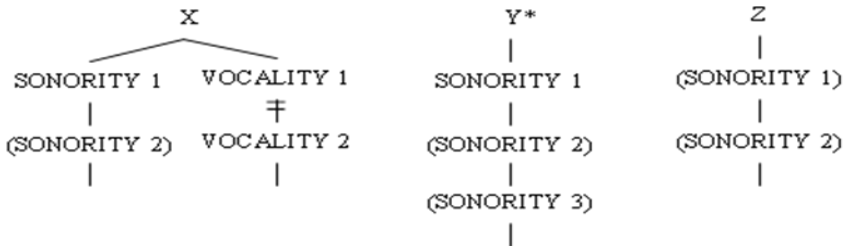
Delink VOCALITY DEGREE 2 **in env.**

$$\left[\ \frac{\text{SONORITY DEGREE } n\ (1 \le n \le 2)}{}\ \right]\ [\text{SONORITY } n\ (1 \le n \le 2)]^{*}\ [\text{SONORITY } n\ (n \le 2)]$$

(with the convention that a break after a word boundary has sonority degree 0)

Neutralization in the strong form allows the cluster Y* to contain sonorants. For this purpose, we extend Y by adding SONORITY 3 with a dangling | in parentheses for the strong form:

(40) Voicing Neutralization--the strong form



(41) Voicing Neutralization -- the strong form (in phrase)

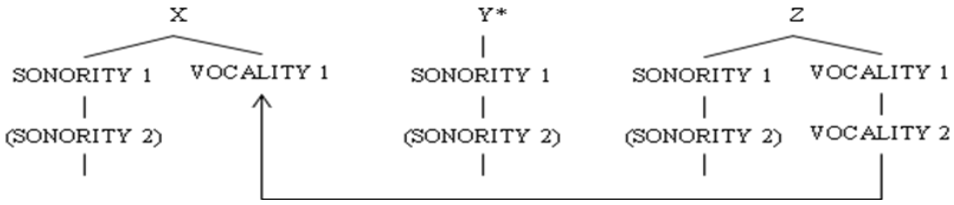
Delink VOCALITY DEGREE 2 **in env.**

$$\left[\ \frac{\text{SONORITY DEGREE } n\ (1 \le n \le 2)}{}\ \right]\ [\text{SONORITY } n\ (1 \le n \le 2)]^{*}\ [\text{SONORITY } n\ (n \le 2)]$$

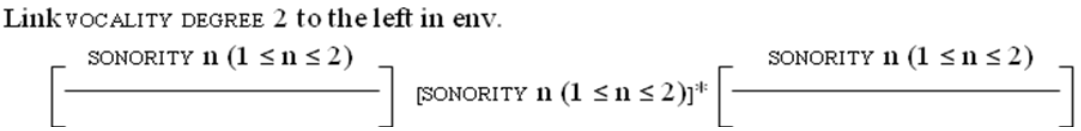
(with the convention that a break after word boundary has sonority degree 0)

Next, I present the rule of Voicing Assimilation.

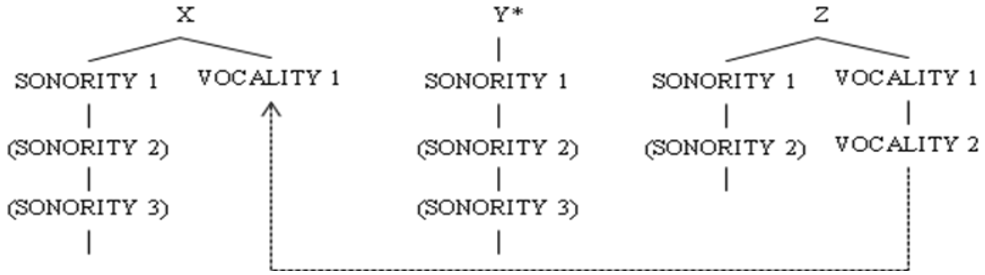
(42) Voicing Assimilation -- the weak form



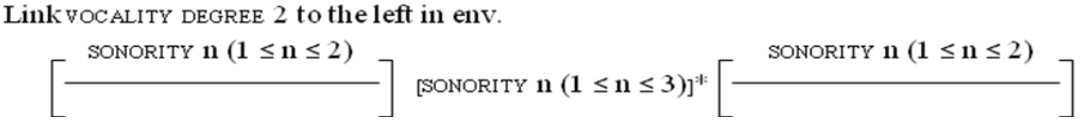
(43) Voicing Assimilation-- the weak form (in phrase)



(44) Voicing Assimilation -- the strong form



(45) Voicing Assimilation-- the strong form (in phrase)



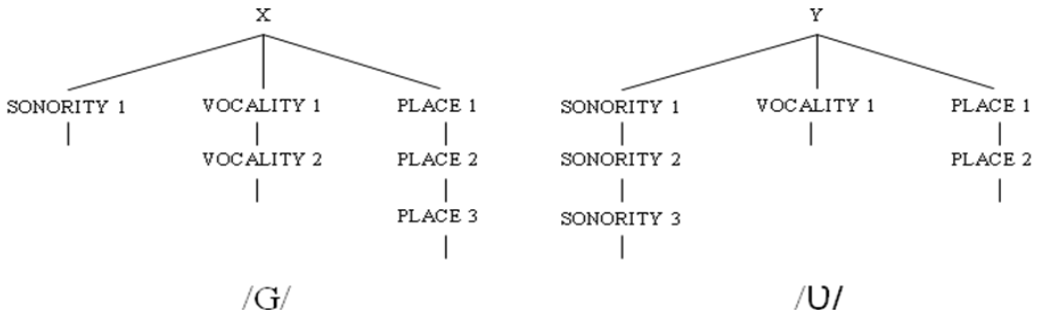
I assume that there are two dialects: 1) the weak dialect, with the weak forms of Neutralization and Assimilation, and 2) the strong dialect, with the strong form of Neutralization and Assimilation. The strong dialect is the language Hayes (1984) described. In Hayes's analysis, Neutralization and Assimilation are bled by an optional rule of syllabification. I will not be concerned with this optional rule at this point.

4.2.3. *Examples*

We are going to go through the facts presented previously and show the derivation in terms of a-geometry. For reasons of space and typography, I will present only a few examples of derivation in terms of node trees; I will present the rest in terms of the representation based on Roman letters, Greek letters, and phonetic symbols according to the convention introduced in section 2.4 above. To recall, we transcribe a phonological segment (which is a abstract node tree) by the capital font of the Roman or Greek letter or phonetic symbol which would represent the sound into which the segment would be transformed if it is interpreted by the *standard* interface conditions. For example, according to this transcription convention, <G> and <ʊ> represent the following trees X and Y, respectively. <G> may be turned into [g], but not necessarily by non-standard

conditions, for example, into [ŋ]; cf:(13).

(46)



We are concerned with Russian phonology/phonetics only to the extent relevant to our project. Hence, so long as phonological/phonetic details do not matter for our immediate concern, I let letters of orthography in Roman transliteration liberally represent sound segments, even where I enclose the phonetic representations of examples in square brackets as in common practice. (In particular, [y] to represent the sound of ы.)

Let us recall at this point another notational convention introduced earlier by means of which a node tree is represented linearly by the names of the last nodes of the branches enclosed in brackets. If the last node of a branch has a dangling bar, its name is underlined. According to this convention, the two trees in (46) are represented as follows:

(47) X = [SONORITY 1, VOCALITY 2, PLACE 3] Y = [SONORITY 3, VOCALITY 1, PLACE 2]

<G> <ʊ>

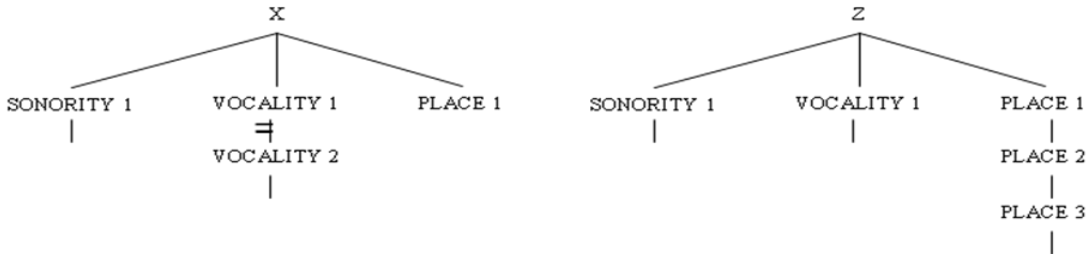
After these reminders, let us discuss the examples. First, recall that "a sequence of obstruents assimilates in voicing to the last." [K: 103] In conformity with our analysis, we describe this phenomenon as the effect of neutralization and assimilation.

(48) Neutralization and Assimilation

Orthographic	*gorodka*	*Mcensk by*	[K:(47)]
Gloss	'little town'	'if Mcensk'	
Underlying Representation	GoRoD+K+a	MceNSK#By	
Neutralization	GoRoT+K+a	_____	
Assimilation	_____	MceNZG#By	
Surface Representation	GoRoT+K+a	MceNZG#By	
Phonetic Form	[gorotka]	[mcenzgby]	

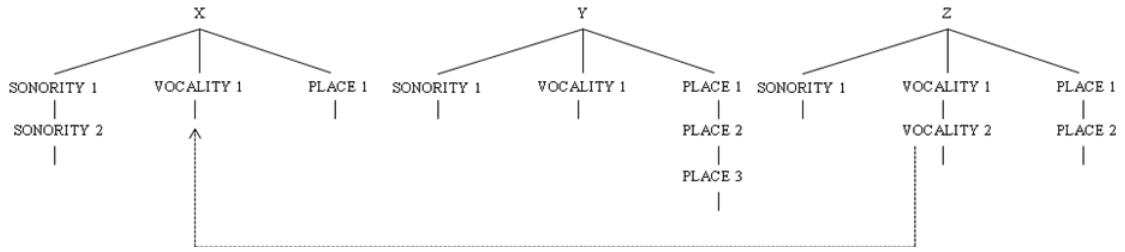
Let us confirm the effect of Neutralization on the relevant part of the derivation of *gorodka* in tree form below:

(49) *gorodka* = goro[tk]a

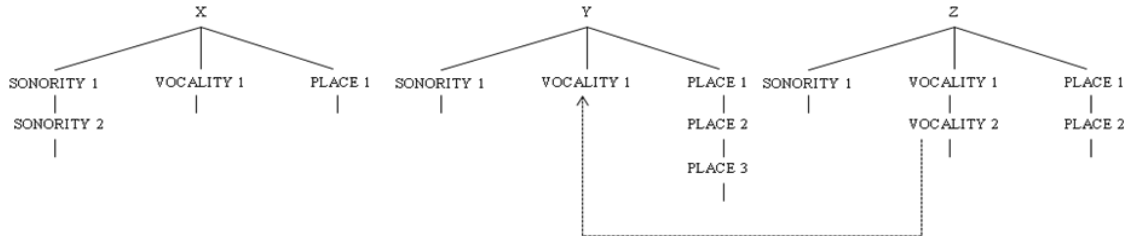


The relevant part of the effect of Assimilation in the derivation of *Mcensk by* is given below. I assume that a simultaneous double application of Assimilation vocalizes /s/ and /k/:

(50) MceNSK#By => MceNZK#By



MceNSK#By => MceNSG#By



Next, "final obstruents are devoiced" [K:103]:

(51) Neutralization in word-final position

Orthographic	*klub*	*kluba*	[H:318]
Gloss	'club nom.'	'..gen.sg.'	
UndlyingRprsnttn	KLuB	KLuB-a	
Neutralization	KLuP	_____	
Assimilation	_____	_____	
SurfaceRprsnttn	KLuP	KLuB-a	
Phonetic Form	klup	kluba	

To recall, by convention (24) the break is represented by a root with a dangling bar. I illustrate below how neutralization works with this convention with the next example (52)/(53).

Hayes and Kiparsky give *vizg* [visk] 'scream' and *mozg* [mosk] 'brain' as examples of "final devoicing feed[ing] Voicing Assimilation." [H: 318, K: 103] But in our analysis,

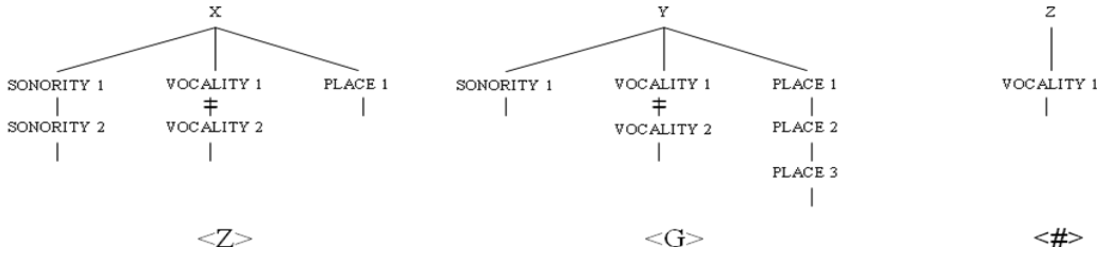
we would simply have an application of Neutralization, and there is no feeding relation between these rules, as shown below. There is no empirical evidence that the underlying form for *mozg* must be MoZG = Mo[SONORITY 2, VOCALITY 2, PLACE 1]G, rather than MoSG = Mo[SONORITY 2, VOCALITY 1, PLACE 1]G. Formal phonology cannot choose between them, and the underling form may in fact be indeterminate. Empirical evidence to choose one or the other may be obtained from language acquisition or historical phonology. But here I entertain both possibilities:

(52) Neutralization in word-final position

Orthographic	*mozg*	*mozg*	[K: (48)]
Gloss	'brain'	'brain'	
UndlyingRprsnttn	MoZG	MoSG	
Neutralization	MoSK	MoSK	
Assimilation			
SurfaceRprsnttn	MoSK	MoSK	
Phonetic Form	mosk	mosk	

The application of Neutralization for MoZG is shown in the tree form below:

(53) Word-final neutralization



Finally, "Voicing and Devoicing Assimilation propagates across sonorants," that is, in our terms, the strong form of Neutralization and Assimilation is at work:

(54) Neutralization and Assimilation propagates across *sonorants*

Orthographic	*ot mzdy*	*iz Mcenska*	[H:318, 320]
Gloss	'from the bribe'	'from M.'	
UndlyingRprsnttn	oT MZDy	iZ MCenSKa	
Neutralization	oT MSDy	iS MCenSKa	
Assimilation	oD MZDy		
SurfaceRprsnttn	oD MZDy	iS MCenSKa	
Phonetic Form	odmzdy	ismcenska	

5. The problem of *v*

5.1. *The facts*

We will now discuss the problem of *v*. The following data is again reproduced from Hayes (1984) and Kiparsky (1985).

(55) Word-final devoicing

1. *v*, like obstruents, devoices word-finally:
   zdorov zdoro[f] 'healty' [H: 318]
2. except when it precedes a clitic with initial sonorant:

zdorov#li zdoro[v l'] 'is he healthy' [H:321]

(56) Assimilation

1. *v*, like sonorants, does not trigger assimilation:
   o[t v]raga 'from the enemy' [K:(51)]
2. even when it is devoiced word finally:
   trezv tre[zf] 'sober' [K:(51)]
3. *v,* like obstruents, assimilates
   krivd kri[ft] 'justice' (gen. pl.) [K:(50)]
   korov+k+a koro[fk]a 'little cow' [K:(50)]
   bez vpuska [sfp] 'without admission' [H:319, , 326 (10)]
4. *v*, like sonorants, is a non-target and transparent to assimilation
   ot vdov+y o[d vd]ovy 'from the window' [K:(53)]
   ot vtor+ogo o[t vt]orogo 'from another' [K:(53)]

We apparently get conflicting information from (56)3 and (56)4. Observe the pair *bez vpuska* be[sfp]uska in 3 and *ot vtor+ogo* o[t vt]orogo in 4. In the former *v* assimilates to *p* and gets devoiced, while in the latter *v* does not assimilate to *t* and remains intact, voiced. It might appear that Hayes's optional rule of syllabification of sonorants is extended to apply to *v* in *ot vtor+ogo* and prevents it from being devoiced.

5.2. *The analysis of Russian v*

5.2.1. *The standard analysis*

Jakobson succinctly characterized the problem of *v* as: "*v* behaves like a sonorant when preceding a sonorant, and like an obstruent otherwise." (Jakobson 1956, quoted by Padgett 2002) Let us see how the standard generative account accommodated Jakobson's insight into its analysis. The following ordered rules are given by Hayes (1984:319f) to account for the behavior of *v*.

(57) The standard account

a. *Final Devoicing*

C → [-voice] / ___#

b. *Voicing Assimilation*

In a consonant cluster, assign the voicing of the last obstruent to all consonants on its left.

c. *W Strengthening*

$$\begin{bmatrix} \text{C} \\ \text{-cons} \\ \text{+labial} \end{bmatrix} \longrightarrow \text{[-son]}$$

d Sonorant Revoicing

[+son] → [+voice]

"Given this split behavior [of *v* like a sonorant and like an obstruent], a reasonable guess," as Hayes sees it, "is that /v/ should be derived from underlying /w/, a segment that is in fact absent on the surface in most dialects of Russian." [H:319] Then, *Voicing Assimilation* is formulated in such a way that on the one hand only obstruents trigger assimilation (hence *v* ≠ /w/) but, on the other hand, it targets consonants in general, including sonorants (in particular *v* = /w/).

By formulating Assimilation this way, Hayes so to speak has turned around Jakobson's observation, to wit: an obstruent behaves like an obstruent when it precedes a

sonorant (and triggers assimilation) but like a sonorant otherwise (by being targeted by Assimilation)"! *W Strengthening*, then, transforms the sonorant /w/ into *v* = /v/ or /f/, to join in the surface representation the other obstruents which behave like sonorants at an intermediate level when Assimilation applies.

Hayes was led to formulate *Voicing Assimilation* as a rule affecting not only obstruents but also sonorants, because otherwise "there is no way to order a /w/ --> /v/ rule with respect to Voicing Assimilation so that /v/ will undergo, but not trigger, the rule." [H:319] Let us reconfirm this point by citing Hayes. Consider *v svažine* [fskvažine] 'in the chink'. This form contains two occurrences of *v*. The first one is supposed to behave like a consonant, the second like a sonorant. But either of the two possible orderings of the two rules cannot distinguish them and fails to derive the expected form:

(58) Ordering paradox with the Assimilation rule targeting only obstruents [H: (2)]

underlying	w skwažine	underlying	w skwažine
/w/ --> /v/ rule	v skvažine	Assimilation	_____
Assimilation	*v zgvžine	/w/ -> /v/	*v skvažine

If Assimilation can target sonorants, in particular /w/, we can derive the right form as follows:

(59)

underlying	w skwažine
Assimilation	w̥ skwažine
W strengthening	f skvažine

The price this arrangement pays is that not only the underlying phantom sonorant /w/, but also the genuine sonorants, liquids /l, r/ and nasals /m, n/, get targeted by *Voicing Assimilation* as well and get devoiced in some environments. Luckily, this overapplication does not cause fatal damage, because voicing is not phonologically distinctive for liquids and nasals. But we need *Sonorant Revoicing,* which applies after *W Strengthening* and neutralizes all occurrences of sonorants in favor of [+voiced], as its phonetics requires.

One might suggest an alternative to Hayes's account by somehow restricting W Strengthening to apply only to obstruent-behaving *v* and order it before Assimilation; then one could let Assimilation target only obstruents. Unfortunately, this solution does not work even at the expense of complicating the rule, because a word-final *v* devoices and surfaces as [f] but does not trigger Assimilation, hence cannot be strengthened before Assimilation.

5.2.2. *Towards an a-geometry analysis 1: Neutralization and Assimilation*

5.2.2.1. *The two issues raised by the standard analysis*

The ingenious solution to Jakobson's problem reproduced above has, as expected, occasioned much discussion and controversy. There are two points that would be of particular concern about the above analysis. One is to take /w/ as the underlying representation of *v*, which surfaces /f/ or /v/. The other is to make liquids and nasals targets of assimilatory devoicing, only to re-voice them later to conform to the phonetic reality.

As far as the first point is concerned, Padgett (2002), citing various sources, claims that *v* should be interpreted phonetically as a labial approximant represented by ʋ. Hayes also remarks that "for many speakers, /w/ and /v/ vary freely on the surface, at least in certain environments." [H: 321]

I am not in a position to judge the extent to which [ʋ] and/or [w] can be taken as adequate for the actual phonetic representation of the Russian sound represented by orthographic *v*. It seems plausible, though, that *v* actualizes as [ʋ] and/or [w] in broad context. It is reasonable to entertain the assumption that *v* is underlyingly not an obstruent. If that is the case, to take Ʊ = [SONORITY 3, VOCALITY 1, PLACE 2] (rather than W = [SONORITY 4, VOCALITY 1, PLACE 2]) as underlying *v* for its function as a "sonorant" and upgrade its SONORITY DEGREE by 1 for its phonetic realization as an obstruent would be a minimal hypothesis for Russian phonology in the framework of a-geometry.

The other point of contention in Hayes's account, to recall, is the need to revoice liquids and nasals to counteract overapplication of assimilatory devoicing. Some justification for this unwelcome but unavoidable overapplication has been made in the literature on the basis of the fact that sonorants also get devoiced *in rapid speech* in about the same context as predicted by *Voicing Assimilation* (57)b above. (See Hayes 1984, Kiparsky 1985, Padgett 2002) However, such devoicing of sonorants in rapid speech, which is immaterial to phonological contrast, is a matter of phonetic detail and in a-geometry should be left aside from our *phonological* account and may not be used as justification of the overapplication of Assimilation to sonorants.

In fact, any attempt for such justification is ruled out in a-geometry on formal grounds. For sonorants the contrast in terms of VOCALITY DEGREES 1 and 2 is implemented in terms of the contrast between non-nasal vs. nasal, not in terms of voiced vs. devoiced, and hence is not phonologically redundant. If Assimilation targets a VOCALITY DEGREE 1 sonorant, for example *r*, and makes it *marked* (i.e., links VOCALITY DEGREE 2 to it), *r* would not *become* a voiced approximant, but would be transformed into a nasal, *n*. On the other hand, if Strengthening applied to *r*, too, it would derive *t* from original *r* or *d*, if assimilated to a voiced obstruent. If Neutralization targets VOCALITY DEGREE 2 sonorants in general, and hence *n*, and *unmarks* it, *n* would be changed into an approximant, *l* or *r*. The later application of a *remarking* rule would cause dire consequences, converting all approximants to nasals. Thus, Hayes's type of approach to the problem of *v* is ruled out in a-geometry.

To recapitulate, we have the following situation. We need to keep *v* = Ʊ as a *sonorant* [SONORITY DEGREE 3] when Assimilation applies, so that we can trigger Assimilation only by an *obstruent* [SONORITY DEGREE not greater than 2], hence not by *v* = Ʊ; in contrast, if we let Assimilation target *sonorants* as well, we risk obliterating the distinction between *approximants* and *nasals* in general.

5.2.2.2. *Turning to a new perspective*

We need to somehow restrict the target of Assimilation to obstruents in general and only those occurrences of *v* = Ʊ that behave like consonants. If we formulate this restriction and add it to the rule of Assimilation, such a rule would take a complicated form not worthy of a general phonological rule. If the phenomenon of Voicing Assimilation in Russian looks complicated due to the intervention of *v*, the burden of such complication should be borne *not by* the formulation of a general rule of

Assimilation *but by* the description of the function of *v* in Russian. An adequate theory should provide a descriptive device to achieve such a goal. I claim that a-geometry is equipped with such a device.

Recall that a sonorant may occupy a CONSONANTAL SITE or a SONORANT SITE in a-geometry. I propose the following specifications for Russian sonorants. First of all, sonorants except for ʊ (i.e., segments with specification [SONORITY DEGREE 3], and without [VOCALITY DEGREE 1, PLACE DEGREE 2]) always occupy SONORANT SITES. Secondly, we want ʊ to occupy a SONORANT SITE only where it is supposed to behave like a sonorant, that is, where it "precedes a sonorant" in Jakobson's terms, that is, more precisely put, where it precedes a sonorant, a vowel or a word boundary; this is the environment where ʊ, unlike obstruents, does not trigger Neutralization. Then, ʊ must be at a CONSONANTAL SITE when it precedes a segment with SONORITY DEGREE 1 or 2. This amounts to specifying that ʊ is at a CONSONANTAL SITE when it precedes a CONSONANTAL SITE, and otherwise at a SONORANT SITE. Hence, we introduce the following site-type specification for sonorants in Russian:

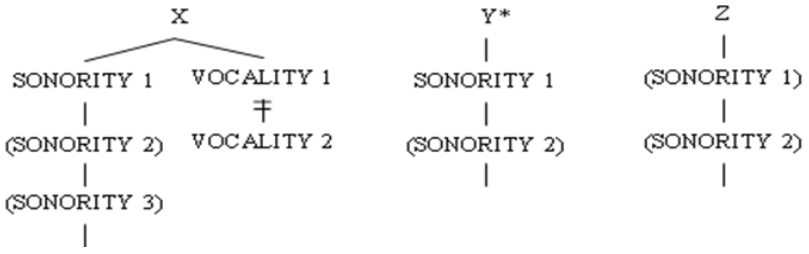
(60) Site type specification for Russian [SONORITY DEGREE 3] segments
A SONORITY DEGREE 3 segment X is at a CONSONANTAL SITE if X = ʊ and X precedes a CONSONANTAL SITE; otherwise X is at a SONORANT SITE.

It follows from these specifications that a sonorant is at a CONSONANTAL SITE if and only if it is ʊ and precedes an obstruent [SONORITY DEGREE n, $1 \leq n \leq 2$].

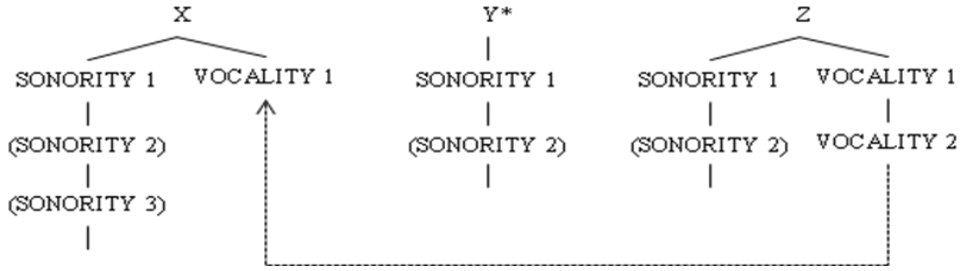
Following Hayes, I will formulate assimilation (i. e., Neutralization and Assimilation) to apply to sonorants as well, or in my terms, to SONORITY degree 3 segments. However, unlike in Hayes's analysis, it does not affect node trees that are to be interpreted as liquids and nasals; for, thanks to (60), such trees are at SONORANT SITES and they do not meet the structural description of the rules. I will formulate the generalized form of these rules just below.

I reformulate Voicing Neutralization and Assimilation by simply adding SONORITY 3 in parentheses at the end of SONORITY BRANCH under X. For the weak dialect, we get from (39) and (42):

(61) Voicing Neutralization (reformulated)--the weak form

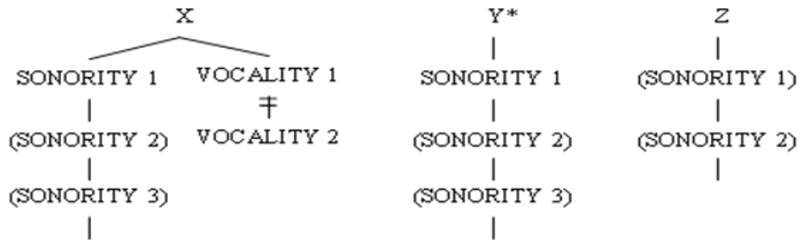


(62) Voicing Assimilation (reformulated)--the weak form

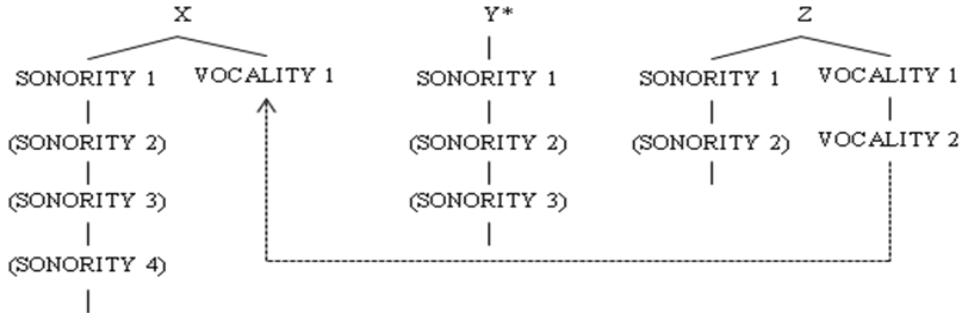


For the strong dialect, we reformulate (40) and (44) as follows:

(63) Voicing Neutralization--the strong form



(64) Voicing Assimilation -- the strong form



SONORITY 3 segments are targeted by these rules, but they have no effect on X if X is located at a SONORANT SITE, for at a SONORANT SITE, the VOCALITY BRANCH of a SONORITY 3 segment is upside down and has one of the following forms:

(65) The VOCALITY BRANCH at a sonorant site

Voicing Neutralization cannot delink VOCALITY DEGREE 2 from these branches, nor can Voicing Assimilation link VOCALITY DEGREE 2 to these branches.

Thus, with the specification (60) about the site types for SONORITY DEGREE 3 segments, (61)/(62) and (64)/(65) affect only obstruents and those occurrences of *v* = ʊ that precede an obstruent, and not those that precede a sonorant or a vowel or other sonorants (that are to be interpreted as liquids and nasals); this is a desired result. It thus turns out that we do not have to reformulate and complicate the Neutralization and the Assimilation rules in order to take into consideration the problematic behavior of *v*.[6]

In order to get the right phonetic form for ʊ targeted by these rules, the output of the rules must be strengthened. Strengthening will be discussed in section 5.2.3 below.

5.2.3. *Towards an a-geometry analysis 2: ʊ Strengthening*

5.2.3.1. *The formulation of ʊ Strengthening*

ʊ = [SONORITY 3, VOCALITY 1, PLACE 2] has yet to be strengthened before it can be phonetically implemented as a voiceless or voiced fricative [f] or [v]. Let us recall Hayes's rule of W Strengthening (57)c:

(66) *W Strengthening*

$$\begin{bmatrix} \text{C} \\ \text{-cons} \\ \text{+labial} \end{bmatrix} \longrightarrow \text{[-son]}$$

This rule targets glide [w] or its voiceless counterpart derived from it by Final Devoicing or Assimilation,, as the case may be, and converts it to a fricative [f] or [v]. We can directly reformulate this rule in our framework: Delink SONORITY 3 from a PLACE 2 segment:

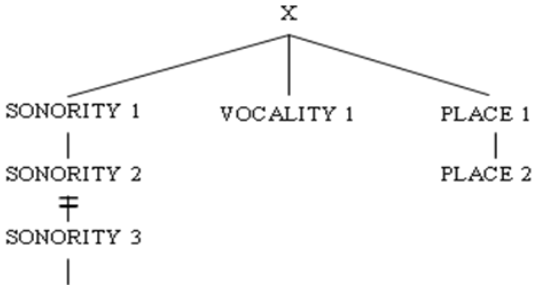
---

[6] It might appear that we are engaged in a tradeoff of *ad hoc* stipulations in one way or other, in order to meet descriptive adequacy. On the one hand, in Hayes's analysis, one must introduce a revoicing rule to counteract the excess application of assimilation; on the other hand, in our analysis, one needs a stipulation for SONORANT SITES. This assessment might have to be accepted as fair for now. But this is because at present I am not presenting any general theory on PROJECTION REVERSAL we can depend on; with such a theory, we might be able to claim that an apparent *ad hoc* stipulation about PROJECTION REVERSAL is in fact a reflection of the general properties of languages and is to be justified on cross-linguistic and/or universal grounds.

For example, the specification we propose to introduce in Russian phonology according to which sonorants, except for ʊ, generally occupy SONORANT SITES may be a characteristic of a *consonant-dominant* phonology like Russian, as suggested earlier in section 3.2; in such a phonology sonorants would have to behave less like consonants and more like glides or vowels, to help form viable syllable nuclei.

The exception for ʊ for the SONORANT SITE specification in Russian introduced above may also be grounded on phonetics. Compared with coronal approximants, the labial approximant might be phonetically less stable to hold to its sonorant status and be able to occupy a sonorant site only in favorable environment.

(67) ʊ Strengthening (the first version)

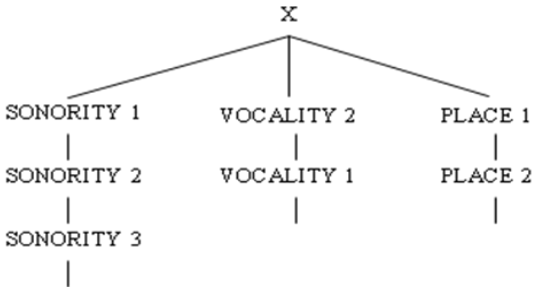


Note that there is no dangling bar under VOCALITY 1 in (67). By convention, then, (67) targets both underlying ʊ = [SONORITY 3, VOCALITY 1 PLACE 2] as well as [SONORITY 3, VOCALITY 2 PLACE 2] which is derived from it by the process of assimilation. Thus, it appears that we have the Strengthening rule corresponding to Hayes's W Strengthening.[7]

However, there is a significant difference between (66) and (67), since the structural description of (67) implies that it applies only at a CONSONANTAL SITE, where the projection of VOCALITY branch is not reversed. ʊ may be found at SONORANT SITES, too. While Hayes's W Strengthening strengthens all occurrences of [w], our (67) misses ʊ at SONORANT sites.

At a SONORANT site, ʊ is represented by the following tree:

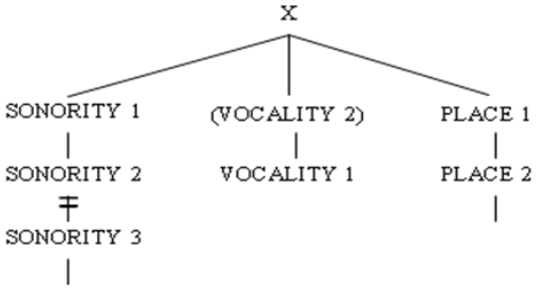
(68) ʊ at a SONORANT site



We can combine the structural descriptions of the above two rules as follows:

[7] It may appear that (67) targets and strengthens *m*, but it does not. *m* is at a sonorant site and its VOCALITY branch is reversed.

(69) ʊ Strengthening (the second version)



Note that there is a dangling bar under VOCALITY 1 in (68), but we do not put a dangling bar under VOCALITY 1 in (69). On the one hand if we do not choose VOCALITY 2 in parentheses in (69), we get (67), as desired. Hence, we cannot put a dangling bar under VOCALITY 1 in (69). On the other hand, if we choose VOCALITY 2 in parentheses in (69), we get the tree in (68) minus a dangling bar under VOCALITY 1. But no VOCALITY node can extend the reversed VOCALITY branch under VOCALITY 1, hence no tree other than (68) = ʊ can satisfy (69) at a SONORANT site. We can conclude that (69) is the right form to combine (67) and (68).

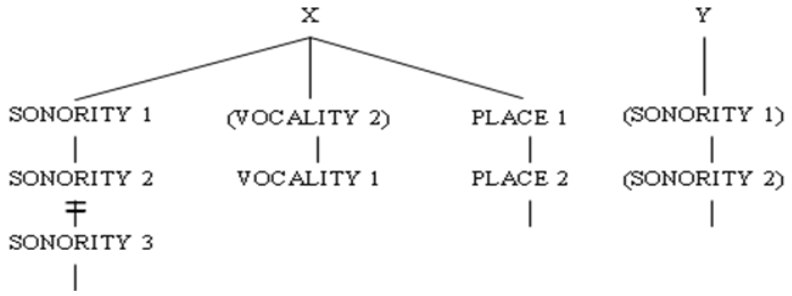
But do we want to strengthen ʊ at a SONORANT SITE? Before answering this question, let us consider how the process of Strengthening works. ʊ Strengthening corresponds to *W Strengthening* in the standard generative account. However, as the attentive reader may have noticed, there is a notable "twist," so to speak, in the way the effect of this strengthening process works. This process transforms ʊ = [SONORITY 3, VOCALITY 1, PLACE 2] into F = [SONORITY 2, VOCALITY 1, PLACE 2] and [SONORITY 3, VOCALITY 2 PLACE 2] into [SONORITY 2, VOCALITY 2 PLACE 2]. Before Strengthening, given the specification SONORITY 3, the contrast brought about by final devoicing and assimilation, i.e., the contrast VOCALITY 1 *vs*. VOCALITY 2, is the one that would, but for Strengthening, actualize as the phonetic contrast [voiced] vs. [nasal] (i.e., [approximant] vs. [nasal]), according to the standard interface conditions. But now with SONORITY 2 after Strengthening, the contrast VOCALITY 1 *vs*. VOCALITY 2 is the one that will actualize as the contrast [voiceless] vs. [voiced]. It is important to note that there is no actual process that involves the conversion of the sounds [ʊ] to [v] and to [f] or [ʊ] to [□□] and to [v]. The necessary conversion is plotted behind the scene by the conversion among abstract nodes, which brings about the effect of *sonority strengthening* and *devoicing*. [8]

Now, let us return to our question on ʊ at a SONORANT SITE. According to (60), *v* = ʊ is at a SONORANT SITE if (i) it precedes a liquid, nasal or vowel, or (ii) it is at word-final position. Consider (i). In this case, neither liquid, nasal n vowel triggers Assimilation. Hence, if ʊ is Strengthened, the output is F = [SONORITY 2, VOCALITY 1, PLACE 2], which actualizes as [f]. But *v* is not pronounced as [f] before a liquid, nasal or vowel. Hence, we have to conclude that Strengthening must not apply in this case. In case (ii), on the other hand, we have final devoicing of *v*: *v* is pronounced as [f]; Strengthening must apply.

[8] For the sake of argument, let us entertain the possibility of leaving the Strengthening rule in the form of the first version (67). Then, ʊ at a sonorant site is not strengthened, and retains SONORITY 3; ʊ actualizes as [ʊ] instead of as [v]. Then, due to (60), we predict that the orthographic *v* is pronounced as approximant [ʊ] instead of fricative [v], if it precedes a sonorant or a vowel. It is an intriguing prediction. But one problem with this approach is that Strengthening also fails to apply to word-final *v*.

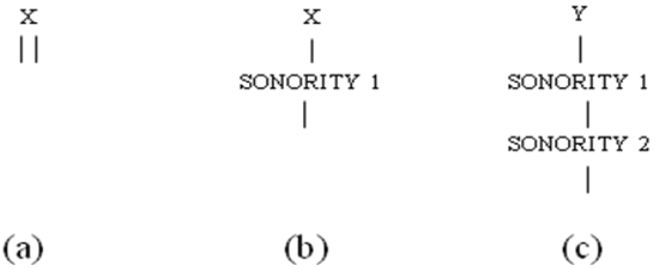
Thus, (67) targets too narrowly and (69) too broadly. But we can get out of this difficulty by putting a restriction on what is to the right of ʊ in (69) as follows:

(70) ʊ Strengthening (the final version)



Y in (70) is either of the following forms:

(71)



If we choose (a), X is in word-final position. Then, ʊ is at a SONORANT SITE, hence VOCALITY 2 must be chosen under X in (70); thus, in effect we have chosen (69). If we choose (b) or (c), ʊ precedes an obstruent and is at a CONSONANTAL SITE, due to (60), hence VOCALITY 2 may not be chosen under X in (70); thus, in effect we have chosen (67). Thus, whether we choose (a), (b) or (c), we have a desired result. On the other hand, if a segment that follows ʊ is a nasal, liquid or vowel Y is not satisfied in (70), hence, (70) cannot apply to ʊ; ʊ does not get strengthened.

To recapitulate, with (70), we have the following result: If ʊ is followed by an obstruent or is in word-final position, ʊ gets Strengthened, and it actualizes either as [f] or [v], as the case may be (that is, whether Assimilation changes VOCALITY 1 to VOCALITY 2 or not); if ʊ is followed by a nasal, liquid or vowel, ʊ does not get Strengthened and it gets actualized as [ʊ].

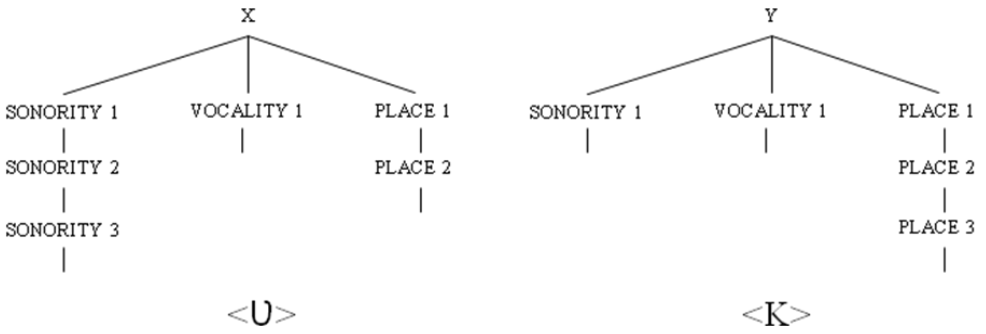
To conclude, then, we have attempted to transfer Hayes and Kiparsky's rule of *W Strengthening* into our framework of a-geometry, and arrived at an analysis that makes somewhat different predictions from the Hayes/Kiparsky analysis. According to the Hayes/Kiparsky analysis, *v* is strengthened from [w] to fricative [f] or [v].[9] Our analysis

[9] In contrast to Hayes and Kiparsky, Padgett (2002:15) takes the position that *v* is a sound "having a status intermediate between the [obstruents and sonorants]," and represents it by [□□]. Padgett's position may appear to be similar to mine. However, I assume *v* to be underlyingly a sonorant ʊ and a fricative or sonorant on surface, while Padgett proposes "a surface-based account" and presumably takes [□□] as a uniform surface representation of *v*.

predicts that *v* is a fricative before an obstruent or in word-final position, but an approximant before a sonorant or vowel. The phonetics of *v* is a matter of considerable complexity and subtlety and defies any simplistic phonemic analysis. Nonetheless, I would summit our analysis of *v* Strengthening as one providing a viable prediction on this matter. Let us examine how rule (70) works.

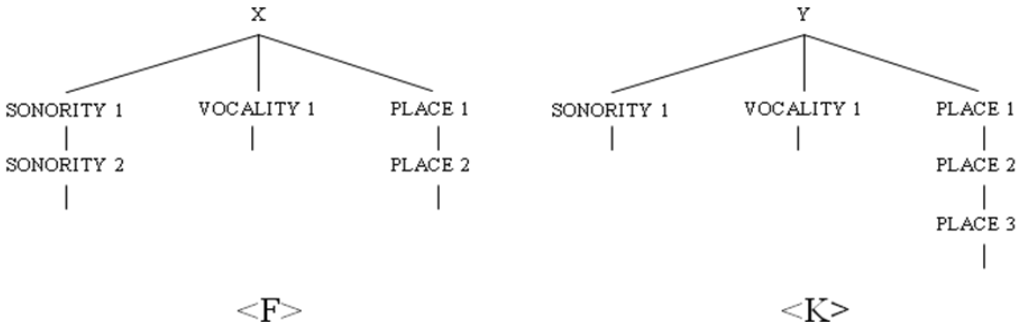
Consider first *korov-ka* 'cow (dimin)' [H:318]. The underlying representation is KoRoʊ Ka. This form is affected by neither Neutralization nor Assimilation. The relevant part of the input to Strengthening is as given below. Note that ʊ precedes a CONSONANTAL SITE, hence itself is at a CONSONANTAL SITE:

(72)



This sequence X satisfies the structural description of (70), and SONORITY 3 is delinked from X; we get X Y = F K:

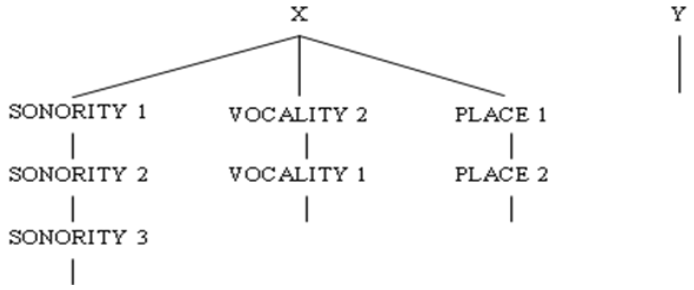
(73)



Thus, we have KoRoF Ka, which is phonetically implemented as [korofka]. A remarkable feature of this account is that even though the derivation captures the devoicing of *v*, it does not involve a process of *devoicing*, only ʊ Strengthening.

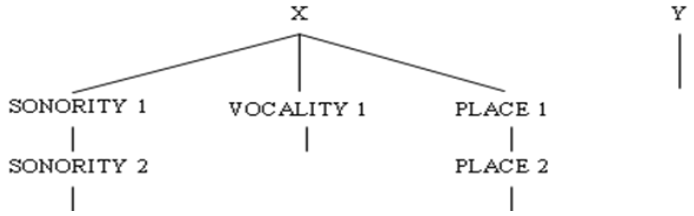
Next we consider the case in which *v* strengthens and devoices at word-final position. Take *zdorov* 'healthy' [H:318]. The underlying form is zdoRoʊ. Neutralization and Assimilation do not affect this form. We have ʊ is at word final position, hence, by (60), at a sonorant site. Hence we have the following sequence:

(74)



As X satisfies the structural description of Strengthening(70). SONORITY 3 gets delinked from X. X becomes an obstruent and its site cannot remain a sonorant site; the vocality branch must re-reverse to the normal projection. Hence after Strengthening applies, we have the following sequence:

(75)

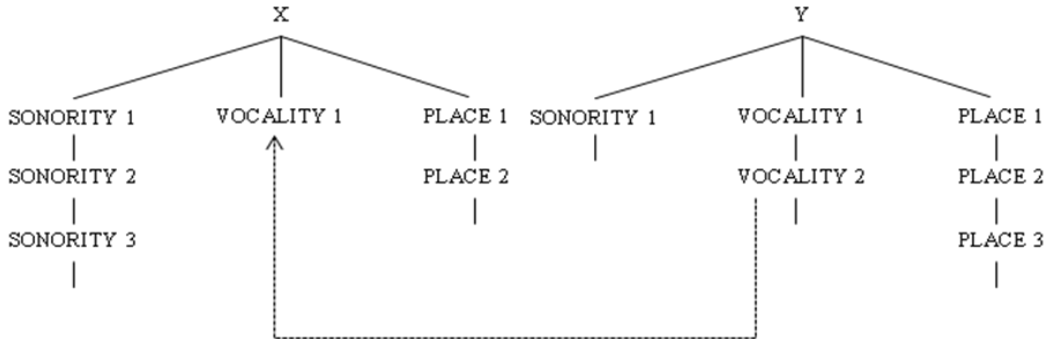


X = <F>; it is phonetically implemented by [F]. Thus, the phonetic form of *zdorov* is [zdorof].

ʊ Strengthening corresponds to *W Strengthening* in the standard generative account. However, as we have seen above, it transforms ʊ = [SONORITY 3, VOCALITY 2, PLACE 2] into F = [SONORITY 2, VOCALITY 1, PLACE 2], and hence, in effect, voiced [ʊ] into devoiced [f]. This is because the standard interface condition interprets VOCALITY degree 1 as a voiced approximant for a SONORITY DEGREE 3 segment and as a voiceless fricative for a SONORITY DEGREE 2 segment. Thus, ʊ Strengthening has the combined effect of *sonority strengthening* and *devoicing.*

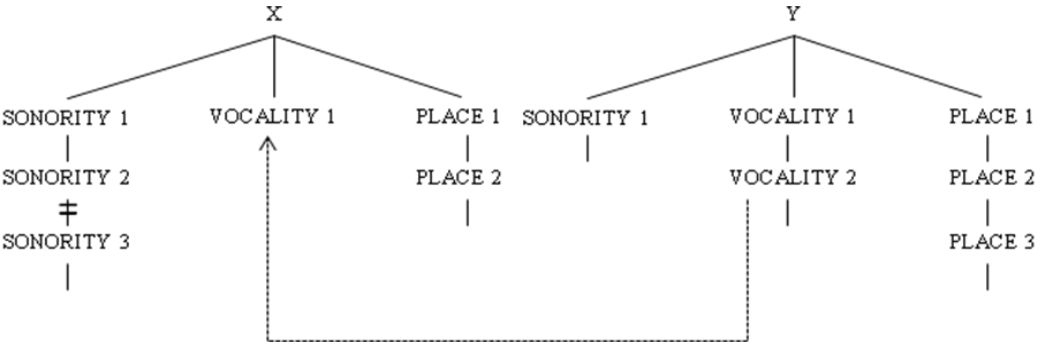
Finally, let us consider *avgust* 'August'. The underlying form is aʊGust. Assimilation assimilates ʊ = [SONORITY 3, VOCALITY 1, PLACE 2] to G = [SONORITY 1, VOCALITY 2, PLACE 3] and changes it into [SONORITY 3, VOCALITY 2, PLACE 2]. Strengthening acting on this segment derives [SONORITY 2, VOCALITY 2, PLACE 2]. The standard interface conditions interpret this segment as [v]. Hence we get *a*[v]*gust*. Let us confirm this derivation by examining the relevant part in tree form:

(76) Assimilation



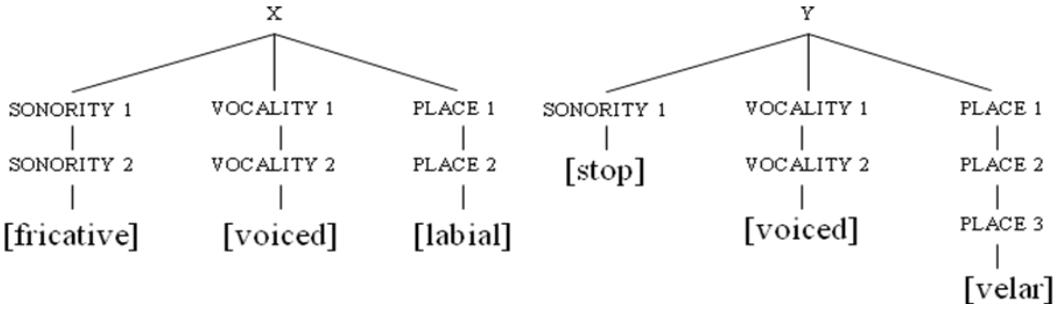
(76) matches the structural description of (69):

(77) Strengthening



The standard interface condition converts this tree to the following phonetic form:

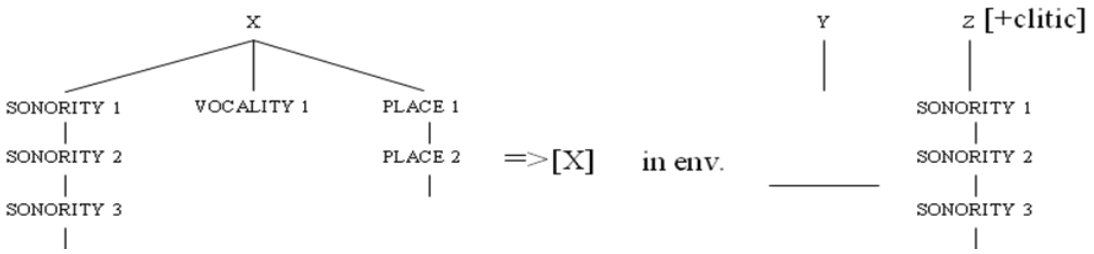
(78)



5. 2.3.2. *An exception to ʊ Strengthening*

There is an exception to the phenomenon of *W Strengthening*. "The segment /v/ differs from other obstruents in that it appears voiced in word-final position if a sonorant-initial clitic follows: compare *zdorov#li* [vl'] 'Is he healthy?' with *grjob#li* [pl'] 'Did he row?'" [H:321]. It might appear that we have to complicate ʊ Strengthening by adding a negative environment. Instead, we could *send* the relevant form to phonetics before it reaches ʊ Strengthening. Thus, we can introduce a rule of the following form ordered before ʊ Strengthening:

(79) Sonorant-initial clitic rider to ʊ Strengthening



By convention (18), the bracketed [X] on the right side of => indicates that X is a phonetic segment. X is sent to phonetics (converted into a phonetic symbol) and is not to be available to phonological rules any more.

5.2.2.3. *The problem of "syllabification"*
Recall that according to Hayes's/Kiparsky's analysis there is an optional rule of syllabification that bleeds assimilation, which is supposed to account for the alternation illustrated by (31)2.3, which I repeat here:

(80) Sonorants are *optionally transparent to* assimilation:

iz# mcensk+a	i[s mc]ensk+a	~ i[z mc]enska	'from Mcensk'	[K:(49) (71)]
ot#mzd+y	o[d mzd]y	~ o[t mzd]y	'from the bribe'	[K:(49) (71)]

Hayes and Kiparsky introduce a rule of syllabification that syllabifies sonorants (*m* in the above examples) in the relevant environment; syllabified sonorants, like vowels, would block assimilation from propagating just as vowels do, a plausible proposal. What is the relevant environment? Kiparsky formulates Syllabification in the following form:

(81) *Sonorant Syllabification* (optional) [K:(57)]

$$\begin{bmatrix} +\text{son} \\ +\text{cons} \end{bmatrix} \longrightarrow [+\text{syll}] \;/\; \#\_\_C$$

But Hayes, as I cited before, states: "Voicing Assimilation is sometimes bled by an optional rule, motivated in Reformatskij (1971), which syllabifies sonorant liquids and nasals *that are not adjacent to a vowel*" (H: 327, note 1; italics supplied.) Given the discrepancy between Hayes's and Kiparsky's description of the environment as well as the uncertainty for how to interpret "adjacent to a vowel" in Hayes's phrasing, , conforming to the relevant examples given by Hayes and Kiparsky, I am tentatively taking the liberty of formulating the syllabification rule as follows:

(82) *Sonorant Syllabification* (optional)
Syllabify a sonorant between two obstruents.

I would like to propose that in a-geometry we achieve the same effect as Hayes's and Kiparsky's rule of syllabification by having recourse to projection reversal. We wish to designate sonorants at the relevant environment to be optionally at a SYLLABIC SITE,

where, to recall, the SONORITY BRANCH as well as the VOCALITY BRANCH are projected in reverse. See section 3.3.

Before giving a precise formulation to the rule of syllabification in terms of the formalism of a-geometry, we need to deliberate on an exact range of targets of this rule. For Hayes, according to the passage cited just above, this rule syllabifies *sonorant liquids and nasals*. For Kiparsky, the rule applies to [+son, +cons]. For neither of them does the rule apparently target *v*, which, for Hayes and Kiparsky, is underlyingly (hence when the rule applies) [w]. But for us, *v* is underlyingly ʊ, a [SONORITY 3] segment, as underlying abstract representations of nasals and liquids are. It would then be natural to suspect that *v* in the relevant environment also behaves like nasals and liquids and is to be targeted by the syllabification rule.

In fact, among the examples Kiparsky gives, there is some evidence that supports this prediction. Recall that we have conflicting information in (56) 3 and 4, the relevant part of which I repeat here:

(56) 3. *v,* like obstruents, assimilates
bez vpuska [sfp] 'without admission' [H:319, , 326 (10)]
4. *v*, like sonorants, is a non-target and transparent to assimilation
ot vdov+y o[d vd]ovy 'from the window' [K:(53)]
ot vtor+ogo o[t vt]orogo 'from another' [K:(53)]

In these examples, *v* is in the relevant environment. In *bez vpuska* and *ot vdov+y,* presumably *v* does not get syllabified and does not bleed assimilation. In contrast, in *ot vtor+ogo*, *v* does not get assimilated to the following *t*; this can be accounted for only if we assume that *v* gets syllabified.

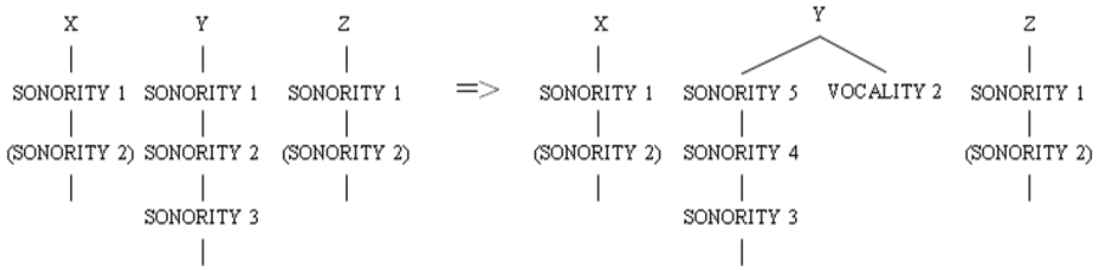
But according to the data we get from Hayes and Kiparsky, the evidence is not quite perfect. If our *optional* rule should literally extend to *v*, the data in (56) should expand to the following alternations:

(83) *bez vpuska* [s fp] ~ ***bez vpuska*** [z vp] 'without admission'
ot vdov+y [d vd] ~ ***ot vdov+y*** [t vd] 'from the window'
ot vtor+ogo **[t ft]**~ *ot vtor+ogo* [t vt] 'from another'

But the forms in boldface are missing in Hayes's and Kiparsky's data. The predicted alternation is thus attested by the structural pattern, but not by individual words in the form of minimal pairs.

Nonetheless, I here assume that the syllabification rule applies to *v* as well, that is, that its targets are [SONORITY 3] segments in general. I formulate the rule in terms of a-geometry as follows:

(84) "Syllabification" (optional)

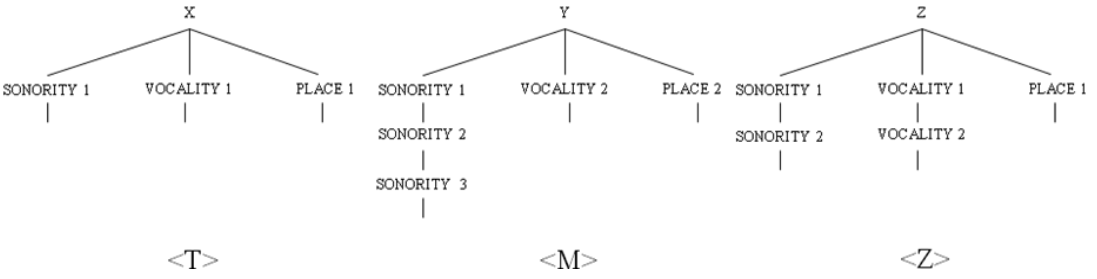


If the target Y is the underlying form of a liquid or a nasal, it is at a sonorant site, due to (60), and the VOCALITY branch is reversed before the rule applies. In contrast, if Y is ʊ, it is at a consonantal site, due to (60), as it precedes an obstruent Z; hence, its VOCALITY branch is projected normally, and the rule reverses the projection. The rule is ordered before Neutralization and Assimilation.[10]

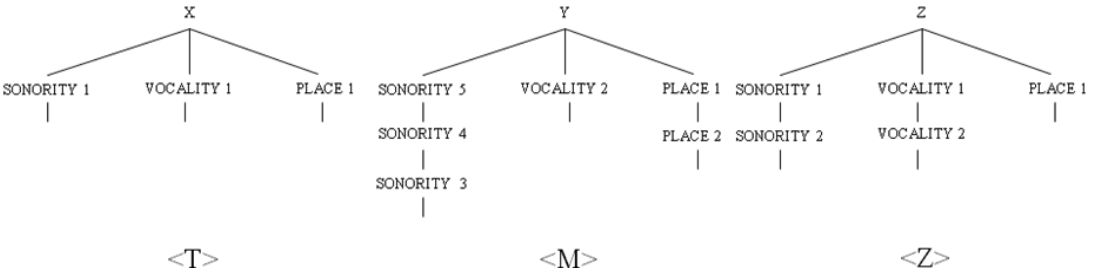
Let us see how the rule works by examining the relevant parts of the derivations *ot mzdy* [t mzd] 'from the bribe' (the right hand alternant of the second line in (80)) and *ot vtorogo* [t vt] 'from another':

(85) Examples of the application of Syllabification

Underlying representation for *ot mzdy*:

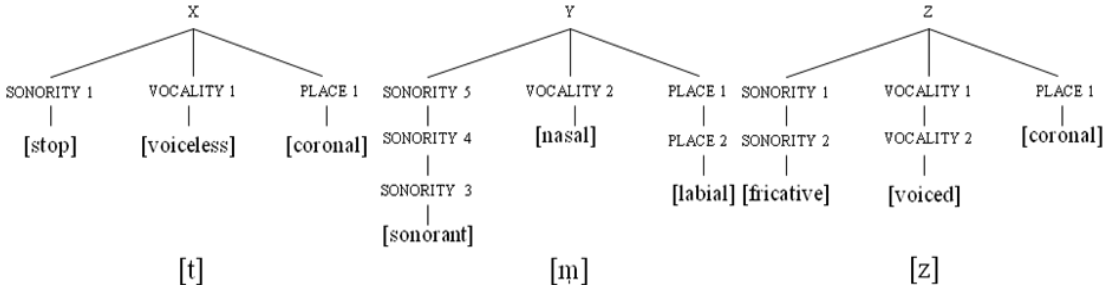


Output of Syllabification:

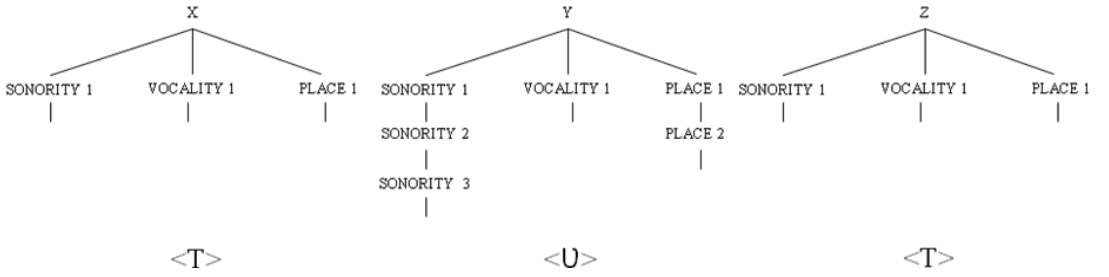


[10] As far as I can see, *ot vtor+ogo* [t vt] [K:(53)] cannot be derived by the set of rules given by Kiparsky [K:(56)-(62)]. Sonorant Syllabification as formulated by Kiparsky [K: (57)] cannot target [w] which underlies *v*, since it is presumably [-cons].

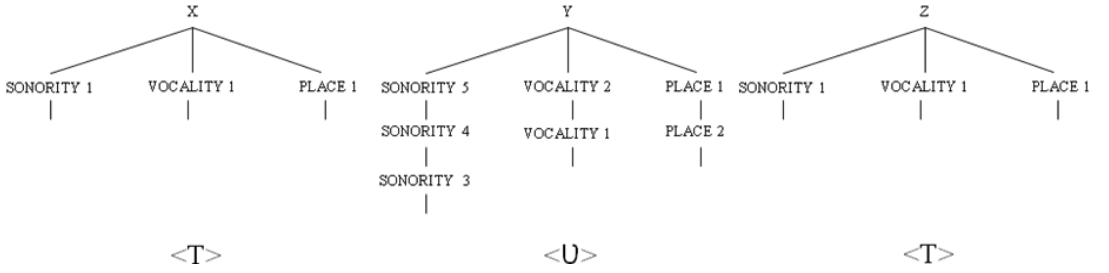
Interface conditions:



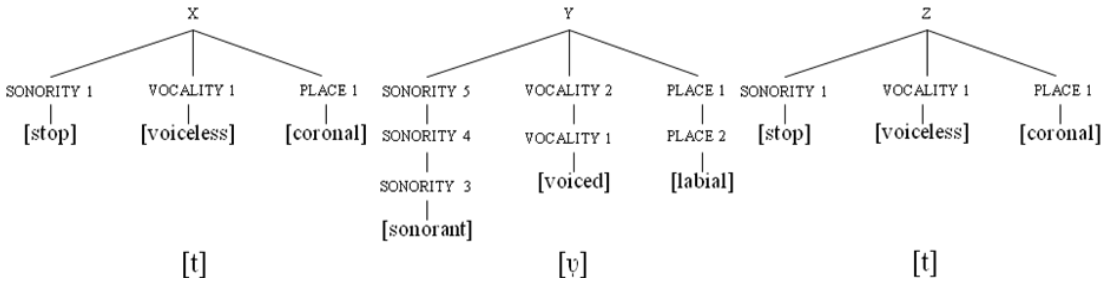
Underlying representation for *ot vtorogo*:



Output of Syllabification:



Interface conditions:



6. The analysis formulated in terms of a-geometry

6.1. *The analysis*

Let me summarize the analysis presented above by putting together the rules and conventions.

Notations

(86) Phonetic segments (= (18))
Phonetic segments may be indicated by a symbol for a segment tree put in brackets: [X]

Representations

(87) Representation of a break (= (24))
X represents a break (silence).
|

(88) Underlying representation of v
v = [SONORITY 3, VOCALITY 1, PLACE 2]

Conventions

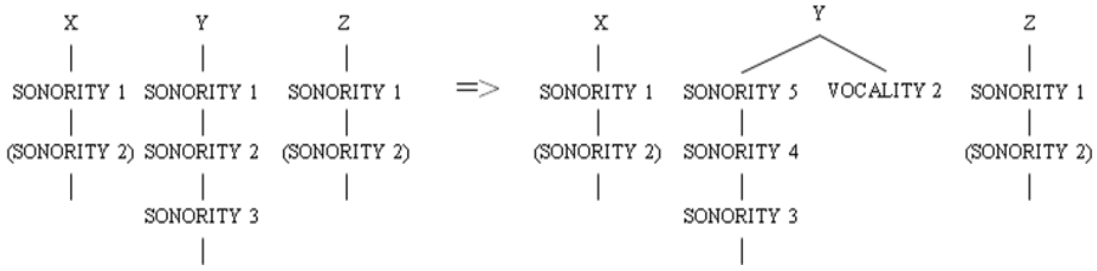
(89) The convention for a dangling bar attached to branch B of X(= (25))
(a) For X as part of a structural description
For a segment Y to satisfy X, Y's branch B must terminate at the same node as the one to which the bar is attached.
(b) For X as a segment in a phonological representation
Branch B is sent to phonetics and has become invisible to phonology.
(c) A bar attached to root X indicates that X is a break (word-boundary).

(90) The maximality convention for structural description(= (38))
A rule applies to the maximal string that fits the structural description.

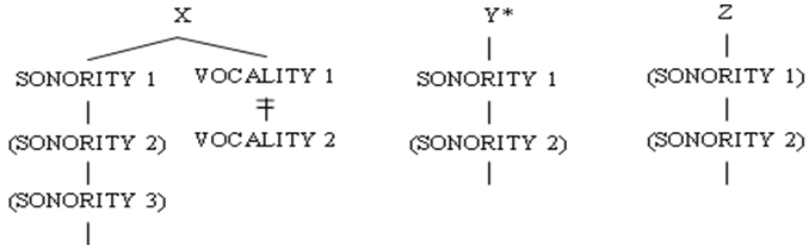
(91) Site type specification for Russian [SONORITY 3] segments(= (60))
A SONORITY 3 segment X is at a consonantal site if X = ʊ and X precedes a consonantal site; otherwise X is at a sonorant site.

Ordered set of rules

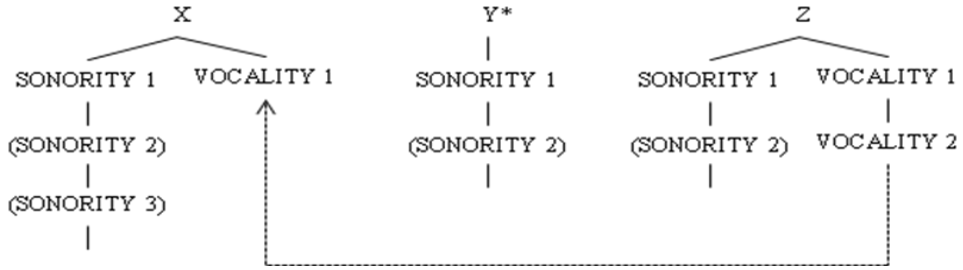
(92) "Syllabification" (optional) (= (84))



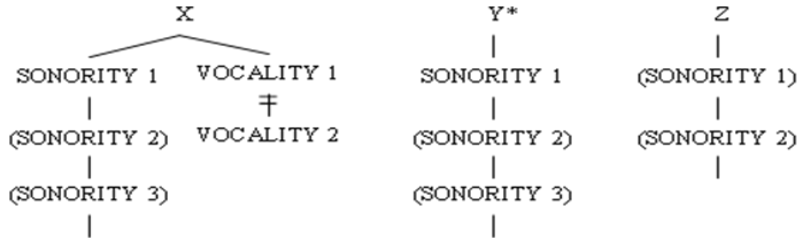
(93) Voicing Neutralization (reformulated)--the weak form (= (61))



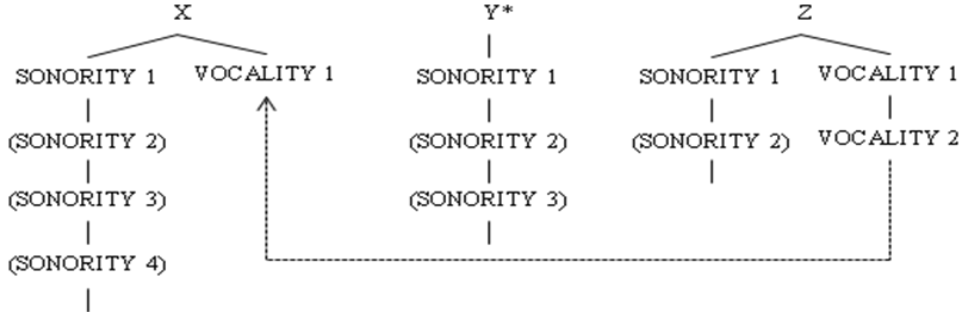
(94) Voicing Assimilation (reformulated)--the weak form (= (62))



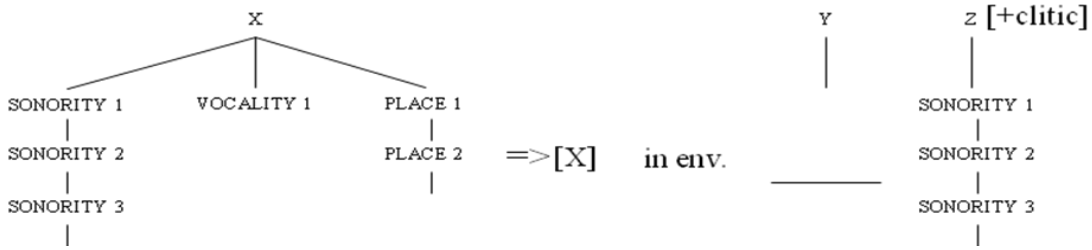
(95) Voicing Neutralization--the strong form (= (63))



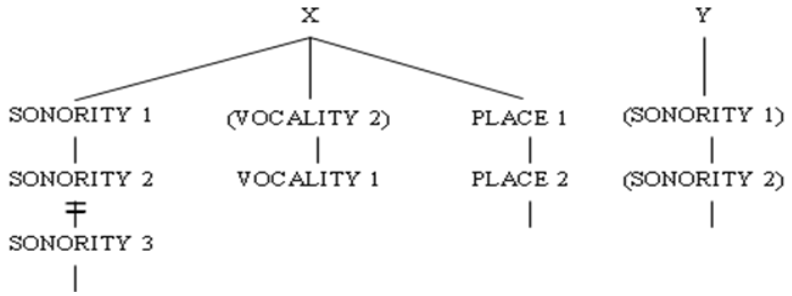
(96) Voicing Assimilation -- the strong form (= (64))



(97) Sonorant-initial clitic rider to ʊ Strengthening (= (79))



(98) ʊ Strengthening (the final version) (= (70))

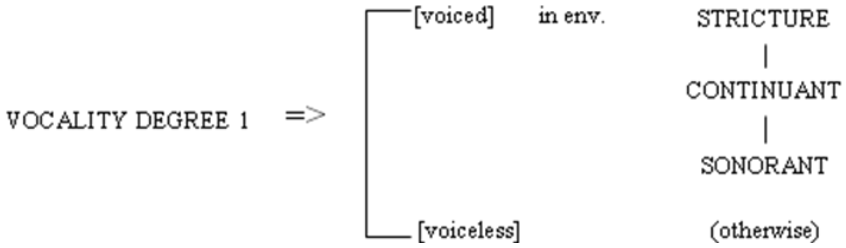


Standard interface conditions for the PF representation

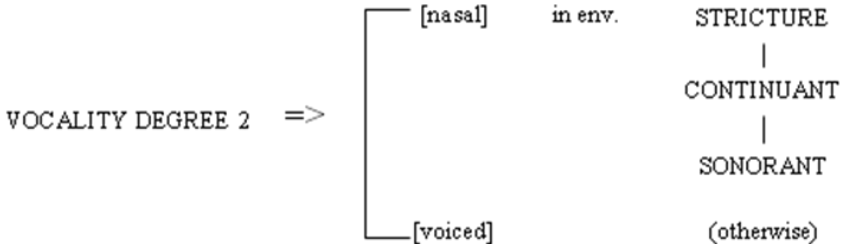
(99) The interface conditions for SONORITY

SONORITY DEGREE 1	=>	[stop]
SONORITY DEGREE 2	=>	[fricative]
SONORITY DEGREE 3	=>	[sonorant]
SONORITY DEGREE 4	=>	[glide]
SONORITY DEGREE 5	=>	[vowel]

(100) The interface conditions for VOCALITY DEGREE 1



(101) The interface conditions for VOCALITY DEGREE 2



(102) The interface conditions for PLACE

PLACE 1 (CENTRAL)	=>	[coronal]
PLACE 2 (PERIPHERAL)	=>	[labial]
PLACE 3 (BACK)	=>	[velar]

6.2. *Examples* of derivations

(1) *v* strengthens and devoices at word-final position

Orthographic	*zdorov*			[H:318]
Gloss	'healthy'			
UndlyingRprsnttn	SDoRoʊ	or	ZDoRoʊ	
Neutralization	_____		SDoRoʊ	
Assimilation	ZDoRoʊ		ZDoRoʊ	
Strengthening	ZDoRoF		ZDoRoF	
SurfaceRprsnttn	ZDoRoF		ZDoRoF	
Phonetic Form	zdorof		zdorof	

Remark. The underlying form is indeterminate from the formal point of view.

(2) *v* strengthens and devoices before a voiceless obstruent

Orthographic	*korov-ka*	[H:318]
Gloss	'cow (dimin)'	
UndlyingRprsnttn	KoRoʊ Ka	
Neutralization	_____	
Assimilation	_____	
Strengthening	KoRoF Ka	
SurfaceRprsnttn	KoRoFKa	
Phonetic Form	korofka	

(3) *v* strengthens and devoices before a devoiced final obstruent

Orthographic	*krivd*	cf:	*krivda*	[H:318]
Gloss	'falsehood' (gen. pl.)		'---nom.'	
UndlyingRprsnttn	KRiʊD		KRiʊ D-a	
Neutralization	KRiʊT		KRiʊ D-a	
Assimilation	_____		KRiMD-a	
Strengthening	KRiFT		KRiVD-a	
SurfaceRprsnttn	KRiFT		KRiVD-a	
Phonetic Form	krift		krivda	

Remark. One should not be misled by the symbol *M* in *KRiMD-a* above and understand that the derivation undergoes nasalization only to get de-nasalized at the next stage. *M* is only a convenient notational convention for denoting the segment [SONORITY 3, VOCALITY 2, PLACE 2]. *M* simply hints at the marked specification at the VOCALITY BRANCH for the SORNOTIY DEGREE 3 level. This marked status is kept intact when the segment is strengthened up to SONORITY DEGREE 2 level.

(4) *v* fails to trigger Assimilation

Orthographic	*s vami*	
Gloss	'with you'	
UndlyingRprsnttn	S ʊaMi	
Neutralization	_____	
Assimilation	_____	
Strengthening	S ʊaMi	
SurfaceRprsnttn	S ʊaMi	
Phonetic Form	s ʊami	[H:319] =[H:(4)c]

(5) *v* permits "voicing assimilation" to propagate across it

Orthographic	*ot vdovy*	[H:319]
Gloss	'from the window'	
UndlyingRprsnttn	oT ʊDoʊy	
Neutralization	_____	
Assimilation	oD MDoʊy	
Strengthening	oT VDoʊy (M is before a CONSONANTAL SITE, ʊ is not.)	
SurfaceRprsnttn	oD VDoʊy	
Phonetic Form	odvdoʊy	

Remark. Either the strong or the week form of Assimilation works, since the first ʊ on line 3 is at a CONSONANTAL SITE. Similarly for (6) below.

(6) *v* permits "devoicing assimilation" to propagate across it as well

Orthographic	*bez vpuska*	[H:319] =[H:(4)f]
Gloss	'without admission'	
UndlyingRprsnttn	BeZ ʊPuSKa	
Neutralization	BeS ʊPuSKa	
Assimilation	_____	
Strengthening	BeS FPuSKa	
SurfaceRprsnttn	BeS FPuSKa	
Phonetic Form	bes fpuska	

(7) Word-final devoiced v does not trigger Assimilation

Orthographic	*trezv*	[H:319]
Gloss	'sober'	
UndlyingRprsnttn	TReZʊ	
Neutralization	_____	
Assimilation		
Strengthening	TReZF	
SurfaceRprsnttn	TReZF	
Phonetic Form	trezf	

Remark. ʊ is at a SONORANT SITE and does not get targeted by Neutralization.

(8) Different effects of Strengthening on ʊ in different environments

Orthographic	*v skvazine*	[H:(4)a]
Gloss	'in the chink'	
UndlyingRprsnttn	ʊ SKʊaZiNe	
Neutralization	_____	
Assimilation	_____	
Strengthening	_____	
SurfaceRprsnttn	F SKʊaZiNe	
Phonetic Form	fskʊazine	

Remark. According to Hayes's analysis, the first *v* = [w] gets devoiced and strengthened to [f]; the second *v* does not get devoiced and get strengthened to [v].Our analysis takes the second *v* to be a labial approximant.

(9) "Like sonorants *v* is transparent to Voicing Assimilation" [K:104]

Orthographic	*ot vtor-ogo*	[K:53]
Gloss	'from another'	
UndlyingRprsnttn	oT ʊToR-ogo	
Syllabification	oT ʊToR-ogo (optional)	

		(ʊ is put at a SYLLABIC SITE; its SONORITY as well as VOCALITY BRANCH gets reversed.)
Neutralization	_____	
Assimilation	_____	
Strengthening	_____	(Since ʊ is at a SYLLABIC SITE, Strengthening does not apply.)
SurfaceRprsnttn	oT ʊToR-ogo	
Phonetic Form	ot ʊtor-ogo	

7. Summary and conclusion

The sonorant is a versatile phonetic element. It can function just like a consonant in the onset or display its sonorous character in the coda or the transition to the nucleus, or serve as the nucleus. This versatility causes difficulties for a geometry based on the classificatory conception of features. My earlier work, Aerodynamic Feature Geometry (ADFG), severed phonological geometry from the idea of class features; geometry is to represent the markedness hierarchy, not the classificatory hierarchy of set-theoretic extensions. In the present work ADFG has further advanced to Aerodynamic Phonological Geometry (ADPG) by altogether severing its ties with phonetic features in phonology. The geometry now consists of abstract nodes, only formally representing the markedness hierarchy. Nodes are related to phonetic features indirectly, phonetically implemented only by interface conditions in phonetics.

The idea of projection reversal was first introduced naturally into ADFG to deal with different perspectives on sonority markedness from the consonantal and vocalic viewpoints, and was later productively extended to deal with phonological phenomena involving sonorants. It was applied to the problem of Sonorant Assimilation in Korean, then to Coda Nasalization in Japanese, and has now found a particularly productive application in ADPG to the problem of Voicing Assimilation in Russian.

Working through technical details might, I am afraid, cause undesired weariness in the reader and invite unwelcome aversion. However, working out an unfamiliar formalism in detail is unavoidable for an entirely new formal approach. I only hope that the attentive reader will have noticed that the ideas behind the proposed formal analysis of this Russian phenomenon are in fact rather simple and even quite intuitive.

Abstract node geometry is empirically grounded in discrete contrasts observed in phonological functions. It is concerned with the cognitive reality of the grammar of human language (I-language). The abstract phonological node representation, a cognitive entity, must ultimately be implemented in the physiological and acoustic reality via the articulatory-perceptual interface. The principal assumption underlying ADPG is that abstract node geometry must in some significant way be rooted in the nature of this physical reality and how the human articulatory-perceptual ability can exploit it. ADPG intends to steer clear of the temptation to construct a geometry by allowing itself to take functional but otherwise unmotivated contrasts as its basis, a current tendency noticeable in feature geometry.

In contrast to abstract phonological nodes, there is no a priori, conceptual or empirical basis for assuming that this link from cognitive to physical reality (in the narrow sense) must be mediated by interface conditions at the articulatory-perceptual level represented in a *discrete system* of *phonetic* features in the way understood in contemporary phonology. Articulatory-perceptual interface conditions might as well be described by a non-discrete, strongly context sensitive mechanism, such as the C/D model presently

explored by Osamu Fujimura and others (See Fujimura 1992, 1996, 2002, among others). Representations in terms of phonetic features in the classical sense as employed above might then be a scientific artifact. Such an artifact would be misleading relative to the understanding of the human cognitive capacity, but in a historical perspective should be allowed to have the role of an interim, convenient heuristic guide in the still advancing science of speech; it might well even be a necessary artifact for human scientists for understanding their own achievement. But, of course, I am not claiming that the case for ADPG made here provides any argument in favor of such a view of phonetic features. I only wish to point out that in spite of the reference to phonetic features in the presentation in this paper, the principal idea of ADPG is independent of the ontological or cognitive status of *phonetic* features.

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Printed 10/9/13