The Phonology of *Wanna*-contraction Part II: A lexically based algebraic analysis*

Sosei Aniya

1. Preliminary Remarks

Aniya (1999) examines three generative phonological analyses of *wanna*-contraction: Selkirk's (1972) tap-detap analysis, Radford's (1997) geminate-degeminate analysis, and Suiko's (1978) deletion-oriented analysis. Rejecting the first two analyses as inappropriate, Aniya (1999) offers an alternative analysis on the basis of Suiko's (1978) analysis. The alternative analysis not only eliminates Suiko's (1978) technical problems but suggests an explanatory and straightforward account with corroborative arguments and supportive data. Moreover, Aniya (1999) ventures a hypothesis regarding the phonological processes involved in the creation of [war̃ə] (*wanna*). The hypothesis assumes that [war̃ə] (*wanna*) is created once and for all from its host /want tu/ (*want to*) through a series of effort-minimizing phonological processes: the deletion of the word-final /t/ of /want/; the deletion of word-initial /t/ of /tu/; the vowel reduction of the word-final /u/ of /wantu/; and the nasal tapping, transforming /n/ into /r̃/. The hypothesis is given support by confirmatory arguments and concrete evidence.[1] Aniya's (1999) analysis, however, does not take into account recent theoretical developments in phonology. To address this shortcoming, the present sequel discusses the issue from a wider perspective including an evaluation-oriented analysis within the framework of Optimality Theory.

The present sequel pursues two purposes. The first aim is to analyze the phonology of *wanna*-contraction under Optimality Theory (OT) and show its advantages and disadvantages. The second goal is to analyze the phonology of *wanna*-contraction within lexically based algebra (LBA) originated by Brame (1997) and developed by Brame & Kim (1998). It will be shown that important observations of OT can be incorporated into an LBA analysis advanced in this paper. Moreover, the spirit of Aniya's (1999) hypothesis is also implemented in the LBA analysis. Furthermore, the LBA analysis shows its superiority over the OT analysis in three respects. First, general algebraic machinery employed in LBA extends the horizon of interfacial inquiry. Second, the LBA analysis accounts for the duality of production and recognition by general algebraic operations. In production, words are combined to make larger units by left-to-right concatenation, while in recognition words produced are cancelled out (mentally recognized) in real-time computation. Therefore, the duality corresponds to the real time language processing of the speaker and hearer. Finally, the LBA analysis offers a morphology-phonology interfacial account of the *wanna*-contraction thereby achieving a higher goal than the OT analysis.

2. An Optimality Theoretic Analysis and Its Problems

2.1. Preliminaries

No analysis has been attempted to account for specifically the phonology of *wanna*-contraction within the framework of Optimality Theory (OT) as far as my knowledge goes. Therefore, I will develop a hypothetical analysis based on the work of Prince & Smolensky (1993), Archangeli & Langendoen (1997), Kirchner (1998), Roca & Johnson (1999), among others. It will be shown that the hypothetical OT analysis enjoys two advantages over the generative phonological analyses discussed in Aniya (1999). First, the rule-governed derivation is totally dispensed with in favor of OT's constraint-based evaluation for selecting an optimal candidate. Second, the OT analysis offers a solution from the point of view of language universals, backed by cross-linguistic observations. The OT's two advantages outweigh the credits of generative phonological analyses. However, the OT analysis bears two basic problems. First, it fails to account for the etymological relation of three variants: [wantu] (*want to*), [wantə] (*wanta*) and [war̃ə] (*wanna*). Nor does the OT analysis explain the difference in syllable structure between the host [want.tu] (CVCC.CV) and its offspring [wañ.ə] (CVC.V) [The dot shows the syllable boundary.] Therefore, the OT analysis calls for some device to account for the morphology-phonology interface.

The next section shows in detail the OT analysis of the phonology of *wanna*-contraction and its problems.

2.2. A hypothetical OT analysis and its problems

For the sake of heuristic purposes, let us construct a hypothetical OT analysis on the basis of Archangeli & Langendoen (1997); Hammond (1997); Kirchner (1998); Roca & Johnson (1999); among others. Two basic OT contrivances are GEN and EVAL. The former is a device for generating a set of (infinitely many) outputs. The latter is a set of universal (or typologically general) constraints. The constraints are strictly ranked, by which an optimal output is singled out out of possible outputs generated by GEN. Given below are constraints relevant to the issue under consideration.

(1) Relevant constraints

a. FAITHFULNESS: Pronounce everything as is. (cf. Hammond, 1997)

b. LAZY: Minimize articulatory effort. (cf. Kirchner, 1998:18)

c. ONSET: Syllables begin with a consonant. (cf. Hammond, 1997)

d. NOCODA: Syllables end with a vowel. (cf. Hammond, 1997)

Constructed on the ground of wide cross-linguistic observations, the above four constraints apply to (O)V(C) type languages such as English. For example, codas may be present but only in order to satisfy FAITHFULNESS (*no* [no] vs. *note* [not]). LAZY accounts for the effort-minimizing (ease-of-articulation) phenomena such as degemmination, flapping/tapping, spirantization, and complete elision. Degemmination shortens long consonants to short ones. Flapping/tapping reduces an alveolar stop to a flap or tap. Spirantization replaces a stop with a fricative. Complete elision deletes a segment. The definition of ONSET and NOCODA is self-explanatory.

The constraints are ordered hierarchically left to right ranked from most powerful to least as shown in (2). All constraints in principle are violable, and the degree of violability decreases as the ranking goes toward left. Here the double angle brackets systematizes ranked constraints, while the slash divides unranked constraints.

(2) The hierarchy of relevant constraints

FAITHFULNESS>>LAZY>>ONSET/NOCODA

Bearing in mind the above exposition, consider now the table given under (3). Four candidates for evaluation are listed down in the left-most column with the constraints listed horizontally at the top row. Here the solid vertical line separates ranked constraints, whereas the dotted vertical line divides unranked constraints. The number of asterisks corresponds to the degree of violation of the constraint. The exclamation mark after the asterisk denotes a fatal violation by which candidates are eliminated. The pointed hand ☞ shows the winner, i.e. the optimal candidate. The shaded cells indicate that the violations of constraints are irrelevant to the evaluation procedure.

(3) FAITHFULNESS>>LAZY>>ONSET/NOCODA Ordering

/want tu/	FAITHFULNESS	LAZY	ONS	NCO
☞ a. want.tu		**!		*
b. wan.tu	*!	**		*
c. wan.tə	*!	*		*
d. war̃.ə	*!		*	*

Only candidate (a) observes FAITHFULNESS, the most powerful constraint therefore it is claimed to be optimal. The other three candidates all violate the constraint, therefore claimed to be non-optimal candidates. Neither violation nor observance of the rest of the constraints is now relevant to the evaluation, therefore the cells are shaded. The result is an expected one since the usage of *want to* [wantu] is salient in formal speech. As shown in the above exposition, the strength of OT springs from its innovative assessment method for selecting an optimal candidate from possible candidates in terms of ranked constraints.

Let us now see, for the sake of argument, what happens if we change the order of the first two constraints.

(4) LAZY>>FAITHFULNESS>>ONSET/NOCODA Ordering

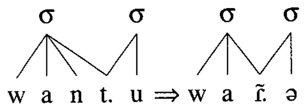
/want tu/	FAITHFULNESS	LAZY	ONS	NCO
a. want.tu	**!			*
b. wan.tu	**!	*		*
c. wan.tə	*!	*		*
☞ d. wař.ə		*	*	*

Candidates (a), (b) and (c) all violate LAZY, the most powerful constraint. On the other hand, candidate (d) outranks the rest by being most 'lazy', thereby claiming the winner. The above outcome is an expected one because *wanna* [wař.ə] is in frequent use in casual connected speech.

A close examination of the above OT analysis brings about at least five problems: three theory internal problems and two technical problems. First, how does GEN generate a set of infinitely many outputs? The generation mechanism of GEN remains unclear. Second, it is not clear how a great number of outputs generated by GEN is reduced to an appropriate minimum by the time candidates for screening are input to EVAL. Third, the strict ranking of constraints may change to account for facts as illustrated in table (3) and (4). Hammond (1998:4) assumes that the typological generalization of languages calls for four distinct ranking with respect to FAITHFULNESS, ONSET and NOCODA. This assumption raises doubt in the universal (or typologically general) ordered constraints in EVAL. If the ranking of constraints varies not only from language to language, but from phenomenon to phenomenon, the speaker has to face a significant number of possible rankings to consider. This is an unwelcome consequence seen from the point of view of language acquisition.

Next are a couple of technical problems. The first technical problem is that the OT analysis fails to account for the etymological relation between *wanna* [wařə] and its host *want to* [want#tu]. Due to this inadequacy, the OT analysis cannot explain the change in syllable structure illustrated in (5), where the dot indicates syllable boundary.

(5)



The issue is nontrivial. The OT devices for singling out an optimal candidate do not explain in detail the production of *wanna* [war̃.ə]. Neither do they bring to light the relevant sound changes involved in *wanna*-contraction, nor do they explain the essential point that the deletion triggers off the tapping of nasal alveolar stop.

The above problems cannot be adequately dealt with without assuming a series of phonological changes. Aniya's (1999) analysis systematically accounts for the syllable-structure change in terms of /t/-deletion in homorganic and coarticulatory environment, and the intervocalic nasal tapping.

The second technical problem is that the OT analysis cannot account for the etymological relation of variants. The three leading candidates (b), (c), and (d) in table (3) all stem from the host *want to* [want#tu]. Of significance is the fact that the host and all of its three offspring occur synchronically in contemporary English. (The speaker's choice of one out of the three variants depends on pragmatic conditions. This issue is beyond the scope of this paper. Aniya (in preparation) offers a unified account of the issue).

The OT's unaccountability of the above problems raises an issue from the point of view of morphology-phonology interface. One of the basic assumptions of OT is that "sound patterns arise from interactions of principles, each of which directly expresses some notion of phonetic or cognitive functionality (Kirshner, 1998:17)." OT has not gone deep enough to integrate relevant components of the grammar. To achieve the goal, OT should find a way to devise some solution. In this respect, the generative phonological analyses deserve some credit at least since they attempted to account for the etymological relation in terms of the derivational-driven approach.

In the next section, we will see that a lexically based algebraic analysis brings about a natural and straightforward solution by unifying the morphology and phonology of *wanna* in a principled fashion in terms of algebraic expressions.

3. A Lexically Based Algebraic Approach

3.1. Preliminaries

This section presents a brief sketch of lexically based algebra (LBA) advanced in Brame & Kim (1998). The knowledge of basic machinery of LBA is essential for the reader to understand the LBA analysis of *wanna*-contraction suggested in section 3.2.

The LBA lays its base on modern abstract algebra. The underlying mechanisms of LBA can be explicated in four steps. First comes the lexical specification of generator or lex, a basic building block of language. A lex is an ordered pair comprising of a vocabulary item and its directed type. The directed type may consist of one or more directed type. The initial directed type is called 'head type', while the second directed type is called 'argument type'. With these in mind, consider the following examples.

(6) Generators/Lexes

a. [*exist*, $^{\leftarrow}V$]

b. [*wonder*, $^{\leftarrow}VQ^{\rightarrow}$]

c. [*whether*, $^{\leftarrow}QS^{\rightarrow}$]

d. [*we*, $^{\leftarrow}SV^{\rightarrow}$]

The word *exist* is an intransitive verb, therefore its lex consists of the ordered pair [*exist*, $^{\leftarrow}V$]. Due to the lack of argument type, this and other intransitive verbs have only a head type with no argument. On the other hand, the word *wonder* is a transitive verb, therefore its lexical specification [*wonder*, $^{\leftarrow}VQ^{\rightarrow}$] contains its head type $^{\leftarrow}V$ and its argument type $Q^{\rightarrow}$. The superscripted arrowhead shows the direction of lexical composition. This point will be explicated in detail shortly.

Second, a binary operation ⊗ induces lexical composition as defined in (7). The symbol ⊗ means an associative binary operation on *LEX!*, indicating that we have a semigroup, (*LEX!*, ⊗).

(7) Lexical Composition

⊗: *LEX!*×*LEX!*→*LEX!*

$[x, \varphi] \otimes [y, \psi] = [x \wedge y, \varphi * \psi]$

The symbol ∧ designates an ordinary concatenation, while ∗ depicts an associative binary operation called type composition.

Third comes the simplification and particularization of lexical composition. For the concatenation of natural language vocabulary items, the equation in (7) can be simplified by eliminating the symbols ∧ and ∗ as shown in (8).

(8) [*we*,$^{\leftarrow}$SV$^{\rightarrow}$]⊗[*exist*,$^{\leftarrow}$V]=[*we exist*,$^{\leftarrow}$SV$^{\rightarrow\leftarrow}$V]=[*we exist*,$^{\leftarrow}$S1]=[*we exist*,$^{\leftarrow}$S]

Finally the last two results in (8) require explanation and formalization. For all directed types T, the type reduction (9) exerts force. In addition, the law of identity (10) comes into force.

(9) Type Reduction: T$^{\rightarrow}$∗ $^{\leftarrow}$T=**1**

(10) Law of Identity: T∗**1**=T=**1**∗T

Given the above development, words can be combined to produce a larger unit as shown in the following examples of production.

(11) Production examples

[*we*,$^{\leftarrow}$SV$^{\rightarrow}$] [*wonder*,$^{\leftarrow}$VQ$^{\rightarrow}$] [*whether*,$^{\leftarrow}$QS$^{\rightarrow}$] [*we*,$^{\leftarrow}$SV$^{\rightarrow}$] [*exist*,$^{\leftarrow}$V]

=[*we wonder*,$^{\leftarrow}$SQ$^{\rightarrow}$] [*whether*,$^{\leftarrow}$QS$^{\rightarrow}$] [*we*,$^{\leftarrow}$SV$^{\rightarrow}$] [*exist*,$^{\leftarrow}$V]

=[*we wonder whether*,$^{\leftarrow}$SS$^{\rightarrow}$] [*we*,$^{\leftarrow}$SV$^{\rightarrow}$] [*exist*,$^{\leftarrow}$V]

=[*we wonder whether we*,$^{\leftarrow}$SV$^{\rightarrow}$] [*exist*,$^{\leftarrow}$V]

=[*we wonder whether we exist*,$^{\leftarrow}$S]

The production algebra finds its dual recognition algebra, to which we now turn. The fact that the duality of production and recognition is accountable in a unified algebraic framework constitutes a strong argument for the LBA approach. This motivates the following definition.

(12) Definition (Brame & Kim, 1998:128)

Let *LEX* be an arbitrary set of lexical generators. Define a function from *LEX!* to its dual for all lexical specifications $L=[x,\varphi]\in LEX!$ as follows.

$$^{\lrcorner}: LEX! \rightarrow LEX^{\lrcorner}!$$

$$L^{\lrcorner}=[x,\varphi]^{\lrcorner}=[x^{-1},\varphi^{\lrcorner}]$$

By Definition (12) we obtain the following results.

(13)

a. $[exist, {}^{\leftarrow}V]^{\lrcorner}=[exist^{-1}, V^{\rightarrow}]$

b. $[wonder, {}^{\leftarrow}VQ^{\rightarrow}]^{\lrcorner}=[wonder^{-1}, {}^{\leftarrow}QV^{\rightarrow}]$

c. $[we\ wonder, {}^{\leftarrow}SQ^{\rightarrow}]^{\lrcorner}=[(we\ wonder)^{-1}, {}^{\leftarrow}QS^{\rightarrow}]$

d. $[we\ wonder\ whether\ we\ exist, {}^{\leftarrow}S]^{\lrcorner}=[(we\ wonder\ whether\ we\ exist)^{-1}, S^{\rightarrow}]$

Listed below are the relevant cogenerators obtained in terms of Definition (12).

(14) Cogenerators

a. $[exist^{-1}, V^{\rightarrow}]$

b. $[wonder^{-1}, {}^{\leftarrow}QV^{\rightarrow}]$

c. $[whether^{-1}, {}^{\leftarrow}SQ^{\rightarrow}]$

d. $[we^{-1}, {}^{\leftarrow}VS^{\rightarrow}]$

Let us now show how the string of words *we wonder whether we exist* is recognized as a sentence of type ${}^{\leftarrow}S$. By letting the cogenerators act on the lexical specification $[we\ wonder\ whether\ we\ exist, {}^{\leftarrow}S]$, we obtain the following result.

(15) Recognition examples

a. $[we^{-1}, {}^{\leftarrow}VS^{\rightarrow}]\ [we\ wonder\ whether\ we\ exist, {}^{\leftarrow}S]$
$=[wonder\ whether\ we\ exist, {}^{\leftarrow}V]$

b. $[wonder^{-1}, {}^{\leftarrow}QV^{\rightarrow}]\ [wonder\ whether\ we\ exist, {}^{\leftarrow}V]$
$=[whether\ we\ exist, {}^{\leftarrow}Q]$

c. $[whether^{-1}, {}^{\leftarrow}SQ^{\rightarrow}]\ [whether\ we\ exist, {}^{\leftarrow}Q]$
$=[we\ exist, {}^{\leftarrow}S]$

d. $[we^{-1}, {}^{\leftarrow}VS^{\rightarrow}]\ [we\ exist, {}^{\leftarrow}S]$
$=[exist, {}^{\leftarrow}V]$

e. $[exist^{-1}, V^{\rightarrow}]\ [exist, {}^{\leftarrow}V]$
$=[\lambda, 1]$

The above equations show that the constituents of [*we wonder whether we exist*, $^{\leftarrow}S$] are cancelled out from left to right by applying cogenerators. Notice that we obtain the equation $[\lambda,1]=1$. This means that the string of words *we wonder whether we exist* is recognized in a step-by-step fashion as an intransitive sentence type $^{\leftarrow}S$. This in turn corresponds to the fact that the string of words is a grammatical sentence. The grammaticality in LBA is formalized as the following proposition.

(16) Proposition (Brame & Kim, 1998:136)

L is a rational language if and only if *L* is generated by some left monadic production algebra and recognized by its dual right monadic recognition algebra.

By Proposition (16) the grammaticality of *we wonder whether we exist* is ensured on the basis of production example (11) and recognition example (15).

We now wish to show the structural similarity between the production and recognition together with their resolution.

(17) Example (Brame & Kim, 1998:135)

PRODUCTION	RECOGNITION	RESOLUTION
[λ,1] [*we*, $^{\leftarrow}SV^{\rightarrow}$]	[*we wonder whether we exist*, $^{\leftarrow}S$] [*we*$^{-1}$, $^{\leftarrow}VS^{\rightarrow}$]	[*we wonder whether we exist*, $^{\leftarrow}S$] [λ, $^{\leftarrow}SS^{\rightarrow}$]
[*we*, $^{\leftarrow}SV^{\rightarrow}$] [*wonder*, $^{\leftarrow}VQ^{\rightarrow}$]	[*wonder whether we exist*, $^{\leftarrow}V$] [*wonder*$^{-1}$, $^{\leftarrow}QV^{\rightarrow}$]	[*we wonder whether we exist*, $^{\leftarrow}S$] [λ, $^{\leftarrow}VV^{\rightarrow}$]
[*we wonder*, $^{\leftarrow}SQ^{\rightarrow}$] [*whether*, $^{\leftarrow}QS^{\rightarrow}$]	[*whether we exist*, $^{\leftarrow}Q$] [*whether*$^{-1}$, $^{\leftarrow}SQ^{\rightarrow}$]	[*we wonder whether we exist*, $^{\leftarrow}S$] [λ, $^{\leftarrow}QQ^{\rightarrow}$]
[*we wonder whether*, $^{\leftarrow}SS^{\rightarrow}$] [*we*, $^{\leftarrow}SV^{\rightarrow}$]	[*we exist*, $^{\leftarrow}S$] [*we*$^{-1}$, $^{\leftarrow}VS^{\rightarrow}$]	[*we wonder whether we exist*, $^{\leftarrow}S$] [λ, $^{\leftarrow}SS^{\rightarrow}$]
[*we wonder whether we*, $^{\leftarrow}SV^{\rightarrow}$] [*exist*, $^{\leftarrow}V$]	[*exist*, $^{\leftarrow}V$] [*exist*$^{-1}$, $V^{\rightarrow}$]	[*we wonder whether we exist*, $^{\leftarrow}S$] [λ, $^{\leftarrow}VV^{\rightarrow}$]
[*we wonder whether we exist*, $^{\leftarrow}S$]	[λ,1]	[*we wonder whether we exist*, $^{\leftarrow}S$]

We see in (17) the idempotency[2] of even products. Notice that the idempotency of (18i) is proven by (18ii).

(18) Idempotency of Even Products (cf. Brame & Kim, 1998: 134)

i. $[we, {}^{\leftarrow}SV^{\rightarrow}] \otimes [we^{-1}, {}^{\leftarrow}VS^{\rightarrow}] = [\lambda, {}^{\leftarrow}SS^{\rightarrow}]$

ii. $[\lambda, {}^{\leftarrow}SS^{\rightarrow}] \otimes [\lambda, {}^{\leftarrow}SS^{\rightarrow}] = [\lambda, {}^{\leftarrow}SS^{\rightarrow}]$

In connection with the grammaticality condition, it should be noted here that Brame & Kim (1998) suggest that 'intransitivity' yields well-formedness. The final result in (11) is intransitive as indicated by the left monadic sentence type ${}^{\leftarrow}S$. I believe that Brame's grammaticality condition and well-formedness criterion need to be reinforced by some fail-safe device. This issue is of great importance, therefore it is taken up in section 3.3.

We are now in a position to analyze the phonology of *wanna*-contraction within the framework of LBA. Unfortunately (or fortunately depending on which way you look), phonology in LBA constitutes a frontier. Fortunately, the basic algebraic machinery is general enough and thus applicable in the domain of phonology without any special theoretical device. The next section deals with an LBA analysis of the phonology of *wanna*-contraction.

3.2. A lexically based algebraic analysis

The three variants, [wantu] (*want to*), [wantə] (*wanta*) and [wal̃ə] (*wanna*) are all lexicalized words of contemporary English. This fact, however, does not nullify the possibility of combining sound segments into a larger unit by the generalized algebraic binary operation. Recall that we have algebraically induced the production and recognition of [*want to*, ${}^{\leftarrow}VV^{\rightarrow}$] in section 3.1. The same algebraic engine can generate a phonological counterpart without any theoretical patching and darning. Before proceeding to see the phonological composition in action, we should discuss a phonological counterpart of lex. Let us agree to use 'syllablex' to mean an ordered pair of segments and its directed type(s). The underlying assumption here is that a syllable-oriented composition is preferred over a segment-oriented composition. At least three arguments support this assumption. First, the assumption that all words are composed of syllables is convincible. (See Hooper, 1972; Kahn, 1976; Ito, 1989; and Hammond, 1995). Second, syllables are psychologically real therefore constitute a unit of cognitive organization (See Hammond, 1997). Third, a segment-oriented composition does not reflect the human computation of production and recognition of speech sounds. An enormous workload for computing possible combinations of segments prevents the speaker from sorting out licit strings in production, and prevents the hearer from processing words by a segment-oriented parsing mechanism in comprehension.

Let us now take [war̃ə] (*wanna*) as an example and show its phonological composition in lexically based algebra (LBA). First, the lexical specification of relevant syllablexes should be in order. Syllablexes are combined to form a larger unit of the type Σ. In (19), the type σ represents syllable, while the type Σ represents a meta-syllable unit. The latter type can be thought of as a 'syllabled word.'

(19)

a. [war̃,${}^{\leftarrow}\Sigma\sigma^{\rightarrow}$]

b. [ə,${}^{\leftarrow}\sigma$]

The inverses of the above syllabexes are producible by Definition (12).

(20)

a. [war̃$^{-1}$,${}^{\leftarrow}\sigma\Sigma^{\rightarrow}$]

b. [ə$^{-1}$,$\sigma^{\rightarrow}$]

Given (19) and (20), we obtain both the production and recognition of [war̃ə, ${}^{\leftarrow}\Sigma$] as illustrated below under (21) and (22), respectively.

(21) Production of [war̃ə,${}^{\leftarrow}\Sigma$]

[war̃,${}^{\leftarrow}\Sigma\sigma^{\rightarrow}$][ə,${}^{\leftarrow}\sigma$]=[war̃ə,${}^{\leftarrow}\Sigma$]

(22) Recognition of [war̃ə,${}^{\leftarrow}\Sigma$]

a. [war̃$^{-1}$,${}^{\leftarrow}\sigma\Sigma^{\rightarrow}$][war̃ə,${}^{\leftarrow}\Sigma$]=[ə,${}^{\leftarrow}\sigma$]

b. [ə$^{-1}$,$\sigma^{\rightarrow}$][ə,${}^{\leftarrow}\sigma$]=[λ,1]

We saw in table (17) the structural similarity between the production and recognition together with resolution in the domain of syntax. We now see a phonological counterpart under (23).

(23) Example

PRODUCTION	RECOGNITION	RESOLUTION
[λ,1] [waɾ̃,←Σσ→]	[waɾ̃ə,←Σ] [waɾ̃$^{-1}$,←σΣ→]	[waɾ̃ə,←Σ] [λ,←ΣΣ→]
[waɾ̃,←Σσ→] [ə,←σ]	[ə,←σ] [ə$^{-1}$,σ→]	[waɾ̃ə,←Σ] [λ,←σσ→]
[waɾ̃ə,←Σ]	[λ,1]	[waɾ̃ə,←Σ]

The idempotency of even products can be also observed in the above case as pictured below. Compare (18) with (24).

(24) Idempotency of Even Products

i. [waɾ̃,←Σσ→]⊗[waɾ̃$^{-1}$,←σΣ→]=[λ,←ΣΣ→]

ii. [λ,←ΣΣ→]⊗[λ,←ΣΣ→]=[λ,←ΣΣ→]

We have seen the structural similarity between the syntax and phonology of *wanna*. This shows that the duality of production and recognition in phonology as well as syntax is accountable in terms of general algebraic methods.

3.3. Grammaticality and well-formedness

Brame & Kim (1998) devise two warrant devices: the production-recognition duality and intransitivity. The former guarantees grammaticality of the string of words, while the latter ensures the well-formedness of production products. To further strengthen and refine the warrant system, I would like to suggest a failsafe mechanism.

The mechanism consists of a set of conditions called GRAMMATICALITY CONDITIONS (GC), and a proposition termed WELL-FORMEDNESS CRITERION (WFC). The GC contains phonological, morphological, syntactic, semantic, and pragmatic conditions.

(25) GRAMMATICALITY CONDITIONS (GC)

GC={*PhonC, MorpC, SynC, SemC, PragC*}, and

PhonC={phc_1,..., phc_n}

$MorpC=\{moc_1,..., moc_n\}$
$SynC=\{sync_1,..., sync_n\}$
$SemC=\{semc_1,..., semc_n\}$
$PragC=\{pragc_1,..., pragc_n\}$, where n>1.

The conditions include language specific and universal conditions. Given below are some representatives of *PhonC*.

(26)

a. phc_{11}: $\overset{*V}{\begin{bmatrix} +\text{high} \\ +\text{low} \end{bmatrix}}$

b. phc_{51}: $\overset{*C}{\begin{bmatrix} +\text{nasal} \\ -\text{sonorant} \end{bmatrix}}$

c. phc_{77}: Licensed Voicing in Adjacent Conditions (VOICING), English

$[...C \quad C...]_\sigma$
\/
VC

d. phc_{79}: If $\overset{C}{\begin{bmatrix} \alpha \text{ stop} \\ \beta \text{ alveolar} \\ +\text{nasal} \end{bmatrix}} \overset{C}{\begin{bmatrix} \alpha \text{ stop} \\ \beta \text{ albeolar} \end{bmatrix}} \#$
1 2 3⇒13

e. phc_{34}: $\overset{V}{[-\text{stressed}]} \Rightarrow ə$

f. phc_{71}: $\overset{C}{\begin{bmatrix} -\text{nasal} \\ +\text{alveolar} \\ +\text{coronal} \end{bmatrix}} \Rightarrow ɾ/\overset{V}{[+\text{stressed}]}\_V$

The first two examples are universal constraints, whereas the rest are language specific conditions. The third condition prohibits anomalous onsets and codas in English: *[sb], *[sd], *[zp]; and *[pd], *[pz], *[fd], *[bt], *[bs], *[fd], *[vt], respectively (cf. Mohanan, 1993). Condition (26d) rules out anomalous clusters such as *[nt] and *[nd] in English casual connected speech. Condition (26d) together with conditions (26e) and (26f) account for the sound changes involved in the production of [waɾ̃ə] *wanna* from its host [wantu] *want to*. Condition (26d) eliminates post-nasal alveolar stops. Condition (26e) changes an unstressed vowel into a schwa. Condition (26f) changes an alveolar stop into a tap.

The WFC can be formalized as in (27). Here the numeral 1 should not be confused with the identity **1** discussed in section 3.1.

(27) WELL-FORMEDNESS CRITERION (WFC)

i. Let $p{\cdot}x{=}y$ be a well-formedness algebra.
ii. Let p be a lexical composition product, and assign p value 1.
iii. If p is a violator of GC, then assign x value 0; if not, then assign x value 1.
iv. If y is 1, then p is well-formed; if y is 0, then p is ill-formed.

The WFC is in resonance with two algebraic axioms: multiplicative identity property and multiplicative property of zero. To see the significance of WFC, consider a pair of examples under (28). Here p represents a lexical composition product, whose value is set as 1 by (27ii); and x represents a variable whose value is either 1 or 0 according to (27iii). The value of y determines the well-formedness of p: If $y{=}1$, then p is well-formed; if $y{=}0$, then p is ill-formed. Example (28a) exemplifies the multiplicative identity property, whereas example (28b) represents the multiplicative property of zero.

(28)

a. [waɾ̃ə]·1=1·1=1
↑ ↑ ↑
p x y
↓ ↓ ↓
b. [wanɾə]·0=1·0=0

The value of y in (28a) is 1, therefore [waɾ̃ə] is well-formed; while that of y in (28b) is 0, thus [wanɾə] is ill-formed. As shown above, grammaticality is well accounted for without resorting to any special ad hoc devices.

The GRAMMATICALITY CONDITIONS is justifiable in two respects. First, it is a warrant device for grammaticality as indicated above. Second, it is a means for accounting for sound changes. Let us now turn to the second point. As an indispensable preliminary, I make the following two assumptions. I assume, as a self-evident truth, the existence of a universal impetus of energy efficiency (EE). I also assume that the EE is operative in all quarters of the grammar. Phonologically, the EE is responsible for minimizing articulatory quantity of motion. In this respect, Kirchner's (1998) LAZY discussed in section 2.2 can be thought of as a phonological particularization of EE.[3]

The phonological particularization of EE constitutes a set of rules, for example deletion, vowel reduction, tapping, etc. The three rules correspond to (26d), (26e), and (26f), respectively. Given the rules we can account for the etymologically related three variants [wantu] (*want to*), [wantə] (*wanta*), and [waɾ̃ə] (*wanna*) as shown below. Here A>B means 'B is derived from A'.

(29) want#tu>wantu>wantə>waɾ̃ə

a. ∅ by (26d)
b. ə by (26e)
c. ∅ by (26d)
d. ɾ̃ by (26f)

What we see here is a two-bird-one-stone solution. The GRAMMATICALITY CONDITIONS plays a double role: a warrant for grammaticality and explanatory apparatus for sound changes.

3.4. Analogy in lexically based algebra

Syllabic sound sequences can be combined algebraically in a step-by-step fashion as we saw in section 3.1. As an alternative to the lexical composition, we can think of 'analogy' as a single-leap means for creating words. Analogy has been considered a working force in word-formation. Diachronically, verbs which had irregular past tense forms in Old English came to be produced with the regular *-ed* ending, e.g. *help* becoming *helped* (Crystal, 1985: 16)." Synchronically, we find ample evidence in child speech as exemplified in the following pairs of overgeneralizing words: *man-mans*; *men-mens*; *mouse-mouses*; *go-goed*; *see-seed*; *know-knowed*; etc. The suffix *-able* offers another example. Originally the suffix *-able* was added to French loan words as in *measurable*, *reasonable*, and *comfortable*. The suffix *-able* is now productive and it can be added not only to Anglo-Saxon words but to other loan words, acronyms and blends as in *drinkable*, *acceptable*, *blamable*, *passable*, *changeable*, *xeroxable*, *faxable*, *e-mailable*, etc. An analogous example is the suffix *-burger*. It was originally a part of German word '*Hamburger*'. The suffix has become productive and can be added to create words as in *beefburger*, *cheeseburger*, *teriyakiburger*, etc. (cf. Crystal, 1985; Araki & Yasui, 1992). The above examples show that analogy is indeed active in creating words.

Assuming analogy to be a systematization of psychological association, Paul (1880), a *junggrammatiker*, attempted to translate analogy into a proportional equation. Given below is his example (Paul, 1880: 117).

(30) animus:animī=senātus: *x*

x=senatī

Unfortunately, Paul (1880) does not give details with respect to how he computed the solution, *x=senatī*. Nor does he develop the idea further in order to achieve a generalization.

Although Paul deserves credit for pioneering the way to a new horizon, his proportion as it stands is insufficient. Proportion (30) does not produce the solution *x=senatī*. To see this, examine the equations in (32) in light of the calculation methods shown in (31).

(31) Special proportion algebra

$a{:}b=a{:}x$

$\frac{\mathrm{a}}{\mathrm{b}}=\frac{\mathrm{a}}{x}$ *Cross multiply*

$ax=ba$

$\frac{\mathrm{a}}{1}\cdot\frac{1}{\mathrm{a}}x=b\frac{\mathrm{a}}{1}\cdot\frac{1}{\mathrm{a}}$ *Simplify both sides*

$x=b$

(32) animus:animī=senātus:x

$$\frac{\text{animus}}{\text{animi}}=\frac{\text{senatus}}{\text{x}}$$

$$\text{animus}\cdot\text{x}=\text{animī}\cdot\text{senātus}$$

$$\frac{\text{animus}}{1}\cdot\frac{1}{\text{animus}}\,\text{x}=\text{animī}\cdot\text{senātus}\cdot\frac{1}{\text{animus}}$$

$$\text{x}=\frac{\text{animus}\cdot\text{senātus}}{\text{animus}}$$

Notice that the final result is far from the desired solution, *x= senatī.*

I wish to push Paul's idea a step further and convert the analogy into a refined mathematical expression. Consider first the following proposition, in which the use of variables α and β is crucial.

(33) Proposition

If α*us*→α*i*, then β*us*→β*i*.

Suppose α=*anim* and β=*senat*, then we obtain the paradigm *animus/animī* and *senātus/senatī.* In order to implement the above idea into the present LBA analysis, I devise a proportion algebra shown in (34). Here the short horizontal line corresponds to the outlined string of segments as indicated by the arrowhead.

(34) animus : animī = senātus : x

$$\uparrow \qquad \uparrow \qquad \uparrow$$

$$-us : -\bar{\imath} = -us : x$$

$$\frac{-us}{-\bar{\imath}}=\frac{-us}{x}$$

$$-us\cdot x=-\bar{\imath}\cdot -us$$

$$\frac{-us}{1}\cdot\frac{1}{-us}x=-\bar{\imath}\,\frac{-us}{1}\cdot\frac{1}{-us}$$

$$x=-\bar{\imath}$$

By assuming '-=*senat*' in *x*=-*ī*, we obtain the value *senati* as illustrated in (35).

(35) x=senatī

In what follows I will show that the idea spelled out in (34) can account for a skip-over production of words. Compare the examples in the second and third rows in the following table.

(36)

I to [tu]	II ta [tə]	III na [ɾ̃ə]
going to [goɪŋtu]	gointa [goɪntə]	gonna [gəɾ̃ə]
want to [wantu]	wanta [wantə]	wanna [waɾ̃ə]

Two common characteristics are observable. First, the morphological changes of to→ta→na take place. Second, the phonological changes of [tu]→[tə]→[ɾ̃ə] occur in parallel with the morphological changes. Let us now see how the proportion algebra in (31) account for the analogy in creating *wanna* [waɾ̃ə]. Consider the equations in (37). Notice that the short horizontal line corresponds to the string of segments as indicated by the arrowhead.

(37) going to : gonna =want to : x

↑ ↑ ↑

$$-to : -na = -to : x$$

$$\frac{-to}{-na}=\frac{-to}{x}$$

$$-to\cdot x=-na\cdot -to$$

$$\frac{-to}{1}\cdot\frac{1}{-to}x=-na\frac{-to}{1}\cdot\frac{1}{-to}$$

$$x=-na$$

By assuming '-=*wan*', we obtain the value of x as *wanna*.

(38) x=*wanna*

Notice that the single-leap analogy retains the etymological parent-offspring relation of *want to*→*wanna*.

4. Concluding Remarks

From the vantage point of language universal, the hypothetical OT analysis has provided a feasible solution to the phonology of *wanna*-contraction. Granting theory-internal problems, the OT solution still leaves behind unexplained problems with respect to the etymologically related variants [wantu], [wantə], and [wan̄ə]. On the other hand, the lexically based algebraic analysis advanced in this paper not only offers a natural and straightforward solution to the etymological relation but also provides a unified solution to the morphology-phonology interface in terms of algebra. Moreover, the lexically based algebraic analysis accounts for a duality between production and recognition in morphology and phonology in terms of the generalized algebraic machinery.

Notes

* Special thanks go to my colleague Peter M. Skaer whose valuable comments illuminated Optimality Theory devices greatly. I also thank to the participants at the 212th meeting of Gengobunka-danwakai (Workshop in Language and Culture). Their comments contributed to the clarity of the hypothetical OT analysis given in section 2.2 of this paper.

1. See Aniya (1999) for details. The last two processes are supported by the observation that the /nt/ cluster found in words like *winter* changes into a single nasal flap in American English (See Kirchner, 1998: 111). Kirchner (1998), however, does not discuss in detail how the cluster of /nt/ is transformed into a single nasal tap. Aniya (1999) hypothesizes the following phonological processes, where the double-deletion of /t/ is crucial.

```
[want#tu]→[wantu]→[wantə]→[wanə]→[waɾ̃ə]
    ↓                 ↓
    ∅                 ∅
```

   The second deletion of /t/ finds support in examples such as
   Want a beer?

```
[want#ə]→[wanə]→[waɾ̃ə]
    ↓
    ∅
```

   Additional support for Aniya's (1999) hypothesis comes from Lombardi (1999), in which she argues, based on cross-linguistic data, that voicing assimilations are always regressive. Her conclusion not only confirms Aniya's hypothesis but also points out the deficiency of Radford's (1997) progressive assimilation analysis of /nt/→/nn/.
2. Brame & Kim (1996:134) define the term 'idempotent' as follows: "Let ♥ be a binary operation on a set M. We say that $e \in$♥ is an idempotent with respect to ♥ provided that the following equation is satisfied. *e*♥*e*=*e*."
3. See Kempson (1996:563) for an illustration of EE in pragmatics.

References

Aniya, S. 1999. "The Phonology of *Wanna*-contraction Part I: Generative Phonological Analysis Revisited," *Hiroshima University Gengobunkakenkyu* V, 1-16.

Aniya, S. (in preparation). "The Phonology, Morphology, Syntax, Semantics, and Pragmatics of the *Wanna*-contration."

Araki, K. and M. Yasui eds. 1992. *Sanseido's New Dictionary of English Grammar.* Tokyo: Sanseido.

Archangeli, D. & T. Langendoen. 1997. *Optimality Theory: An Overview.* Malden, Massachusetts: Blackwell Publishers.

Brame, M. 1997. "Whence Infinity?" paper delivered at the University of Washington, spring 1997.

Brame, M. and Y. G. Kim. 1998. "Directed Types: An Algebraic Theory of Production and Recognition," *Linguistic Analysis* 28, 3-4, 117-184.

Crystal, D. 1985. *A Dictionary of Linguistics and Phonetics.* New York: Basil Blackwell Inc.

Hammond, M. 1995. "Syllable Parsing in English and French," ms., University of Arizona, Rutgers Optimality Archive.

Hammond, M. 1997. "Optimality Theory and Prosody," in Archangeli, D. & T. Langendoen (eds). *Optimality Theory: An Overview.* Malden, Massachusetts: Blackwell Publishers.

Hammond, M. 1998. "Parsing in OT," ms., University of Arizona, Rutgers Optimality Archive

Hooper, J. 1972. "The Syllable in Phonological Theory," *Language* 48:525-540.

Itô, J. 1989. "A Prosodic Theory of Epenthesis," *Natural Language and Linguistic Theory* 7:217-259.

Kahn, D. 1976. Syllable-Based Generalizations in English Phonology, Ph.D. dissertation, MIT.

Kempson, R. 1996. "Semantics, Pragmatics, and Natural-Language Interpretation," in Lappin, S. (ed.), *The Handbook of Contemporary Semantic Theory.* 561-598. Oxford: Blakwell Publishers.

Kirchner, R. 1998. *An Effort-Based Approach to Consonant Lenition.* UCLA Ph.D. dissertation.

Lombardi, L. 1999. "Positional Faithfulness and Voicing Assimilation in Optimality Theory," *Natural Language and Linguistic Theory* 17: 267-302.

Mohanan, K.P. 1993. "Fields of Attraction," in J. Goldsmith (ed.) *The Last Phonological Rule.* 61-116, University of Chicago Press.

Paul, H. 1880 (reprinted in 1975). *Prinzipien Der Sprachgeschichte.* Tuebingen: Max Niemeyer.

Prince, A. and P. Smolensky. 1993. *Optimality Theory: Constraint Interaction in Generative Grammar*. ms. Rutgers Optimality Theory Archive.

Radford, A. 1997. *Syntactic Theory and the Structure of English: A minimalist approach*. Cambridge University Press.

Roca, I. and W. Johnson. 1999. *A Course in Phonology*. Malden, Massachusetts: Blackwell Publishers.

Selkirk, E. 1972. "The Phrase Phonology of English and French," in Hankamer J. ed. *Outstanding Dissertations in Linguistics*. 1980. New York: Garland Pub.

Suiko, M. 1978. "A Phonological Analysis of *Wanna* Formation." *Studies in English Literature* Vol. LV, No. 2. 303-317.