Universal Grammar, Optimality Theory and First Language Acquisition

Peter M. Skaer

1. Overview

In this paper, I look at the broad question of the acquisition of a first language phonology, focusing on both the issue of phoneme acquisition as well as the development of the prosodic unit, the syllable. I begin by reviewing a few of the earlier important contributions to this field of inquiry, such as Jakobson's universal order of phoneme acquisition, but move quickly to the present day, where I assume the basic tenets of Optimality Theory, and attempt to account for some child language data. While I intend to demonstrate that OT makes some accurate observations about the development of a child's phonology, I suggest that the main difference between an adult's native language phonology, and a child's, cannot be characterized simply as a reversal of how constraints in OT are ordered, where the familiar dominance of Faithfulness constraints over Markedness constraints in Adult phonology is reversed for the emerging phonology of the young child, as first suggested by Gnanadesikan, 1995, and widely adopted elsewhere, nor is it simply a primitive model of the adult's grammar. I suggest in fact that the basic components (i.e. a "universal grammar") of an adult grammar are present in the early phonologies of children, with obvious physical and mental limitations. I will conclude by offering some directions worth investigating that may shed light on what it is children acquire, and in what order, but more importantly, resolving the heretofore unanswered question of why certain structures emerge cross-linguistically in children's phonologies. To this

end, I will introduce the idea of "articulatory cost", and argue that this addition and/or supplement to OT can resolve some of the classic issues concerning the dichotomy between the child's rich and inherently complete input, and the deficient and varied nature of the child's output. This discussion is more suggestive than definitive, and by nature, leaves many issues unresolved. It is hoped, nonetheless, that the notion of articulatory cost can at least point us in the direction of better handling the difficult task of accurately characterizing the emerging first language phonologies of children.

2. Preliminaries.

In the general study of human behavior, the study of the communication act narrows focus on certain aspects of the act, depending upon the discipline, rarely studying all aspects (of the speech act) in their entirety. As such we have divisions of study such as pragmatics, semantics, phonology, and so forth. Even in each of these sub-disciplines, boundaries are drawn. Phonology, for example, covers the communication act from the point of view of the vocalization of the message, primarily concerned about the organization and planning of the message in the human brain. Phonological theory assumes that there are universal characteristics to the organization, and thus implementation, of such vocalizations.

Recently, under the guise of Optimality Theory (OT), these universal tendencies have been characterized using a system of constraints, based on frequency, where the more frequently found structures are characterized as natural, or universal, while the less frequent structures are characterized as unnatural (exceptional). Since of course all languages operate in organized ways, OT suggests that a universal set of constraints is enacted to constrain and conform acceptable vocalized output. Constraints are ordered differently from language to language, but the actual constraints themselves are common (universal) to all languages. That these constraints are indeed innate (hardwired into the child's brain and accessible from

birth), or learned, is still somewhat controversial, but we adapt the former position at least in general for the purposes of this paper.

OT is, however, built on a set of negative conditions, or constraints, presupposing, with no stated positive conditions, that humans are born to vocalize in order to communicate, and that their only basic restrictions are the physical and acoustic parameters of such vocalizations. Despite the empirical shortcomings of a scientific theory built on a rather intangible premise (having no clearly defined predisposed generative component other than an urge to vocalize—see Skaer, 2002, Reiss and Hale, 2002, for further discussion of these shortcomings), OT has gained some degree of acceptance in the recent study of phonology.

In order to better understand what it is a child is equipped with to begin the acquisition of phonology, and what ways this information can be adequately described, let us begin our investigation by noting some of the important stepping stones in the field of phonology as they relate to the learning of a first language.

3. Historical Contributions.

The idea of language universals has been around for a long time in the field of first language acquisition research. One of the most important landmarks in the evolution of this research was Roman Jakobson's 1941 list of the universal order of phoneme acquisition. Below is a simplified version of Jakobson's list. Keep in mind that this list was developed cross-linguistically, and represents his proposed view of universally shared language tendencies.

(1) The Order of Phonemic Acquisition (Jakobson, 1941)

a. /p/ versus /a/
b. /b/ versus /m/
c. /p/ versus /t/
d. /p/ versus /f/
e. Front consonants precede back consonants (e.g. /p, b/ > /k, g/)

One important aspect to note in Jakobson's list is that it is essentially a

set of contrasts, beginning with a child first distinguishing between consonants and vowels in 1.a., between consonant manner in 1.b., between consonant place in 1.c., between complexes (manner and feature combinations contrasted with other such combinations) in 1.d., and between paradigmatic relationships (unified groups contrasted with other similarly unified (shared features) groups.

There are, however, a few major problems with the listing of universal tendencies, problems that have in fact not been adequately addressed even to this day. First, the list itself is simply an account of what Jakobson observed. In other words, the list is based on observations of frequency and commonality. The vowel/consonant contrast (1.a.), then, is widely and readily seen in all emerging phonologies. This basic distinction is then followed by the emerging ability to distinguish (and thus produce), the two labial consonants (/p/ and /m/), and later, between the two voiceless stops (/p/ and /t/) and so forth. The problem with this is twofold: First, it really doesn't say anything about why one set of contrasts are ranked higher (emerge earlier) than another, and; second, it really doesn't provide any way to factor in language-specific exceptions. Both of these problems, however, must be resolved for such an observation to be of any explanatory value in the description of the emerging child's phonology. Later attempts were not much more successful. For example, Ervin-Tripp, 1966, proposed the following list.

(2) Ervin-Tripp's Order of Phoneme Acquisition (1966)

a. Vowel-consonant contrasted.
b. Stops-continuants contrasted.
c. Stops > fricatives in onsets.
d. Place > voice in contrasts.
e. Stops, nasals > affricates, liquids
f. +Hi/+Lo V > +Frnt/+Bk V
g. C > CC > CCC
h. #[C > [...C...] > C]#

Ervin-Tripp's list, while slightly more illustrative, and even addresses

syllabification issues (consonant clustering contrasts in 2.g. and 2.h.), still fails in the two areas noted above for Jakobson; the list does not tell us why certain contrasts are acquired early, and others later, and it does not allow for observed language specific exceptions.

In fact, both lists, and all others like them (before and since) suffer from (at least) these two major problems. They are in fact simply descriptions, or labels, for readily observed common tendencies. They tell us what we see, or can expect, generally, but they do not tell us why we see this, nor can they make any kind of predictions beyond the generally observed tendencies (they cannot accommodate commonly observed exceptions, or missing links, that are found in the emerging phonologies in a wide variety of specific languages). The following is an attempt to formalize these two major deficiencies concerned with observations based on frequency of occurrence (in other words, lists of "universal" tendencies). There are of course other important questions, such as why some languages contain marked structures in deference to unmarked ones, but we will assume that the answers, if ascertained, to our two main questions may in fact shed light on these other related issues as well.

(3) Critical Questions Concerning an Emerging Child's Phonology

1. Given two phonological structures, "i" and "j", where in general, "i" is observed to emerge before "j" in a child's phonology in most languages, and where both "i" and "j" share at least one phonological feature in common, why does "i" emerge before "j".
2. Given, (1), why, in some languages, does "j" emerge before "i"?

To summarize, universal grammar (UG) lists such as those discussed above are essentially descriptions, or labeling, of tendencies based on frequency of occurrence. The more frequently a structure is produced at the early stages of language development (or in language in general), the more common, unmarked, or "universal", the structure is. Unfortunately, this does not *explain* why one structure is more common, or frequent, than another, and is in fact merely stating an

obvious fact, and giving it a name. Noting what happens is only the first step in the process of understanding the child's developing phonology. We want to explore why such stages are universally attended to, and how exceptions are caused to arise. Further, though Ervin-Tripp at least addresses the subject, most discussions on these issues have dealt primarily with phoneme acquisition, at the expense of the development of higher order prosodic units. In the following sections, we consider all these issues in more detail.

4. Optimality Theory and Universal Grammar.

It is not necessary to review all of the basic components of OT for the purposes of this short paper, but it would be useful to cover at least the primary constraints that drive the system and consider the role that universal grammar plays in OT. Universal tendencies are the expected tendencies of language production, the ones all (or most) languages share. For example, all languages have inventories of both vowels and consonants in their phonology, all languages have CV syllables, and all languages exhibit some sort of assimilation processes when certain sounds are placed in juxtapositions of certain other sounds during production. Extending this further, we note that virtually all languages have stops, but not all have the same stops, many languages have fricatives, but not all have the same ones, and still further, some languages have affricates, but most do not, as some languages have liquids, but not all do, and so forth. As we get more and more specific about the constituents of a given language's phonology, we find more and more language-specific features, features that are not universal, and may in fact be quite rare (marked).

Let us now consider, below, some of the OT constraints that apply to constrain the generation of phonemes in a given language. These interact in such a way that they are all in fact violable (a primary tenet of OT), where one may lose out to another "higher-ordered" constraint when both come into conflict at a particular juncture. These constraints are ordered differently according to language-specific

tendencies, where, for example, language "A" may place a certain constraint, "i", higher than another, "j", while language "B" may employ the opposite ordering. Again, all constraints are considered universal (available to every language), while specific languages may not employ a subset of these constraints, or order them in a unique language-specific way.

(4) Constraint Ordering Variation by Language

a. Language A: i>j

b. Language B: j>i

Let us now review some of the constraints that apply to phonemes, in random order (since these constraints apply in any language, where it is a separate task to determine the language-specific ordering).

(5) Some OT Constraints on Phoneme Quality (adapted from Roca & Johnson, 1999, pg 585).

Ⅰ. Vowels:

a. *[+high, +low] vowels cannot be high and low simultaneously

b. *[−high, −low] vowels cannot be non-high and non-low simultaneously

c. *[+low, -back] vowels cannot be low and front at the same time

d. *[+low, +round] vowels cannot be simultaneously low and round

e. *[αround, -αback, -low] non-low vowels cannot have opposite values for roundness and backness

f. *[αATR, αlow] vowels cannot have the same value for lowness and ATRness

Ⅱ. Consonants:

a. *[dorsal] consonants cannot be dorsal

b. *[labial] consonants cannot be labial

c. *[-anterior] consonants cannot be non-anterior

d. *[+distributed] consonants cannot be distributed

e. *[+lateral] consonants cannot be lateral

f. *[+round] consonants cannot be round

g. *[+continuant] consonants cannot be continuant

h. *[αcontinuant, -αstrident] consonants cannot have opposite

values for continuancy and stridency

Ⅲ. Common to consonants and vowels:

a. *[αconsonantal, αsonorant] values for consonantality and sonorancy cannot agree

b. *[αsonorant,−αvoice] values for sonorancy and voice cannot disagree

c. *[+nasal] segments cannot be nasal

d. *[+nasal, −sonorant] nasals cannot be obstruent

There are a large number of other constraints for both vowels and consonants. As they are listed here, there is no implied order, or ranking, but in the description of any specific language, these constraints are in fact ordered so that violations of low order constraints will be allowed in deference to higher order constraints when they are in conflict.

By employing all of the "language universal" OT constraints listed above in (5) without ranking, or deference, to the phoneme inventory of English, there would only be four permissible (unconstrained) phonemes, in English: The vowels /a, i, u/ and the consonant /t/ (cf. Roca & Johnson, 1999).

(6) Unconstrained (Default) Phonemes, in English OT

a. Vowels: /a, i, u/

b. Consonants: /t/

By implication, we might logically assume that these four "default" phonemes represent the least marked melodies in English phonology, or, in other words, the most unconstrained (universal) segments in the inventory of English. It is relevant for the context of this paper to note that these same unmarked segments are also found in the phoneme inventory of Japanese. Gnanadesikan, 1995, suggests that the least marked (universal) features, segments and structures represent innate, hard-wired, structures in the brain of every normally developed child, and as such represent the basic set of phonological primes at a child's disposal. So, based on this, we would expect by further implication that these unmarked structures would be the earliest

structures to emerge in a child's phonology. We will discuss these issues in subsequent sections, below.

All constraints are organized into various groups, but most are subsumed under two main family branches; Markedness and Faithfulness. Markedness (MARK-also referred to as Well-Formedness (WF)) constraints in OT are essentially another label for UG formalizations, which are summarized above positively as general tendencies (Jakobson and Ervin-Tripp), and negatively, in OT as constraints. Faithfulness (FAITH), on the other hand, deals with structure preservation, and promotes a one-to-one relationship between input and output (although these, too, are "universal"). Essentially, FAITH constraints work to promote consistency in both quantity and quality of INPUT to OUTPUT.

For purposes of our discussion here, it would now be useful to consider a few constraints that apply to the structural integrity of the unit which dominates the phoneme, that of the prosodic unit, the syllable. At this level, we have constraints on both the quantity and quality of the constituents of a syllable, guiding the nature and composition of the onsets, nuclei and codas.

(7) Syllable-structure Constraints (summary based on Roca & Johnson, 1999, pg 594) :

a. ONSET (all syllables have onsets)
b. NUCLEUS (all syllables have nuclei)
c. NO-CODA (syllables do not have codas)
d. *COMPLEX (constituents must not be complex—e.g. consonant clusters are disallowed)
e. *M/V (vowels must not occupy syllable margin—i.e. cannot be in onset or coda position)
f. *N/C (consonants must not occupy syllable nucleus)

Here too, we see violations of several of these constraints in English since there are of course many words (and therefore syllables) that begin with vowels just as there are many words (and syllables) that do have codas, and in both the cases of English onsets and codas, many

are indeed complex (as in consonant clusters)

Now, do these constraints tell us anything more about *why* certain features, sounds and structures are favored over others? We can begin trying to answer these questions by attempting to make predictions based on these constraints. In terms of phonemes, as noted above, we would certainly expect the three permissible, non-constrained vowels, /a, i, u/, and the one consonant, /t/, to turn up early, and frequently, in virtually all languages, just as we would in the emerging children's phonologies of specific languages. Similarly, we would expect prosodic structures essentially of the form CV (the least marked, and most preferred, structure to emerge from the constraint set, described in (7), above) to predominate languages in general, as well as in emerging child languages. A quick review of relevant children's corpus data reveals that the problem is unfortunately not this simple, particularly in terms of features and phonemes, and certainly not true in the case of adult phonologies.

First, considering the issue of the default phonemes for English, /a, i, u/ and /t/, we can quickly dismiss these as the basic "primes" of this language. A simple review of virtually any list of universal phoneme acquisition will show us that while the low vowels, such as /a/, do indeed represent the most common vowels to emerge first in the child's early stages of phonology, the two high "default" vowels are in fact noticeably delayed in acquisition, with both /i,/ and /u/ arriving relatively late to the child's phonemic inventory, relative to other vowels (cf. Kirchner 2000, Kawamura, 1999). It is even more well-documented that the consonant /t/ usually follows somewhat later the emergence of the labial stops such as /b/ and /p/ (see Jakobson and Ervin-Tripp, above).

When all is said and done, however, we have really developed no particularly useful insights through OT regarding why certain features, phonemes and structures would be favored over others in a given language, why some would emerge early, others late, in an emerging phonology, or even why some are more "natural" (universal),

than others. In other words, OT of course addresses the same basic facts that Jakobson and Ervin-Tripp did, and adequately describes what is observed, and in what order (by language-specific ranking constraints in OT), but it comes no closer to answering the first of our two critical questions posed earlier, and repeated here:

(8) Critical Questions in An Emerging Child's Phonology ((3) repeated)

1. Given two phonological structures, "i" and "j", where in general, "i" is observed to emerge before "j" in a child's phonology in most languages, and where both "i" and "j" share at least one phonological feature in common, why does "i" emerge before "j".
2. Given, (1), why, in some languages, does "j" emerge before "i"?

In other words, in OT, constraints would suggest that a given structure "i" is preferred over "j" (as in "i>j", in 8.1), but in some uncommon situations, the more marked situation is found, violating this universal tendency (as in "j>i", in 8.2). While OT does not provide any useful insights in regards to the first question, regarding why certain structures emerge before others, it does handle adequately the second question, by simply acknowledging that language-specific exceptions (to the least marked, universal, pattern) are a result of a language-internal re-ranking of the relevant constraints, allowed within a given language.

5. English Data.

In a very influential, if unconvincing, article, Gnanadesikan, 1995, suggests that OT constraints are re-ranked for a child to account for the wide variation in the OUTPUT of children, assuming that the INPUT conforms to the adult target phonology. Specifically, she suggests that children place MARK above FAITH, and as a result, acquire new structures guided more by universal properties of language than by a propensity to conform his or her OUTPUT strictly (and faithfully) to the parameters of the INPUT. I will focus on one of her points here. She suggests that children, in English (or in any

language), are strongly driven by the constraint against complex onsets (*COMPLEX), which restricts onsets to a single consonant. This then would reduce words with consonant clusters in INPUT of two or more consonants to one.

(9) Onset Reduction (Gnandadesikan, 1995)

a. clean [kin]
b. draw [dɑ]
c. please [piz]
d. friend [fɛn]
e. sky [gay]
f. spill [bɪw]
g. straw [dɑ]

The following tableau shows the MARK constraint, *COMPLEX is ordered above FAITH, and generates the correct observed OUTPUT (in the child's phonology). Here, "please" is contrasted with the word "peas", both of which obviously have different INPUTs, but result in identical OUTPUTs in the child's language.

(10)

	*Complex	FAITH
please: /pliz/→[pliz]	*!	
☞ /pliz/→[piz]		*
☞ peas: /piz/→[piz]		
/piz/→[iz]		*!

In the tableau, above, "please" has a complex onset, /pl-/, which violates *COMPLEX, so is disallowed, whereas MARK/WF requires an onset, so one of the two consonants is chosen. Ganadasikan further claims that which consonant is chosen is governed by a tendency to choose the consonant with the least sonorancy (/p/, as opposed to /l/). She goes on to make an interesting claim whereby children are driven to develop optimal syllables based on this sonorancy issue, where the onset chosen would always be the one available from input (or its best substitute) which has the lowest sonority. She lists the possibilities in a typical Sonority Hierarchy, but unfortunately goes no further in formalizing this line of argument, something I will attempt to do below.

First, let us consider the English Sonority Ranking (Skaer, 2001 & 1996) that coincidentally is nearly identical to Kirchner's 1998

Composite Aperture Ranking (an effort-based ranking, where the only difference is that fricatives (affricates) follow stops, rather than precede them, and where the effort-based ranking rates the order from least effort to greatest effort):

(11) Sonority Ranking for English, Most Sonorous to Least (Skaer, 2001)

low vowel>mid vowel>high vowels>glides>liquids>nasals>fricatives>stops

Now returning to the problem Ghanadesikan noted for the child in choosing which consonant of an input cluster to use, she suggests that the Sonority Ranking is the guiding force. To quote Gnanadesikan, "In a word such as /sbun/ 'spoon', the *s*, as a fricative, is more sonorous than the stop *b* [note: the subject vocalized /p/ as /b/ here]. The stop is thus the best available onset, so the *s* is deleted and the *b* remains in the output *bun*. In a word like /sno/, 'snow', the *s* is less sonorous than the nasal *n*, so the *s* is retained in the output *so*. In a word like /pliz/ 'please', the stop *p* is less sonorous than *l*, so it is the surviving output onset in *piz*." (pg. 12)

I would like to suggest here that there are some logical inconsistencies in Gnanadesikan's reasoning. She suggests that a child begins with a ranking of the major family constraints inverse to that of adults, where for a child, MARK dominates FAITH. Let us review the facts for 'please'. We start with the standard assumption that perception precedes production, and that in fact, the child is capable of fully perceiving, as INPUT, /pliz/. Convincing arguments for this position are provided by Hale & Reiss, 1996. Thus, we can also assume, that for 'peas', the perceived INPUT is correctly /piz/. Now, what role does OT play between this input, and the production of a child's rendition? Traditionally it has been assumed that there are two structures in a given vocalization; deep (or underlying), and surface. However, Hale & Reiss convincingly argue that there are indeed at least three levels worth noting; (1) underlying representation, (2) output of grammar, and (3) output of body. Essentially, phonology takes us from the underlying representation to the output of the

grammar. This is what the mind understands it is to do. However, understanding what to do, and being able to do it are two different things. So, there is a noticeable gap between the output of the planning stage, and the output of the production stage. We can more easily view this as: (1) target, (2) plan, and (3) product. We of course know that there is wide variation between the target and the product in children's language, but the question before us here concerns the planning stage—is the error in production due to an incorrect plan, or is it due to an incorrect implementation of the plan? According to Gnanadesikan's reasoning, it is due to the plan (the phonology), where the child has reversed the two major systems of constraints in order to conform to some unspecified, and empirically questionable theory that suggests that while the components of the grammar in the child are essentially intact at birth, they are reversed hierarchically for some reason. Let us see how the derivation of 'peas' and 'please' look from this perspective.

(12) Derivation of Peas and Please (loosely based on Hale & Reiss, 1996)

	Grammar A		Grammar B	
	'peas'	'please'	peas'	'please'
Target	/piz/	/pliz/	/piz/	/pliz/
(OT) Phonology	↓	↓	↓	↓
Plan	[piz]	[piz]	[piz]	[pliz]
Articulatory Codification	↓	↓	↓	↓
Product	[piz]	[piz]	[piz]	[piz]

According to Gnanadesikan, children proceed along the lines of Grammar A, where the phonology, by virtue of the re-ranked constraints, has determined phonologically identical outputs of [piz] for both the input with a simple onset (/piz/) and the one with the complex onset ([pliz]) (the latter of which is disallowed by the MARK constraint, alleviated to out rank FAITH in the child's grammar, thereby producing the intermediate structure, which is then codified into a articulatory routine). While Gnanadesikan does not elicit feedback from her subject to determine whether indeed the child could

differentiate between the two INPUT targets, there is ample evidence elsewhere to suggest, contrary to her claims, that the child is in fact capable of making the distinction between the two INPUTS (i.e. knows the phonology well enough to "hear" the difference between [pliz] and [piz]) though unable to produce the differences. This is representative of the pathway suggested in Grammar B, which suggests that while the child is capable of perceiving and producing the difference at least at the level of planning, the child is not yet capable of fully implementing the plan, perhaps due to the immaturity of the vocal apparatus, or perhaps dues to lack of experience ("rehearsals") or perhaps a combination of these and other factors. To illustrate how children can be seen to distinguish contrasts at the planning stage, and not be able to produce a product that shows the richness of the plan, let us look at two familiar examples from Dale, 1976.

⒀ Plan Precedes Production (taken from Dale, 1976, pg. 278)

a. Older brother to 4-year old David: "David wants to go to the mewwy-go-wound"
(where the brother intentionally replaces his /r/s with /w/s, thereby imitating David's speech.)

David: "You don't say it wight."

b. Therapist: "Johnny, I'm going to say a word two times and you tell me which time I say it right, and which time I say it wrong: /ræbɪt/ /wæbɪt/."

Johnny: [wæbɪt] is [wayt] and [wæbɪt] is [waʊ].

While the examples above are anecdotal in nature, they illustrate the commonly held fact that children are indeed capable of distinguishing various features and contrasts well before being able to clearly produce them themselves, which effectively argues against the need to re-rank constraints simply because a child is not capable of producing such plans as finished products. In fact, there is little to suggest that the child does anything more than attempt to reproduce faithfully a given target input, but is limited in doing so by limitations in stored prototypes, in articulatory routines, and in mature articulatory

apparatus. In other words, either as a result of limited experience, or immature vocalization abilities, the child is unable to produce licensed products, relative to the adult's phonology—this, combined with the various universal and language-specific tendencies, will conspire to create highly variable surface structures, or products, in the child's output—the variation, though, is decidedly not a deficiency in the child's grammar or a re-ranking of the adult's grammar.

Returning to the issue raised earlier in regards to the effect sonorancy has on syllable structuring, I would like to suggest here that we can formalize the sonority principle as two OT constraints on syllable structure, and perhaps in doing so, replace the constraints introduced earlier regarding syllable margin and nucleus constituency (*N/C and *M/V), which seem both ad hoc and devoid of any true generalized insights--just another label for an observed fact. Using the device of N, to indicate the nuclear center, or weight bearing portion of the syllable, we can suggest that the optimal nucleus is a low vowel, such as /a/, in English, followed by mid vowels, which are then followed by high vowels, and likewise, the optimal onset, O (and Coda, C), is the least sonorant (i.e. a voiceless stop), followed by voiceless fricatives, and so forth. Following the original constraints, we will use M to indicate margin, representing either O or C. While of course recognizing that all constraints are violable, we can now suggest constraints on constituents of the syllable that reflect these sonority relationships, where essentially the least sonorous onset and the most sonorous nucleus reflects the optimal syllable.

(14) Sonority Constraints

a. *N/−*S*

b. *M/+*S*

We assume that *N/−*S* would disallow a low sonorant segment as a syllable nucleus (where *S* stands for sonorancy), showing preference for the most sonorous candidate available, while on the other hand, *M/+*S* would disallow highly sonorous segments to occupy a syllable margin, favoring the least sonorous candidate. These revised constraints

introduce a desirable explanation into the grammar that tells us why, from a structural point of view, certain compositions, or configurations, of the syllable are favored over others in early phonologies, given the obvious requirement that virtually all syllables must have nuclei (with the possible exception of perhaps Berber), and as such, there is already an established sonorant core, relative to onsets and codas (margins), thereby requiring onsets (and codas) to exhibit some distance, in sonorancy, from this core, so as to increase perceptibility. Let us now reconsider a tableau for determining the optimal output for 'peas' and 'please'.

(15)

	*COMPLEX	*M/+S	FAITH
please: /pliz/→[pliz]	*!	*	
☞ /pliz/→[piz]			*
/pliz/→[liz]		*!	*
☞ /piz/→[piz]			
/piz/→[iz]			*!

We have now resolved the question regarding which consonant would be chosen from a complex cluster in the child's early production of "optimal" CV syllables. This does not, at first glance at least, tell us anything about why certain phonemes are preferred, in acquisition terms, over others, when there are in fact no competing alternatives. Our discussion above was concerned with choosing one of (in our examples) two possible INPUT onset candidates (e.g. /p/ or /l/ in /pliz/), but what of the situation involving even simpler INPUTs, where the target words contain just one onset consonant to begin with, and where the child produces an "incorrect" (unfaithful) consonant onset, or where, in the case of complex onsets, neither of two consonant candidates are reproduced, as in the following, also from Gnanadesikan? Let us consider the latter case below.

(16) Onset Reductions, Revisited (Gnanadesikan, 1995)

a. sky [gay]

b. spill [bɪw]

c. straw [dɑ]

In these last cases, we can see from our previous discussion why the fricative /s/ would be disallowed (since it is more sonorant than the stops included in the onset clusters, as is the final liquid in 'straw'). This leaves us with three voiceless consonants which all have been replaced by their voiced counterparts. Keeping in mind that voiceless stops are less sonorous than voiced consonants, it seems possible that the child has opted for placing the issue of sonorancy above FAITH in these examples, since voiceless consonants rank slightly lower on the sonorancy scale than their voiced counterparts, with homorganicity retained.

(17)

	*COMPLEX	*M/+S		FAITH
		Stop>Fric	+vc>−vc	
sky: /skay/→[skay]	*!			
☞ /skay/→[gay]				*
/skay/→[kay]			*!	*
/skay/→[say]		*!	*	*

As we can seen in the suggested tableau, above, the two syllable structuring constraints based on sonorancy are both ranked above FAITH, in the tableau, along with *COMPLEX, but perhaps are mistakenly ranked here as part of the phonology, since in fact these constraints appear to be primarily due to limitations of maturity, effort and experience, and thus, more concerned with taking the "plan" and implementing it, in the generation of a "product".

As noted in the last paragraph, I suggest that in fact, these restrictions on syllabification may be more motoric than phonological (having more to do with problems implementing the plan, rather than in the plan itself), and as such, perhaps have no place in the constraint hierarchy at all. To this end, I suggest articulatory effort leads us to the

question of articulatory cost, which involves the more common notion of articulatory effort, and is combined with some additional expenditures, as discussed below.

6. Articulatory Cost.

The ideas proposed in this section are more exploratory than definitive, and represent a composite built on points developed in some of my earlier analyses. The points of this section are notably directed toward the movement from the second level of vocalization, the "plan", towards the output of the body, the "product", as characterized in (12), above. I suggest that limitations in a child's ability to implement the plan in producing a product has more to do with the surface variations noted above for children's language than deficiencies in the phonological system (the grammar).

In the most basic form, I suggest that "articulatory cost" represents the amount of effort a speaker must expend in order to produce a given phonological structure. There are at least two separate subcomponents to this cost. One is based on the amount of physical and mental effort expended in codifying and producing the structure, including, but not limited to, issues such as constellar complexity, displacement, sonorancy extremes, and so forth. The other subcomponent refers to the amount of physical and mental effort required to *acquire* the ability to produce the structure. Thus, using the argument proposed above, that the least marked constituents of phonology represent an innate base of structures in the child's mind, we would assume that for these constituents, there is little cost expended in gaining access to their use. While this point is controversial, the first subcomponent, involving the cost in mental and physical effort in producing a structure, suggests a possible answer to the critical questions posed above regarding what is acquired early, and why. Specifically, I suggest that the general orders of phonological acquisition, discussed above, can be at least partially explained by articulatory cost, where the earliest acquired structures are by their

nature low in cost compared to those acquired later. I suggest that this approach overcomes some of the shortcomings of OT, while retaining its useful contributions, and at the same time offers useful positive generalizations that do at least suggest an explanation for, and answer to, the questions posed earlier about why certain structures emerge earlier than others. As shown above, OT does provide a reasonable solution regarding the second question, regarding why there are exceptions (a language-specific re-ranking of constraints—but not an individual's, or child's re-ranking of his or her personal grammar).

Least marked features, sounds and structures are the cheapest articulatorily/cognitively (aggregate cost of codification and implementation). In theory, the "cheapest" forms would represent the innate hard wired underpinnings of language available to every child at infancy, while as he or she matures, more complex functions become possible, and are derived out of an interaction of these basic primes with a developing grammar, dependent on language-specific characteristics and guided by universal constraints. Thus, the earliest child forms would be expected to be ordered based quite naturally on issues concerning cost, while later forms would integrate this with other known factors such as saliency, sonorancy, frequency, and so forth.

Returning to the question of which vowels are acquired earliest, and why, we have stated that of the three default vowels in English, the low vowel /a/ emerges before the high vowels, /i/ and /u/, in languages such as English and Japanese. Why is there a difference, since all three vowels are relatively unconstrained, from the perspective of OT, and should therefore be considered optimally natural? Kirchner, 2000, describes one of the main distinguishing factors between high versus low vowels as the amount of effort required to articulate them, with high vowels requiring significant tongue displacement (extension) and with low vowels requiring little tongue movement, relatively speaking, in lowering the tongue slightly (from its central mid/low at-rest position). The difference, then, between high and low vowels is that relatively greater effort is

required to produce the high vowels than the low vowels (see also Skaer, 2003, and Skaer 2002).

While it is beyond the scope of the current paper to cover the concept of articulatory effort in its entirety, we suggest here that it involves the physical and mental effort required to activate the articulators in such a way as to vocalize a given target structure. The effort is expended in the coordination and activation (orchestration?) of several muscle groups, including, but not limited to jaw aperture, lip movement, air flow through the glottis, tongue movement, and so forth. The articulation of consonants of course involve precise tongue placement in many cases, or tongue constriction in others, as well as affected air flow, possible vocal cord constriction, lip shaping, and so forth. We can offer a few general notes regarding consonants in terms of relevant effort here, but will have to leave a formal characterization of the entire phonemic inventories of specific languages such as English for future investigations.

In terms of articulatory effort, the consonants that require the least amount of effort are clearly the labial stops (cf. Kirchner, 2000). It is quite easy to understand why, since in the production of the /p/ and /b/, for example, the tongue plays a virtually non-existent role (it need not extend, retract, or come in contact with any other articulator, as is required in the production of most other consonants). With all other factors being equal (labial consonants still require lip movement, possible voicing, and so forth), the absence of tongue displacement alone satisfies the criteria for relative ease of articulation, relative to other consonants.

Vowels, for similar reasoning, are even less costly (no lip closure), and other complex consonants, even more (since tongue positioning becomes critical). We will suggest a very tentative costing hierarchy that may be factored into OT, as one nearly identical to the sonority hierarchy, stated earlier, but following Kirchner, 1998, assumes that fricatives follow, rather than precede consonants (we leave the voicing distinctions out of the present analysis). We feel that this factor of

articulatory cost can be employed to better describe the processes involved in first (and perhaps even second) language acquisition, as well as casual speech processes, than current theory allows. Note the following relative COST estimates, based on Skaer 2001 and Kirchner, 1998.

(18) Articulatory Cost -COST (ranked low to high)
low vowel (1) > mid vowel (2) > high vowels (3) > stops (4) > fricatives (5) > nasals (6) > glides (7)> liquids (8): $i>>$j (where i<j)[1]

In (18) we have re-formalized the margin constraint dominated by *M/+S, listed in (17) as "Stop>Fric" (but meant to represent all cost-based, sonority-influenced dominance relationships), as a simple notation of $^{i}>>$^{j} (where "$" represents cost, and where a lower cost segment, such as a stop with a value of $4, is favored over a higher cost segment, such as a fricative, with a value of $5).

Now, with the idea of articulatory cost, we have at least the foundation of an explanation as to why certain phonemes are more likely to appear before others in the emerging child's phonology. It would seem very likely that given all other things being equal, the child would produce those structures in the target input that require the least amount of articulatory effort, or cost, while remaining as faithful as possible to the INPUT. This would explain why bilabial stops would be ordered before alveolar stops (where COST can be further factored out over various phoneme continuums), and why low vowels would be ordered before high vowels, countering the relative equality afforded them from the perspective of OT.

It is my proposal, then, that a reranking of constraints, such as MARK>>FAITH, as Gnanadakin suggests, is not required, but rather, a new set of constraints be added to the description of vocalizations, one of articulatory cost (COST). COST may in fact represent a family of constraints that allow for maximum and minimum cost parameters, and that would affect certain adjacency issues such as found at syllable, morpheme, word and phrase boundaries. From the

perspective of OT, COST would be ordered very high in a child's grammar, even above FAITH, but would gradually lose strength as the phonemic inventory is acquired. This constraint is never wholly abandoned in adult language, as it can be re-ranked higher in the case of casual speech, where it would cause various FAITH constraints to be summarily demoted (see Skaer, 2001, for a discussion of casual speech rules). Let us see how these three constraint families might look for different grammars.

(19) Constraint Family Ranking
Child's Emerging Phonology: COST>>FAITH>>MARK[2]
Adult's Careful Phonology: FAITH>>MARK>>COST
Adult's Casual Phonology: COST>>FAITH>>MARK

The Markeness constraints noted above for dealing with the reduction of complex onsets in a child's phonology, including *COMPLEX and *M/+*S*, are both assumed to be governed by COST—but how can this be, since we already have MARK listed in the ranking, and we have already suggested that re-ranking is both unnecessary and undesirable?

7. Conclusions.

Here I propose my final thoughts for future research. I suggest that these COST constraints, as well as many other markedness constraints which owe their allegiance to language universals, might be better reanalyzed as post-phonology, *implementational* constraints, which would further suggest a rather new area of study for the phonologist (the "applied" phonologist?), that of the implementation of the schema produced by standard phonology. In other words, there appears to be an important, and overlooked (or simply misunderstood), dimension of the vocalization of children; namely, what occurs between the formation of a phonological plan for a vocalized token, to the realization of the vocalized product—clearly what the child can and cannot do with the intact plan is worth careful investigation, separate from, but aligned with, the understanding of the underlying

phonological processes which generated the plan in the first place. We conclude by offering a revised look at the derivational sequence of moving from Target to Product, for Gnanadesikan's 'peas' and 'please' data, based on this suggestion.

⑳ Derivation of Peas and Please

	A Child's Grammar	
	'peas'	'please'
Target	/piz/	/pliz/
Phonological Constraints		
FAITH>MARK	↓	↓
Plan	[piz]	[pliz]
Implementational Constraints		
COST	↓	↓
Product	[piz]	[piz]

We assume that the constraints that serve to formulate a given language do so as before, in the phonology. Our only addition has been to suggest that certain constraints obviously affect the implementation of the phonological plan, and that they do so in a regular, and predictable way, governed by our tentative theory of articulatory cost constraints. That some of the COST constraints are similar or identical to grammar-forming (phonological) constraints may suggest that in fact some of the universal well-formedness constraints, at least in the grammars of children, and likely in the casual speech processes of adults as well, might be better characterized as implementational constraints, rather than phonological. I leave the resolution of these issues to future research.

I conclude with a brief summary of the points made in this discussion. First, I contend that a child's phonology does not differ from the adult's by order of constraints (contrary to Gnanadesikan), and that the adult's ranking of faithfulness over markedness is maintained in the child's merging phonology. Second, I have suggested that OT, in its present form, does little more to *explain* the order of phoneme acquisition than previous analyses, and that this is because

of a confusion between the idea of a two stage production system (INPUT→OUTPUT), versus a three stage production system (Target→ Plan→Product). The three stage system allows for a recognition of the issues involved with implementing the phonological plan, and allows for variations in the output as a result of the constraints imposed by articulatory effort, or COST.

References.

Dale, P. 1976. Language Development. Holt, Rinehart and Winston.

Ervin-Tripp, S. 1966. "Language Development." In L. W. Hoffman and M. L. Hoffman (Eds.), Review of Child Development Research, Vol. 2. New York: Russell Sage Foundation. Pp. 55-105.

Gnanadesikan, A. 1995. Markedness and Faithfulness Constraints in Child Phonology. Unpublished Manuscript—Rutgers Optimality Archive.

Hale, M. & C. Reiss. 1996. The Initial Ranking of Faithfulness Constraints in UG. Unpublished Manuscript—Rutgers Optimality Archive.

Jakobson, R. 1941 (1968). Child Language, Aphasia and Phonological Universals. Mouton.

Kawamura, M. 1999. The Early Phonologies of Japanese and English Speaking Children. Hiroshima University Senior Thesis.

Kirchner, R. 1998. An Effort-Based Approach to Constraint Lenition. Doctoral Dissertation, UCLA.

Kirchner, R. 2000. Phonological Contrast and Articulatory Effort. Unpublished Manuscript—Rutgers Optimality Archive.

Reiss, C. & M. Hale. 2002. The Comprehension/Production Dilemma in Child Language: A Response to Smolensky. Unpublished Manuscript—Rutgers Optimality Archive.

Roca, I. & W. Johnson. 1999. A Course in Phonology. Blackwell.

Skaer, P. 1996. "Towards a theory of the acquisition of second language phonology." Hiroshima University Journal V: 109-134.

Skaer, P. 2001. "An introduction to the phonology of casual spoken English." Hiroshima University Journal V: 23-49.

Skaer, P. 2002. "Modern generative phonology: All form and no substance?" Hiroshima University Journal V: 49-70.

Skaer, P. 2003. "Features and gestures in Phonology." Hiroshima Women's University Journal 11: 81-106.

1 This characterization reflects a slight revision of the original, as suggested by Professor J. Yamada (personal communication).

2 While it may be interesting to consider an OT tableau here to illustrate how COST constraints are dealt with in the three families of constraint rankings, I argue in

the next section that in fact COST-affected OUTPUT represent issues that do not occur wholly in the *phonology* of language production, and thus, cannot be adequately characterized by OT given it present framework. Rather, I suggest that COST is a post-phonological vocalization constraint, thereby rendering an OT-based tableau characterization both misleading and meaningless.