The Initial Ranking of Faithfulness Constraints in UG

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Abstract
This paper shows that, contrary to popular opinion, it is a necessary assumption of the theory of the acquisition of OT phonological systems that faithfulness constraints be ranked above well-formedness constraints in UG.

"The obvious is literally that which stands in one's way…"
R. D. Laing (cited in Barton 1978:122)

I. What is Phonological Acquisition?

There are two assumptions which we will make in attempting to formulate an answer to this question. While we do not feel that either assumption is particularly controversial, we will spell them out before proceeding. The first is simply that the type of OT Phonology we as linguists are interested in is a subcomponent of the *grammar* — with all of the normal implications of the use of that term in modern linguistics. In particular, we will assume that it is necessary, indeed, critical, to distinguish between the grammar, which is a computational system operating upon and generating mental representations, and a production system, which takes the output of the grammar and converts it into articulatory output. The contrast is well-known in phonological circles in the study of adult phonology, where it is used to determine which aspects of adult output phonological theory needs to concern itself with and which aspects it does not. The second principle we will be assuming sometimes goes by the label 'the Strong Identity Hypothesis,' which holds that the analysis of children's speech should invoke only those systems needed for the proper analysis of adult speech. This gives rise to the expectation that a contrast between the grammar and the production system should be observed in the study of children's speech, just as it is in the study of adult speech.

An OT Phonology consists of a set of ranked constraints. It is generally recognized that there are two distinct types of constraints: faithfulness constraints, which inhibit modification of input representations, and well-formedness constraints, which license modification of input representations. The set of constraints — of both types — is assumed to be given by UG, and thus need not be learned. In addition, it is commonly assumed (and we will follow other scholars in assuming this) that the constraints are ranked within UG (i.e., before any input data has been parsed). The observed similarities between the phonological systems attested in human languages are to be attributed in part to the fact that the set of constraints is part of the innate human linguistic endowment known as UG. The differences between the phonological output of human languages have two sources. First, during the course of acquisition children acquire a *lexicon* which provides the input representations upon which the computations performed by the

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phonology operate. The lexicon is different for different languages and thus must be learned. In providing the 'raw material' which the OT Phonology processes, the lexicon plays a central role in determining the output of the grammar in any particular language. Second, while the set of constraints and their initial ranking is given by UG, individual grammars show the effects of a re-ranking of the universal set of constraints during the course of the acquisition period. This re-ranking is, of course, also the result of learning. It is assumed that all attested phonological differences between possible human languages reduce to just these two factors: the lexicon and the rank order of the universal constraints.

The perceptual system of children appears to be very well-developed, at least for the parsing of stressed syllables. Indeed, it is crucial that children be sensitive to any distinction which could be used by the phonological system of any human language since, without such sensitivity, acquisition of the hypothetically 'imperceptible' distinctions could not take place.[1] If we assume, with most other scholars working on acquisition, that children correctly store the phonetic details (to the degree necessary to license acquisition of any human language) of adult output forms, we need to ask why they do not simply feed these stored, highly accurate representations into their production systems, thereby producing accurate output to the extent possible, given their immature control of their output devices. Put another way, why assume a phonology at all? We will adopt the traditional answer to this question: the lexicon, at this stage (with full phonetic specification of all adult output forms), grossly overdetermines the output of the grammar. In particular, it contains two types of information which turn out to be eliminable from underlying representations with no loss in output accuracy. First, some phonetic features found on particular segments turn out to be predictable on purely distributional grounds (e.g., aspiration on voiceless stops in English). Second, after the child has achieved some morphological parsing, the existence of morphophonemic alternations licenses the further elimination of redundancy in the lexicon. For example, the voiceless /s/ of 'cats' and the voiced /z/ of 'dogs' can be reduced to a single underlying representation. Both of these processes involve the optimization of lexical storage — we will refer to these aspects of the acquisition process as 'lexical optimization'.

> "What a fuss people make about fidelity! … it is purely a question for physiology. It has nothing to do with our own will …."
> Oscar Wilde, *The Picture of Dorian Gray* (1891)

II. The Grammar and the Production System

There is very little work available at this time on how phonological acquisition should be handled within an OT framework; however, one very influential paper on this topic is that of Gnanadesikan (1995). We will take this paper as representative of a

[1] Experimental results such as those of Streeter (1976), who found that infants growing up in a Kikuyu-speaking environment distinguish between initial stops with a +10ms VOT and those with a +40ms VOT, in spite of the fact that Kikuyu does not have an aspirated:unaspirated distinction in its grammar, confirm this view.

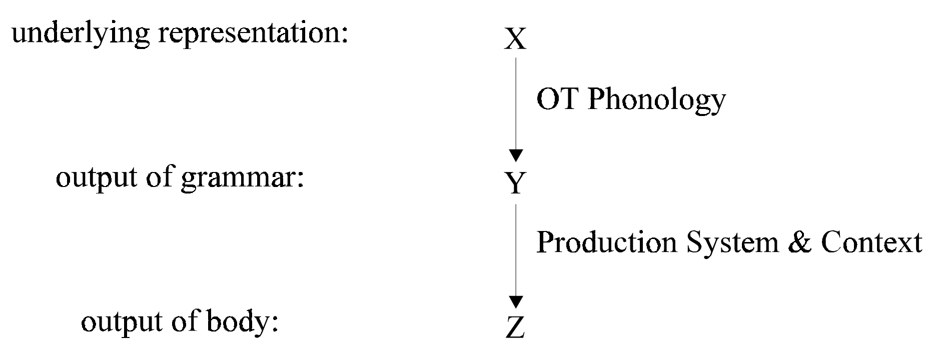
relatively standard view of OT acquisition in the relevant respects.[2] As we will show in detail below, we believe that some of the conclusions of Gnanadesikan (1995) are not necessary features of a theory of OT acquisition and, indeed, we do not believe that those conclusions are justified on the basis of the empirical evidence available on L1 acquisition.

Critical to the concerns of this paper is one particular result presented by Gnanadesikan (1995) which has received widespread acceptance in the OT literature, cited below.

> The initial state of the phonology, I propose, is one in which constraints against phonological markedness [‘well-formedness’ constraints in the terminology of this paper – mh&cr] outrank the faithfulness constraints, which demand that the surface form (output) is identical to the underlying form (input, in OT terminology). The result is that in the initial stages of acquisition the outputs are unmarked. The process of acquisition is one of promoting the faithfulness constraints to approximate more and more closely the adult grammar, and produce more and more marked forms.
>
> Gnanadesikan (1995:1)

An evaluation of this hypothesis involves confronting the difficult problem of distinguishing, in children as we do in adults (in keeping with the Strong Identity Hypothesis), between the output of the grammar (a mental representation) and the output of the body under some particular circumstances (those in effect at the time of utterance). The standard approach to the study of the speech of adults can be sketched as in (1) below.

(1)



The OT phonology (for ease of exposition we will assume a single level of phonology — i.e., a single OT) represents a mapping relationship between the underlying representation X and the output of the phonology for the string in question, Y (where Y may be equal to

[2] This move is justified based on (1) unpublished conference papers which the authors have had occasion to hear which make the same assumptions — in the (for our purposes) relevant domain — as Gnanadesikan (1995) and (2) informal discussions of these issues on the OT List.

X if the relevant faithfulness constraints outrank the potentially relevant well-formedness constraints). The production system of the adult, responsible for directing the body to hit the output target in question, converts the mental representation Y to a set of articulatory commands which, filtered by contingent environmental factors (including accidental features of the body in question — its size, shape of its resonating cavity, etc. — as well as contingent features of the context in which the body finds itself at the moment of utterance — air pressure, humidity, wind speed and direction, etc.), generate an acoustic output (Z). As is well-known from the study of adult phonetics, Z is highly variable (e.g., multiple articulations of /æ/ from the same speaker in the same session in the same phonological environment will still differ from one another acoustically). Given the complex set of factors determining its form (physical attributes — stable and accidental — of the speaker as well as numerous environmental effects) this is to be expected. Note that Z cannot, under any circumstances, be the same as Y: Y is a mental representation and Z is an acoustic (or articulatory) event.

Each of the arrows in (1) represents a mapping relationship: the OT grammar is responsible for the mapping of lexical entries onto output representations, the production system (and environmental factors) for mapping the output representation onto an acoustic realization. It is to be expected that these relationships, therefore, will be relatively systematic and regular; indeed, such systematicity is implicit in the notion of 'mapping relationship.'[3]

It is widely acknowledged that while the speech perception skills of even very young infants is highly developed, the articulatory skills of these same infants are much less sophisticated. Indeed, the general conception is that the sensitivity of the speech perception system is generally reduced to attend only (or primarily) to those distinctions critical for parsing the target language, while the production system moves from a state of virtually complete inarticulateness to full competence in articulating the target language. We would not be surprised, then, if the effects of an immature and generally incompetent production system on the Y of (1) were more dramatic than the effects of the adult production system are. That is, we would predict from general considerations such as these that Z should be more distant from Y (and more variable in its realization of a given Y) in children than it is in adults — this, indeed, is the definition of immature control of the production system.

The importance of distinguishing between the output of the body and the output of the grammar is not lessened by the enormity of the task. The significance of the undertaking is often noted; e.g., in her survey of phonological acquisition, Macken (1995:672) notes that "we must attempt the difficult, perhaps impossible, task of separating the grammar from the processor." If we fail to rise to this challenge, we have abandoned the core concern of linguistics: to understand the nature of human linguistic competence.[4]

The goal of distinguishing between these various effects can be stated as a simple question: how can we determine Y given the variability of Z? Even in the case of adults,

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[3] We are unlikely to be in a position to ascertain the systematicity of the effects of contingent environmental factors in most cases. The relevant information is not typically provided in studies of phonetic output.

[4] The difficulty of establishing and maintaining the distinction between the grammar and processing systems is often noted in studies of adult linguistic competence as well.

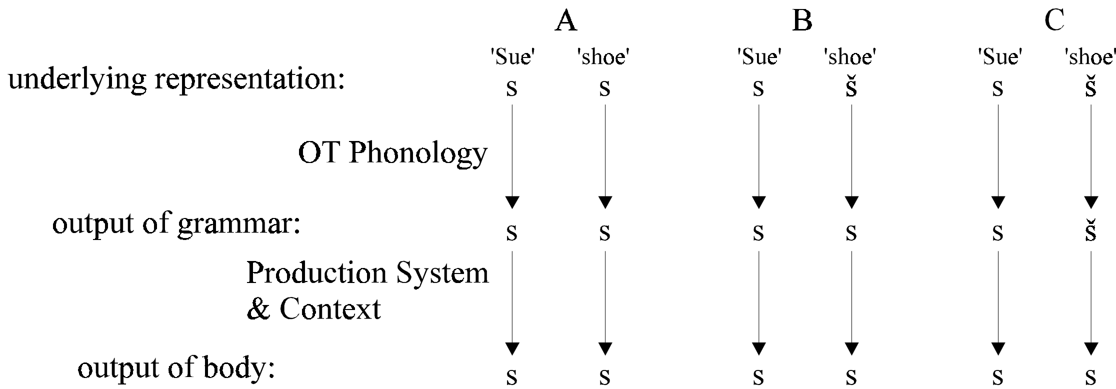
where the relationship between Y and Z is assumed to be relatively close and stable over time, this question has proven to be a considerable challenge. One approach to answering this question for adult grammars which has been useful involves the assumption that the parsing system involves essentially the same mechanisms as the generating system, applied in ‘reverse,’ as it were. That is, given some other person’s output Z, the listener strips Z of contingent effects of the body and environment (such as the cues as to speaker identity), thereby generating a hypothesized Y. The listener then ‘undoes’ the effects of the phonological computational system to produce an underlying representation, X, (or, in the case of ambiguous strings, a set of underlying representations) which would be expected, given the listener’s grammar, to generate Y. The lexical item(s) corresponding to this X is then accessed and passed to the other computational components of the grammar.

Undoing the effects of the body and environment, i.e., converting a given Z to its corresponding Y, clearly involves fairly sophisticated knowledge on the part of the listener regarding the effects of different physiological properties (male vs. female, large resonating cavities vs. small, etc.) and conditions (passing train, high wind, etc.) on the acoustic information contained in any given Z. The ability of listeners to successfully perform this conversion is key to their ability to parse a given realization of [k^hæt] as being a reflex of ‘cat’ regardless of what speaker produced it under what conditions. It is important to note that, in this model of parsing, the listener’s own bodily output, the listener’s Z for a given Y, is completely irrelevant. The listener, who may be a 40-year old male, does not compare the output of a 12-year old female to his own bodily output — the grammar output ‘augmented’ by the effects of his own body and its context of utterance — but rather to the output of his grammar, his Y, which does not have speaker-specific characteristics (except, of course, for possible idiolectal features).

The Strong Identity Hypothesis would lead us to believe that it would be most sound, methodologically, to assume that precisely the same components and processes are to be posited for child speaker-listeners as we have sketched above for adults. If this is correct, it seems clear that the study of children’s phonological parsing provides us with a critical tool to access information regarding Y without confronting directly the problems raised by the child’s immature control of his or her production system. Since parsing by-passes the listener’s bodily output (Z), accessing instead the listener’s grammar output (Y) and phonological system to arrive at an X, the study of children’s parsing skills makes manifest aspects of the relationship between Y and Z which a study of children’s bodily output may be unable, without this additional evidence, to reveal.

An example may help make this clear. It is well-known that a certain stage in their development, children learning English may fail to distinguish, in their bodily output, between /s/ and /š/, producing both ‘shoe’ and ‘Sue’ as [su]. There are three likely scenarios which could account for this phenomenon, sketched in (2A-C).

(2)



Under the scenario in (2A), the child has constructed underlying representations for both 'Sue' and 'shoe' which contain /s/. Nothing affects these UR's in the computational component of the phonology[5] and the production system implements the segments (more or less) accurately, thus the body produces [s] (abstracting away from the speaker-specific and environmentally-triggered effects). This hypothesis can be excluded on several grounds. First, it implies that the child's innate perceptual sensitivity to phonologically relevant contrasts in acoustic signals does the child no good in the acquisition of the grammar responsible for its own output, for it is not exploited in the construction of underlying representations or constraint ranking. Second, it is difficult to imagine how a child who had posited the system in (A) could ever acquire English: the child accepts both adult [š] and adult [s] as realizations of his/her /s/, i.e., s/he has constructed the acoustic target space for /s/ as covering both the [s] and the [š] space of universal phonetics. The child will thus posit for the lexemes 'ship', 'sip', 'shame', 'same' the underlying representations /sɪp/, /sɪp/, /sem/, and /sem/. Since the child accepts both adult [s] and [š] as 'hits' for his/her own target [s], no positive evidence will ever reveal that the phonological system posited by the child fails to match that of the adult.[6] While the lexicon will contain more homophony than the adult lexicon, homophony must be permitted (given 'night' and 'knight'), so this will not rule out the child's constructed grammar. Indeed, the fact that homophony can come into being through diachronic change indicates that this type of event does indeed take place on occasion (Hale 1995). However, it cannot hold in our case, which assumes that the child eventually converges upon the adult output. Since hypothesis A essentially precludes acquisition of the s/š contrast, it must be rejected.

Hypothesis B holds that the child, no doubt by making use of his/her inborn sensitivity to phonetic contrasts of potential phonological relevance, has constructed accurate underlying representations for 'Sue' and 'shoe', encoding the /s/:/š/ contrast correctly. However, the child has ranked the constraints in the OT phonology in such a manner that Faithfulness to /š/ is ranked *lower* than a well-formedness constraint such as

[5] Note that this would require that Faithfulness to /s/ be ranked higher in the phonology than any well-formedness constraint that would favor changing /s/.

[6] This is, in fact, the Subset Principle at work in phonology (see Reiss 1995a, 1995b).

*š (i.e., 'do not have a [š] in the output representation'). As can be seen from the tableau in (3), the correct output will be generated by such a scenario.[7]

(3)	*š	FAITH
☞ šu > su		*
šu > šu	*!	
☞ su > su		
su > šu	*!	*

It should be noted that the scenario hypothesized under (B) is a standard example, indeed, it is the definition, of *structural ambiguity*: distinct underlying structures have the same representation in the output of the grammar.[8]

Under hypothesis (C) in (2) the underlying representations are, as in the (B) scenario, set up correctly by the child. However, under this scenario, the output of the grammar maintains the [s]:[š] contrast. The failure on the part of the child to distinguish between the two segments in his/her output is attributed to a shortcoming of the production system, which responds to the instruction to produce a [š] by emitting a [s] instead. Such mismatches are, as pointed out above, to be expected if one assumes, as everyone does, that the child is not a competent articulator or processor.

The question of whether or not we can distinguish between the output of the grammar and the output of the body amounts to this: is there any empirical evidence that bears on the question of whether the child has [s] or [š] as the output of their *grammar* in the word for 'shoe' at the stage under discussion. Given the parsing model discussed above, there is, of course, a simple test which will resolve the question. Since the child, like any adult, is assumed to use the output of their own grammar to parse input from other speakers, rather than the output of his or her own body, it can be seen that if the child treats other speakers' [šu] as 'shoe' and other speakers' [su] as 'Sue' then the contrast between [s] and [š] persists to the level of the output of the grammar. It is well-known that children are indeed capable of identifying accurately whether an adult has said 'Sue' or 'shoe' in spite of their own production merger at this stage. Indeed, they reject adult renderings of 'shoe' as [su] — in spite of the fact that the adult output then matches their own — strongly supporting the hypothesis that their parser is not making reference to their own bodily output form.

Additional support for this conception of the child's parsing mechanism can be seen in the results of Dodd (1975). Dodd showed that children failed to parse *their own output* when it differed significantly from the output of an unfamiliar adult. Only by

[7] I have simplified the set of Faithfulness constraints — which should be separated into one constraint for each feature — into a single super-constraint FAITH, following the practice of Gnanadesikan (1995). This is of course just an abbreviation of the real tableau; however, this 'abbreviatory' convention may have serious empirical consequences.

[8] Structural ambiguity (2B) is distinct from lexical ambiguity (2A), where identity in input structures is responsible for the ambiguity of the output, as well as from production ambiguity (2C), where forms which are distinct at the level of the output of the grammar are, due to some difficulty with the production system, produced the same.

recognizing the irrelevance of the child's Z-form, the output of their body, to the parsing procedure can this result be accounted for.

Note that under hypothesis (2B) the consistent and accurate parsing of the adult [s]:[š] contrast by children is completely unexpected. Some earlier approaches to the study of children's phonology, which adopted Hypothesis B, needed to invoke special 'perception' grammars, distinct from 'production' grammars (Ingram 1976, 1989a,b). These perception grammars allowed the child direct access to underlying forms (rather than having the parser operate on the output of the child 'production' grammar). Such a theory is far too powerful, and severs the connection between the child's linguistic competence and that of adults. Gnanadesikan (1995) clearly sees the difficulties with such approaches, asserting that her approach avoids these complications:

> By contrast, Optimality Theory does not give the child an extra processing load. The child does not have more rules or more levels than the adult.
>
> Gnanadesikan (1995:30)

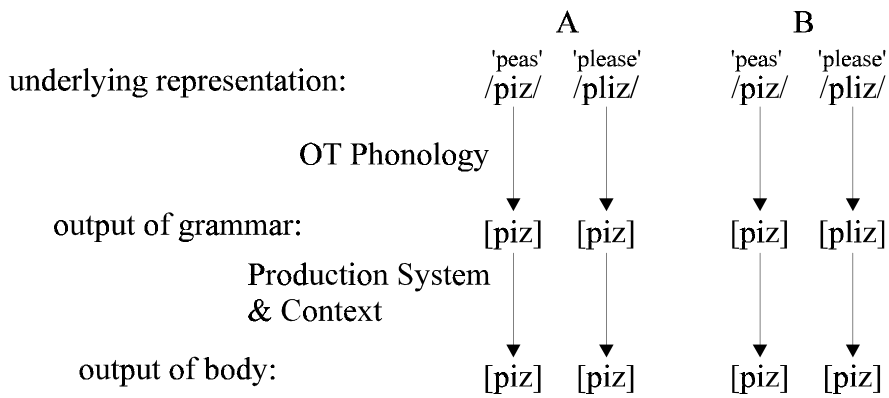
We have shown above that adoption of either Hypothesis A or Hypothesis B would indeed require an additional 'level' — an extra processing load — since the grammar fails to distinguish in its output between adult [s] and adult [š], but the child does not. The Strong Identity Hypothesis, a version of Occam's razor, thus requires the abandonment of these hypotheses in favor of the scenario sketched in (2C), in which the input representations for the child contain /s/ and /š/, the output of the grammar contains [s] for /s/ and [š] for /š/, but the production system fails to realize these two segments as distinct, producing [s] in both cases. Since the production system is not implicated in parsing, the failure of the child's playback system to distinguish these segments is irrelevant to his or her ability to parse the contrast.

Unfortunately, though Gnanadesikan (1995) asserts that she assumes no additional processing load for the child, the analyses offered make no effort to distinguish between the output of the body and the output of the grammar. For example, both 'please' and 'peas' are pronounced [piz] by G (Gnanadesikan's subject). Gnanadesikan attributes this to the ranking of the constraints *COMPLEX (which prohibits complex onsets) and FAITH (which is a convenient cover term for a set of faithfulness constraints). A tableau such as that in (4) reveals that such an OT would produce the desired result (see Gnanadesikan 1995:5).

(4)	*COMPLEX	FAITH
pliz > pliz	*!	
☞pliz > piz		*
☞piz > piz		
piz > iz		*!

The tableau in (4) provides some of the evidence offered by Gnanadesikan that faithfulness constraints must be low-ranked in children's phonological systems and that, therefore, it is reasonable to assume that they are low-ranked in UG. Drawing this conclusion from the tableau in (4) requires that we assume that Gnanadesikan shares our assumption that the type of OT she is interested in is OT phonology — that is, an OT which models the computations of the phonological component, mapping underlying representations onto grammar outputs. If the OT posited by researchers working on child language is to have implications for constraint ordering within UG, it must, by definition, share this assumption. However, nowhere does Gnanadesikan provide the evidence that would allow one to distinguish between the two scenarios sketched in (5).

(5)



In scenario A the OT phonology is structured as claimed by Gnanadesikan. If this hypothesis is correct, the data cited above regarding onset simplification in G's speech is relevant for our theory of acquisition of the grammar. In scenario B, on the other hand, the realization [piz] represents the response of an immature body to an instruction to articulate [pliz]. In this case, while the result may tell us much about the physiological constraints of immature human speech production systems, it is quite irrelevant to our understanding of the acquisition of the grammar.[9]

Unfortunately, Gnanadesikan (1995) provides no information as to whether G correctly distinguishes between adult productions of 'please' and 'peas'. In any case, the evidence available in other studies indicates that in such circumstances children do in fact successfully link up adult [pliz] with 'please' and adult [piz] with 'peas'.[10] This lends strong support, given the parsing considerations outlined above, to hypothesis (5B), rendering Gnanadesikan's result irrelevant for the question of constraint ranking within UG.

There are independent considerations which might lead us to favor hypothesis (5B) in any case. As Joe Pater pointed out on the OT List, Drachman (1978) has observed that the output of children does not parallel the steady approximation to a possible adult

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[9] Note that although Gnanadesikan (1995) discusses 'constraint reranking' as one of the central aspects of phonological acquisition, an approach such as hers in which no distinction is drawn between the output of the production system and the output of the grammar can no longer invoke the primary mechanism for such reranking: exposure to linguistic data from the target language which conflicts with the UG ranking. Her subject, G, knows that adult output forms have complex onsets and hypothesizes that their underlying representations contain complex onsets, but having learned this, G does not rerank the constraint against such onsets. The trigger for reranking in Gnanadesikan's model is never specified.

[10] For example, Dodd (1975) includes in his list of words identified correctly when produced by adults, but misidentified by children when their own output was presented to them, examples such as 'bridge' ([bɪd] in the children's form) and 'glass' ([gɑs] in the children's form).

grammar in the way implied by Gnanadesikan's theory of step-wise constraint re-ranking. For example, as Drachman (1978:128ff.) noticed, vowel harmony is attested widely in the earliest output of children, but disappears at a relatively early stage in the acquisition process. On the other hand, stop assimilation across intervening vowels (of the [gək] 'duck' type) steadily increases during the acquisition process, disappearing relatively late. A survey of existing human languages, however, indicates that vowel harmony is relatively wide-spread, whereas long-distance stop assimilation (of place) is, to our knowledge, completely unattested as an output constraint on all words. That is, whereas we find human languages in which all the vowels of a given prosodic domain (e.g., the phonological word) must agree in height or roundness, we do not find human languages in which all stops within the phonological word must agree in place. Presumably we would like to constrain our OT grammars such that such languages are precluded. If this is true, then the appearance of such regular effects in the output of children can *only* be attributed to the effects of the production system. Otherwise, the child will need to be able to construct phonologies which are not possible human phonological systems. Since the set of possible human phonological systems is a simple function of the set of possible constraint rankings, allowing the child to construct an 'impossible' grammar entails allowing the child to create new constraints not given by UG. Since long distance stop assimilation is widespread, if not universal, in the output of children, we would need not only to permit this undesirable event, but make it in some compelling way necessary. This does such damage to the concept of UG that it seems highly preferable to simply acknowledge that children's production systems are not particularly good at bringing certain types of representation to articulate realization — in the case in question, for example, representations which contain two different specifications for the place realization of two stops within the phonological word. Additional examples of this type can easily be found in Drachman (1978).[11]

Gnanadesikan (1995) presents, as one of the more compelling arguments for an OT account for the acquisition data presented in her paper, the occurrence of the phenomenon known as 'the emergence of the unmarked.'

> In the OT framework the phonology is one of output constraints which are universal, and hence shared by children and adults. The output candidates evaluated by children and adults are the same, but children select different winning candidates than adults do. Reranking of the constraints provides the means by which the phonology develops. Certain rankings of the constraints will cause the child's language to exhibit emergence of the unmarked. Such cases provide strong evidence that child phonology is best modeled by a hierarchy of constraints as in OT.
>
> Gnanadesikan (1995:3)

[11] Note that Gnanadesikan's treatment of her subject's output data (like that of many researchers working on phonological acquisition), in its failure to distinguish between the output of the grammar and the output of the body, contains in its method an implicit assumption that children are in possession of virtually flawless control of their articulators and production system.

If the effects observed by Gnanadesikan are to be explained by invoking the child's production system, as we have argued above, why are these effects so nicely paralleled in the *phonological* phenomenon of the 'emergence of unmarked'? Given the presence of phonological conditioning (such as reduplication, in the Sanskrit case discussed by Gnanadesikan) and the fact that such processes are not universal, the adult processing system cannot be held responsible for such processes. We will not venture into a full exposition of this matter at this time (see Hale & Reiss, forthcoming, for an extensive discussion), however, the fact that there is some observational overlap between effects of the production mechanism and features of grammars must be recognized. As an example of this consider the report of Johnson, Pisoni, and Bernacki (1990) on the intoxicated speech of the captain of the *Exxon Valdez* around the time of the accident at Prince William Sound, Alaska. They note that, as in other studies of intoxicated speech, the realization of segments may be affected by intoxication. They include among their list of observed effects

- misarticulation of /r/ and /l/
- final devoicing
- deaffrication

The accurate articulation of /r/, /l/, and affricates, as well as the existence of a voicing contrast in final position, all represent 'marked' features of English whose presence in the grammatical output is attributed, within OT theory, to relatively high-ranked faithfulness constraints regarding the features of the segments in question. To account for Captain Hazelwood's output we have two options: either these instances of the 'emergence of the unmarked' are to be attributed to the impairment of his *production system* by alcohol, or the consumption of alcohol in sufficient quantities leads to constraint re-ranking in adults.[12] The latter analysis does such serious injury to any meaningful concept of 'the grammar' that we clearly must recognize that the fact that 'emergence of the unmarked' is a feature of children's bodily output does not permit one to draw the conclusion that the source for this aspect of their output is to be sought in the grammar, rather than in the 'impairment' of their production system by immaturity.

It is important to point out that we are not claiming that the analyses of G's speech in Gnanadesikan (1995) are necessarily incorrect. It is an empirical question, in our view, whether or not in each case the output which forms the basis for the constraint rankings posited in that paper represent output of the grammar or output of the body. The issue is simply not addressed by the author; no evidence which would allow one to decide the matter is presented.

"It does not matter how small you are if you have faith and a plan of action."
Fidel Castro, NY Times, 22 April 1959

[12] In fact, we hypothesize that the latter analysis would fail in any event. Adult processing results for heavily intoxicated speakers are not known to us, but personal experience leads us to believe that intoxicated adult speakers do not misparse sober adults' [šu] as 'chew', [kæp] as 'cab', or [waɪt] as 'ride'.

III. The Acquisition of the Lexicon

Up to this point we have focused on two particular problems with the approach to the analysis of G's language in Gnanadesikan (1995): the failure to recognize any role for the immature production system on the specific shape of G's bodily output and the resulting positing of processes which appear to be impossible in adult human grammars (e.g., distant stop place assimilation as a regular process) in the *grammar* of the child. While these shortcomings prevent the approach found in this work, and widely in the study of child language, from providing any evidence for the initial ranking of faithfulness constraints within UG, they merely tell us that such approaches leave the issue indeterminate. They do not themselves bear on the empirical validity of the assumption of low-ranked faithfulness constraints in UG. There is, however, a third major methodological issue which arises from a reading of Gnanadesikan (1995) which does, in our view, reveal that the assumption of low-ranked faithfulness cannot be correct. It is to this issue that we now turn.

As Gnanadesikan (1995) notes in several places in her paper, her analysis "assumed that G's inputs are segmentally like those of adults, that is that they are phonemicized versions of the forms she hears around her" (10).[13] As we pointed in Section 1 of this paper, languages may differ phonologically under OT assumptions in two ways: they may have distinct rankings of the constraints provided by UG and/or they may have different lexica. The acquisition of phonology thus involves two major tasks: the establishment of the target's constraint ordering and the establishment of appropriate phonological representations in the lexicon. Approaches to child acquisition which simply assume adult underlying forms (particularly *phonemicized* adult underlying forms) have simply given up on one of the major responsibilities of the study of language acquisition.

This could be a defensible methodological move under an assumption that the two tasks were independent of one another. It is, however, simple to demonstrate that the phonological information stored with a lexical entry interacts directly with the ordering of constraints in an OT model. Imagine that the child hears, and stores, [t^{h}ɛn] 'ten' and [t^{h}ɛn̪θ] 'tenth' (surely phonetically accurate data such as this will be required if the child is *ever* to acquire a reasonable approximation of the 'phonemicized adult underlying forms). At some point (probably not particularly early) in the acquisition process the child performs a morphological segmentation of these (and other similarly-related) forms and isolates the ordinal suffix /-θ/.[14] One result of that segmentation will be the existence, as by-products of the analysis, of two shapes meaning 'ten': [t^{h}ɛn] and [t^{h}ɛn̪].[15] The latter has a fully predictable 'dentalization' of its final /n/, occurring as it does only before [θ]. At the moment when the child posits a single lexeme for these two shapes, presumably

[13] This is considerably more accurate than the assertion on the second page of the paper: "I will show evidence that G's inputs (underlying forms) are in general segmentally accurate, that is they are phonemicized versions of the adult spoken forms." Since such forms are assumed by the analyses, the analyses can hardly be considered 'evidence' for the correctness of the assumption. No alternatives are considered.

[14] The suffix must be productive, given the infinite size of the set of nameable ordinal numbers.

[15] We will not consider at this time the issue of the aspiration on the initial /t/. It is, of course, trivially parallel to the *n*-facts under discussion.

/tɛn/, the well-formedness constraint *nθ, which prohibits alveolar [n] before [θ] in English, must be elevated above faithfulness to the alveolar /n/ of the lexeme /tɛn/.

As this example shows, there is an intimate relationship between the phonological shape of underlying forms and the constraint ranking provided by the phonology. The underlying form selected by the acquirer for storage is that form which, when fed through the computation system provided by the OT phonology, produces the desired output as the 'winning' candidate. (We emphasize that we mean, of course, output of the grammar, not of the body.) We have sketched our theory of this aspect of parsing above.

If the child were born with a UG which had *no* ranking of constraints — as some OT acquisition theories hold — the child will not converge upon a representation for any adult input form.[16] Since 'faithfulness' in OT is due to constraints, not a necessary by-product of the generative scheme (as in rule-based systems), one cannot claim under such an assumption that the child should simply store the phonetic string (reduced, presumably, to its linguistically relevant — i.e., featurally-represented — aspects) he or she is exposed to. Storing precisely what one has received as input in the lexicon is *equivalent* to assuming high ranking of faithfulness to all features (those used in *any* human language, not in the target language). There is little to be gained by assuming UG provides unranked constraints if, in order to store a single lexeme, the child must immediately rank all relevant faithfulness constraints above all relevant well-formedness constraints.

The assumption, argued for in Gnanadesikan (1995) and elsewhere, that faithfulness constraints are all ranked below well-formedness constraints in UG has the following implication: the child is born with a grammar which leads them to posit underlying forms and output forms which are *maximally distinct*. Since well-formedness constraints are responsible for all phonological alterations to an underlying form attested in any human language, only the higher ranking of faithfulness constraints 'suppresses' the modifying effects of this universal set of well-formedness constraints. If faithfulness constraints are all ranked low, the minimal possible relationship between input and output forms will be the result.

In fact, it can be shown that the child will be unable to converge upon *any* underlying representations if s/he starts with a UG with all faithfulness constraints ranked low. Given an adult string such as [dɔgi] as a target, there is *no* input representation which will produce this as the 'winning candidate'. Indeed, an OT phonology with universal constraints in which all well-formedness constraints outrank all faithfulness constraints will presumably produce *only* the ideal phonological word — this is of course the famous *ba*-problem. Gnanadesikan (1995) contains an implicit recognition of this fact when she asserts that

> In adult languages certain faithfulness constraints outrank certain markedness constraints. This is required by

[16] The available 'learnability' proofs for OT grammars unfortunately only consider the question of the learnability of the constraint rankings *given* an input and an output. While these proofs are non-trivial given that GEN produces an infinite set of candidates, they are, of course, not proofs that the lexicon itself is learnable under the assumptions made. Since the lexicon must be learnable, OT models of UG must license the establishment of a lexicon.

> the need to have enough contrasts to support a large lexicon.
>
> Gnanadesikan (1995:1)

The passage above clearly implies that the acquisition of a lexicon 'segmentally like those of adults … phonemicized versions of the forms she hears around her' will require that faithfulness constraints *not* be ranked low.

Under widely-endorsed assumptions that the child has access to no special grammatical modules — no extra 'levels' as Gnanadesikan (1995) puts it — no synchronic analysis of a child's output such as that presented by Gnanadesikan (1995) can tell us much, if anything, about the phonological aspects of UG, for it sidesteps one of the key pieces of evidence for what the grammar the child is born with must look like: the phonological shape of lexical entries. In the next section we will present an alternate model of how acquisition takes place, assuming an OT computational component in the phonology.

> "Faith is not a thing which one 'loses,' we merely cease to shape our lives by it."
> Georges Bernanos, *The Diary of a Country Priest* (1936)

IV. The High Ranking of Faithfulness Constraints in UG

Having pointed out above that neither an assumption of 'no ranking' of constraints within UG, nor the widely-held view that all well-formedness constraints are ranked above all faithfulness constraints will allow us to posit a UG which will let infant learners converge upon a lexicon, numerous possibilities persist. A very large set of possible preset rankings, interspersing faithfulness and well-formedness constraints could be entertained, for example. We will argue in this section, however, that a compelling case can be made for the assumption that all faithfulness constraints are ranked, in UG, above all well-formedness constraints.[17]

As we mentioned in passing in Section I above, the key to understanding acquisition under OT assumptions (or, indeed, under rule-based assumptions) is centered around the answer to the question of why there are well-formedness constraints (or, in rule-based systems, rules) at all . Since we assume, with most other researchers on child language, that children's perception of adult output forms is quite accurate, what prevents the simple storage of strings to which the child is exposed (reduced to linguistically-relevant featural representations) both as input form and output form? This is, of course, the question of why we assume that phonological processes exist. We will not go through the well-established experimental results which show that allophonic relations exist, nor the *wug*-test and related proofs of the existence of phonological processes. It is clear, however, that two factors, both involving optimizing lexical storage, are central to this issue: (1) the possibility of reducing the amount of information stored for a given segment because of distributional restrictions on the segment in question which render some

[17] This still describes a rather large class of possible UG's: there is a faithfulness constraint for every feature used in any human language and there is presumably a rather large set of well-formedness constraints. Within its constraint class (faithfulness vs. well-formedness), we are not in possession of any evidence which would allow us to determine a unique ranking for these constraints.

phonetic features of the grammar-output representation of that segment predictable (e.g., in the case of allophones); and (2) the possibility of reducing the size of the lexicon by linking via phonological processes morphologically-related (but possibly representationally-distinct, before the linking) forms. The only 'work' the computational component of the phonological system does is to license the elimination of predictable information from the lexicon. If we do not believe in such reduction, we do not need well-formedness constraints (or, indeed, any constraints) at all. With each elimination of redundant information from lexical entries, a well-formedness constraint must come into play to resupply that information. The well-formedness constraints do nothing else in standard models of OT phonology.

We assume that children are innately sensitive to all possible phonological contrasts, an assumption dictated by every child's ability to learn any human language, regardless of which subset of the universal feature inventory is used in that language, or what the distribution of those features in that language is. Lexemes must be initially stored in a fully specified phonetic form (i.e., specified to the degree allowed by the universal feature system used for human languages), for only language-specific information, deducible once a reasonable-sized set of such forms has been stored, will tell the child which features are relevant within the target language and which are not. A child who hears [k^hæt], posits this form as the target output for his or her grammar, and stores this as his or her underlying form has — through that act — posited high-ranking for faithfulness to all the features in [k^hæt].[18] Put another way, only if UG had high-ranking for faithfulness constraints could the child, using the computational system of UG as its sole guide to the relationship between target and input form, posit /k^hæt/ as the underlying form for a perceived target of the shape [k^hæt].

Given a sufficient number of forms stored in this manner, the process of lexical optimization (which is assumed to be a constant constraint on the procedure of establishing underlying forms) will lead the acquirer to deduce that, for example, the aspiration on [k^hæt] represents lexically redundant information in that it is predictable. It will therefore no longer be licit to store such aspiration information in the lexicon. The output target will not change because of this, of course — it was established on the basis of the child's interpretation of the adult target. Since the OT phonology represents the mapping between underlying representation and output target, a change in the underlying representation without a corresponding change in the target will require a simultaneous change in the computational component linking the two. Such changes will, of necessity, reduce the role of a particular faithfulness constraint — the addition of aspiration represents 'unfaithfulness' to the underlying representation — by the elevation of a well-formedness constraint previously dominated by the faithfulness constraint in question. Similar elevations of well-formedness constraints over higher-ranked faithfulness constraints will be triggered once the lexical optimization procedure has sufficiently clear evidence that it can posit morphophonemic alternations of the normal type.

Under this conception of acquisition, faithfulness constraints must be ranked high within UG. The elevation of well-formedness constraints takes place as a result of lexical optimization. The 'emergence of the unmarked' (e.g., in Sanskrit reduplication, which observes the complex onset constraint, as discussed by Gnanadesikan 1995) is therefore

[18] Additional phonetic detail to which the child certainly may attend is left out here for ease of exposition.

to be seen as the result of learning, rather than the accidental by-product of the structure of UG or the nature of OT grammars as opposed to other types. While this result may be seen by some phonologists as costly, it comes at considerable gain: the lexicon is, under these assumptions, acquirable, as, indeed, it must be.

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