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A CONSTRAINT-BASED APPROACH TO
RUSSIAN VOICING ASSIMILATION

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A CONSTRAINT-BASED APPROACH TO RUSSIAN VOICING ASSIMILATION

By

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ABSTRACT

A CONSTRAINT-BASED APPROACH TO
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This thesis investigates Russian voicing assimilation within the framework of non-linear phonology. Two topics dealt with are the nature of assimilation rules and asymmetry effects.

In autosegmental phonology, a '[Spread αF]' analysis has been considered a sole mechanism of assimilatory processes. This single spreading analysis, which requires a binary feature system when both values of a feature assimilate, is problematic if a feature is indeed privative. Assuming Lombardi's (1991) privative analysis of [voice], I propose a constraint-based approach to assimilation, which allows a feature to be expressed in any type of feature systems. Russian voicing assimilation is expressed by two types of processes: spreading or delinking of [voice]. Persistent constraint-motivated rules of assimilation eliminate extrinsic rule-ordering.

Explanation of the asymmetrical segment v in Russian requires Radical Underspecification. The segment must be underlyingly unspecified for the contrastive feature [sonorant], which cannot be so under Contarstive Underspecification.

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Finally, with love and gratitude, I would like to dedicate this thesis to my family and Ban, without whom I could have never enjoyed underspecification of my life.

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1. Introduction

Recent nonlinear phonological research has revealed the importance of focusing primarily on representations rather than rules. Phonologists' attention has shifted from the conditions on rules to the conditions on the representations based on the assumption that we cannot have the right rules without defining the right representations (McCarthy 1988: 84). The correct representations may entail the correct rules, but not conversely.

As the importance of phonological representations in constructing phonological rules and grammar has been realized, approaches appealing to conditions or constraints on representations have begun to take a central role in current nonlinear phonological theories.

It is also recognized in nonlinear phonology that a set of modular theories is more restrictive and thus preferred to a homogeneous one. A formal theory does not itself have to explain every phonological phenomenon (Kiparsky 1985: 85, McCarthy 1988: 84). One subtheory explains certain aspects of phonological phenomena such as asymmetry of a phonological segment and another subtheory accounts for some other aspects like vowel harmony.

In this thesis, I will reanalyze widely assumed non-linear approaches to phonological phenomena, examining Russian voicing assimilation.

One issue considered here is the nature of assimilation rules. In autosegmental phonology, which uses multi-tiered representations of segment-internal structure, assimilation phenomena, just like harmony processes, have been analyzed in terms of the spreading of features, usually being preceded by the delinking of a formerly or inherently associated feature value. This is particularly convenient for a type of assimilation which involves both values of a feature since we can express the assimilation of both values by a single spreading rule. This has been a strong claim for autosegmental spreading in a binary feature system.

As a component of phonological representations, the n-arity of a feature has become an important issue. Recently, Trubetzkoy's notion of a mixed feature system has captured phonologists' attention (Goldsmith 1985, Steriade 1987, Mester & Ito 1989, Lombardi 1991). Trubetzkoy (1969 (1939)) considered three types of feature oppositions: privative, binary and multi-valued oppositions based on the behavior of individual features. One extreme position in non-linear phonology is that all features are privative[1], single-valued. While it is not clear whether phonological features are in fact all privative, several desirable consequences of the use of privative features (not necessarily all features) have been brought into discussion. Goldsmith (1985) uses the combination of binary and privative features to account for vowel harmony processes of several languages, based on the assumption that the choice between privative and binary feature systems is determined by each

[1] In this thesis, the term 'privative' is used interchangebly with single-valued or unary features as it is used in recent works (Goldsmith 1985, Mester & Ito 1989, Lombardi 1991).

language. Others argue that some features are universally privative. Steriade (1987) claims that some features like [round] are single-valued and that treating such features as single-valued enables us to eliminate a number of redundancy rules and issues of rule-ordering. Mester & Ito (1989) suggest the adoption of privative voicing and point out that a privative feature system can restrict a theory more than a binary system can. Lombardi (1991) provides evidence for privative laryngeal features.

There are some difficulties for privative features, one of which is assimilations of both values. These must be analyzed by using binary features since there is no way to express the spreading of the minus value of a feature which is simply expressed by the absence of the feature (den Dikken & van der Hulst 1988: 45).

However, I argue that it is not a privative feature system itself that is problematic in accounting for assimilations of both values. What is problematic is a rule which always requires any feature to be binary regardless of the nature of each feature when both values of a feature assimilate when a feature is indeed proved to be privative. This does not follow one of the basic assumptions of non-linear phonology that right representations entail right rules. Therefore, we have to know first what the correct representations or more sepcifically feature systems of features are. Lombardi (1991: 9-11), using the privative [voice], analyzes Polish voicing assimilation, which involves both values, by two independently motivated mechanisms: delinking and spreading. In her analysis, assimilaiton of both values is accounted for by two separate processes: voicelessness assimilation is expressed by the delinking of [voice]; voicedness assimilation by the spreading of [voice].

Another issue considered in this paper involves the treatment of asymmetry of a phonological segment. It is not uncommon that a phonological segment behaves differently from other segments of a group in a single language system. With help from the autosegmental framework, theories of underspecification have provided an account for this phenomenon. According to one theory of underspecification, Radical Underspecification, a particular segment shows asymmetrical behavior not because phonological rules treat such an asymmetry of a segment as special. It is rather because of the difference in segment-internal structure. More specifically, phonological segments are expressed in terms of an organized set of features on multi-tiered representations. Phonological rules also refer to the segment-internal structure: they apply to a particular tier or feature value in a hierarchically organized segment-internal structure. Some segments simply lack or are unspecified for certain features in their phonological representations. When a phonological rule refers to a certain feature, segments which lack the feature fail to undergo the rule.

Two types of underspecification available within non-linear phonology are Radical Underspecification Theory (Kiparsky 1982, Archangeli 1984, Archangeli & Pulleyblank 1986; henceforth RUT) and Contrastive Underspecification Theory (Steriade 1987, Mester & Ito 1989; henceforth CUT). Both theories agree that certain predictable feature values are unspecified underlyingly, while they differ in the degree of underspecification. RUT requires underspecification of all predictable features, both redundant and unmarked feature values. It also assumes that at most one value is present underlyingly. CUT, on the other hand, distinguishes redundant feature values

from contrastive or distinctive feature values and is limited to underspecification of the former type and requires distinctive features to be underlyingly specified for both values.

RUT's strong claim is that it explains asymmetry effects better than CUT (Archangeli 1988). Under RUT, which insists on maximal underspecification, a phonological segment can be treated as featureless[2]. CUT, on the other hand, does not allow completely featureless segments and has difficulty in accounting for asymmetry effects under a binary feature system.

Comparing the phonological derivations under the two theories, RUT has fewer specifications but needs more redundancy rules than CUT needs to supply all unspecified feature values. According to proponents of CUT, RUT involves complexity in derivations (Christdas 1988). I will show that this problem can be resolved by adopting the privative features.

Russian voicing assimilation is, in these respects, particularly interesting. It involves the assimilation of both values of the voicing feature and has an asymmetrical segment. Briefly, voicing assimilation in Russian takes place within an obstruent cluster. All members of an obstruent cluster must agree with the final member of the cluster in voicing. It also takes place across sonorant consonants, which are transparent to the process. Among obstruents, the voiced labio-dental fricative v is asymmetrical: it shows dual-

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[2] By a featureless segment, I mean a segment without autosegmentalizable phonological features; thus, while a segment may be without this type of features, the presence of the segment is expressed by the presence of an entity on the CV tier, which is as a core tier not underspecifiable.

characteristics. It fails to trigger voicing assimilation like other sonorant consonants while it undergoes the assimilation like other obstruents.

In traditional analyses, it is assumed that the Russian voiced labio-dental fricative v is derived from a sonorant w (Lightner 1965, Coats & Harshenin 1971, Hayes 1984, Kiparsky 1985: 103-114). In order to account for this asymmetric segment within the context of voicing assimilation, any segmental iterative approach had to construct extrinsically ordered rules, one of which changes the feature of the segment: [+sonorant] -> [-sonorant] (w->v). Voicing assimilation was considered to apply to all consonants in an obstruent cluster iteratively; a devoiced intervening sonorant consonant becomes revoiced by a separate rule (Hayes 1984).

In this paper I will provide a less costly solution to Russian voicing assimilation, integrating subtheories of non-linear phonology: autosegmental and underspecification theories and the privative feature system. In particular, assuming Lombardi's (1991) privative analysis of voicing, I will provide an account for the phenomena of voicing assimilation by using a structural constraint on obstruent-cluster voicing, privative [voice] and Radical Underspecification. A constraint on structural conditions of obstruent clusters allows the use of privative [voice] in Russian. Since a structural constraint allows any type of feature systems, we only have to investigate the n-arity of a feature depending on each feature's behavior with respect to phonological processes. I will also show that when privative voicing is adopted, not only can we eliminate a number of redundancy rules, but also the assimilation processes become non-feature-changing operations. Since cross-linguistically feature-

changing assimilation is considered very rare (Vago 1988), Russian voicing assimilation, which is not a rare type of assimilation, should be expressed in non-feature-changing rules. This constraint on obstruent-cluster voicing motivates two language-specific processes, namely delinking and spreading, referring to linking relations of the voicing feature to both the trigger and targets. In other words, the constraint-motivated rules apply, depending upon whether or not the trigger has [voice]: spreading of [voice] in the case of voicedness assimilation; delinking of [voice] in the case of voicelessness assimilation. These rules have persistent application: they apply whenever the structural descriptions are met. As an effect of privative voicing, the devoicing of word-final obstruent also becomes a single process: delinking of [voice].

The use of privative features brings us some desirable effects on underspecification as well. A privative feature system eliminates some redundancy rules (complement rules in RUT) and their ordering. This is a desirable consequence especially for RUT, whose derivation has been claimed to be more complex than that of CUT (Christdas 1988: 85). The elimination of exstrinsic rule ordering contributes to the simplification of the grammar.

Russian data provide a support for Radical Underspecification Theory. RUT provides a natural account without requiring any extrinsic rule-ordering, obeying a constraint on the interaction of redundancy rules with phonological rules (the RROC, see 2.2.3). Radical Underspecification of w replaces the feature-changing rule of w->v by a redundancy rule. CUT is at pain in accounting for the asymmetrical segment v, which must be specified for [sonorant] under the binary system.

This thesis is divided into six chapters. Chapter two introduces the theories which focus primarily on phonological representations and constraints on representations, namely Autosegmental Phonology and two theories of Underspecification. Two kinds of feature systems, privative and binary features, will also be introduced. Chapter three examines phenomena involved in Russian voicing assimilation. There, we will see the assimilation of both values of the voicing feature and the dual-characteristics of the voiced labio-dental fricative v. Chapter four presents some historical perspectives on voicing assimilation and the special behavior of the labio-dental fricative v. In particular, we attend to Hayes's (1984) ordered set of rules and Halle & Vergnaud's (1981) foot incorporation. Chapter five provides a constraint-based approach to the problems, using Radical Underspecification and privative voicing. I will then discuss the preferability of my solution by pointing out problems associated with a spreading analysis and the principles of Contrastive Underspecification.

2. Theoretical Framework

This section presents an overview of the theories which are assumed in the later chapters: Autosegmental Phonology and two theories of Underspecification, Radical Underspecification and Contrastive Underspecification. Then, we will see two types of feature systems, privative and binary features and their effects on autosegmental representations and underspecification approaches.

2.1. The Theory of Autosegmental Phonology

2.1 1 Autosegmental Representations

The autosegmental framework characterizes phonological properties or features by separate autonomous tiers: the CV (skeletal) tier and melodic tiers (Clements & Keyser 1983). The CV tier is the core tier in autosegmental representations, playing the role of anchor for other elements on other tiers. The CV tier consists of C and V slots (positions), to which consonantal and vocalic elements, respectively, are to be linked. For instance, given a Swahili word *mbu* 'a fly', we can assign each segment to the CV-tier as follows:

(1)

C V-tier	C	C	V
	m	b	u

In (1) above, the segments [m,b,u] themselves are not autosegments but just phonological segments. Phonological segments are decomposed into or

expressed by a set of features, which are represented on melodic tiers. Each melodic tier consists of autosegments, a feature-valued set such as [+nasal] and [-nasal] (in binary terms) for the nasal tier. Autosegmental tiers are associated with or linked to one another by association lines. Association lines indicate temporal associations or linkages between an autosegment P and a P-bearing unit.

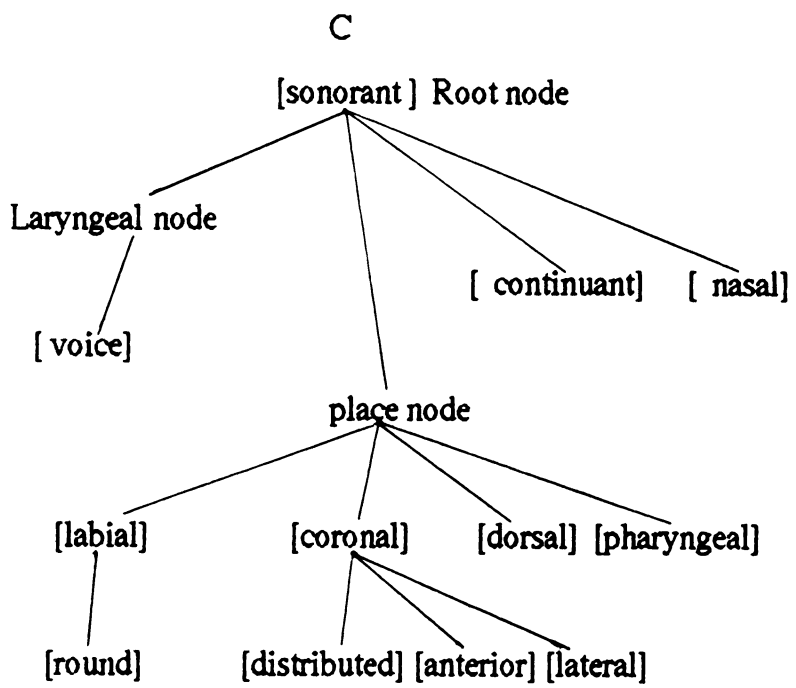
We can associate autosegments to the CV tier. Since each phonological segment consists of a set of features, we can decompose each phonological segment with respect to phonological features: m consists of [+son,+nasal, +labial...], b=[-son,-continuant,+labial,-nasal,+voiced...], and u=[+sonorant,+high,-labial,..].

There is a good reason to suspect that phonological segments are not simply an unorganized set of features. That is, a certain related class of features such as [round] and [labial] function together as a group in undergoing phonological processes (McCarthy 1988, Lombardi 1991). This fact has led to the innovation of feature geometry (Clements 1985). In feature-geometric approaches, features are hierarchically organized to represent a segment-internal structure.

In this work, I assume the slightly modified version of the feature geometry proposed by McCarthy (1988), in which the feature [sonorant] occupies the root node and the voicing feature is not directly but indirectly linked to the root node through the laryngeal node. The CV-tier is added to his geometry for the reason that Russian voicing assimilation requires a consonant-

vowel distinction to identify obstruent clusters, to which the process applies. The geometry is given below:

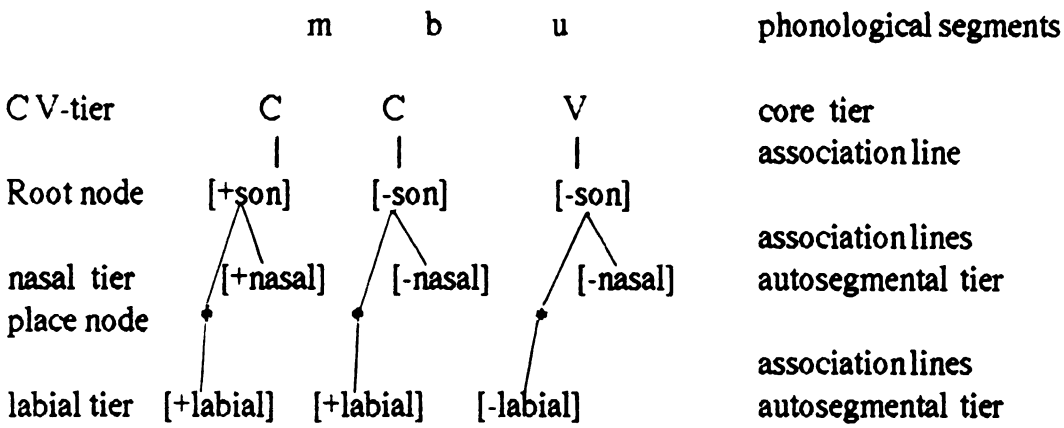
(2) (modified version of McCarthy 1988:105)



It is important to note that, in McCarthy's model, the major class feature [sonorant] is not functioning as an autosegment: it can neither be spread nor be delinked by rules (1988: 97). This becomes crucial later when we come to formulate rules for voicing assimilation in Russian.

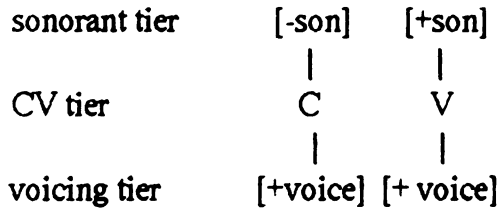
So each phonological segment of the word *mbu* 'a fly" can be partially autosegmentalized with respect to the features [nasal] and [labial] and indirectly linked to the CV (skeletal) tier through nodes by association lines.

(3)



For the purpose of this thesis, we will be concerned only with the relevant features of the Russian voicing assimilation process such as [sonorant], [voice], and the CV tier(skeleton). Since there is no justification for the direct dependence between sonorant and voicing features, they are separately linked to the CV tier (through the laryngeal node, which is understood). For simplicity of representation, they are expressed as below:

(4)



We see that association lines indicate temporal association or linkage of an autosegment P to a P-bearing unit such as C in the CV tier. All association lines are subject to a constraint prohibiting line-crossing as in (5).

(5) Line-crossing prohibition (Goldsmith 1976):
Association lines between the same two tiers may not cross.

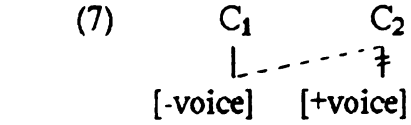
This constraint motivates Tier-Conflation, which is introduced later in this section. In addition, a P-bearing unit cannot be associated to two opposing feature values such as [+voice] and [-voice] at the same time.

In this paper, we will deal with two basic mechanisms of autosegmental phonology (Clements 1985; Hayes 1986; McCarthy 1988):

(6) a. delinking of association lines
b. spreading a feature or an autosegment P, which is already associated to a P-bearing unit, to another P-bearing unit

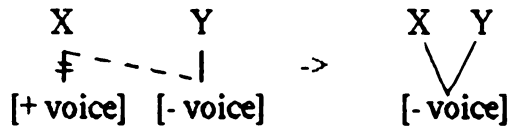
Delinking is a deletion of association lines and spreading is an insertion of them. These mechanisms can be used for a feature-changing process like (7) where the voicing feature of C_1 spreads onto C_2 and the voicing feature of C_2 gets delinked.

(7)



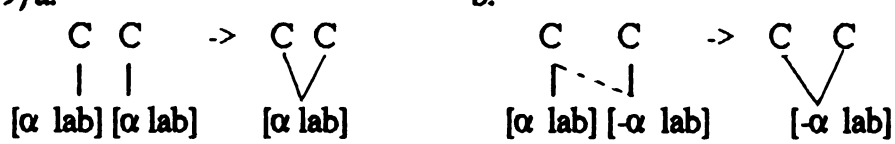
Autosegmental representations place phonological features on different tiers so that assimilation processes such as vowel harmony and voicing assimilation can be expressed autosegmentally with rules referring to associations of only relevant features. Given that X is a target and Y a trigger of voicing assimilation as in (8), we can express assimilation by inserting the assimilation feature of Y [-voice] into the target X, delinking the association line between X and [+voice]. The example in (8) is the case of leftward spread, which is observed in Russian voicing assimilation:

(8)



Strictly speaking, two types of processes are available in autosegmental phonology to explain assimilation phenomena (Mester 1986: 74): fusional and spreading harmony. In fusional harmony, there must be a feature shared by triggers and targets. Fusion cannot apply to a sequence of different values of a feature. In spreading harmony, the voicing feature of the trigger spreads onto all targets, delinking any feature stranded by the process. Fusional and spreading processes are illustrated below as in (9) a and b, respectively:

(9) a. b.



I assume that voicing assimilation is explained by fusional harmony when the targets share the same voicing feature as the trigger; otherwise, it is explained by spreading harmony when the targets and the trigger do not agree in voicing.

2.1.2 Rules and constraints on autosegmental representations

Apart from autosegmental representations, the nature of rule applications in autosegmental phonology can be characterized as persistent or non-persistent: rules and constraints can be either persistent or nonpersistent (Halle & Vernaud 1987, Myers 1991).

Nonpersistent rules (language-specific ordered rules) and universal constraints, on the one hand, block any application of rules which create a violation. Thus, we can predict that there is no occurrence of representations which are to be ruled out by the latter type of rules.

Persistent rules, on the other hand, apply whenever structural conditions are met, changing the ill-formed representations to well-formed ones. Syllabification is claimed to be persistent; so is Foot Formation (Halle & Vergnaud 1987). Rules of this type never block occurrence of ill-formed representations or block application of a rule which creates a violation.

Persistent rules have reasons to exist. First, since they fix ill-formed representations by changing them to well-formed ones, underlying representations of a language do not always have to be well-formed (Myers 1991: 341). This aspect explains the fact that when a foreign word is introduced into a language, the language changes the sound pattern of the word to the permissible sound pattern of the language. Second, persistent application of rules simplifies the grammar: persistent rules reduce burdens associated with rule-ordering. This concludes the illustration of non-persistent rules and universal constraints.

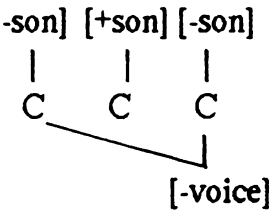
Tier Conflation:

Finally, the principle of Tier Conflation (McCarthy 1986, McCarthy & Prince 1986; henceforth TC) has to be defined. According to McCarthy (1986), it is a process which reshapes multi-tiered representations into single linearized representations. When TC linearizes representations, some multiply

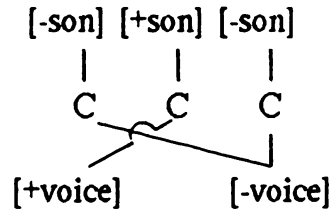
linked associations may have to be broken in order to satisfy the line-crossing constraint (McCarthy 1986: 7).

For example, suppose that a language has a representation like (10a), in which a link of the voicing feature to the obstruents is created by spreading across any sonorant consonants or vowels. When a rule supplies the intervening sonorant the redundant feature [+voice], the multiple-linking of the voicing feature of the obstruents must be broken since association lines cannot cross (10b). We thus have to break the multiple-association of the voicing feature to the obstruents so that the redundant feature [+voice] is inserted to be linked to the sonorant (10c):

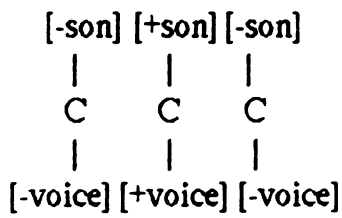
(10) a.



b. *



c.



2.1.3 Feature-changing and non-feature changing assimilation

It has been assumed in the autosegmental framework that spreading is the sole mechanism of assimilation processes (Halle & Vernaud 1980; McCarthy 1984, 1986; Hayes 1986; Goldsmith 1990). That is, any type of assimilation,

regardless of the value of a feature, can be expressed simply by the spreading of the assimilation feature value: spread [αF]. In this type of approach, which presupposes the use of a binary feature system, voicing assimilation in both values can be expressed by a single spreading rule.

Assimilation processes can be motivated either by non-feature-changing or feature-changing rules (McCarthy 1984). A non-feature-changing rule fills in a feature to an unspecified p-bearing unit by means of spreading. Thus, any non-feature-changing rule is explained by a single spreading process without a prior delinking operation. A feature-changing rule delinks the association of a feature value to a p-bearing unit, and then spreads another feature value to the dissociated p-bearing unit. Any feature-changing operation has two processes, the delinking of a feature value and the spreading (or insertion) of another.

I will argue that the use of the privative feature [voice], which amounts to inherent underspecification[3], enables us to reduce the feature-changing processes of Russian voicing assimilation to non-feature-changing ones.

2.2 Theories of Underspecification

The notion of underspecification is not new to non-linear phonology. In fact, Halle (1959) considered leaving some redundant features unspecified. This attempt was objected to by Lightner (1963) and Stanley (1967) for the

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[3] The term 'inherent underspecification' is due to Archangeli (1988), where she talks about several aspects of the underspcification effects of single-valued features. See also Steriade (1987) and Christdas (1988) for their role in underspecification.

reason that underspecification in a binary system creates the third value, i.e., a zero value besides plus and minus values. Chomsky & Halle's (1968) solution to this problem was the full specification of features prior to application of any phonological rule; underspecification was permitted only in the lexicon, in which unmarked features such as voicing for sonorants are unspecified (Chomsky & Halle 1968, Archangeli 1984: 74).

Since SPE it has been assumed that only idiosyncratic information is stored in the lexicon and all redundant information is left unspecified. Such unspecified information is supplied by rules. Recent developments in nonlinear generative phonology have led us to be concerned with the role of the lexicon more than before. Underspecification approaches provide a way to investigate what kind of information is in fact present or absent from the lexicon, more specifically, underlying representations. Underspecification theories also provide us with a way to supply such unspecified features by rules (Archangeli 1988: 183).

There are two types of underspecification theories which share the assumptions mentioned above: Radical Underspecification Theory (RUT) and Contrastive Underspecification Theory (CUT). These two types share the position that all redundant feature values must be unspecified underlyingly and are derived by redundancy rules. But they differ in underlying specification of distinctive feature values: both values of distinctive features in a language are underlyingly specified in CUT; at most one value of each such feature is specified in RUT.

2.2.1 Radical Underspecification Theory (Kiparsky 1982; Pulleyblank 1983; Archangeli 1984, 1988; Abaglo & Archangeli 1989; henceforth CUT)

Kiparsky (1982) was the first to propose to underspecify all predictable features in lexical entities to prevent the occurrence of ternary contrast in underspecification (see 2.2). This idea was further developed by Pulleyblank (1983) with respect to tonal underspecification and by Archangeli (1984) for the underspecification of phonological features in general.

The theory of Radical Underspecification claims that a grammar is highly preferred when it differentiates all phonemes of a language by the minimum number of distinctive features (Archangeli 1984). It approaches this goal by simplifying underlying phonological representations and grammar, that is, eliminating of all predictable features from underlying specifications.

Therefore, this theory may be characterized as maximum minimization of underlying representations: in addition to the underspecification of all redundant feature values, the theory requires that for a given feature only either one of the two values + or - can be specified underlyingly. Accordingly, there is no feature which has both values present underlyingly; there is no feature which is assigned to all phonemes of a language. All unspecified feature values are supplied by redundancy rules (discussed in section 2.2.4).

RUT also claims that underspecification must be determined at least in part on a language specific basis (Archangeli 1984, Abaglo & Archangeli 1989; Archangeli & Pulleyblank 1989). While RUT takes the notion of markedness into account, markedness does not always hold cross-linguistically. Underlyingly specified feature values are unpredictable features in a language

and do not have to be universally marked ones (Archangeli & Pulleyblank 1989: 197). For a given feature the marked (or unmarked) feature value may be determined on a language-specific basis. Since if the marked feature value is specified, the unmarked counterpart is predictable, the unmarked value of distinctive features must also be unspecified underlyingly.

Radical Underspecification Theory gives the following underlying specification of distinctive features for [m,p,b,f,w,y] in Russian:

(11) Distinctive Features for consonants /m,p,b,f ,w,y/

a. Full specification

	m	p	b	f	w	y
sonorant	+	-	-	-	+	+
labial	+	+	+	+	+	-
continuant	-	-	-	+	+	+
voiced	+	+	+	+	+	+
nasal	+	-	-	-	-	-

b. Radical underspecification

	m	p	b	f	w	y
sonorant		-	-	-		
labial	+	+	+	+	+	
continuant				+	+	+
voiced			+			
nasal	+					

(The blanks indicate the unspecified feature values.)

Under RUT, only the marked value [+voice] for obstruents is specified underlyingly. Since voicing for sonorants is predictable, it is unspecified and is later supplied by a redundancy rule.

RUT account of asymmetrical segments:

Asymmetrical segments are those which behave asymmetrically to any other segment in a group of sounds. For instance, in Russian the voiced labio-dental fricative v shows such a characteristics in voicing assimilation. It

functions as an obstruent in undergoing voicing assimilation while acting like a sonorant in failing to trigger the process. Radical Underspecification Theory is claimed to be successful in accounting for asymmetry effects by fully underspecifying a segment (Archangeli 1984, Pulleyblank 1988). Since under this theory, at most one value, either plus or minus, may be underlyingly specified, it is possible for a segment to be without features in the underlying representation though an entity C or V of the CV tier must present for a segment to exist.

One of principles of RUT that underlying representations are determined at least in part language-specifically predicts the fact that asymmetrical segments may differ among languages.

2.2.2 Contrastive Underspecification Theory (Steriade 1987, Christdas 1988, Mester & Ito 1989; henceforth CUT)

This theory distinguishes redundant feature values from distinctive ones (Steriade 1987, Christdas 1988). It restricts underspecification to all and only noncontrastive (i.e., non-distinctive) redundant features and requires the specification of distinctive features for both values (Steriade 1987, Christdas 1988, Mester & Ito 1989). For example, in English the feature [voice] is redundant for all sonorants, and so it is unspecified. On the other hand, voicing is distinctive for obstruents: /t/ and /d/ contrast only in voicing, so the feature [voice] is specified for both values underlyingly.

While RUT treats features as phonological primitives, CUT takes combinations of features as primitives. CUT assumes that any theory of

feature specification must express natural classes of segments at all levels (Christdas 1988:92). Thus, it insists on full specification of features which are necessary to group segments into natural classes. It regards distinctiveness as idiosyncratic information of a language and takes it into consideration in determining the underlying specification of phonological segments.

As for the distinction between redundant and distinctive feature values, Christdas (1988) classifies phonological features into two types: primary and secondary features. Primary features like [sonorant] and [consonantal] are those which are necessary to express natural classes of phonological segments in all languages. They are distinctive and are fully specified underlyingly. Secondary features are those which may not have to be present in underlying representations. Examples are laryngeal features like [voice] and [aspiration], and primary vowel features like [high], [back], [low]. Unlike primary features which are always distinctive, secondary features may function redundantly as well as distinctively depending on each language. When secondary features function in distinctive capacity in a language, they must be specified for both values underlyingly. For instance, if voicing is distinctive for sonorants in a given language, the feature must be specified for both values underlyingly. According to Christdas, secondary features (but not primary features) are candidates for one-valued or unary features.

Like RUT, CUT underspecifies all redundant features; unlike RUT, it specifies contrastive features for both values underlyingly.

(12) Distinctive Features for consonants /m,p,b,f ,w,y/

Contrastive underspecification

	m	p	b	f	w	y
sonorant		-	-	-	+	+
labial	+	+	+	+	+	-
continuant		-	-	+	+	+
voiced		-	+	-		
nasal	+					

cf. Radical underspecification (13b)

	m	p	b	f	w	y
sonorant		-	-	-		
labial	+	+	+	+	+	
continuant				+	+	+
voiced			+			
nasal	+					

Only noncontrastive and redundant features of the language are unspecified under CUT. For example, m, like any other nasal consonant, is unspecified for the feature sonorant since it is redundant. With respect to voicing, this feature is specified for all obstruents for both values since it is contrastive for obstruents, while all sonorants are unspecified for voicing.

For both theories, nasals are unspecified for the feature sonorant since it is predictable in the language. Both theories can have a redundancy rule such as [ ] -> [+son] / [___ ,+ nasal]. As for any other sonorants such as w and y, they are specified for [+son] under CUT since the theory requires both values of contrastive features to be specified underlyingly. For the same reason, obstruents are specified underlyingly as [-son]. On the other hand, with respect to the voicing feature, the two theories make different underlying specifications: [-voice] is unspecified and [+voice] is specified for obstruents under RUT, while both values are specified under CUT since voicing for obstruents is contrastive. It differs from RUT in that RUT unspecifies [-voice] for obstruents while CUT requires [+voice] as well as [-voice] to be underlyingly specified for obstruents since the voicing feature is contrastive

for obstruents. In addition, the feature sonorant must also be specified for both values under CUT

2.2.3 Redundancy Rules under RUT (Archangeli 1984)

Redundancy Rules are rules which assign segments the unspecified values. Hence, they are feature-filling rules as opposed to feature-changing rules. In the underspecification frameworks, both RUT and CUT, redundancy rules were assumed to apply as late as possible unless specific constraints motivate them to apply earlier in the derivation. Under RUT, redundancy rules are of two types: complement and default rules. This classification is not really crucial here, but for the purpose of clarity I will briefly mention the difference. Default rules are universal rules while complement rules are rules which require knowledge of the underlying representations of a given language. To put it simply, complement rules assign the value which is opposite to the underlyingly specified value. Suppose, in a given language, [-son] is underlyingly specified for consonants and the voicing feature for sonorants is unspecified. Then we have redundancy rules as follows:

(13) a. [ ] -> [+son]

b. [ ] -> [+voice] / [+son]

Rule (13b), which assigns [+voice] to segments specified as [+son], is a default rule since it applies to any segment specified as [+son] and needs no language-specific information. Rule (13a), which assigns [+son] to a consonant is a complement rule since the rule applies after the underlyingly specified value [-son] is identified.

We have seen that Kiparsky (1982) proposes what we now call Radical Underspecification to prevent such an undesirable consequence as ternary oppositions. Even in an approach using RUT with binary features, however, we cannot avoid creation of ternary oppositions (Pulleyblank 1983). This problem was solved by Archangeli (1984), who introduces a constraint on the ordering of redundancy rules and phonological rules:

(14) Redundancy-Rule Ordering Constraint (Archangeli 1984: 52; henceforce RROC)

A redundancy rule assigning α to F, where α is "+" or "-", is automatically ordered prior to the first rule referring to [α F] in the structural description.

This constraint states that if a rule P refers to a feature value [αF] in its structural description, then the redundancy rules assigning the feature [αF] must automatically apply prior to the application of rule P. For example, if we have a rule which refers to [-son], any redundancy rule which assigns [-son] to unspecified segments must automatically apply before the rule. This constraint hold for RUT, not for CUT. Once we adopt this system of automatic application of redundancy rules, we no longer need rule-ordering among redundancy rules and phonological rules[4].

Moreover, as Archangeli points out , the RROC avoids the occurrence of ternary oppositions of a feature (Archangeli 1984: 54-55). Since [αF] can

[4] For the argument against the RROC, see Mester & Ito (1989: 265-266).

refer to both [+F] and [-F], they must be present prior to application of the rule which refers to [αF]; there cannot be any segment unspecified for the feature.

This also means that when a rule specifically refers to only one value of a given feature like [-sonorant], the RROC motivates only a redundancy rule supplying the value [-son] but not the one supplying [+sonorant]

2.2.4 Redundancy Rules under CUT

As underlying specification of segments differs between the two theories of underspecification, redundancy rules of the two theories differ as well. CUT defines redundancy rules as rules which fill in redundant feature values. In this sense, those rules correspond to default rules of RUT. Unlike RUT, it has no need to supply unmarked distinctive feature values, which are already present in underlying representations. Because the RROC does not hold in this theory, redundancy rules apply before or after a phonological rule.

2.2.5 Summary: RUT and CUT compared

	RUT	CUT
a. unspecified features	redundant and unmarked value of distinctive features	only redundant features
b. underlyingly specified feature values	at most one value	both values for distinctive features
c. redundancy rules	language-universal and language-specific	language-universal
d. rule-ordering of RRs	by the RROC	before or after phonological rules

2.3 Theories of feature systems

Binary and privative oppositions are not new to generative phonology. In fact, a pre-generative phonologist Trubetzkoy (1969 (1939)) considered such oppositions. What has been needed is the formal theory of feature systems. In early generative phonology (Chomsky & Halle 1968), the binary feature system was adopted as a formal device and claimed to be universal. Recently, Trubetzkian feature oppositions have captured attention, which has been deserved for decades.

In this section, I will introduce the two feature systems, privative (or unary) and binary feature systems.

2.3.1. Trubetzkoy's feature system

Trubetzkoy (1969) classifies phonological features into three types of oppositions: privative, gradual, and equipolent (binary). Some features such as nasality, rounding and voicing are privative, i.e., single-valued features which are expressed, for example, as [nasal] and [voice]. They are characterized only as presence or absence of the feature, not in terms of binary or multi-valued features. The property of being nasal is simply present or absent.

Some other features are by nature to be expressed by virtue of the difference in degree (gradation) of the same property. Vowel height and tonal features in a tone language belong to this feature type, according to Trubetzkoy.

Equipollent features are a type of features that are also known as binary features and those whose opposition has an equal status: two opposing properties are logically equivalent (den Dikken & van der Hulst 1988). This type of opposition cannot be described either as privative or gradual oppositions: it is the most frequent type (Trubetzkoy 1969: 75).

2.3.2 Binary Feature Hypothesis (Chomsky & Halle 1968)

The binary feature hypothesis claims that all features have binary values, two opposing values such as + or -. In 'The Sound Pattern of English' (1968; henceforth SPE), Chomsky & Halle suggest that all features be fully specified in binary feature-values prior to any application of phonological rules, responding to the problem observed by Lightner (1963) and Stanley (1967) that underspecification of a feature may allow ternary oppositions during the derivations. So, since SPE, phonologists followed underlying specification of features prior to the application of any phonological rules until underspecification came back in Kiparsky (1982), Pulleyblank (1983) and Archangeli's (1984) work solve the problem of the three-way distinction in underspecification.

Underspecification theories of phonological segments within generative phonology were originally developed in the early 1980's with the use of binary features (Kiparsky 1982, 1985, Archangeli 1984) while recent versions of the underspecification framework claim that certain features are by their nature privative. For example, Steriade (1987) treats the feature [round] as privative

and [voice] and [lateral] as underlyingly privative in some languages. Goldsmith (1985) claims that the determination of the privativity or the binary nature of a given feature is language-specific, accepting the combination of privative and binary features in a language system.

2.3.3 Privative Feature Theory

Privative or single-valued features play a role in phonological representation with respect to the presence or absence of a feature. So, the feature [+voice] in the binary system is expressed by the presence of [voice] and [-voice] by the absence of the feature in the privative feature system.

In recent research, Trubetzkoy's feature system has been revived, as in Goldsmith (1985), Mester & Ito (1989), Lombardi (1991). In this thesis, I adopt Mester & Ito and Lombardi's claim that voicing is privative. I do not assume that all features are privative unless there is some evidence. Thus, I keep a binary system for other features such as [sonorant].

2.3.4. Privative vs. Binary Features

Some have pointed out advantages of the use of a privative feature system for certain features (Goldsmith 1985, Steriade 1987, Christdas 1988, Mester & Ito 1989, Lombardi 1991). For instance, the adoption of single-valued features eliminates the issue of language-particular ordering among redundancy rules (Steriade 1987). The privative feature [voice] reduces a number of processes involved with voicing assimilation and simplifies the process (Mester & Ito

1989). Privative features will also result in simplification of the underspecification approach (Mester & Ito 1989).

On the other hand, there is a case against privative features. den Dikken & van der Hulst (1988: 45), though arguing against binary features, see the case of the spreading of both values as problematic for the privative feature system. Kiparsky (1991) also argues that assimilation or harmony where both values spread must be analyzed in terms of binary features. If this is the case, then Russian voicing assimilation argues for binary [voice]. However, this position is based on the assumption that the spreading of both values is symmetrical: the negative value [-F] spreads in the same way as the positive value [+F]. For example, if the harmonizing feature is expressed in binary terms, then the feature only needs to be spread by a single rule, regardless of the value, since the spread of both positive and negative values are in symmetry in such a case.

The claim that privative features cannot work if a rule refers to both values is reasonable since given a single spreading rule while the rule can spread the plus value, there is no way to spread the opposite value.

However, this type of argument may seem questionable. Suppose that a language has assimilation of both values of a feature [F]. As far as the feature [F] is binary, we have no problem with expressing the assimilation of both values in terms of a single spreading rule 'spread [αF]'. However, when the feature is indeed proved to be privative, then a single spreading rule, which requires any feature to be binary, becomes problematic.

Recall that the basic assumptions of non-linear phonology that right phonological representations entail correct rules. In the case above, a single

spreading rule cannot be right since the rule requires the feature [F] to be binary and the feature is not properly expressed. It is rather correct phonological representations that yield correct rules. Given this assumption, we must first ask whether a feature is privative, binary or even multi-valued. If a feature is indeed privative, then a rule which expresses assimilation of both values of the feature cannot be a single spreading rule. With respect to Russian voicing assimilation, which involves both values of the voicing feature, an assimilation rule with privative voicing has to be something other than a single spreading rule. Below we will see some evidence for the privativity of the laryngeal features.

Lombardi (1991) convincingly argues for the privativity of laryngeal features, based on the behavior of laryngeal features in laryngeal neutralization. She observes that in laryngeal neutralization, which is characterized as a loss of laryngeal distinctions, laryngeal features such as voicing, aspiration, and glottalization often behave as a group; neutralized obstruents are always plain voiceless. For example, Sanskrit (Whitney 1885, 1889 (cited in Lombardi 1991: 5)) has voiceless, voiced, voiceless aspirated and voiced aspirated stops. In this language, only plain voiceless stops are found word-finally.

(15) [C^h = an aspirated C]

a. /agnimat^h/ ->[agnimat] 'being near the fire'

b. /viirud^h/ -> [viirut]

c. /suhrd/ -> [suhrt] 'friend'

(Translations for 17a and b are due to Cho 1990:147-148, for b, it is not given in Lombardi 1991: 5)

This fact can be explained only in the feature-geometric analysis by means of a delinking of the Laryngeal node of a segment, which dominates the laryngeal features. The delinking of the Laryngeal node results in the delinking of laryngeal features altogether. Moreover, the hypothesis that laryngeal features are privative explains the fact that a neutralized obstruent is always plain voiceless. If they are binary, then, we have to insert the minus value of each feature involved. If this is the case, then it must be possible that a neutralized obstruent can retain some of the laryngeal distinctions such as aspiration while losing the voicing distinction. This, according to Lombardi, is not the case. Thus we cannot explain why laryngeal neutralization always results in loss of laryngeal distinctions altogether unless we take her privative analysis of laryngeal features.

She also considers consequences of privative laryngeal features. She regards voicing assimilation of both values not as a traditionally assumed single rule but as two independently motivated mechanisms: one is the delinking of a feature and the other the spreading of the feature.

Sanskrit voicing assimilation appears to support the privative analysis of the laryngeal features as well. One example given in Cho (1990: 147) shows that devoiced consonants result in plain voiceless.

(16) /bod^{h} + syate/ -> [b^{h}otsyate] 'wake up'

1 2

In example (16), Cho (1990) regards this devoicing process as a coda devoicing. Observe that in (18) the aspiration is lost as consonant 1 becomes devoiced. Although more data are needed, this phenomenon may also support the privativity of laryngeal features since if the process is simply the delinking of [+voice] and the insertion of [-voice], the aspiration feature does not have to be lost.

If we adopt privative features, voicing assimilation of the Russian type must be treated as asymmetrical. That is, the positive value [voice] can spread whereas there is no way to express the spreading of the negative value, which is simply absent in privative feature terms. The use of privative features, therefore, requires us to have at least two rules to account for the data: one for voicedness assimilation and the other for voicelessness assimilation. Voicedness assimilation may be expressed by a single spreading rule such as 'spread [voice]' while voicelessness assimilation needs to be expressed by 'delink [voice]'.

2.3.5 Privative features and assimilation processes

Section 2.1.3 defined the notion of feature-changing and non-feature-changing processes in autosegmental phonology. When an assimilation rule expresses an assimilation feature by unary-features in place of binary ones, the rule becomes non-feature-changing. Similarly, Russian voicing assimilation, which was once analyzed in terms of a feature-changing process (Kiparsky 1985), is treated as non-feature-changing ones under a privative feature system.

3. Russian Voicing Assimilation

This chapter addresses the facts and problems of Russian voicing assimilation. In particular, I will call the reader's attention to assimilation of both values within an obstruent cluster, the dual-characteristics of the voiced labio-dental fricative v, and the transparency of sonorants (nonvocalic consonants) to voicing assimilation.

3.1 The Russian sound pattern and transcriptions

Russian is a Slavic language with thirty six consonants and five vowels as phonemes. Palatalization is phonemic in this language. The phonemic inventory for Russian (Halle 1959, Jones & Ward 1969) is provided in (17):

(17) Russian Phonemic Inventory[5] (C'=palatalized C)

	bilabial	labio-dental	alveolar	palatal	velar
plosive(stop)					
voiceless	p p'		t t'		k k'
voiced	b b'		d d'		g
fricative					
voiceless		f f'	s s'	š š'	x
voiced			z z'	ž ž'	
affricate					
voiceless			t͡s	č	
nasal	m m'		n n'		
flap			r r'		
lateral			l l'		
glide	w w'			j	

[5] The phonemes w and w' never appear on surface; however, for the purpose of the discussions, they are assumed to be the underlying forms of v and v', respectively.

Vowels

front		back	
	i	u	high
	e	o	
		a	low

As for the transcriptions of Russian data, basically I use broad transcriptions throughout (Ladefoged 1982: 34-38, Lockwood, personal communication). The underlying representation is indicated in / /. With respect to a surface representation of Russian sounds, only sounds relevant to discussions such as obstruents and intervening sonorants are phonetically transcribed within brackets [ ]; unbracketed sound, which are not directly relevant to discussions, remain unchanged (except w and w')[6]. For instance, given /jug/-> ju[k], jug in / / is the underlying representation and k in [ ] is phonetically transcribed and other sounds remain unchanged in terms of transcriptions.

For palatalized consonants, C' stands for a palatalized C. While I use most of the data from published works, the sound pattern is due to Moscow dialect. s' and z' are found in the Moscow version of standard Russian[7].

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[6] Because I assume that [v] is derived from /w/ and both underlying and surface representations of the segment is at issue in this thesis, /w/ is transcribed as [v] as the surface representation even when the segment is not in an obstruent cluster.

[7] For instance, these sounds are not found in St. Petersburg version of standard Russian (Lockwood, personal communication) as the comparison of the pronunciation of two words below show:

SP: /jiščo/ 'still' Moscow: /jiš'o/
/ dažd'a/ 'of rain' /daž'a/

3.2 Language Data

It has been argued that Russian has two phonological processes involving obstruents: neutralization and voicing assimilation (Kenstowicz & Kisseberth 1979; henceforth K&K). The neutralization rule is the devoicing of a word-final obstruent. This rule is argued to feed the rule of voicing assimilation (K&K 1979), a regressive assimilation that requires the members of an obstruent cluster to agree with the cluster-final obstruent in voicing, either voiced or voiceless. In addition, both processes are independent of place of articulation. Russian voicing assimilation is not determined by syllabification. Rather, Russian voicing assimilation takes place word-internally (across a morpheme-boundary) as well as across a word boundary.

(18) Word-Final Obstruent Devoicing (Neutralization)

a. /zapad/ -> zapa[t] 'west'

b. /jug/-> ju[k] 'south'

cf. na yu[g']e 'in the south'

c. /muž/ -> mu[š] 'a husband' cf. mužja 'husbands'

d. /sos'ed/ - > sos'e[t] 'a neighbor' cf. sos'edi 'neighbors'

(19) Voicing Assimilation

Word-internal (+ : morpheme boundary)[8]

a. /pros'+ba/ -> pro[z'b]a 'request'

b. /s + dača/ -> [zd]ača 'submission'

c. /sos'ed+ka/ -> sos'e[tk]a 'a female neighbor'

---

[8] I provide a morpheme boundary and a boundary between a proclitic and a word where it is relevant to the discussions.

Across the word-boundary (- : boundary between a proclitic and a word)

e. /k - zapadu / -> [gz]apadu 'to the west'

f. /kak - d'ela/ -> ka[gd']ela 'How are things ?'

g. /ot -doma/ -> o[dd]oma 'from the house'

cf. o[t k]uda 'from where ?'

h. /b'ez-kukli/ -> be[sk]ukli ' without a doll '

(20) Interaction of Final Devoicing and Voicing Assimilation

a. /vizg/ -> vizk -> vi[sk] 'scream, nom.sg.'

cf. vi[zg]a ' scream, gen.sg.'

While all obstruents do undergo voicing assimilation, not all obstruents can trigger it. For instance, the voiced labio-dental fricative /v/ fails to trigger the assimilation:

(21) a. [tv]oj 'your, masc.sg.'

b. [sv]oj ' one's own, masc.sg '

c. zdra[stv]ujt'e ' hello'

d. mo[skv]a 'Moscow'

e. ka[k v]ipaživaet'e ' how are you? '

cf. /kak d'ela / -> ka[g d']ela ' how are things ?'

f. [s v]am'i 'with you'

[f] can be derived either from /f/ or /v/. In addition, [f] derived from /v/ and the one not derived from /v/ behave differently in triggering the voicing assimilation: derived f, just like v, fails to trigger the voicing assimilation

(Reformackij 1971 [9], Jakobson 1978, Hayes 1984, Kiparsky 1985) whereas underived f does trigger the assimilation:

(22) [f] from /v/

a. /tr'ezv/ -> tr'e[zf] (* tr'e[sf]) 'sober, predicative adj.'
(Hayes 1984, Kiparsky 1985)

cf. [tr'ezvij] 'sober, attributive adj.'

b. /r'ezv/ -> r'e[zf] (*r'e[sf]) 'frisky' (Jakobson 1978)

cf. [r'ezvijt's'a] 'frisk'

c. /xorugv'/ -> xoru[gf'] (*xoru[kf']) 'gonfalon' (Jakobson 1978)

This fact strongly argues for the asymmetry of the segment v: it never triggers voicing assimilation while it undergoes it. Although there is a controversy over the pronunciation of words like the above. Some argue that word-final v not only undergoes the word-final devoicing but also triggers voicing assimilation. For instance, /tr'ezv/ is pronounced rather as [tr'esf], which is a result of devoicing and voicing assimilation. Some other argue that as a fast speech effect after final devoicing tr'e[zf] becomes tr'e[sf] (Hayes 1984). Yet, I take the pronunciation given in (22), as it has been analyzed in recent works (Jakobson 1978, Halle &Vergnaud 1981, Hayes 1984, Kiparsky 1985).

Underived /f/, on the other hand, can both undergo and trigger the voicing assimilation.

(23) /f/ as a target of the assimilation /f/ -> [v]

a. /prof-b'uro/ -> pro[vb']uro 'trade union bureau' (Grebnev 1959)

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[9] I am grateful to Prof. D. Lockwood for introducing me this important article.

In normal speech, many Russian proclitics, e.g. prepositions, are pronounced as if they belong to the following word: so the last segment of a preposition undergoes voicing assimilation.

(24) /f/ as a trigger of the assimilation: a voiced consonant becomes voiceless when it is followed by underived f:

a. /b'ez- fonet'iki/ -> b'e[sf]onet'iki 'without phonetics'

cf. /b'ez- gori/ -> b'e[zg]ori 'without a mountain'

b. /iz - frant^{s}ii / -> i[sf]rant^{s}ii ' from France'

From these facts, we can state that all obstruents except v both trigger and undergo voicing assimilation; v undergoes voicing assimilation but fails to trigger voicing assimilation.

We still need to examine cases in which voicing assimilation affects an obstruent cluster which contains v or sonorant consonants like nasals.

(25) [v] as a target of voicing assimilation

a. /ot -vzriva/ -> o[d vz]riva 'from an explosion' (J)

b. /ot- vzdoxa / -> o[d vzd]oxa 'from a sigh' (J)

Observe that intervening sonorant consonants[10] in obstruent clusters are transparent to voicing assimilation in Russian (Jakobson 1978: 108, Hayes 1984: 318-320):

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[10] In rapid speech, Russian sonorant consonants may devoice before a voiceless obstruent, e.g., [r̥t]a 'mouth, gen.sg.' (Jones & Ward 1965 (cited in Hayes 1984: 321)).

(26) Voicing assimilation across sonorants:

a. /iz-mtˢenska/ -> i[smtˢ]enska 'from Mtˢenska' (Hayes 1984)

b. /ot-mzdi/ -> o[dmzd]i 'from the bribe' (H)

c. /nad- rtut'yu/ -> na[trt]ut'yu 'over mercury' (J)

d. /k- lzivim slovam/ -> [glz]ivim slovam 'to the mendacious words' (J)

e. /s- rd'ejustˢim rum'antˢem/ -> [zrd']ejustˢim rum'antˢem
'with a glowing color' (J)

In short, we have seen the phenomena of Russian voicing assimilation. The assimilation is of both values. It takes place within an obstruent cluster, in which sonorant consonants may intervene. Word-final obstruent devoicing seems to interact with voicing assimilation. As for the asymmetrical behavior of the labio-dental v, the segment, just like a sonorant, never triggers voicing assimilation while it undergoes both final devoicing and voicing assimilation as any other obstruent does. Intervening sonorant consonants in an obstruent cluster are transparent to the process. One aim of this thesis is to provide a natural account for the special behavior of v in comparison with underived /f/ and with other obstruents within the context of voicing assimilation.

4. Historical Perspective

Russian voicing assimilation and final devoicing has been studied for decades with respect to the definition of labio-dental fricatives and classification of the sounds which involve the process. Russian voicing assimilation was quite challenging for segmental iterative approaches since it is unbounded propagating assimilation which affects the voiced labio-dental fricative v in an obstruent cluster. Although several attempts have been made within an autosegmental framework, none has provided a uniform account for both the asymmetrical behavior of the voiced labio-dental fricative v and voicing assimilation of both values. In this section, I will provide a summary of published analyses of labio-dental fricatives in section 4.1 and those of voicing assimilation in Russian in section 4.2.

4.1 Russian labio-dental fricatives

4.11 Interpretation of Russian labio-dental fricatives

The peculiar behavior of Russian [v] mentioned in the previous chapter has been studied for decades in the literature. Many researchers have suggested that [v] is underlyingly /w/, a sonorant and becomes an obstruent v at some point of derivation (Jakobson 1948, Halle 1959, 1973, Lightner 1965, Coats & Harshenin 1971, Hayes 1984, Kiparsky 1985). This analysis seems plausible since v behaves like an obstruent on the one hand, and like a sonorant on the other. On the other hand, Barkai & Horvath (1978: 82) have objected that deriving a segment from another which never surfaces is not realistic and such analysis requires extrinsic rule-ordering. From the standpoint of second

language acquisition, as observed by Shapiro (1966: 193), native speakers of Russian learning English tend to substitute v for w.

(27) a. wine -> [v]ine b. woman -> [v]oman

c. Taiwan -> Tai[v]an d. lower -> lo[v]er

e. warsaw -> [v]arsa[v]a

Below we will see how such a peculiar segment v has been conceived of in relation to voicing assimilation. Although various authors, both phonologists and phoneticians, disagree on some data like tr'e[zf] vs. tr'e[sf], we take the analysis that v fails to trigger voicing assimilation like other sonorants but does undergo the process like other obstruents. Among /w/ analyses, I present that of Lightner (1965) and Hayes (1984). As for the one against /w/ analyses, Barkai & Horvath's analysis (1978) is introduced.

Lightner (1965 (cited in Barkai & Horvath 1978: 79)) takes the abstract w analysis. He distinguishes two types of /w/: w at the word-final position and before an obstruent; w in all other environments. While w in any circumstances becomes obstruent v, only the former type undergoes voicing assimilation. He constructed extrinsically ordered rules to prevent the latter type of w from triggering the assimilation.

(28) (Lightner 1965 (Cited in B & H 1978 :79-80))

a. w -> v / __ { [-sonorant] , # }

b. Voicing Assimilation

[-son] ->[a voice] / __ [-son, α voice]

c. w ->v (elsewhere)

(condition: rule-ordering a-b-c)

(29)	a. / b'ez wpuska/	/tvoj/
by 28a	z v p	n/a
by 28b	z f p	n/a
by 28b	s f p	n/a
by 28c	n/a	t v
	b'e[s fp]uska	[tv]oj

As derivation (29a) clearly shows, rule (28b) entails that v which is derived by rule (28a) does trigger the voicing assimilation. His rules thus fail to capture the generalization that v never triggers voicing assimilation. This is a problematic aspect for any segmental iterative approach, according to which a segment can affect only an adjacent one at a given time. We will come back to this issue in the following section.

Barkai & Horvath (1978) argue against the abstract /w/ analysis of the Russian labio-dental fricative v. According to them, an approach of deriving [v] from /w/ is unrealistic and undesirable since the abstract /w/ never surfaces in Russian and it also requires extrinsic rule ordering (B&H 1978: 82).

Their close examination of the peculiar behavior of v found in three unrelated languages Hebrew, Hungarian and Russian has led them to introduce a sonority-based approach, in which the labio-dental fricative v is ranked between fricatives and nasals (B & H 1978: 83).

(30)

stops	fricatives	v	nasals	y	r	l
1	2	3	4	5	6	7

(the higher number, the higher degree in sonority)

Based on the sonority scale provided above, Barkai & Horvath propose a voicing assimilation rule for Hungarian and Hebrew(B & H 1978: 83):

(31) m. sonorant -> [α voice] /_____ [n. sonorant, α voice]

where $m \leq 3$ and $n \leq 2$

The rule above states that a segment with sonority equal to or less than degree three assimilates to the following segment in voicing if its sonority is equal to or less than degree two. All stops and fricatives except v can be the potential trigger of voicing assimilation and v can only undergo the process.

It cannot explain the case that an obstruent cluster contains [v] cluster-medially. Their rule is a segmental iterative one, under which [v] blocks voicing assimilation because their rule cannot allow [v] to trigger voicing assimilation. For instance,

(32) a. b'ez vpuska -> * b'e[z fp]uska 'without permission'

cf. b'e[s fp]uska

b. kak vdova -> * ka[k vd]ova 'like a widow'

cf. ka[g vd]ova

Hayes (1984), supporting the view of treating v as a sonorant /w/ underlyingly, reanalyzes Coats & Harshenin's (1971) approach. He proposes a set of extrinsically ordered rules. Among them, the devoicing of a word-final obstruent and voicing assimilation which apply to any consonant including sonorants. For now, we concentrate on the treatment of v and we will discuss his autosegmental rule for voicing assimilation in the next section.

(a simplified version of Hayes 1984: 319-320)

(33) Final Devoicing

C -> [-voiced] /____ #

(34) Voicing Assimilation

Assimilate all consonants in a cluster to the voicing of its rightmost obstruent.

(35) W strengthening

[C, -cons, +labial] -> [-son]

(36) Sonorant Revoicing

[+son] -> [+voiced]

(condition: rules are ordered as 34-35-36-37)

(37) Derivations:

UR	(a) /b'ez-wpuska/	(b) /iz-mtˢenska/	(c) /tr'ezv/
by (33)			zw̥
(34)	s w̥p	s m̥ tˢ	n/a
(35)	s fp	n/a	zf
(36)	n/a	s mtˢ	n/a
SR	[b'es fpuska]	[is mtˢenka]	[tr'ezf]

In derivation (37a), rule (33) devoices z and w then w becomes f by w strengthening. In (37b), voicelessness assimilation also takes place; the devoiced sonorant m gets revoiced by a sonorant revoicing rule. In (37c), w devoices as a word-final consonant and becomes f by the w strengthening rule, which bleeds the sonorant revoicing rule.

Thus, sonorants become devoiced by undergoing neutralization (i.e., word-final devoicing) and voicing assimilation. Hayes, then, has to construct a rule which later revoices the devoiced sonorant, assuming that /v/ is not a phoneme in Russian while /f/ is. During the derivation, /w/ is treated as a sonorant and gets devoiced by the former rule. But he constructs the rule /w/

strengthening, /w/ ->[v] and /w̥/ -> [f]. This rule is ordered to apply before the sonorant revoicing rule. As in (37b), all sonorants except /w/ have to go through two processes, devoicing and revoicing in order to explain the asymmetry of [v]. Thus, such operations should be replaced by a simpler set of rules.

The difficulty that Hayes's analysis has seems to stem from the nature of his assimilation rule since the rule affects all consonants in an obstruent cluster, both obstruents and sonorants, even though at the surface only obstruents show agreement in voicing.

4.12 Abstract /w/ and underspecification

We have seen the abstract /w/ analysis and the argument against the /w/ analysis. Barkai & Horvath (1978) are right in pointing out that /w/ never surfaces in the language. Yet we have no evidence that it is underlyingly not sonorant. Underspecification, specifically, Radical Underspecification, enables us to treat it as a neutral segment, while we assume that it is underlyingly /w/ not /v/. According to RUT, at most one value of a feature can be present in underlying representations, we can specify [-sonorant] and so unspecify [+sonorant]. Consequently, v, which is assumed to be /w/, is underlyingly underspecified for the feature sonorant. So underlyingly it is neither sonorant nor obstruent. It becomes [-sonorant] by a default rule [ ] -> [-sonorant] / [_ , +continuant, +labial]. We can explain without any feature-changing rule why it fails to trigger the assimilation while it undergoes it. We no longer need to decide when the labio-dental fricative v underlyingly belongs to one of the two groups.

4.2 Approaches to Voicing Assimilation and Final Devoicing

In the last three decades or so, several attempts have been made to provide a uniform account for the phenomena involved with the two phonological processes final devoicing and voicing assimilation in Russian. In early generative phonology, the phenomena were analyzed and expressed by means of segmental or directional iterative rules. For instance, Kenstowicz and Kisseberth (1979) formulate segmental iterative rules within the framework of generative phonology:

(38) Final Devoicing: (K&K, P409)

[-sonorant] -> [voiceless] / ___ #.

(39) Voicing Assimilation

[-sonorant] -> [α voice] / ___ [-sonorant , α voice]

Rule ordering: 38-39

• Rule 38 feeds rule 39.

(40) Derivations

	a. /vizg/	b. /pros'+ ba/
by38	zk	n/a
by 39	sk	z'b
	vi[sk]	pro[z'b]a

Their rules are not meant to cover every phenomenon of Russian voicing assimilation: they deal with simple cases like /vizg/ ->vi[sk] but they fail to explain cases like /tr'ezv/ -> tr'e[zf] or /b'ez wpuska/ -> b'e[s fp]uska.

Aside from this, there is a case in which segmental iterative approaches in general are shown to be inadequate to explain phenomena involved with Russian assimilation.

For example, Hayes (1984) provides examples to argue against the segmental iterative approach to voicing assimilation. He claims that Russian v allows unbounded propagating assimilation, which, according to him, can be better accounted for by a prosodic approach than by a segmental iterative one, supporting the analysis of Halle & Vergnaud(1980).

The unbounded propagating assimilation in the Russian case means that, in a given obstruent cluster, the voicing assimilation trigger, i.e, the last member, affects all targets, thus its adjacent segment as well as nonadjacent ones. In other word, the voicing feature of the trigger spreads onto all consonants until the end of the cluster. Consider the examples below:

(41)

a. /b'ez z'ertv bj/ -> b'ez z'er[dv b]j 'without sacrifices' (Shapiro 1966)

b. /kak vdova/ -> ka[g vd]ova 'like the widow' (S)

c. /vot v d'etstv'e/ -> vo[d v d']etstv'e 'but in childhood' (S)

d. /ctob vzjat/-> cto[b vz]jat ' in order to take' (S)

e. /b'ez-wpuska/ -> b'e[s fp]uska 'without permission'

(42) Assimilation across nasals:

a. /iz mtsenska/ -> i[s mts]enska 'from Mcensk' (Hayes 1984)

b. /ot mzdj / -> o[d mzd]j 'from the bribe' (H)

(43)

a. [tv]oj 'your, masc.sg.' b. [s v]ami 'with you'

c. /tr'ezw/ -> tr'e[zf] 'sober'

First, nasals are transparent to assimilation (42). Second, the voiced labio-dental fricative v is not transparent (41). As (43) shows, v cannot trigger the voicing assimilation. Therefore, it follows that assimilation is not a process of transmitting the voicing feature of the final member of each obstruent cluster in a segmental iterative way such that a trigger affects only the adjacent segment, which in turn affects the segment to its left. It is rather a propagation process, by which the final member of the cluster affects all targets.

Under a segmental iterative rule, any segment that undergoes the rule is at the same time a potential trigger (Halle and Vergnaud 1981; Hayes 1984; Kiparsky 1985). Accordingly, segmental iterative analysis is problematic since it require the cluster-medial labio-dental fricative v to affect the adjacent one in propagating assimilation. To illustrate the point,

(44) b'e z w p uska -> b'e z f p uska -> b'e[s fp]uska

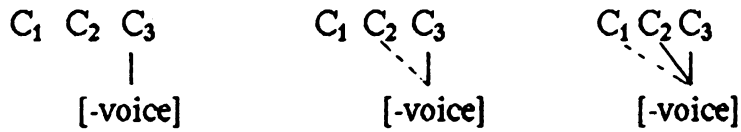
C_1 C_2 $\mathbf{C_3}$ C_1 $\mathbf{C_2}$ C_3

Under a segmental iterative approach, the last member C_3 triggers C_2, which in turn triggers C_1. On the surface it seems that voicing assimilation has taken place iteratively. The facts that v fails to trigger voicing assimilation as in words like *tvoj* 'your' and *svoj* 'one's own' and also that sonorant consonants are transparent to voicing assimilation tell us that it is not the case.

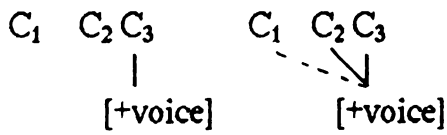
Any segmental iterative analysis such as that of Lightner (1965), Coats & Harshenin (1971) and Kenstowicz & Kisseberth (1979) fails to explain a case like (44) in which the C_3 triggers C_2 and C_1 iteratively without making C_2 a trigger. As we have seen, Lightner (1965) had to classify v into two types: v which both triggers and undergoes voicing assimilation and v which does not. Thus, under a segmental iterative analysis, phenomena like Russian voicing assimilation are never interpreted as unbounded propagation.

An autosegmental analysis, on the other hand, accounts for unbounded propagation phenomena by affecting segments at a long distance by means of spreading.

(45) a. /b'e z w p uska/ ->b'e z f p uska -> b'e[s f p]uska



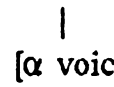
b. /o t m z d j/ -> o[d m z d]j ' from the bribe'



Hayes formulates what he calls a prosodic rule for Russian voicing assimilation as follows:

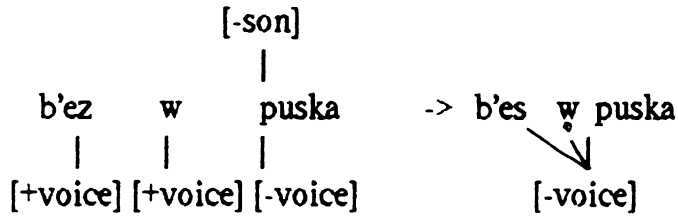
(46) (Hayes 1984: 325)

In the configuration [-son], reassociate [α voice]



with the maximal string of consonants to the left, deleting any autosegments stranded in the process.

e.g.



As I mentioned above (p46-47), Hayes's assimilation rule, even when prosodically formulated, applies to any type of consonant including sonorants: any sonorant may be devoiced if the process is triggered by a voiceless obstruent. Thus, under his approach, we need a rule which revoices sonorants devoiced by the earlier application of rules. In addition, his rules are so ordered that the /w/ strengthening rule bleeds the sonorant revoicing rule in that v, which is already an obstruent, cannot undergo sonorant revoicing. Hayes justifies his sonorant revoicing rule by saying that it is not a phonological rule but phonetic implementations of the language.

Hayes's approach consists of an ordered set of rules. Unlike a segmental iterative rule, in his prosodic rule the final member of an obstruent cluster is the only trigger affecting all the consonants in the cluster. Although this is a great improvement, the existence of the two rules, w strengthening and sonorant revoicing, assures that the assimilation process takes place iteratively, without skipping any consonant which never shows agreement in voicing on the surface.

In other words, Hayes's autosegmental rule can prevent a sonorant from triggering the voicing assimilation, but it cannot prevent the trigger from skipping or affecting sonorants since the rule does not refer to the feature sonorant for the targets. My claim, then, is that if we can have a rule which

refers only to relevant features of targets, i.e., the feature obstruent, we will no longer need such rules as w strengthening and sonorant revoicing.

Halle & Vergnaud's (1981) also make use of autosegmental rules and are quite successful in affecting only obstruents in voicing assimilation. Their identifying obstruent clusters prior to any phonological rules is the key to such a success.

They consider Russian voicing assimilation as directional harmony: the process takes place in one direction, being triggered by the final member of an obstruent cluster. Their approach is simpler than Hayes's in the sense that their voicing assimilation rule affects all and only obstruents by constructing a tree that consists of only obstruents. This is done by what they call foot incorporation. Foot incorporation determines an obstruent cluster and takes place before any phonological rules. It reshapes a tree, which is already formed by tree construction, by terminating a branch dominating a sonorant so that a tree comes to consist of only obstruents. Only elements constituting a tree participate in voicing assimilation. Voicing assimilation is expressed in terms of copying the voicing feature of the last member of the tree onto all other members. Since sonorants are disregarded by foot incorporation, voicing assimilation takes place skipping intervening sonorants.

Halle & Vergnaud provide a set of rules as below:

(47) (slightly modified version of Halle & Vergnaud 1981: 17)

a. Tree Construction

b. Foot incorporation

c. w ->v

d. word-final obstruent devoicing

e. copy feature on root

Let us see how these rules generate voicing assimilation. Only two types of obstruent clusters are given here; The tree construction is limited to segments relevant to voicing assimilation for the purpose of discussion:

(48)

examples

/iz- mtsenska/ -> i[s mtsenska 'from Mcensk'

/ot-mzdi/ -> o[d mzd]i 'from the bribe'

Derivations

Rules

a.  

iz- mtsenska ot-mzdi

b.  

iz- mtsenska ot-mzdi

c. n/a n/a

d. n/a n/a

[-v] [+v]

e.  

is- mtsenska od-mzdi

(Tree construction of only relevant segments are given)

First, by initial tree construction (a), all segments are clustered together to form trees with the condition that vowels are opaque, i.e., triggering the harmony. Then, by foot incorporation (b), sonorants are eliminated from the trees and adjacent obstruents are incorporated into a single tree. At this point, obstruent clusters are recognized. The trees are right-headed; that is, the final member of a tree governs the obstruent cluster voicing as in copying rule (e). By (e), the voicing feature of the final member of the tree is copied onto other members of the tree.

Unlike Hayes's assimilation rule which affect all consonants in an obstruent cluster, Halle & Vergnaud's analysis allows the assimilation trigger to affect only obstruents by the copying rule. Thus, they do not need two processes, devoicing intervening sonorants and revoicing them.

Although Halle & Vergnaud (1981) are successful in disregarding sonorants, which never participate in Russian voicing assimilation, their rules have not explained the asymmetrical behavior of v. They have to add an ad hoc rule for the voicing of v (Hayes 1984:320) as below:

(49) [-sonorant, +labial, +continuant] -> [α voice] / __ [α voice, -sonorant]

(H & V 1981: 17)

This problem must be worked out; yet I take their analysis as significant and as an important step toward the most appropriate explanation for assimilation phenomena of the Russian type. As we will see in the following chapter, their notion of foot incorporation is somehow modified and adopted in underspecification approaches to the phenomena.

4.3. Summary

As we have seen, many researchers have given a very insightful explanation for some of the Russian voicing assimilation phenomena over the decades, however, none have provided a uniform account for every single phenomenon.

The traditional analysis of deriving [v] from /w/ seems plausible, given the segment's dual-characteristics. When the /w/ analysis is assumed, a feature-changing w strengthening rule is required to explain the asymmetry of the voiced labio-dental fricative v in the approaches which fully specify /w/.

While Hayes's assimilation rule expresses propagation phenomena by spreading the voicing feature of the trigger onto targets, his rules are extrinsically ordered. They devoice sonorants and then revoice them, which is irrelevant to the surface realization of obstruent-cluster voicing.

Halle & Vergnaud's autosegmental analysis has shown that an autosegmental rule of voicing assimilation can affect all and only obstruents. Their approach identifies obstruent clusters early in the derivation before any phonological rules apply.

In the following chapter, I will propose an approach to Russian voicing assimilation, solving the problems that previous analyses had.

5. A Constraint-based Approach to Russian Voicing Assimilation

In this chapter, I will present an approach which uses a structural constraint on obstruent-cluster voicing, Radical Underspecification and privative voicing. This approach solves the problems that previous studies had and gives a uniform account for the phenomena of Russian voicing assimilation.

In my approach, a structural constraint on obstruent-cluster voicing motivates persistent application of two processes: spreading and delinking of [voice]. By Radically underspecifying the voiced labio-dental fricative v, we can eliminate the need for the feature-changing rule [+sonorant] to [-sonorant] for the segment. By adopting privative [voice], we can reduce feature-changing assimilation to a non-feature-changing type. In this approach, assimilation triggers are identified by Obstruent-Head Licensing (OHL) prior to any application of rules, both redundancy and phonological ones, and thus before the unspecified w becomes v. Voicing assimilation affects all and only obstruents by referring to the contextual feature [-sonorant]. By OHL, all obstruents except v can trigger voicing assimilation. Application of OHL is not subject to extrinsic rule ordering because it is not like any phonological or redundancy rules. It rather provides a domain, in which voicing assimilation takes place.

Then I will defend my solution by objecting to two other analyses, which one might easily come up with. One is based on the modified version of Hayes's spreading rule using binary features. The other is privative voicing

with Contrastive Underspecification. I will show why an approach using a structural constraint is desirable, pointing out problems with Hayes's spreading rule. I also favor Radical Underspecification over Contrastive Underspecification in the Russian case.

When examining how the use of privative voicing is more advantageous than binary alternative with regard to representations and rule applications for voicing assimilation in Russian, we keep binary values for any other feature, since voicing is the only assimilation feature here and since we have no evidence that other relevant features like sonorant are privative.

Before analyzing the data within the underspecification framework, let us look at rules, constraints, and assumptions for underspecification.

5.1 Underspecification

The Russian data will be examined in terms of the underspecification theories, which can differentiate v from any other obstruent and sonorant in order to explain the special behavior of labio-dental fricative v and the two phonological processes in Russian more simply than Hayes's proposal. There are several assumptions to be made here within the framework of underspecification.

First, I take basically the traditional analysis of Russian labio-dental fricatives: [v] is derived from /w/; [f] can be derived either from /f/ or /w/. [f] is derived from /w/ if it has undergone a devoicing process. Underived f is underlyingly an obstruent /f/ and triggers voicing assimilation. v is a consonant with the features [+labial] and [+continuant] underlyingly and will become an obstruent at some point of derivation by a redundancy rule.

Although it may be highly misleading, I assume that underlyingly /w/ just stands for a consonant with the specification [+continuant, +labial] and is unspecified for [sonorant] and [voice]. This consonant is expressed as /w/. So, underlying /w/ is specified neither as a sonorant nor as an obstruent under RUT (but not CUT). Thus, as far as features relevant to Russian voicing assimilation are concerned, v is underlyingly a segment without features [sonorant] and [voice] under RUT. Under CUT, on the other hand, w cannot be featureless (in a sense that w without [+sonorant]) since the theory insists on underlying presence of both values of the contrastive feature [sonorant]. As we will see in the later section, the underlying presence of [+sonorant] brings CUT a problem: it cannot explain the asymmetry of v as simply as RUT does.

It is widely accepted that an approach with extrinsic rule-ordering involves complexity and is thus highly disfavored over one without (Hudson 1974, Barkai & Horvath 1978). In the previous chapter, we saw approaches using a set of extrinsically ordered rules such as application of w strengthening before sonorant revoicing. Those rules need rule-ordering because the asymmetrical segment v is always specified for either value of the feature sonorant: it is underlyingly specified as sonorant and later becomes an obstruent. In other words, in spite of its dual-characteristic in voicing assimilation, in the previous approaches, the labio-dental fricative v always had to belong to either of the two groups of consonants, sonorants or obstruents.

Recall that the dual-characteristic of v is that it undergoes voicing assimilation while it fails to trigger the assimilation. Now that as a consequence

Recall that the dual-characteristic of v is that it undergoes voicing assimilation while it fails to trigger the assimilation. Now that as a consequence of underspecification, we have v as a segment without the features [sonorant] and [voice], we can easily differentiate the asymmetrical segment from any other obstruent and sonorant.

5.1.1 Obstruent clusters and Obstruent-Head Licensing

We have seen in chapter four that various authors provide different rules for the phenomena of Russian voicing assimilation. Though those rules differ in fundamental assumptions as well as in formulation, all seem to agree that it is the final member of an obstruent cluster that triggers the assimilation.

I take Halle & Vergnaud's analysis, in which obstruent clusters are identified prior to any application of phonological rules as significant. But I do not maintain such a process as tree incorporation because autosegmental phonology does make it possible for a rule to refer to a particular group of sounds like obstruents and sonorants. H & V's foot incorporation is a process which excludes all sonorants from a tree so that a tree consisting only of obstruents results. This process is not necessary because when an autosegmental rule explicitly specifies [-son] in its structural description, then segments with [+sonorant] are simply ignored in the application of the rule.

Instead, I propose below a rule which identifies the trigger of voicing assimilation. First, I term the final member of an obstruent cluster the obstruent head. Second, I define an obstruent cluster as a sequence of obstruents, within which sonorant consonants may intervene. My proposal is a language-specific process called Obstruent-Head Licensing, which scans the

CV and sonorant tiers and identifies the head, the potential trigger of voicing assimilation within an obstruent cluster:

(50) Obstruent-Head Licensing(OHL):

License the final member of an obstruent cluster identified in the underlying representation as the trigger of voicing assimilation.

```
[-son]  [-son]
  |       |
  C  (C)  C1                ( C1 = Obstruent head )
```

The CV-tier is needed for this process since whatever is to be identified as an obstruent cluster must be a sequence of consonants specified as [-son]. The cluster may contain intervening consonants unspecified for [-son] while it cannot allow any intervening segment specified as V, that is, a vowel. Obstruent-Head Licensing applies only once after underlying representations and prior to any application of rules, licensing the final member of an obstruent cluster as the trigger of voicing assimilation. OHL provides the environment for the voicing assimilation rule. This OHL applies only to underlying representations. It means that v, which is not specified as [-son] underlyingly while becoming [-son] later in the derivation, is not subject to the rule. Thus, v never becomes the trigger of voicing assimilation even in such a configuration as [__zv] or [tv__]: v never triggers voicing assimilation, which is in accordance with the facts. Consequently, we no longer need extrinsic rule-ordering, since as the effect of O-head Licensing, there is no circumstance in which v becomes a trigger of assimilation

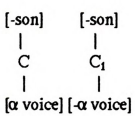
5.1.2 Obstruent-Cluster Constraint

In the previous chapter, we saw that Hayes's assimilation rule affects all consonants in an obstruent cluster and requires a sonorant revoicing rule while at the surface only obstruents show agreement in voicing. We can economize such seemingly unnecessary processes by formulating a rule which refers to the contextual feature for the assimilation [-sonorant].

I propose a structural constraint on the voicing feature of obstruent-clusters, which motivates persistent application of a rule changing ill-formed representations to well-formed ones. I assume that voicing assimilation is persistent to eliminate the need for rule-ordering. To see how such a structural constraint motivates a persistent rule and how a persistent rule interacts with redundancy rules, we first look at a constraint expressed with a binary feature. Then, we will see a constraint using privative voicing.

(51) Obstruent-Cluster Constraint (OCC)

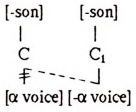
*



This says that no members of an obstruent cluster can have an opposing value to that of the head: all members of o-cluster must agree in the voicing feature with the head. Observe that the rule simply refers to [-son] and voicing features; any intervening sonorant consonants, which are unspecified for the features sonorant and voice, are disregarded. This constraint motivates a

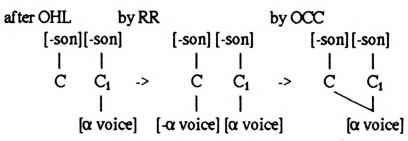
leftward spread of the voicing feature of the head and then motivates a delinking of the voicing feature assigned to non-head members of the cluster as illustrated in (52).

(52)



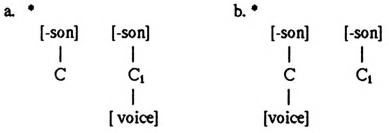
To be clear, it is constraint (51) that motivates the persistent application of rule (52). I assume that the OCC-motivated rule applies persistently, that is, it applies whenever structural conditions are met (for persistent rules, see 2.1.2). So this constraint-motivated rule interacts with redundancy rules, changing ill-formed representations to well-formed representations. Unlike universal constraints, which prohibit the occurrence of ill-formed representations like the existence of adjacent identical features, the OCC does not block the application of a rule which creates ill-formed representations. In (53), a redundancy rule (RR) supplies the unspecified feature value [a voice]; then by the OCC effect, the voicing feature of the head [b voice] becomes multiply linked to all members of the obstruent cluster. The OCC does not disallow the application of RR while the RR creates the representation which is subject to the OCC. It is also true that the OCC, in this case, functions to prevent ternary oppositions.

(53)

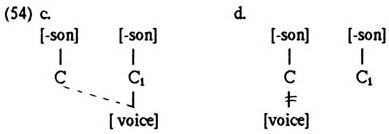


If we use privative features, which have only one value present, we need two types of structural constraints on obstruent-cluster voicing:

(54) the OCC for privative voicing



Constraints (54) a and b will motivate processes (54) c and d, respectively:

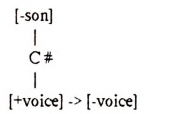


In (54c), the voicing feature of the o-head spreads its voicing feature onto the obstruent(s) in the cluster whereas in (54b), a delinking of all non-head occurrences of the voicing feature takes place.

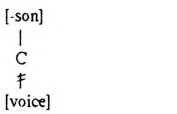
Next, the devoicing of word-final obstruents is formulated below. (55a) is expressed in binary terms and (55b) in privative terms:

(55) Word-Final Obstruent Devoicing

a.



b.



We derive all predictable distinctive features by the interaction of redundancy rules and rules motivated by a language-specific constraint on the voicing of the representations of obstruent clusters. As mentioned before (2.2.3), redundancy rules play a crucial role in underspecification theories. Following the main tenets of RUT and CUT, a set of redundancy rules under each theory is to be constructed.

I will deal with seven types of voicing assimilation shown below in (56). We will consider which combination of underspecification theories and feature systems explains the voicing assimilation phenomena best. First, we consider a constraint-based approach using privative [voice] and Radical Underspecification. Using privative features, we will consider their effects on representations and rule application under RUT, since it requires the simplest derivations and fewer rules; then comparisons among other combinations of theories and feature systems will be made.

(56) a. /wakzal/ -> va[gz]al 'station'
b. /b'ez fonet'iki / -> b'e[s f]on'etiki 'without phonetics'
c. /wizg/ -> vi[sk] 'scream' (gen.sg.)
d. /tr'ezw/ -> tr'e[zf] 'sober'

e. /ot- wzryva/ -> o[d vz]ryva ' from an explosion'
f. /b'ez wpuska/ -> b'e[s fp]uska 'without permission'
g. /iz- mt*enska/ -> i[s- mt*]enska 'from Mcensk'
h. /twoj/ -> [tv]oj 'your, sg.'

5.2 Privative features and Underspecification

In this section, we will see how a constraint-based approach allows the privative feature [voice] to play a significant role in accounting for Russian voicing assimilation.

The use of the privative feature [voice] requires us to regard assimilation of both values as two independent operations taking place within the same domain: devoicing and assimilation. The voicelessness assimilation is expressed by the delinking of [voice] and the voicedness assimilation by the spreading of [voice]. Besides Lombardi's (1991) observation, the adoption of privative [voice] in place of its binary counterpart is strongly supported for the following reasons.

One consequence is that the use of privative [voice] reduces feature-changing assimilation processes to non-feature-changing ones. As we have seen in the previous section, under privative feature [voice], voicing assimilation of both values is explained by two types of single processes: voicedness assimilation by spreading and voicelessness assimilation by delinking of [voice]. The processes are simpler than when the binary feature [voice] is used. The privative voicing eliminates the need for a complement rule supplying [-voice]. Another desirable consequence of the adoption of privative [voice] is that it makes final devoicing a single delinking operation as

well. Final devoicing, which is found in many unrelated languages like Sanskrit and Polish, is now expressed by a single delinking process.

The following section presents an approach using privative voicing in Radical Underspecification since it gives simpler derivation and has no feature-changing rules. Because Russian voicing assimilation involves an asymmetrical segment, RUT turns out to be preferred to CUT. As we go on to look at privative features and CUT, we will consider problems associated with CUT in dealing with voicing assimilation of the Russian type and implications for feature theories.

5.2.1 Privative Voicing and Radical Underspecification Theory

In this section, I present what I believe to be the best solution to Russian voicing assimilation, using Radical Underspecification and privative voicing within the authentic autosegmental rules.

My approach is strongly supported for the following reasons. First, by Radical underspecification of /w/, we can eliminate the need for Hayes's w strengthening rule, which involves the delinking of the major class feature [sonorant]. Second, the use of privative [voice] brings RUT one advantage. It resolves a problematic aspect of RUT that derivations are complex due to maximal underlying simplification of segments. Since privative voicing means that the unmarked value [-voice] is simply absent from the phonology, there is no need to formulate or apply a complement rule inserting the value; thus, a simplification of the grammar results.

(57) Obstruent-Head licensing:

License the final member of an obsturent cluster identified in the underlying representation to be the trigger of voicing assimilation.

```
[-son]  [-son]
   |       |
   C  (C)  C1          ( C1 = Obstruent head )
```

We have to make up a redundancy rule which assigns a segment two features at once in order to prevent the rule from assigning [voice] to the underived f. If we have two rules, one assigning [-son], the other assigning [voice], the later rule derives not only v from /w/ but also v from /f/ since the difference between f and w is only the underlying presence or absence of [-son]. Undesirable redundancy rules and derivations are provided below:

(58) a. [ ] -> [-son] / [___, +cont, +labial]

b. [ ] -> [voice] / [___ , -son, +cont, +labial]

(59) a. /w/ -> [v]

```
UR                          SR

   by RRa    RRb
     [-son]     [-son]
        |          |
C  ->  C   ->     C
                   |
                 [voice]
```

b. /f/ -> [v]

UR SR

by RRb

[-son] [-son]

| |

C -> C

|

[voice]

Consequently, we need redundancy rules as follows:

(60) Redundancy Rules

a. [ ] -> [-son, voice] / [____ , +labial, + cont]

b. [ ] -> [+son]

c. [ ] -> [voice] / [___ , +son]

The adoption of privative features leads to the elimination of the complement rules. That is, once we adopt privative [voice], we no longer need a complement rule for the voicing feature, a redundancy rule assigning the value opposite to the underlyingly specified value, [-voice] at point.

(61) Word-Final Obstruent Devoicing

[-son]

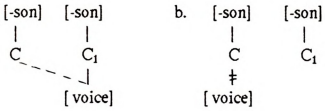
|

C #

ǂ

[voice]

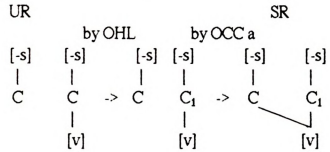
(62) Effects of Obstruent-Cluster Constraint (OCC)



(Condition: persistent application; propagating within a given o-cluster)

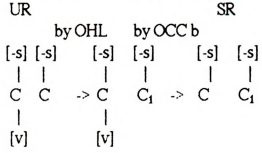
(63) Derivations: ([s] = sonorant; [v] =voice)

a. /wakzal/ -> va[gz]al 'station'



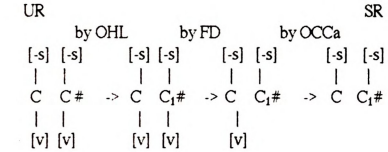
After OHL, the voicing feature of the trigger spreads. Unlike binary voicing, it is a spreading process, delinking of the target's feature is not needed.

b. /b'ez fonet'iki/ -> b'e[s f]on'etiki 'without phonetics'



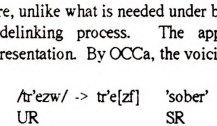
This is the delinking of the [v], motivated by the structural constraint OCC b. As soon as OHL licenses the final member as the trigger, the OCCb-motivated rule fixes the ill-formed representation.

c. /wizg/ -> vi[sk] 'scream' (gen.sg.)



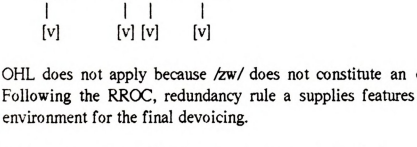
Here, unlike what is needed under binary voicing, the final devoicing is simply a delinking process. The application of FD creates an ill-formed representation. By OCCa, the voicing feature of the target is delinked.

d. /tr'ezw/ -> tr'e[zf] 'sober'



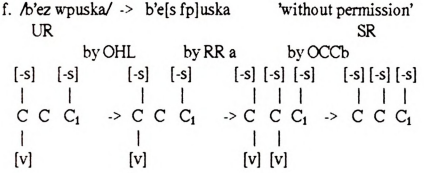
OHL does not apply because /zw/ does not constitute an obstruent cluster. Following the RROC, redundancy rule a supplies features and provides an environment for the final devoicing.

e. / ot- wzryva / -> o[d vz] ryva 'from an explosion'



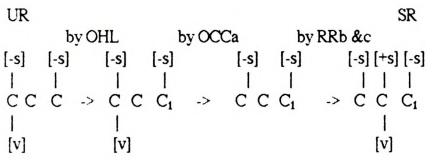
Under privative voicing, there is no need to insert [-voice] to underlyingly unspecified segments by RRs. RRa becomes activated prior to the application of OCC, which make reference to features [-son] and [voice]. OCCa motivates the spreading of [v] onto the targets.

f. /b'ez wpuska/ -> b'e[s fp]uska 'without permission'



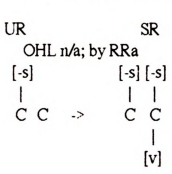
After OHL, RRa supplies /w/ features necessary to be an obstruent to undergo voicing assimilation. Since the ill-formed representation is due to the presence of [voice] in the targets, OCCb applies. In the case of voicelessness assimilation, we have to simply delink the voicing feature of all the targets.

g. /iz- mtsenska/ -> i[s mts]enska 'from Mcensk'



This is the voicelessness assimilation across a nasal. The delinking of [v] takes place ignoring the nasal, which is transparent to the process. On the surface, the nasal must be realized as [+sonorant, voice], which has no effect on the voicing of the o-cluster.

h. /twoj/ ->[tv]oj 'your,sg.'



This case does not involve voicing assimilation since /w/ underlying form of v is not subject to the OHL and thus these segments do not create an o-cluster.

To summarize, the approach presented above has several desirable consequences. First, the use of privative voicing yields the simplest way to explain the phenomena. It results in the simplification of assimilation processes as well as that of the derivations under RUT as a whole. In this analysis, a complement rule which supplies [-voice] to obstruents is eliminated due to the use of privative [voice]. So, RUT with privative voicing requires fewer redundancy rules than binary voicing while keeping maximally unspecified underlying representations. As an effect of Radical underspecification of /w/, w strengthening is unnecessary.

Second, no feature-changing rule is required: each rule involves one process. Voicing assimilation processes are expressed by either one of the two non-feature-changing operations, delinking and spreading.

Third and more importantly, these processes are motivated by a language-specific constraint on obstruent-cluster voicing. The constraint permits the privative voicing in assimilation of both values. The desirable consequences mentioned above are therefore due to this type of approach

which allows privative features to play a role in expressing assimilation of both values.

Finally, since the two mechanisms independently apply to different contexts in a given obstruent cluster, it is fair to say that Russian voicing assimilation is of two types: devoicing and spreading. The devoicing explains voicelessness assimilation and the word-final obstruent devoicing. The spreading takes care of voicedness assimilation of obstruents.

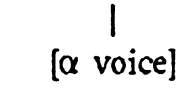
5.2.2 Radical Underspecification and Hayes's prosodic rule

The preceding section presented an approach using constraint, Radical underspecification, and privative voicing. It has shown that a rule which appeals to structural conditions of obstruent-cluster voicing allows privative [voice] to play a role in assimilation of both values. In this section, I favor this constraint-based approach over a spreading analysis.

At the end of the previous chapter, we discussed that Hayes's prosodic rule (p54-55) can be simplified by constraining the rule to refer to the value of the feature [sonorant] of targets. This allows us to eliminate the sonorant revoicing rule since if the rule refers to [-son] of targets, it can skip [+son] consonants, affecting only obstruents. We may reformulate his rule below:

(64) Voicing Assimilation

In the configuration [-son], reassociate [α voice]



with the maximal string of obstruents to the left, deleting any autosegments stranded in the process.

(Condition: Persistent application)

It is stated above that by underspecifying the labio-dental fricative v for [sonorant] and assigning [-son] by a default rule, we can eliminate the ordered rule of w strengthening as well.

Some necessary rules and constraints for underspecification are given below:

(65) Obstruent-Head Licensing (OHL):

License the final member of an obstruent cluster identified in the underlying representation to be the trigger of voicing assimilation.

```
[-son]   [-son]
   |        |
   C  (C)   C1          ( C1 = Obstruent head )
```

(66) Redundancy Rules

a. [ ] -> [-voice] / [___ , -son]

b. [ ] -> [-son] / [____ , +labial, + cont]

c. [ ] -> [+voice] / [___ , -son, +labial,+cont]

d. [ ] -> [+son]

e. [ ] -> [+voice] / [___ , +son]

(The order is irrelevant to rule application; rules apply following RROC (2.2.3))

As for the application of rules a and c, there is no possibility that rule a applies to the context to which rule c also applies since more specific rule c takes

precedence wherever both rules can apply (Kiparsky 1982, 1985, Hudson, personal communication).

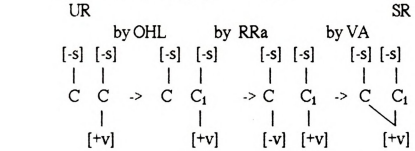
(67) Word-Final Obstruent Devoicing

a. [-son]
|
C #
|
[+voice] -> [-voice]

The final devoicing under the binary feature system must be a feature-changing process, the delinking of [+voice] and the insertion of [-voice] since the final devoicing triggers voicing assimilation by the spreading of [-voice] as we have seen in chapter three.

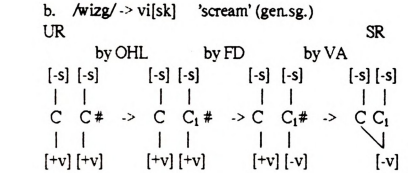
(68) derivation:

a. /wakzal/ -> va[gz]al 'station'



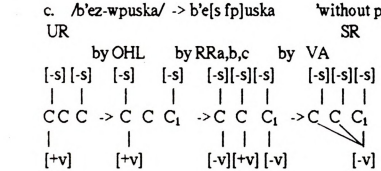
First, the OHL identifies /z/ as a trigger and licenses it; then the RRa supplies the unmarked feature [-voice]; finally the voicing assimilation takes place, deleting the association of [-v] to the target and spreading the feature of the trigger [+v] onto the target. Both values of voicing feature must be present in order for OCC to apply.

b. /wizg/ -> vi[sk] 'scream' (gen.sg.)



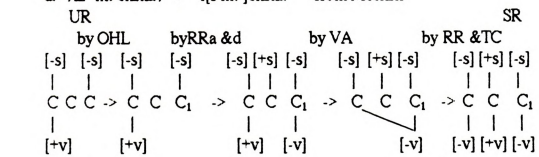
After the OHL, [+v] of the trigger is delinked and instead [-v] is inserted by the final devoicing; by VA the feature of the target is delinked and that of the trigger spreads onto the target.

c. /b'ez-wpuska/ -> b'e[s fp]uska 'without permission'



This is a case of spreading of the negative value. RRs motivated by the RROC apply supplying all the feature values relevant to VA. Here, the asymmetrical segment becomes v. By VA, all the targets lose the voicing feature by delinking and receive [-v] from the trigger by spreading.

d. /iz- mᵗenska / -> i[s mᵗ]enska 'from Mcensk'



This is voicelessness assimilation across a sonorant m. The voicing assimilation takes place across the sonorant m, which is transparent to the process, by delinking of the voicing feature of the target and spreading that of the target. Since the intervening sonorant must be realized as [+voice] on surface, the multiple-linking of the [-v] to the obstruents is split by tier-conflation.

My approach presented in the previous section is preferred to this spreading analysis with RUT for the following reasons.

First, under a spreading analysis like Hayes's rule, the assimilation feature must be binary to be expressed in a single spreading rule: the spreading of an assimilation feature value of the trigger onto the target(s), regardless of the value. Thus, rules entail representations. Privative features cannot work here since the spreading of voicelessness, which is expressed by the absence of the feature [voice], cannot be expressed. It is necessarily a feature-changing rule even though we adopt RUT, which does not specify [-voice] for obstruents underlyingly, we have feature-changing processes as shown in (68) since the RROC requires both values to be present prior to the application of voicing assimilation. Any rule of voicing assimilation under binary features is necessarily a feature-changing operation, changing [α voice] to [-α voice]. A rule which expresses assimilation by changing a feature is highly disfavored (Hayes 1986).

Second, a single spreading analysis requires the devoicing of word-final obstruents to be a two-step process: a delinking of [+voice] and insertion of [-voice] (Mester & Ito 1989). If the devoicing of word-final obstruent is the delinking of [+voice] and the insertion of [-voice], then, as Lombardi argues

(see 2.3.4), laryngeal neutralization phenomena found in many unrelated languages remain unexplained.

On the other hand, as we have seen in the preceding section, those problems do not arise under an approach with structural constraints since it is compatible with the privative feature system.

In the following section, providing derivations using Contrastive Underspecification and privative features, I will show why Radical Underspecification is favored over Contrastive in the Russian case.

5.2.3 Privative Features and the principles of Contrastive Underspecification

The last two sections have shown that privative voicing gives simpler derivations than its binary counterpart does. It is also shown that Radical Underspecification provides a natural account for the asymmetrical behavior of the voiced labio-dental fricative v. In order for us to be really convinced of this, we may have to see the reason why a privative voicing analysis with Contrastive Underspecification is less favored. Contrastive Underspecification does not work nicely in explaining the asymmetry of v because its principle does not allow underspecification of a distinctive feature, which must be present and because the contextual feature for Russian voicing assimilation is the major class feature [-sonorant], which cannot be delinked.

In this section, we consider a problem associated with CUT in using binary features. According to CUT, contrastive features must be specified for both values underlyingly. So the features to be specified for both values are the features voicing and sonorant. Such underlying specification of the feature

sonorant for both values brings us a problem in accounting for the asymmetrical segment v. If the feature sonorant is specified for both values, then the underlying form of the voiced labio-dental fricative v must also be specified as [+sonorant], which is to be changed to [-sonorant] in order for it to undergo voicing assimilation. This is problematic and forces us to instead adopt [obstruent] as a privative feature.

As far as binary features are concerned, under RUT, only the marked feature [+voice] can be underlyingly specified for obstruents while CUT requires both values to be specified underlyingly. Thus, it necessarily involves feature-changing processes, delinking one value of the feature and inserting another.

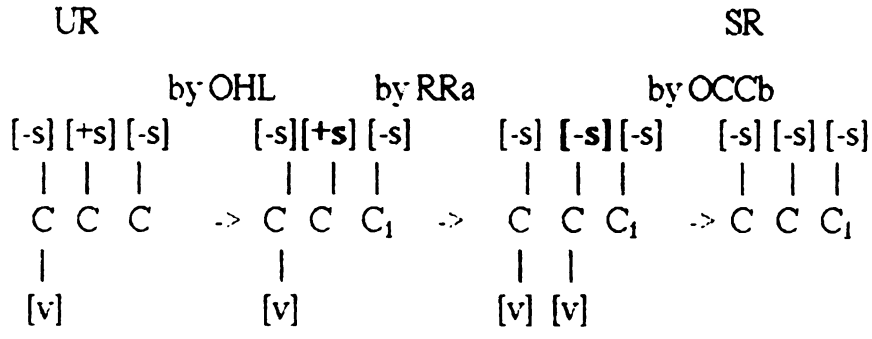
Privative features play a significant role especially in the case of voicelessness assimilation. Once we adopt the privative feature [voice], there is no way to indicate [-voice] other than simply to have it left absent. Thus, RUT and CUT have the same underlying specification for the voicing feature and they have it throughout the derivation. The major difference is the underlying specification of [+son]: RUT does not specify it while CUT specifies it.

It is the underlying specification of [+son] that brings us a problem. That is, when both values for the feature [sonorant] are specified underlyingly, v as a glide must also be specified as [+son]. Consequently, we need a rule changing w to v as [+son] -> [-son] before voicing assimilation applies. We need a more complicated rule than under the principles of RUT. The derivation involving the voiced labio-dental v is given below:

(69) Redundancy Rule:

a. [+son] -> [-son, voice] / [___, +cont, +lab]

(70) /b'ez wpuska/ -> b'e[s fp]uska 'without permission'

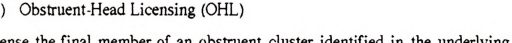


As shown above, it is necessary to change the specification of the labio-dental fricative from [+son] to [-son] so that voicing assimilation affects the segment. It is a feature-changing rule, the delinking of [+son] and the insertion of [-son] by stipulation. Since redundancy rules are by definition all fill-in rules, we have to retain the rule as a phonological one, which is no different from w strengthening. Even if we regard it as a phonological rule, we cannot have it because the major class feature [sonorant] can never undergo delinking or spreading (see p13). To avoid this, we have two alternatives available. One way is to specify the voiced labio-dental fricative v as obstruent [-sonorant] underlyingly. This cannot be accepted since it incorrectly motivates v to trigger voicing assimilation. Another way is to adopt privative [obstruent] instead of the binary-valued [sonorant]. The privative feature [obstruent] is used below while we have at present no evidence to assume that [obstruent] is privative. The feature [+sonorant] in binary terms is then expressed by the

absence of [obstruent]. I will show the effects of the privative features [voice] and [obstruent] on CUT below.

(71) Obstruent-Head Licensing (OHL)

License the final member of an obstruent cluster identified in the underlying representation to be the trigger of voicing assimilation.



(72) Redundancy Rules:

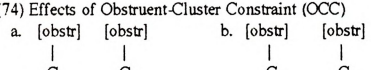
a. [ ] -> [obstr, voice] / [____, +labial,+ cont]

b. [ ] -> [voice] / [____]

(The RROC does not hold in this theory (see p23))

(73) Word-Final Obstruent Devoicing (FD)

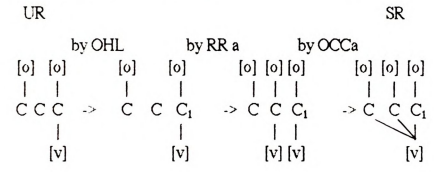
(74) Effects of Obstruent-Cluster Constraint (OCC)



(Condition: Persistent application; propagating within a given o-cluster)

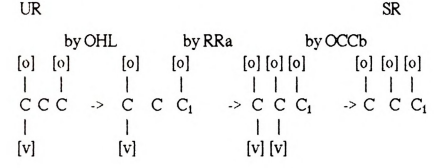
(75) Derivations:

a. /ot- wzriva/ -> o[d vz]riva 'from an explosion'



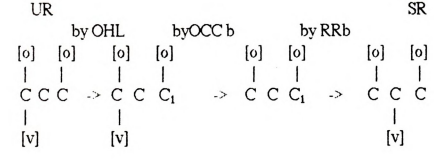
After OHL, redundancy applies; then OCCa spreads [v] onto the targets.

b. /b'ez wpuska/ -> b'e[s fp]uska 'without permission'



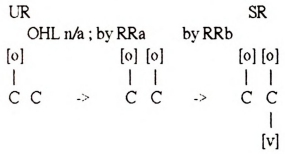
After OHL, RRa , then OCCb fixes the ill-formed representation by deleting all the targets' voicing features.

c. /iz- mtsenska/ -> i[s mts]enska 'from Mcensk'



Assimilation is taking place across the sonorant m. Ignoring the sonorant, OCCb deletes the voicing feature of the target. RRb supplies the sonorant the voicing feature.

d. /twoj/ -> [tv]oj



While the problematic aspect associated with the principles of CUT might be resolved by the use of the privative feature [obstruent] in addition to [voice], again we have to know if [obstruent] is really a privative feature. If [obstruent] is not a privative feature, then we might have to ask whether [sonorant] is privative. There are still some difficulties for CUT. Under a version of CUT, only redundant feature values can be candidates for a single-valued features. As the theory implicitly treats the feature sonorant as a distinctive feature (Christdas 1988), which cannot be single-valued (p26) and must be specified for both values under a binary feature system.

I have shown that the asymmetry of Russian v can be best explained by means of Radical underspecification with privative voicing provided that the contextual feature sonorant is binary. The constraint-based approach with privative voicing gives the simplest and natural account for assimilation of both values in Russian.

Contrastive Underspecification cannot work nicely here since it does not allow the segment to be unspecified for the contextual feature sonorant, which is distinctive. Even though the privative [obstruent] appears to resolve the problem, the privativity of the feature obstruent is not yet justified.

The approach presented here, which appeals to structural conditions of the trigger and targets of assimilation, allows privative voicing even in the case of Russian. They are conditions on representations of obstruent-cluster voicing: a wellformed representation in an o-cluster whose head is voiced, and the other well-formed condition in an o-cluster whose head is voiceless. These two constraints on representations motivate either one of the two non-feature-changing operations: spreading or delinking.

The adoption of the privative feature [voice] reduces the assimilation processes and redundancy rules. Assimilation of both values is expressed by either one of two independent mechanisms, delinking and spreading. This also means that assimilation under a privative feature system (not under a binary one) is really two different processes: voicedness assimilation is an assimilation process (spreading) and voicelessness assimilation is actually a devoicing process (delinking). Assimilation is interpreted as the spreading of the assimilation feature and devoicing as the delinking of it. The voicing assimilation of both values becomes a pair of non-feature-changing processes. The final devoicing also becomes a single operation, delinking of [voice]. We no longer need the insertion of [-voice] word-finally. The two universal mechanisms account for the assimilation of both values and the word-final obstruent devoicing. Voicelessness assimilation and word-final devoicing now become the same rule type. The delinking analysis of voicelessness assimilation

and final devoicing explains the Sanskrit examples where all devoiced obstruents either by laryngeal neutralization or by voicelessness assimilation result in plain voiceless (p33-35).

O-Head Licensing relies on the assumption that v is underlyingly neither obstruent nor sonorant but becomes the obstruent v by a redundancy rule during the derivation. This is possible only under the framework presented here. Only Radical Underspecification treats v as featureless with respect to the relevant features for voicing assimilation.

6. Conclusion

We have seen that three modular theories, i.e., underspecification, autosegmental representation, and the privative feature system, function together to give a uniform account for the phenomena of Russian voicing assimilation. The autosegmental framework, which allows an assimilation rule to affect only segments specified for particular features like [-son], eliminates the need for the rule of sonorant revoicing assumed in a previous analysis (Hayes 1984). Underspecification together with redundancy rules eliminates a need for the w strengthening rule and extrinsic rule-ordering. Finally, the use of privative [voice] has several advantages in explaining the assimilation processes. When privative voicing is adopted, there are only non-feature-changing processes: delinking and spreading of [voice]. This is probably true of any feature if it is privative.

Persistent application of OCC-motivated rules interacts with redundancy rules without extrinsic rule-ordering. Since, by the effect of the RROC, redundancy rules interact with phonological rules, we may say that the approach presented accounts for Russian voicing assimilation without extrinsic rule-ordering.

As for O-head Licensing, it is assumed to apply prior to any application of rules, both redundancy and phonological, providing an environment for voicing assimilation. OHL is neither a phonological nor a redundancy rule. It does not change or affect linkings of features or supply missing values. It is more like a syllabification process. Yet, OHL differs from syllabification in that it does not apply persistently or change structural descriptions. With

respect to non-persistent application of OHL, it refers to the CV-tier and the contextual feature value [-sonorant]. Perhaps, the fact that OHL licenses an entity in the CV-tier, which is by principle not subject to any phonological processes like delinking or spreading, explains its special property.

A rule which expresses an assimilation by spreading any feature value whatsoever is a rule merely using features. In non-linear phonology, which is a theory of representation rather than one of phonological rules, the right rule must be assumed to follow from the right represenation of segments or more specifically, that of features, i.e, the n-arity of a given feature, instead of the case that the n-arity of a feature follows from a rule. We have seen that a single spreading analysis is not in accordance with the evidence for the privative laryngeal features provided by Lombardi (1991). Given her evidence for privative voicing and the Russian data, a constraint-based approach is favored over a spreading one.

The objection that privative features cannot explain assimilation of both values is eliminated by a constraint-based approach. The structural constraint on obstruent-cluster voicing (OCC) allows the use of the privative [voice] even in the case of Russian voicing assimilation. The constraint presented here makes reference to features and their associations to both the trigger and targets in its structural description. This differs from any spreading analysis, which makes reference to the assimilation feature and its association only to the trigger.

Accordingly, the present approach predicts the relationship between the n-arity of assimilation features and assimilation rules: if a feature is privative,

then assimilation of both values of the feature is asymmetrical and needs two rules. If it is binary, then assimilation is expressed symmetrically by a single spreading rule.

I have provided an analysis of Russian voicing assimilation, supporting the position of Ito & Mester (1989) and Lombardi (1991) that the voicing feature is privative. Both values of a feature like voicing can be adequately expressed by the opposition of presence or absence of the feature when a rule is expressed to refer to structural conditions. Logically, we do not need binary features to express binary oppositions. Of course this by no means supports the position of the Strong Privativity (den Dikken & van der Hulst 1988) that all features can be reduced to privative features. Some features by nature may not be candidates for privative status. In fact, if the feature [sonorant] is used as privative, any theory fails to explain the asymmetry of the Russian labio-dental fricative v without requiring a phonological rule changing the values of the major class feature [sonorant]. The question of whether a feature is privative or binary depends on the nature of each feature. We might have to ask whether the nature of features is language universal or language specific. Whatever the n-arity of a feature, a constraint-based approach is shown to be compatible with single valued features as well as binary ones; thus a selection of a feature system follows not from a rule but from the nature of a feature.

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