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# Optimality and the Prototypical Phonological Processes

TAKAHASHI Yukio

One of the sweeping dogmas argued for by the Optimality Theory (hereafter, OT) is that principles of OT contribute to the functional optimization of the overlapping or redundant formulation of (traditionally, unviolable) constraints, rules, and filters. Functional unification of elements of the theoretical apparatus follows from a revolutionarily new interpretation of application of constraints in linguistic theory: The OT introduced an idea that constraints in general are violable. This conception of constraints is a major breakthrough that radically changed another paradigmatic conception in linguistic theory: The OT declared to totally abandon the concept “derivation” in linguistic analysis.

The standard interpretation of the whole architecture of OT assumes (i) three levels of linguistic description, *i.e.*, input, candidate sets, and the optimal output, and (ii) two optimality-theoretic devices, GEN and EVAL. There are no constraints that somehow restrict infinite productivity of GEN: GEN may produce every kind of phonological material from phonological primitives that are assumed, and its outputs will be ranked by the device EVAL, which is assumed to be theoretically and functionally independent and distinguished from GEN. However, in Optimality Theory, the device GEN seems to have a theoretical shortcoming: the internal organization is not made explicit, which brings about two inadequacies. First, if GEN produces an infinite number of phonological outputs, then the EVAL would also have to scan grammaticality of every one of them to decide on (an) optimal output(s). Even if we accept the notion of parallel processing of our mental computation, the infinite number of outputs seems to be too much for the processing to accommodate real-time speech events. Second, if GEN is assumed to be primitive and elementary theoretical device, it may perform any kinds of phonological operation and the theoretical system of phonology presented will not be subject to scientific re-examination.

A scientifically testable system should include that central computational unit that performs linguistically significant tasks. The present paper will commit a new perspective on phonology, which I will dub “Minimalist Phonology” (henceforth, MP). MP internalizes a central computation unit that internalizes three kinds of operations:

## (1) Central Computational Unit

- a . Spread
- b . Strengthen
- c . Weaken

In OT terms, what GEN can do to phonological representations are three kinds of operations that are referred to in (1).

The present paper will proceed as follows. The first section will state the overall architecture of the theory of Minimalist Phonology. The second section will try to list all prototypical phonological processes that are attested in the phonologies of natural languages. The third section will recapitulate and re-evaluate the categorization of phonological processes that are listed and examined in Section 2.

## 1 The Theory of Minimalist Phonology

The present paper shares with the Minimalist Program articulated in Chomsky (1992; 1993) and other related literature the assumption that the linguistic theories should be constituted of those elements that have their conceptual necessities: assumptions on linguistic theories does not include those that are explainable by assumptions on other sub-modules of language. I assume that within the sound system of language three major sub-modules interact with each other: (i) articulatory sub-module, (ii) auditory sub-module and (iii) mental linguistic sub-module. There are two interface levels in the system: articulatory and auditory. The three types of primitive operation listed in (1) are assumed here to constitute the core of phonological systems, which we may interpret to be the OT device GEN.

The overall architecture of the system of phonology will be constrained by some form of boundary conditions that exist at the interfaces where the three sub-modules will interact with each other. One of the sub-modules of phonology, the mental linguistic sub-module, may be compared to a “central format” within the general framework of Conceptual Semantics:

The overall description of the forms of mental information is constrained by some fairly obvious boundary conditions. First, information *entering* the mind comes in many different forms, for example spatial arrays of light intensity provided by retinal receptors, temporal patterns of sound frequencies provided by the ears, spatially arrayed patterns of pressure detected by the skin, and so forth. Second, information *leaving* the mind is primarily in the form of patterns of stimulation to muscles, since it is through movement (including the movement of the vocal tract in the case of language) that we act on the world. The brain’s stimulation of glands probably may also be regarded as a sort of information leaving the mind. Third, none of these forms of input and output information suffices to explain the way we understand the world in terms of objects, their motions, our actions on them, and so forth. Rather, such aspects of our understanding must be encoded in an integrated modality-independent form that I will call a *central format*. (There may be more than one central format, as we will see later on; but there must be at least one.) Fourth, since these different forms of information interact, the mind must have means for translating or transforming information from the input forms into the central format, so that we can perceive and

understand the world in modality-independent fashion. It must also have means for translating from the central format into output forms, so that we can use our understanding of the world as a basis for acting.

Jackendoff, Ray (1993) *Languages of the Mind*, p.3.

Some sort of refinement of the overall framework of phonology that I here presented must await for considerable ramifications in the study of articulatory and auditory phonetics, which in turn may urge some re-examination of the constitution of the phonological primitives of operation. In the following paragraphs, I will briefly summarize the main points concerning the three primitives that are assumed here.

The first primitive operation, "Spread", theoretically depends on the theory of Autosegmental Phonology: the variable " " stands for a terminal feature of geometrically organized phonological representation of the sort that is argued in the theory of Feature Geometry. Takahashi (1993) proposed a generalized constraint on the application of "Spread":

(2) Within the prosodic domain of a phonological word, spread leftward. Otherwise spread it rightward.

The definition of the domain of a prosodic word may include language-specific variations. Universal identification of the domain would depend on the notion "clitic group." As a working hypothesis, I would like to adopt Nespor and Vogel's (1976) definitions of "prosodic word" and "clitic group."

### (3) Definitions of Prosodic Word and Clitic Group

#### a . Prosodic Word

The domain of is Q OR

. The domain of consists of

**a** . a stem;

**b** . any element identified by specific phonological and/or morphological criteria

**c** . any element marked with the diacritic [ +W ]

. Any unattached elements within Q form part of the adjacent closest to the stem; if no such exists, they form a on their own.

#### b . Clitic Group

. C domain

The domain of C consists of a containing an independent (i.e. nonclitic) word plus any adjacent s containing

**a** . a DCL, or

**b** . a CL such that there is not possible host with which it shares more

category memberships

. C construction

Join into an n-ary branching C all s included in a string delimited by the definition of the domain of C.

Independent studies on the prosodic categories may be awaited.

“Strengthen” and “Weaken” have a variable as well. The variable here refers to a root node included in the geometrically organized representation in the sense noted above. Strengthening and weakening of segments are decomposable into more elementary phonological operation, including featural deletion and featural substitution, which interact with the theoretical sub-module of Underspecification. Strength of a root node (i.e., a phonological segment) will be evaluated by principles of phonological strength.

## 2 Prototypical Phonological Processes

We may observe prototypicality in various types of phonological processes of individual languages, and sets of phonological processes exhibit identifiable pivotal formal attribute(s) and some variations that can be categorized as some fixed classes. The periphery of the prototypical processes seems motivated by morphophonological environments. In this section, I would like to cite a rather exhaustive list of the prototypes of phonological processes with examples by which we can identify some parametric variations, and then go on to examine the extent of the variations found in individual languages. Prototypical processes that I will take up here will be (i) assimilation of point of articulation, (ii) assimilation of voicedness, (iii) vowel harmony, (iv) nasalization, (v) spirantization, (vi) intervocalic voicing of obstruents, (vii) syllable-final devoicing.

### 2.1 Assimilation of Point of Articulation

The phonological process of assimilation of point of articulation is an unmarked process that is realized in a number of phonological systems of language. We may find its variation in its constraints on the status of trigger and target: Diola Fogy is a language that does not display any restriction on its target.

Five remarks are in order about the constitution of the core and periphery of the prototype of assimilation of point of articulation. First, assimilation in general seems to be a kind of double articulation. The type of assimilation found in [hɔkkej] may be regarded as a type of total assimilation, which implies the existence of types of partial assimilation of some sort. We can find such cases in Heffner § (1950:193-95) observation on adaptive changes in speech sounds in context. Second, the manner of articulation of the trigger of the process of assimilation of point of articulation may in unmarked cases be identical with that of the trigger of the process. Thus we may find

place assimilation in *horse shoe* but not in *horse back*. Third, the occurrence of the process of place assimilation is in crucial cases overlapped by that of the process of segmental deletion. Fourth, it is particularly remarkable that if place assimilation is prevented by some specific reason then the target may realize deleted. Thus in Japanese a nasal (a target) may be deleted if the trigger is /j/ or /w/: in other cases if the nasal is in a syllable-coda and is in contact with some stop consonant then regressive nasal place assimilation is observed as in [hoŋkau] (buy a book)

## 2.1.1 Total Assimilation

### 2.1.1.1 Toba Batak

We find cases of total assimilation in Toba Batak:

#### (4) Total Assimilation in Toba Batak

- a** . mañan baa an            maña[ b ]baaa an  
       eat    man that        “ that man is eating ”
- b** . lean lali                leal lali  
       given hen-harrier     “ Give a hen-harrier ”

Total assimilation instantiated as in (4) may be explained by deletion of melodic contents cum spreading of terminal features of the triggers. Thus, with respect to the example in (4a), it is crucial delete the feature [ +nasal ] at the word-final position. By the theory of Radical Underspecification advocated by Kiparsky (1982; 1985), the derived representation of the word-final /n/ will crucially include no melodic content, which triggers the application of Spread .

### 2.1.1.2 Italian

Italian also exhibits the process of total assimilation of nasal consonants. In Italian Nasal Place Assimilation, we may observe deletion of nasals at the syllable-coda position that triggers leftward spreading of place features.

#### (5) Total Assimilation in Italian

- a** . [ in+ri ] + [ producibile ]    i [ rː ]producibile
- b** . Total Nasal Assimilation in Italian  
       [ +nasal ]    [ nasal,    anterior,    coronal,    lateral ] / [ ...\_\_\_\_\_ ]  
       [ nasal,    anterior,    coronal,    lateral ]]Word

The phonetic effect of compensatory lengthening of the liquids observed in (5a) may be brought about by deletion of [ +nasal ] and leftward autosegmental spreading of [ -lateral ] As exemplified in English data, *irregular* and *illegal*, the language has taken the option of deleting both the melody and the timing unit of the coda consonants of

the negative prefix.

### 2.1.2 Partial Assimilation

Partial assimilation is a type of assimilation in which the significant portion of the articulatory properties of the target is overlapped by that of the trigger. The instance of the progressive partial assimilation is reported in Jones (1960)

(6) When the phonemes *m n l r w j* are immediately preceded by a voiceless consonant in a stressed syllable, partially breathed varieties of *m n l r w j* are used.

Jones (1960:220)

In an English example *small*, we may observe a rightward spreading of the feature specification [-voiced] over the nasal in the onset. The autosegmental spreading is motivated by the featural specification [voiced] of the nasal: the feature [voiced] is unspecified in the nasal in English because the voicedness of the English nasal is totally predictable. The rightward spreading of the feature specification [-voiced] is supported by the constraint on the direction of the autosegmental spreading (2)

### 2.1.3 Consonant-Vowel Interactions in Assimilation

There are cases of assimilation where interactions among major classes are observed.

#### 2.1.3.1 Phonological Influences from Consonants on Vowels: Cases from Kashaya

Kashaya vowel alternations may present some serious questions about the adequacy of the directionality constraints on “Spread .”

In Kashaya, the vowel /i/ behaves as a neutral vowel and it changes its quality according to its neighboring consonants. Buckley (1994:103-105) argues for an idea that the vowel is phonologically by some operation.

Kashaya vowels /i e a/ realize as [a] after unrounded uvular /q/:

(7) /i e a/ [a] / \_\_\_ /q/

a . /i/ [a]

s<sup>ʔ</sup>u<sup>h</sup>laq-in s<sup>ʔ</sup>u<sup>h</sup>laq<sup>à</sup>n “ while getting a stomach ache ”

b . /e/ [a]

sima q-eti sima qatí “ although he s asleep ”

c . /a/ [a]

mo-aq-an<sup>ʔ</sup>-i moqa du “ keep running out from here ”

After rounded uvulars /q<sup>w</sup>/, these vowels are realized as [o]

(8) /i e a/ [o] \_\_\_ /qʷ/

a . /i/ [o]

woqʷ-in woqón “ while flowing ”

b . /e/ [o]

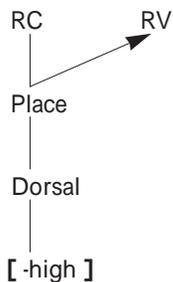
mo-maqʷ-eti momà qoti “ although he ran in here ”

c . /a/ [o]

qašo qʷ-anʷ-i qašoqo du “ be getting well ”

Buckley (1994:107) formulates a phonological rule to account for the data quoted in (7) and (8)

(9) Uvular Assimilation



Buckley's formulation in (9) is problematic in the following two respects: (i) The operation assumed in (9) spreads a non-terminal node, and (ii) rightward spreading is performed in a domain larger than a prosodic word. As for the first case, we may overcome the problem by stipulating that the terminal feature specification [-high] is spread in cases in (8). The second point may provide a serious counter-example to our general assumption on the directionality of the spreading operation.

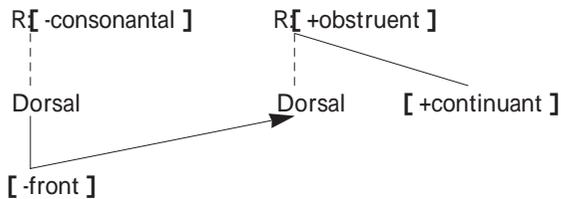
### 2.1.3.1 Phonological Influences from Vowels on Consonants: Cases from German

German exhibits two types of phonological process that spreads phonological attributes of vowels onto consonants:

#### 2.1.3.1.1 Dorsal Fricative Assimilation in German

In German, a vowel place feature [-front] is copied onto the fricative to the right in a prosodic word. Wiese (1994:213) tries to formulate his phenomena in a phonological rule:

(10) Dorsal Fricative Assimilation



The rule in (10) includes specifications on a rather complex description of phonological structure. We may note (i) that the direction of phonological spreading is derived from the directionality principle in (2) and (ii) that the feature specification of the fricative is underspecified by the theory of Underspecification. Therefore the trigger and target of the operation is appropriately specified by two principles, so that the complex specification of the structural description is unnecessary.

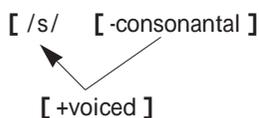
2.1.3.1.2 s-Voicing in German

Word-initial /s/ is voiced immediately before a vowel in German. This process does not apply word-medially:

- (11) a . Sonne, sehen  
b . reissen, dreissig  
c . Smoking, Slalom

Wiese (1994:176) formulates a phonological rule that includes a prosodic specification:

(12) s-Voicing



Three points are in order concerning the formulation of the rule: (i) the trigger of the spreading is the unmarked feature specification, (ii) the direction of the spreading is regressive in spite of its domain of application, and (iii) the specification of the target is too restricted. In more broader terms, the phonological alternation “s z” may be categorized as a lenition process. Thus It is natural to assume that the s-Voicing (12) is not tenable as a rule of German phonology: A reasonable speculation would be lexical specification of the voicedness of the /z/s as exemplified in (11a). As is pointed out in Malsh (1971), fricatives are voiced in intervocalic positions, which may safely be assumed to be a natural context for phonological lenition.

## 2.2 Voicing Assimilation

### 2.2.1 Problems of Russian Voicing Assimilation

Before going on into the examination of Russian Voicing Assimilation, I would like to take notice of the assumption that there is no contrastive specification of the feature [voiced] in the underlying consonantal inventory of Russian.

Behavior of Russian Voicing Assimilation can be summarized as follows: (i) Word-final obstruents are devoiced (e.g., /sad/ [sat] “garden”), (ii) a sequence of consonants assimilates in voicing to the last member word-medially as well as across clitic and word boundaries (e.g., gor[tk]ɐ “little town,” mcer[zg b]y “if Mcensk,” and mcer[zg b]ɐyl “it was Mcensk”), (iii) word-final devoicing feeds Voicing Assimilation (e.g., mozg md[sk] “brain”) and (iv) sonorants are not opaque to Voicing Assimilation (e.g., iz # mcensk + a [s mc]ɐnska “from Mcensk”).

A labial fricative /v/ interacts with the processes of Voicing Assimilation and Word-final Devoicing, and other phonological processes to exhibit properties not only of obstruents but also of sonorants. It behaves as an obstruent with respect to Word-final Devoicing and Word-medial Voicing Assimilation: e.g., zdorov zdor[ɸ] “healthy,” krivd kr[ɸt] “justice” (gen.pl.), korov + k + a kor[ɸk]ɐ “little cow.” It patterns as a sonorant and does not trigger Voicing Assimilation: d[ɸt v]ɐga “from the enemy,” and d[ɸt n]ɐuki “from science.” The devoiced variant of /v/ does not trigger Voicing Assimilation (tr[ɸz] “sober”). It is notable furthermore that /v/ is transparent to Voicing Assimilation (e.g., ot vdov + y d[ɸd vd]ɐvy “from the window,” ot vtor + ogo d[ɸt vt]ɐrogo “from another”).

Kiparsky (1985) examines Hayes (1984) analysis of Russian Voicing Assimilation, and he presents a rather simplified and theoretically well-motivated alternative. Assuming Strong Domain Hypothesis, Structure Preservation, Radical Underspecification and the framework of Lexical Phonology, Kiparsky (1985) proposes two universal marking conditions and four phonological rules:

#### (13) A Lexical Phonological Analysis of Voicing Assimilation of Russian

##### a . Marking Conditions

- i. \*[voiced, +sonorant]
- ii. [+voiced, -coronal, +continuant]

##### b . Phonological Rules

###### i. Final Devoicing

C [-voiced] / [ ]

###### ii. Voicing Assimilation

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

###### iii. Default Voicing

[sonorant] [voiced]

iv. W Strengthening

[+labial, -consonantal] [-sonorant]

Final Devoicing will be applied lexically to derive word-final devoiced obstruents (e.g., [sat]). The case of *mcer* [zg b] is derived by Voicing Assimilation postlexically. The case of word-final cluster of voiceless consonants will be lexically derived by Final Devoicing and Voicing Assimilation. Sonorant's transparency to Voicing Assimilation is explained by the theory of Underspecification and the marking condition (13ai) (i) By the marking condition, sonorants are [voiced] lexically, and (ii) by the Elsewhere Condition, Voicing Assimilation will be applied prior to Default Voicing.

The problematic cases with /v/ are accounted for by the above rule system and an assumption that /v/ is underlyingly [voiced, -coronal, +continuant] (i) Final Devoicing applies to /v/ in the word-final position, i.e., *zdorov*, vacuously, (ii) Voicing Assimilation applies to /v/ in the word-final coda position, i.e., *korov* [f] +k+a, vacuously, (iii) /v/ does not trigger Voicing Assimilation because it has no specification on [voiced] and (iv) /v/ is transparent to Voicing Assimilation because of non-specification of [voiced] W-Strengthening will apply postlexically by Strong Domain Hypothesis and the marking condition (13aii) e.g., *zdorov* [v] i "healthy?" vs. *zdorov* [f].

Comments are in order concerning Voicing Assimilation and W Strengthening. Voicing Assimilation will be drastically simplified into "Spread (" if the target is somehow appropriately specified. The direction of the operation may safely be argued to be derived from the directionality constraint on "Spread ." W Strengthening is assumed here to apply context-freely. The problem is whether the process "/w/ /v/ " is phonetically motivated or not.

### 2.2.2 Voicing Assimilation in Slovak

Rubach (1993) observes that obstruents in a cluster in word-medial positions as well as across words are assigned one and the same specification of the feature [voiced]

#### (14) Voicing

a . inside words

pros+i+t "ask"    pros+b+a [zb] request "

b . across word boundaries

chlap+i "men"    chlap [-b] zavola "the man called "

#### (15) Devoicing

a . inside words

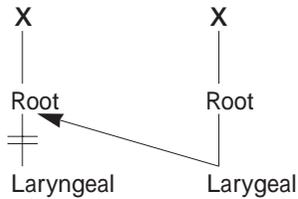
Srb+iek "Serbian"    Srb+k+a [p]

**b** . across word boundaries

plod+u “ fruit ”    pod [-t] práce “ the fruit of work ”

Rubach (1993:281) formulates a phonological rule (16) to account for these facts:

(16) Voice Assimilation



Within the model assumed in this paper, the rule (16) may be simplified into “ Spread . ” The leftward spreading is derived from the directionality constraint. The problem is how the trigger of the process is identified: By default, [-voiced] is not specified lexically in the set of voiceless obstruents. If Spread applies freely, the voicing processes in (14) will be performed globally while those in (15) are restricted to the postlexical level.

### 2.3 Vowel Harmony

Smith (1992) categorizes processes of vowel harmony as a kind of assimilation, in which he includes progressive and regressive harmony processes. In our present approach, the vowel harmony in general is accounted for by an autosegmental spreading operation. What is of interest here is whether or not the directionality constraint on spreading is applicable to cases which include triggers of vocalic specifications.

#### 2.3.1 Vowel Harmony in Yoruba

Archangeli and Pulleyblank (1994) assume a rightward spreading of [-Advanced Tongue Root] in their analysis of Yoruba Vowel Harmony, where /a/ is supposed to be a neutral vowel and has no specification on vocalic place and manner features. Relevant data follow:

- (17) [ate]            “ hat ”  
      [ a ɔ ]            “ cloth ”  
      [ èkpà ]          “ groundnut ”  
      [ ɔjà ]            “ market ”

An inspection of the examples in (17) would suggest that they form prosodic words and that the directionality of the spreading operation would be an automatic

consequence from the specification of the domain.

### 2.3.2 Vowel Harmony in Wolof

Archangeli and Pulleyblank (1994) quote examples of vowel harmony of Wolof and present an argument that the feature [-Advanced Tongue Root] is spread onto the segments on the right. For example, Wolof suffix, -l -al “for,” is subject to progressive vowel harmony from the base.

- (18) a .[jəndəl] “buy for”  
b .[waxal] “speak for”

The behavior of Wolof suffix can be accounted for by (i) a directionality condition on “Spread” and (ii) a language-specific condition that I will describe just below. The Wolof suffix is attached lexically, and the phonological process of vowel harmony is applied at the level. The feature specification [+Advanced Tongue Root] is underlyingly unspecified, and at the level where the phonological process is applied the candidate for the is only [-Advanced Tongue Root]. The distribution of the two specifications, i.e., [-Advanced Tongue Root] and [+Advanced Tongue Root] would participate in the determination of the direction of the spreading operation.

### 2.3.3 Vowel Harmony in Lango

In Lango there are two types of vowel harmony: progressive and regressive. Interestingly, the distinction of the direction of vowel harmony significantly corresponds to semantic distinctions in expressions of alienability of possession. We find regressive vowel harmony in expressions of alienable possession, while we may observe progressive vowel harmony in expressions of inalienable possession:

- (19) Regressive Vowel Harmony  
a . Vɔ(C)  
d k “stew”      dekki “your stew”  
b . VCɔ [+high]  
l t “stick”      lutwu “your stick”

The direction of the spreading in (19) is borne out of the assumption that the suffix of alienable possession is attached syntactically. Since the domain of the spreading is larger than a prosodic word, the direction is specified as regressive.

Lango seems to have a suffix of possession that is attached lexically. The suffix is also the target of the vowel harmony, which is progressive:

(20) Progressive Vowel Harmony

- a. [+Advanced Tongue Root] CV  
wot "son"    wodə "my son"
- b. [+Advanced Tongue Root] C C V  
atɪn "child"    atɪnna "my child"
- c. [-Advanced Tongue Root] C C V  
lwɔkkɔ "to wash"

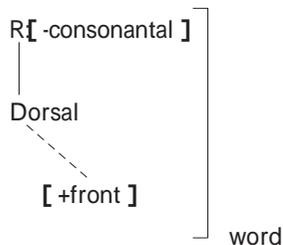
In our assumption, the progressive character of the vowel harmony would suggest that the autosegmental spreading would be delimited within a prosodic word. Some motivation would be needed if the suffix quoted in (20) forms a prosodic word with its host. A reasonable assumption would be to attribute the distinction of the suffixation to the semantic dichotomy of alienable vs. inalienable possession.

2.4 Vowel Assimilation

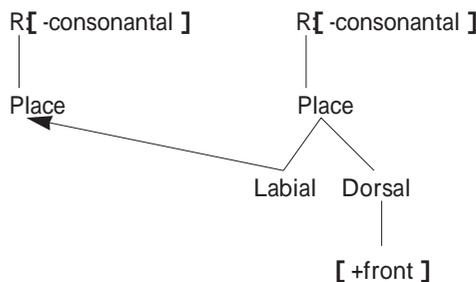
In his analysis of German phonology, Wiese (1996:186) distinguishes Umlaut Rule that deals with alternations as in *Bach / Bachlein* from one that relate *Baum / Baume*.

(21) Rules for Umlaut

a. Umlaut



b. Rounding Assimilation



In his study of front and back high fricatives of German, Hall (1989:6) regards the former type of Umlaut phenomena as a morphophonological one and formulates a rule (22)

(22) Umlaut

[+syllabic] [-back] / \_\_\_\_ C<sub>0</sub> [+U]

Formulation of the rules in (21a) and (22) may not present serious problems to solve to our analysis of prototypical phonological processes, because they are intended to deal with lexical relations among words that are morphologically governed.

Wiese (1994) Rounding Assimilation is problematic in two ways: (i) the spreading operation is triggered by non-terminal geometrical node, and (ii) the direction of the spreading is specified as leftward in spite of its domain of application. The first point is related with the melodic content of the underlying representation of the vowel. The second point has to be open for future research.

2.5 Nasal Place Assimilation in German

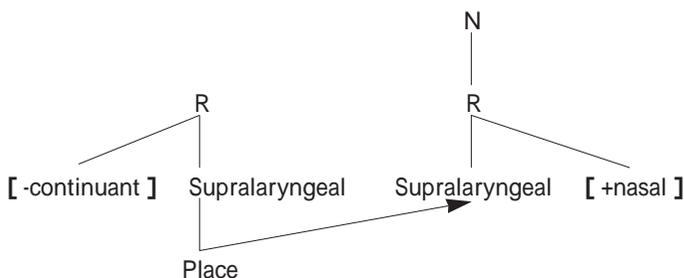
There is a progressive Nasal Place Assimilation in German, which triggers syllabification of the nasal. To cite examples from Wiese (1994:222)

(23) Progressive Nasal Assimilation

- a . geben [ge<sub>1</sub>b<sub>1</sub>n̩]                      tragen [tRa<sub>1</sub>ŋ<sub>1</sub>n̩]                      leiten [la<sub>1</sub>It̩n̩]
- b . kamm<sub>1</sub>n [k m<sub>1</sub>n̩]                      ring<sub>1</sub>n [RIn̩ŋ<sub>1</sub>]                      kenn<sub>1</sub>n [k n̩n̩]
- c . rauf<sub>1</sub>n [Ra f<sub>1</sub>n̩] / [Raf<sub>1</sub>n̩]      reich<sub>1</sub>n [Ra<sub>1</sub>ɪC<sub>1</sub>n̩] / [Ra<sub>1</sub>ɪC<sub>1</sub>n̩]
- rauch<sub>1</sub>n [Ra ɲ<sub>1</sub>n̩] / [Ra ɲ<sub>1</sub>n̩]

Wiese (1994) observes that the type of assimilation (23) is optional when the trigger is a fricative and that it depends on the rate of speech. He formalizes a rule (24) which includes a spreading of a non-terminal node:

(24) Progressive Nasal Assimilation

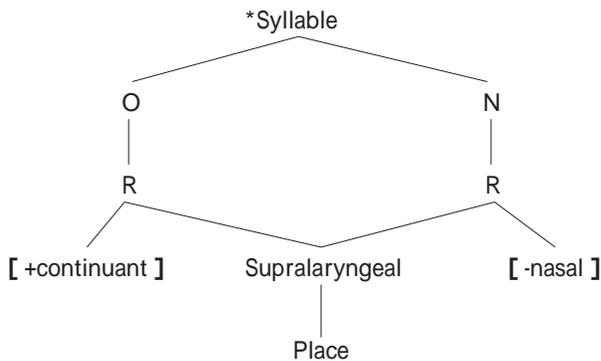


The formulation of the rule in (40) virtually restricts the trigger to stop consonants. In order to circumvent the problem that lurks, Wiese (1994:223) tries to introduce a rather obscure concept:

(25) I will simply assume here that the assimilation is a phonetic phenomenon of (optional) co-articulation with all fricatives as triggers, but a true regularity in the phonological domain with preceding non-continuants.

The phonetic attribute of “ co-articulation ” that is referred to here may be captured by introducing a filter on outputs of phonology:

(26) A Constraint on Syllabic Structure



The filter (26) has a rather complicated structural description, whose function, however, can be translated into another traditional format:

(27) \*["+nasal, +continuant"]

This may be a reflection of the default (28)

(28) ["+nasal"] ["-continuant"]

It appeals to our mind that some form of default system may play the role of filter, though the duplicate function of the default seems to have not been explicitly mentioned.

A caveat against Wiese's (1994) analysis of German Progressive Nasal Place Assimilation is that the nasal is assumed to be in a syllable head position. As far as the presented data are concerned, the syllabification of the nasal is completely predictable. Therefore, by the theory of Underspecification, the information stating the syllabicity of the nasal somehow has to be unspecified lexically. English displays similar behavior of nasals: the nasal place assimilation accompanies the syllabification of the nasal (i.e., open, bacon, and button). In fact, there is no nasal syllabification where there is no nasal place assimilation.

## 2.6 Nasalization

In Japanese, the word-initial voiced velar consonants are nasalized when some kind of prefixes are added: e.g., [gak̚ou] “school” / -- [ŋgak̚ou] “elementary / junior high school” / [gak̚ou] “high school”. This process may be regarded as a lenition triggered by prefixation. The kind of pronunciation which include such velar nasals is in the drift of phonological change: younger generations tend to pronounce these words with non-nasals.

## 2.7 Spirantization and Fricative Voicing in Intervocalic Positions

By definition, spirantization and fricative voicing are processes of lenition, and they share distributional characteristics: they are intervocalic processes.

### 2.7.1 Spirantization in Italian

Nespor and Vogel (1986:205) refers to a phonological rule that is applied to intonational phrases, which would be formalized as follows:

#### (29) Intervocalic Spirantization in Italian

[ -cont, -voiced, -delayed release ] [ +cont ] / [ ... [ -cons ] \_\_\_\_\_ [ -cons ] ... ]

The rule tries to capture phonological alternations found in :

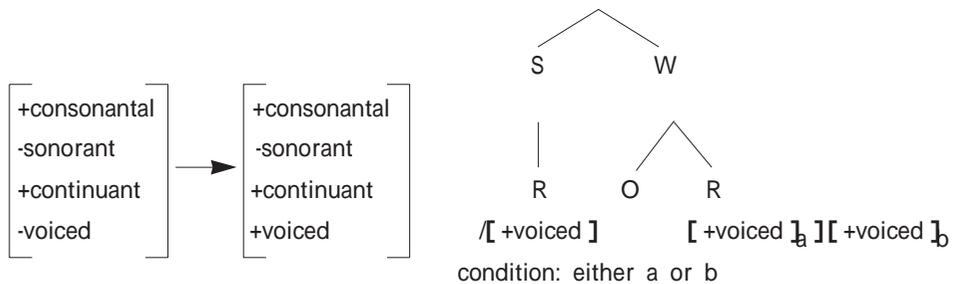
(30) { p t k } { h }

The rule (29) has a structural description that is characteristic to lenition processes.

### 2.7.2 Fricative Voicing in Old English

The formal properties of the environment that triggers lenition instantiated in Italian Spirantization are shared by Fricative Voicing in Old English, which too is by definition a lenition process. Suphi (1988) adopts a rather complex system of phonology to account for the Fricative Voicing. Two comments are in order as for Suphi's formalization: (i) the formal properties of the Fricative Voicing as a lenition process is regrettably not captured explicitly in the structural description of the rule and (ii) the description of the structural change clearly includes redundant information:

(31) Fricative Voicing in Old English (Suphi (1988:195))



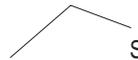
The structural change can only be “[+voiced]” The unwanted complication of the structural description seems to be incurred by the introduction of the two coefficient variables.

Takahashi (1995) presented an alternative to this analysis, assuming Kiparsky’s (1977) syllable template, segmental strength hierarchy and his general phonological framework:

(32) a . Fortition

C [ +spread glottis ] / [ ... \_\_\_\_ [ -consonantal ] ... ]<sub>Foot</sub>

b . Fricative Voicing



[ -son, +cont, -spread glot. ] [ +voiced ] /

c . Default and Complement Rules

i. [ ] [ -spread glot. ]

ii. [ (sonorant) ] [ voiced ]

The rule that plays a pivotal role in performing voicing effect is (32c) which is clearly simpler than . The structural description of the rule can be modified into “[+sonorant]\_\_[+sonorant]” or “[+sonorant]\_\_.”

2.7.3 s-Voicing in Italian

This process also occurs in intervocalic positions. Nespor and Vogel (1985) observe that the domain of this process is a prosodic word and that it does not occur in prosodic domains larger than words:

(33) a . a [ z ] la, [ z ] la

b . la [ s ] rena vs. \*la [ z ] rena

hanno [ s ] minato vs. \*hanno [ z ] minato

c . telefonat [ s ] vs. \*telefonat [ z ]

Nespor and Vogel’s rule for this phenomenon is:

(34) Intervocalic /s/-Voicing in Italian

[+cont, -voiced, +cor, +ant] [+voiced][... [-cons] \_\_\_ [-cons] ...]<sub>Word</sub>

This rule is very similar to the one that Malsch (1971:70) formulate to account for Fricative Voicing in Old English, which is not restricted to /s/. The peculiar delimitation of the target in Voicing in Italian may be attributed to some form of parametric specification in Italian phonology concerning /s/, which I now cannot identify. A tentative proposal as to the treatment Italian /s/ and its voicing is as follows:

(35) Parametric Specification

In Italian, [CORONAL, +anterior, +cont] is specified [+spread glottis]

(36) Onset / Coda Licensing

- a . In the syllable onsets, [ ] [+spread glottis]
- b . In the syllable codas, [ ] [+slack vocal cords]
- c . In the syllable codas, [ ] [+constricted glottis]

(37) Default for PF-Articulatory Interfaces: Foot Medial Release of Consonantal Closure Ambisyllabic consonants are lenited foot-internally. Options for lenition include:

foot-internal voicing: delinking of [+stiff vocal cords]

Another possibility will be to re-assign [+stiff vocal cords] to /s/ in non-intervocalic positions. But this is far more *ad hoc*.

## 2.8 Obstruent Devoicing in Coda

There are two types of obstruent devoicing in coda: lexical and postlexical. In German we observe a lexical devoicing of obstruent in coda, as exemplified in ja<sub>g</sub> [g] en-Jagd[kd]en-Jagd<sub>kt</sub> [kt] A similar phenomena can be found in Japanese loan words, as in [bik<sub>ɪ</sub>na] "big," where we may observe a de-vocalization or deletion of vowel in the second syllable. I would like to leave open the question of how we formalize the Japanese devoicing phenomena.

## 3 A Minimalist Approach to Phonology and OT

I have just discussed the prototypical properties of phonological processes that are attested thus far. The phonological processes that I have take up are (i) assimilation of point of articulation, (ii) assimilation of voicedness, (iii) vowel harmony, (iv) nasalization, (v) spirantization, (vi) intervocalic voicing of obstruents, (vii) syllable-final devoicing. One of the prototypical processes, "Spread", is realized in two types of

assimilation, and vowel harmony. Nasalization, spirantization, and intervocalic voicing of obstruents may be categorized as “Weaken .” I have cited just one example of “Strengthen ”: syllable-final devoicing process. The core of the three prototypical processes is instantiated in “Spread,” “Strengthen,” and “Weaken.” The variable “ ” stands for a trigger of the phonological operation. The target of the operation of “Spread ” is specified by the interaction of the theory of Underspecification and the featural specifications in the lexicon. The operations “Weaken ” and “Strengthen ” may be unified into a generalized form, and one such possibility is developed in Takahashi (to appear), where the two operations are assumed to perform their functions according to principles of phonological strength and the theory of syllable structure.

The phonological system that I have described here assumes the theory of Underspecification and the notion of phonological derivation. An explicit statement concerning the content of the GEN in OT will contribute to the refutability of the theory as a whole, though the basic assumptions adopted here may militate against it. The point will be to make an exhaustive list of prototypical processes of natural languages and then to go on to significantly restrict the notion of possible varieties of phonological processes.

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- (1) Readers are referred to D. Archangeli and D.T. Langendoen's *Optimality Theory: An overview* and the references therein.
- (2) As for the theory of Feature Geometry, readers are referred to Sagey (1986)
- (3) Q stands for a terminal element of a syntactic tree.
- (4) [+W] is a diacritic feature that is assigned to certain phonologically independent suffixes.
- (5) DCL stands for directional clitics, which have an inherent property realized as their phonological dependency on elements to their left or right.
- (6) CL is unmarked with respect its host: it may by definition find the host either to the right or left.
- (7) Takahashi (to appear) tries to derive the effect of (2) from some phonological primitives. The rightward spreading of terminal features within prosodic words is supposed to be due to an atemporal nature of the domain: the phonological processes restricted within prosodic words does not depend on temporal modality of our speech organs.
- (8) See Takahashi (to appear)
- (9) The processes of (i) aspiration, (ii) glottalization, (iii) vocalization of liquids, and (iv) palatalization remain to be noted. As for a tentative examination of these, see Takahashi (1998a)
- (10) We may find some sets of example of place of assimilation of Diola Fogy in Kiparsky (1973)
- (11) See Hayes (1986)
- (12) Takahashi (1996) pointed out that Lango has two types of vowel harmony whose domains of application strictly correspond to their directionality of spreading.
- (13) As for Lango phonology, see Okello (1975) and Noonan (1981)
- (14) The semantic distinction of the suffixes is pointed out in Woock and Noonan (1979)
- (15) [+U] is a morphological diacritic feature.
- (16) See Takahashi (1993) who thinks of lateral syllabification as spreading of laterality and progressive assimilation of point of articulation.
- (17) As for the data and a more traditional generative analysis of Fricative Voicing in Old English, see Malsch (1971)
- (18) The rule is cited from Kenstowicz's (1994:64) survey of Generative Phonology.

