# Consequences of Constraint Ranking

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# Abstracts

Optimality Theory (Prince and Smolensky 1993) makes the claim that well-formedness constraints are ranked and minimally violable. This dissertation examines the consequences of constraint ranking in three areas of phonology: segmental phonotactics (nasal-voiceless consonant sequences), metrical theory (English stress), and in phonological development (child English). These studies demonstrate that the introduction of constraint ranking allows for more principled descriptions of the facts in each of these domains, and often yields the correct predictions about the range of cross-linguistic variation.

La théorie d'Optimalité (Prince et Smolensky 1993) propose que les contraintes de bonne formation sont rangées sur une échelle de préséance et que c'est possible de les violer. Cette thèse examine les conséquences de cette proposition dans trois domaines de la phonologie: au niveau des segments (les séquences nasale-consonne non voisée), au niveau de l'accent (en anglais), et dans le développement phonologique (de l'anglais d'enfant). Ces études démontrent que l'introduction du classement des contraintes permet de meilleures decriptions des données, et fait aussi souvent de prédictions correctes au sujet des différences possibles entre les langues.

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## Acknowledgements for the Thesis

I became a linguist, if I can now call myself one, by accident more than by design. Thanks to Patsy Lightbown for arranging that accident, and to Glyne Piggott and Lydia White for quickly conveying the excitement and challenge that linguistics has to offer. Lydia was also kind enough to take me on as a research assistant when I came to McGill, and though this dissertation unfortunately contains no mention of second language acquisition, I learned much from her rigorous approach to it, which I am sure will serve me well in future endeavours.

An extremely happy accident was that my arrival at McGill coincided with that of my eventual thesis supervisor, Heather Goad. I am very fortunate to have had as a teacher and advisor someone with such insight into both phonological theory and phonological acquisition. Her guidance and her patience were essential in seeing this dissertation through to completion. Thanks also to the other members of the committee, Nigel Duffield, Glyne Piggott, and Lydia White.

I owe a large debt to A.J. Compton for making his child language corpus available to me. In this dissertation, I have only mined of a tiny section of that rich resource. I look forward to continued work with Dr. Compton in further mapping phonological development, and in making the corpus accessible to other researchers. Thanks too to the anonymous mothers of Derek, Julia, Sean, and Trevor, for their incredibly careful and detailed transcriptions of their children's speech.

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## Acknowledgements for the Papers

Each of the chapters in this dissertation are independent papers, and therefore each have specific acknowledgements, which are listed here following information regarding publication or submission status.

Chapter 1, "Austronesian Nasal Substitution and Other NC Effects", will appear in René Kager, Harry van der Hulst, and Wim Zonneveld, eds., *The Prosody Morphology Interface*, published by Cambridge University Press. Portions of it also appear under the title "*NC", in *Proceedings of the North East Linguistics Society* 26, published by the GLSA, University of Massachusetts, Amherst.

Acknowledgments: The comments of John Kingston, John McCarthy, and Donca Steriade have particularly helped to shape the present form of this paper. Thanks also to Abby Cohn, Edward Flemming, Bruce Hayes, Junko Itô, Takako Kawasaki, Jaye Padgett, Sharon Rose, Su Urbanczyk, Rachel Walker, and the participants in LING 751, UMass, and the Rutgers/UMass Joint Class Meeting, Spring 1995, for useful suggestions, and to Heather Goad and Glyne Piggott for their indispensible guidance. I would also like to acknowledge Choirul Djamhari for his help with the Indonesian data, and Lisa Travis for making it possible for me to work with him, as well as Jan Voskuil for his hospitality and assistance in securing many of the Austronesian materials during an all too short visit to Leiden. This research has been supported by SSHRCC fellowship no. 752-93-2773 to the author, and SSHRCC grant no. 410-92-0759 to Glyne Piggott.

Chapter 2, "On the nonuniformity of weight-to-stress and stress preservation effects in English" is currently under revision for *Linguistic Inquiry*.

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Chapter 3, "Minimal violation and phonological development" has been prepared for submission to *Language Acquisition*.

Acknowledgements: Portions of this paper previously appeared as "Truncation without Templates in Child Phonology" in the *Proceedings of the 20th annual Boston University Conference on Language Development*. I would like to especially acknowledge Johanne Paradis, the co-author of that paper, for her help during its preparation, as well as A.J. Compton for making his data available, and Heather Goad for extensive comments. Sections were also presented at Indiana University, McGill University, the University of Maryland, and the University of Toronto. Thanks to the audiences there and at BUCLD 20, as well as Katherine Demuth, Janet Grijzenhout, Glyne Piggott, Martine Kessler Robb, Lydia White for helpful discussion. I also appreciate the assistance of Jacob Brostoff, Nancy Kounadi, and Tania Zamuner in compiling the data. This research was supported by SSHRCC fellowship 752-93-2773, and by a doctoral research grant from the McGill Faculty of Graduate Studies.

For the purposes of this dissertation, I am required to make perfectly clear the extent to which others have contributed to this work. This is an issue only in the case of this last paper, portions of which appeared in an earlier co-authored version. The basic approach to the child truncation problem was developed jointly by both authors. I was responsible for its formal statement, and for extracting and analyzing the data from the corpus. I also wrote the paper, and revised it with comments and suggestions from my co-author. The discussion of minimal violation, most of the onset selection material, and the entire consonant harmony section appear only in the dissertation version. I should also note the contribution of the three research assistants, Jacob Brostoff, Nancy Kounadis, and Tania Zamuner, who helped with the task of formatting the child language database.

## Preface to the Thesis

The primary concern of research in phonological theory in the 1980's was the nature of phonological representations (see Anderson 1985; Goldsmith 1990 for overviews). Perhaps as a consequence of this focus, the research took an essentially modular approach (see esp. Halle and Vergnaud 1987), with sub-theories being developed for various levels of representation, such as segmental, syllabic, and higher level prosodic structure. This contrasts with earlier research, represented by Chomsky and Halle (1968) and following work (see e.g. Dinnsen 1979; Kiparsky 1982a), which sought to uncover overarching principles that controlled the application of rules.[1]

In the last few years, attention has shifted away from the representations themselves back to the principles governing them, though now ordered rules have largely, if not completely, been replaced by constraints on structural well-formedness (see e.g. Goldsmith 1993; Paradis and LaCharité 1993; Prince and Smolensky 1993). One result of this shift of focus is a return to a more unified approach to phonological theory, in which claims are made that have implications across representational levels. To assess these claims, then, often requires an examination of an extremely wide range of data.

Such is the case with Prince and Smolensky's (1993) Optimality Theory. This approach to generative grammar has as its fundamental joint premises that constraints are ranked, and minimally violable. When one constraint is ranked above another, the requirements of the higher ranked constraint take precedence in determining well-formedness, and the lower ranked constraint is violated when necessary to meet those

[1] This program has continued to be developed in the framework of Lexical Phonology (see e.g. Kiparky 1982b).

requirements. As this is a general theory of constraint interaction, the introduction of constraint ranking has consequences at various levels. The aim of this dissertation is to examine these consequences in several domains where they have not been previously explored. The rationale for each of these explorations will be presented following a brief note on the format of the thesis.

Each of the chapters of the dissertation consists of an independent paper that has been, or will be, submitted for publication (see the acknowledgements for the papers). As per the guidelines of the Faculty of Graduate Studies, the following indented paragraphs are included to inform the reader of Faculty regulations concerning the manuscript-based dissertation format:

> Candidates have the option of including, as part of the thesis, the text of one or more papers submitted or to be submitted for publication, or the clearly-duplicated text of one or more published papers. These texts must be bound as an integral part of the thesis.
>
> If this option is chosen, connecting texts that provide logical bridges between the different papers are mandatory. The thesis must be written in such a way that it is more than a mere collection of manuscripts; in other words, results of a series of papers must be integrated.
>
> The thesis must still conform to all other requirements of the "Guidelines for Thesis Preparation". The thesis must include: a table of contents, an abstract in English and French, an introduction which clearly states the rationale and objectives of the study, a review of the literature, a final conclusion and summary, and a thorough bibliography or reference list.
>
> Additional material must be provided where appropriate (e.g. in the appendices) and in sufficient detail to allow a clear and precise judgement to be made of the importance and originality reported in the thesis.
>
> In the case of manuscripts co-authored by the candidate and others, the candidate is required to make an explicit statement in the thesis as to who contributed to such work and to what extent. Supervisors must attest to the

accuracy of such statements at the doctoral oral defense. Since the task of the examiners is made more difficult in these cases, it is in the candidate's interest to make perfectly clear the responsibilities of all the authors of the co-authored papers.

I will now introduce each of the papers that make up the dissertation.

The first paper in this dissertation examines some of the consequences of constraint ranking within the domain of segmental phonology. In "Austronesian Nasal Substitution and Other NC Effects", I present evidence of a heretofore undiscussed constraint against nasal-voiceless obstruent sequences, termed *NC.[2] While postnasal voicing, nasal substitution, nasal deletion, and denasalization are well-known processes (see e.g. Herbert 1986), the hypothesis that they are formally related as alternate means of avoiding a single constraint is novel to this paper. In Optimality Theory, this variety of NC effects can be straightforwardly generated by varying the ranking of *NC relative to the family of constraints that restrict the degree of deviance of the Output from the Input representation (i.e. the Faithfulness constraints of McCarthy and Prince 1995). Neither the traditional rule-based analyses of nasal substitution and postnasal voicing, nor the treatment of postnasal voicing in the Optimality Theoretic analysis of Itô, Mester, and Padgett (1995), capture the relationship between these processes.

Particularly striking evidence for the need to formally express the connection between

[2]Thesis guidelines require me to make clear the degree of originality of this research. In that respect, I should note that Bruce Hayes independently arrived at the conclusion that post-nasal voicingis driven by a phonetically-based constraint against NC sequences. However, a written version of my paper, which did not differ substantively from the present one, was fairly widely circulated before Hayes first presented his research, and before I became aware of his results. As the focus of his work is mostly on thephonetic motivation for this constraint, and mine on its cross-linguistic motivation, the convergence of complementary results is particularly encouraging.

the NC effects is provided by several languages that have conspiracies between them, where *NC is satisfied in one way in one environment (e.g. by post-nasal voicing word-medially), and in another way in another context (e.g. by nasal substitution word-initially). These conspiracies point to the importance of substantive output constraints to an understanding of phonological phenomena, and thus support their promotion to a central role within phonological theory, as in Optimality Theory.

What sets Optimality Theory apart from other constraint-based theories is the notion of minimal violation, that a violated constraint continues to be satisfied wherever there is no conflict with the dominating constraint. This formal innovation is in fact crucial to the account of these conspiracies (see the preface to chapter 2). However, because Faithfulness constraints, which are unique to Optimality Theory, are here being minimally violated, and because these segmental processes are usually given a rule-based rather than a constraint-based treatment, it is very difficult, if not impossible, to contrast an account of these facts that incorporates minimal violation to one based on full satisfaction.

To make this sort of theoretical comparison, we must therefore turn to an area in which we find minimal violation in the application of structural constraints, and which is usually treated primarily in constraint-based terms. Both of these criteria are well met by English stress. English stress provides particularly fertile grounds for theory comparison, since it has been the subject of a number of detailed theoretical studies, starting with Chomsky and Halle (1968). "On the nonuniformity of weight-to-stress and stress preservation effects in English" demonstrates that minimal violation allows for a more satisfactory account of English stress than was possible given the assumption of full satisfaction that underlies earlier analyses. This paper shows that minimal violation permits an explanatory treatment of instances of nonuniform constraint application, where a constraint is satisfied in one environment, but not another. Quantity Sensitivity, 'cyclic' stress preservation, and lexically based exceptionality, all apply nonuniformly in English. These phenomena have resisted explanation in theories in which constraints are simply either on, or off, but can be dealt with elegantly in a theory in which constraint conflict is resolved through constraint ranking.

The final paper presented in this thesis, "Minimal Violation and Phonological Development", discusses the consequences of constraint ranking for the study of phonological development. Children's early sound systems are subject to a number of restrictions that must be overcome in order to achieve adult-like pronunciations. This paper provides evidence that when constraints are overcome, they are outranked, rather than turned off. This evidence comes from a comparison of constraints active in child language to those of the adult system, from aspects of child language itself, and from a comparison of developmental stages. The child language phenomena studied include truncation, onset selection, and consonant harmony, with data being drawn from a computer-aided analysis of an extremely large, previously unpublished corpus of spontaneous produced child English collected by a team under the direction of A.J. Compton in the 1970's (see Compton and Streeter 1977).

The dissertation concludes with a summational discussion of the types of analytic improvements that constraint ranking permits in each of the studies.

# Preface to Chapter 1

In Optimality Theory (Prince and Smolensky 1993), a grammar consists of a set of constraints, rank ordered with respect to one another. When one constraint is ranked above another, the demands of the higher ranked constraint take precedence in determining well-formedness. Variation between languages is captured by variation in constraint ranking; the constraints themselves are held to be universal.

With the exception of a few proposed fixed rankings, there are no limits on how the constraints can be ordered. The prediction this makes is that all possible rankings should yield possible languages (see Prince and Smolensky 1993 on Factorial Typology). Constraints can be broadly divided into two groups: those that demand well-formed output structures, and those that demand a match between input and output (underlying form and surface form). These can be called structural and Faithfulness constraints respectively. The ranking of a structural constraint, for example "no coda [voice]", over a faithfulness constraint such as "retain input [voice]" is what yields a phonological regularity, in this case, no [voice] in codas. The opposite ranking, with the Faithfulness constraint over the structural constraint, would allow a voice contrast in that position.

Since there are a number of different Faithfulness constraints, Optimality Theory predicts a range of possibilities for any given well-formedness constraint, depending on its ranking *vis-à-vis* the faithfulness constraints. Unfortunately, little work has been done to test the resulting predictions. This chapter consists of a case study of the cross-linguistic effects of a particular constraint, with the goal of testing whether all the predicted possibilities are attested. In the case of this constraint, *NC, the cross-linguistic possibilities are for the most part robustly attested.

# Chapter 1

## Austronesian Nasal Substitution and other NC effects

### 1.0 Introduction

Nasal substitution occurs in Austronesian languages as far flung as Chamorro (Topping 1969, 1973), and Malagasy (Dziwirek 1989), as well as in several African languages (Rosenthall 1989: 50). However, it is most famous for its appearance in the Indonesian *məN-* prefixation paradigm (see e.g. Halle and Clements 1983: 125).[1] Nasal substitution refers to the replacement of a root-initial voiceless obstruent by a homorganic nasal (1a). If the obstruent is voiced, a homorganic cluster results instead (1b). As illustrated by the data in (1c), NC (nasal/voiceless obstruent) clusters are permitted root internally:

| | | | | |
|---|---|---|---|---|
| (1) | a. | /məN+pilih/ | məmilih | 'to choose, to vote' |
| | | /məN+tulis/ | mənulis | 'to write' |
| | | /məN+kasih/ | məŋasih | 'to give' |
| | b. | /məN+bəli/ | məmbəli | 'to buy' |
| | | /məN+dapat/ | məndapat | 'to get, to receive' |
| | | /məN+ganti/ | məŋganti | 'to change' |
| | c. | əmpat 'four' | untuk 'for' | muŋkin 'possible' |

Though familiar to most students of phonology, Austronesian nasal substitution has not engendered much theoretical discussion. The standard analysis invokes two ordered rules to generate the single nasal from the underlying pair of segments: nasal assimilation, followed

[1] Though the dialects of Malay spoken in Malaysia and Indonesia are distinct in some ways, unless noted otherwise the phenomena discussed here are common to both Bahasa Indonesia as described in Lapoliwa (1981), and Cohn and McCarthy (1994), amongst others, and the Johore dialect of Malay described in Onn (1980) and Teoh (1988). The Indonesian data cited are all from Lapoliwa (1981). Both Chamorro and Malagasy also display essentially the same pattern as that in (1), as do a number of other languages spoken in the Indonesian archipelago. The unspecified nasal in the underlying form of the /məN-/ prefix is employed only as a matter of convention, and does not imply any particular analysis of the assimilative behaviour of the prefix.

by a language- and construction- specific rule of root-initial, post-nasal, voiceless consonant deletion (e.g. Topping 1973: 49; Onn 1980:15; Herbert 1986:252; Teoh 1988:156; though cf. Lapoliwa 1981:111, Uhrbach 1987:72).

In this paper, I reanalyze nasal substitution as fusion of the nasal and voiceless obstruent, driven by a general, phonetically motivated constraint that disallows nasal/voiceless obstruent clusters (*NC). This analysis is cast in the framework of Optimality Theory, as developed by Prince and Smolensky (1993), and McCarthy and Prince (1993a,b, 1994a,b, 1995). In particular, aspects of Correspondence Theory, and the theory of morphology-phonology interaction expounded in McCarthy and Prince (1995), play a central role.

The generality of the *NC constraint is demonstrated by the fact that nasal substitution is just one of a range of processes that languages make use of to rid themselves of NC clusters, which also include post-nasal voicing, nasal deletion, and denasalization. Permutation of the constraint rankings posited for nasal substitution is all that is needed to provide a unified account of these NC effects. Nasal substitution occurs when the anti-fusion constraint LINEARITY is dominated by *NC and the other Faithfulness constraints. Each of the other NC effects is similarly generated when the Faithfulness constraint that it violates falls to the bottom of the hierarchy.

This approach to NC effects has important advantages over both the standard analysis of nasal substitution, as well as the recent analysis of post-nasal voicing in Itô, Mester, and Padgett (1995). The postulation of a voiceless consonant deletion rule renders completely opaque the relationship of nasal substitution to the other NC phenomena, and also predicts the existence of postnasal voiceless consonant deletion without prior nasal assimilation, an unattested process. Similarly, Itô, Mester, and Padgett's analysis of post-nasal voicing, which is based on conditions on the licensing of redundant features, fails to extend to nasal substitution, and generates unattested patterns of nasal-obstruent voicing. The failure of these other approaches to provide a unified account of the full range of NC effects is particularly acute in light of the existence of languages in which two processes act in 'conspiracy' (Kisseberth 1970) to avoid NC clusters. A wide range of these conspiracies, found in Bantu languages and in dialects of Greek, are documented in this paper.

The analysis of nasal substitution, and the other NC effects, appears in § 1.1 through 1.3. Section 1.1 introduces the *NC constraint. In section 1.2, I discuss the segmental violations of Input-Output Faithfulness that satisfy *NC (e.g. fusion and deletion), and provide an account of the morphological restrictions on Indonesian nasal substitution. Section 1.3 is concerned with the Input-Output mismatches in the featural makeup of NC sequences (e.g. denasalization and post-nasal voicing), and contains a modification to the formulation of Featural Identity that is necessitated by the Identity violations incurred by fusion. In §1.4, I discuss some problems with the standard voiceless consonant deletion analysis, and show how the fusional analysis overcomes them. Section 1.5 focuses on the inability of redundant feature licensing to cope with nasal substitution, and introduces the OshiKwanyama facts, as well as other cases of conspiracy between NC effects. The results are summarized in the final section, with directions for further research.

## 1.1 *NC

In a wide variety of languages, NC clusters seem to be disfavoured. That is, Input NC! (nasal/voiced obstruent) sequences are represented faithfully in the Output, while NC's are somehow altered. The usual result is for the obstruent to be voiced, though there are other possibilities, as enumerated in the Introduction, and below.

The fact that these NC effects, in particular post-nasal voicing, occur with such frequency has long been assumed to stem from the ease of articulation of NC! clusters relative to NC, though a specific hypothesis about the articulatory difficulty inherent in NC's has yet to emerge (Kenstowicz and Kisseberth 1979: 37). However, Huffman's (1993: 310) observation that the raising of the velum occurs very gradually during a voiced stop following a nasal segment, with nasal airflow only returning to a value typical of plain obstruents during the release phase, suggests an articulatory basis for a *NC constraint, since an NC! cluster allows a more leisurely raising of the velum than an NC. Put another way, an NC cluster requires an unnaturally quick closure. The fact that this constraint is asymmetrical (i.e. *NC, and not *CN - see the discussion in §1.5), can then be understood in light of Zuckerman's (1972) finding that 'the velum can be lowered more quickly and with greater precision than it can be raised' (Herbert 1986: 195).[2] Ohala and Ohala (1991: 213 - cited in Ohala and Ohala 1993: 239) provide the following complementary perceptually oriented explanation for nasal deletion in the NC configuration:

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[2] I am grateful to John Kingston and Donca Steriade for very helpful discussion of the phonetic facts, though I hasten to claim sole responsibility for any errors of interpretation. See also Hayes (1995) for a somewhat different hypothesis about the phonetic grounding of *NC.

(2) Among the auditory cues for a voiced stop there must be a spectral and amplitude discontinuity with respect to neighbouring sonorants (if any), low amplitude voicing during its closure, and termination in a burst; these requirements are still met even with velic leakage during the first part of the stop as long as the velic valve is closed just before the release and pressure is allowed to build up behind the closure. However, voiceless stops have less tolerance for such leakage because any nasal sound - voiced or voiceless - would undercut either their stop or their voiceless character.

Additional evidence for the markedness of NC clusters comes from Smith's (1973: 53) observation that they emerged considerably later than NC!'s in his son's speech, with the nasal consonant of adult NC's being deleted in the child's production. This pattern has also been observed in the speech of learners of Greek (Drachman and Malikouti-Drachman 1973) and Spanish (Vogel 1976). Thus, data from typology, phonetics, and acquisition all converge on the existence of a universal, but violable, *NC constraint:

(3) *NC
No nasal/voiceless obstruent sequences

One of the primary strengths of a constraint-based theory like Optimality Theory is that phonetically grounded contextual markedness statements like *NC can be directly incorporated into the phonology (Mohanan 1993: 98, Prince and Smolensky 1993 § 5). In what follows, I demonstrate how the interaction between *NC and constraints on Input-Output Correspondence creates grammars that generate nasal substitution, as well as the other NC effects.[3]

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[3] The discussion here abstracts from two other NC effects: nasal devoicing and obstruent aspiration. These processes cannot be captured by the simple statement of *NC in (3). It is conceivable that the articulatory or perceptual difficulties of post-nasal voicelessness could be overcome by enhancement with aspiration and/or extension of the duration of voicelessness. However, a proper treatment of these phenomena would force a long

## 1.2 *NC and Segmental Correspondence

### *1.2.1 Segmental Fusion*

McCarthy and Prince (1995) propose that the relationship between Input and Output is directly assessed by constraints on Correspondence (cf. McCarthy and Prince's 1994 theory of reduplicative Correspondence). This contrasts with the indirect method of using purely Output-based constraints, and stipulating that the phonological and morphological properties of the Input must be contained in the Output, by the principles of Containment and Consistency of Exponence (Prince and Smolensky 1993, McCarthy and Prince 1993a&b).

In the Containment approach to Input-Output Faithfulness, the constraint PARSE SEGMENT forces the realization of underlying segments (unpronounced Input segments are present in the Output, but unparsed). The equivalent in Correspondence terms is a constraint demanding that every segment in the Input map to a segment in the Output, in other words, that every Input segment have an Output correspondent. McCarthy and Prince 1995 call this constraint MAX. Thus, unlike a Containment-based theory, 'deletion' does involve a loss of structure between Input and Output. The constraint against 'insertion' is the mirror image formulation DEP, which requires a mapping of all Output segments to Input correspondents.

Rather than positing discrete steps of nasal assimilation and voiceless consonant deletion, or of complete assimilation of the voiceless consonant to the nasal and degemination (Uhrbach 1987:72; cf. Herbert 1986:252) I will argue that the relationship between Input

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digression from the central concerns of this paper, since at least the following rather complex questions would have to be answered: What is the nature of the interaction between these processes: does devoicing result from aspiration, or vice versa (cf. Herbert 1986, Nurse and Hinnebusch 1993)? Are voiceless nasals [-Voice], or [+Aspirated] (Lombardi 1991, Huffman 1994)? Are the voiceless nasals in fact even entirely voiceless (Maddieson and Ladefoged 1993: 262)? Related to the last question, are these processes categorical or more implementational in nature? Therefore, for present purposes I leave *NC in its perhaps overly simple form.

*maN–pilih* and Ouput *mamilih* is mediated by fusion, or coalescence of segments (Lapoliwa 1981:111; see also Stahlke 1976 for early arguments for fusion, one of which is recapitulated in §1.4.1 below, as well as Gnanadesikan 1995 and Lamontagne and Rice 1995 for recent discussion within Optimality Theory). The replacement of PARSE SEGMENT with MAX allows an interpretation of fusion as a two-to-one mapping from Input to Output: two Input segments stand in correspondence with a single Output segment (McCarthy and Prince 1995). This results in the satisfaction of MAX, though under a strict interpretation of Containment, PARSE SEGMENT would be violated in this situation (McCarthy and Prince 1993a:163, Myers 1994, Russell 1995). I illustrate the difference between Input and Output in (4), where subscripting is used to indicate the crucial correspondence relationship:

(4) $\text{mə}N_1\text{+}p_2\text{ilih}$ (Input) $\text{mə}m_{1,2}\text{ilih}$ (Output)

Even though fusion does not involve deletion, and so satisfies MAX, it does incur violations of other constraints.

At the featural level, fusion between non-identical segments violates constraints demanding Identity between Input and Output segments (see section 3 below for elaboration of Identity constraints, and for an example in which NC fusion is overruled by a Featural Identity constraint). Because fusion incurs violations of Featural Identity, it tends to occur between segments that are identical, or nearly so (cf. McCarthy and Prince 1993a:163, where fusion is restricted to identical elements). However, even fusion between identical segments is not automatic or universal, so it must violate at least one constraint other than Featural

Identity. Coalescence contravenes LINEARITY, a constraint which is independently needed in Correspondence Theory to militate against metathesis.[4] McCarthy and Prince's (1995) formulation of LINEARITY is as in (5), where $S_1$ and $S_2$ refer to Input and Output strings (or any other string of correspondent segments, such as Base and Reduplicant):

(5) LINEARITY
$S_1$ reflects the precedence structure of $S_2$ and vice versa.

In the fusional I,O relationship depicted in (4), /N/ precedes /p/ in the Input, but not in the Output, so LINEARITY is violated.[5] To command a violation of LINEARITY, *NC must be ranked above the Faithfulness constraint, as illustrated in the tableau in (6). A check mark indicates a grammatical form, and exclamation marks show where other candidates fail. Solid lines between constraints are used when the constraints are ranked, and dashed lines when there is no evidence for their ranking. Unless noted otherwise, all of the following tableaux apply to Indonesian.

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[4] The use of LINEARITY to block fusion was suggested by John McCarthy (p.c.). McCarthy and Prince (1995, this volume) invoke a separate UNIFORMITY constraint for such cases. I have retained the LINEARITY approach because it is still not entirely clear that a separate UNIFORMITY constraint is needed, and because LINEARITY seems to have some interesting possible extensions in the featural domain, which are noted below in the text

[5] Here I am assuming that the Input is made up of a linearly sequenced set of morphemes. It is in fact not crucial to the analysis that this position be maintained, since it is only LINEARITY within the root that must be obeyed, and there are other ways of ruling out trans-morphemic nasal substitution, as discussed in the next section. If the linear sequence of morphemes is unspecified in the phonological Input, there would be no Linearity violation incurred by nasal substitution. Instead, only Morpheme Disjointness would be at issue.

(6) **Nasal substitution: *NC >> LIN**

| Input: $məN_1$+$p_2$ilih | *NC | LIN |
|---|---|---|
| a.$məm_{1,2}$ilih ✓ | | * |
| b. $məm_1p_2$ilih | *! | |

With the ranking reversed, the candidate without substitution (6b) would be optimal. Such a ranking characterizes languages that tolerate NC clusters.

*1.2.2. Morphological conditions on fusion*

The fact that fusion violates LINEARITY leads to a straightforward account of the lack of root-internal nasal substitution in Indonesian. McCarthy and Prince (1994b) show that a large number of disparate phonological phenomena, reduplicative and otherwise, result from stricter Faithfulness requirements within the root than elsewhere in the word, that is, from the relative markedness of roots. The greater markedness of roots is no doubt driven by the need to maintain more contrasts between roots than between affixes. McCarthy and Prince formalize this difference in markedness by proposing a general ranking schema in which root-specific versions of Faithfulness constraints are intrinsically ranked higher than the general, or affix-specific version of the constraints. If nasal substitution were to apply within the root, massive neutralization would result. A root-specific ranking of LINEARITY (ROOTLIN) above *NC stops this from happening. A tableau illustrating the blocking of substitution within the root appears in (7):

(7) **Root-internal NC tolerance: ROOTLIN >> *NC**

| Input: $əm_1p_2at$ | ROOTLIN | *NC | LIN |
|---|---|---|---|
| a. $əm_{1,2}at$ | * ! | | * |
| b. $əm_1p_2at$ ✓ | | * | |

ROOTLIN rules out fusion within the root because fusion destroys the precedence relationship between Input root segments /m/ and /p/ (7a). Since the nasal in /meN+pilih/ is not part of the root, nasal substitution across the morpheme boundary does not disturb the precedence structure of root elements, and ROOTLIN is obeyed.

ROOTLIN is effective in blocking substitution within the root because it is a constraint on the relationship between Input and Output strings, rather than between individual Input and Output segments, or features. If we attempted to rule out root internal fusion with a root-specific constraint on Identity between Input and Output correspondents, substitution in the middle of the root, and at the beginning of it would be assessed equally, since both would turn a voiceless obstruent belonging to the root into an Output nasal. As Donca Steriade (p.c.) has pointed out, it is not at all clear how a theory with Faithfulness constraints demanding only faithful segmental and featural parsing would handle these and other segmental 'derived environment' effects (see Kiparsky 1993 for recent discussion). The main difference between Indonesian nasal substitution, and more commonly discussed cases such as the Sanskrit Ruki rule and Finnish assibilation, is that the latter involve segmental change, rather than segmental fusion. However, if linearity is generalized to sub-segmental elements, such that it forces their underlying precedence relationship to be maintained, and if these cases can all be analyzed as involving partial segmental overlap, then root-specific rankings of sub-segmental linearity would generate non-derived environment blocking effects. Clearly, a great deal of work needs to be done to determine the empirical coverage of root-specific LINEARITY constraints, but it seems plausible that the ranking of morpheme specific Faithfulness constraints above phonotactic constraints is the source of this sort of phenomenon.

Fusion is not, however, free to occur between any two morphemes. Both the prefix+prefix and root+suffix boundaries are impermeable to nasal substitution (8a & 8b respectively):

| | | | |
|---|---|---|---|
| (8) | a. /məN+pər+besar/ | [məmpərbesar] | 'to enlarge' |
| | b. /məN+yakin+kan/ | [məyakinkan] | 'to convince' |

The example in (8a) is particularly interesting, as it shows that it would be wrong to somehow conceive of nasal substitution as a property of the prefix *məN-* itself. This is further brought out by the fact that nasal substitution also occurs between the root and the noun-forming prefix *pəN-* (though cf. Lapoliwa's 1981 underlying representation of *pəN-* as *pə+məN-*):

| | | | |
|---|---|---|---|
| (9) | a. /pəN+pimpin/ | [pəmimpin] | 'leader' |
| | b. /pəN+tulis/ | [pənulis] | 'writer' |
| | c. /pəN+karaŋ/ | [pəŋaraŋ] | 'composer, author' |

These facts lead to the conclusion that nasal substitution is limited not to a particular morpheme, but rather to the prefix+root juncture.

To encode this sort of morphological conditioning, a set of constraints is needed to render particular morpheme boundaries opaque to fusion. This situation is somewhat reminiscent of a restriction on fusion in Axininca Campa, in which coalescence between /a/ and the velar glide is blocked if it would result in the root and suffix being entirely contained within a single syllable. To express this restriction, McCarthy and Prince posit a constraint of ROOT-SUFFIX-SEGREGATION, which shares with the present set of constraints the property of keeping particular pairs of morphemes separated. The constraints needed here can be formulated as demanding that morphemes have no correspondent segments in common, that is, that their sets of correspondents be disjoint:

(10) $M_1$-$M_2$-DISJOINTNESS
A | B
Where A and B are the sets of elements in correspondence with the elements of $M_1$ and $M_2$ respectively

When fusion occurs between two morphemes, they share an Output correspondent, and $M_1$-$M_2$-DISJOINTNESS is violated.[6]

As NC fusion is allowed between a prefix and a root, *NC dominates PREFIX-ROOT-DISJOINTNESS:

(11) **Prefix-Root nasal substitution: *NC >> PRE-RT-DISJOINT**

| Input: $məN_1$+$p_2ilih$ | *NC | PRE-RT-DISJOINT |
|---|---|---|
| a. $məm_{1,2}ilih$ ✓ | | * |
| b. $məm_1p_2ilih$ | * ! | |

All other $M_1$-$M_2$-DISJOINTNESS constraints, including PRE-PRE-DISJOINTNESS, rank above

[6] A nearly identical constraint is independently proposed in McCarthy and Prince (1995).

*NC, prohibiting nasal substitution across other morpheme boundaries:

(12) **Prefix-Prefix NC tolerance: PRE-PRE-DISJOINT >> *NC**

| Input: məN₁+p₂ər+besar | PRE-PRE-DISJOINT | *NC |
|---|---|---|
| a. $məm_{1,2}ərbesar$ | *! | |
| b. $məm_1p_2ərbesar$ ✓ | | * |

This might seem an overly circuitous method of restricting nasal substitution to root-initial position, if it were not for the fact that the DISJOINTNESS constraints are of considerable generality, with observable effects elsewhere. In particular, their existence explains the tendency for geminate integrity and inalterability phenomena to be limited to morpheme internal contexts (Hayes 1986: 468; see Kenstowicz 1994: 412 for further references and discussion), since they would favour 'fake geminate' sequences of unlinked identical consonants over fused 'true' geminates when the segments straddle a morpheme boundary.

### *1.2.3 Segmental Deletion and Insertion*

So far we have only considered candidates with and without NC fusion. Deletion, and epenthesis could also satisfy *NC, without incurring violations of LINEARITY. This means that in Indonesian, the constraints MAX, and DEP, which are violated by deletion and epenthesis respectively, must be ranked above LINEARITY. In fact, these constraints must be placed even higher in the hierarchy, above *NC, since neither deletion nor epenthesis is used to resolve *NC violations root-internally, where fusion is ruled out by ROOTLIN:

(13) **Deletion and epenthesis blocked by MAX, DEP >> *NC**

| Input:əmpat | MAX | DEP | *NC |
|---|---|---|---|
| a. əmpat ✓ | | | * |
| b. əpat | * ! | | |
| c. əməpat | | *! | |

If MAX, or DEP were ranked beneath *NC, deletion (13b), or epenthesis (13c) would be wrongly preferred over the optimal candidate (13a).

Though neither deletion nor epenthesis is resorted to in Indonesian to avoid *NC violations, permutation of the rankings of these constraints (Prince and Smolensky 1993: §6) predicts the existence of other languages in which MAX and DEP are dominated by *NC and the other Faithfulness constraints, producing NC deletion and NC epenthesis.

Examples of segmental deletion in the NC configuration include the aforementioned cases of child English (Smith 1973: 53), child Greek (Drachman and Malikouti-Drachman 1973), and child Spanish (Vogel 1976). Amongst the adult languages with NC deletion is the Kelantan dialect of Malay, which differs from standard Johore Malay in that it lacks nasals before voiceless obstruents, though it permits homorganic NC! clusters (Teoh 1988). This pattern is replicated in African languages such as Venda (Ziervogel, Wetzel, and Makuya 1972: cited in Rosenthall 1989: 47), Swahili[7] and Maore (Nurse and Hinnebusch 1993: 168),

[7] Swahili nasal deletion is historically preceded by aspiration of the following voiceless consonant, which spread to the nasal, though there is no evidence for this intermediate stage in the other languages cited here (see Herbert 1986: 252, Nurse and Hinnebusch 1993: 168).

as well as several others cited by Ohala and Ohala (1993: 239).[8]

What unites all of these examples is that the nasal, rather than the obstruent is deleted. This parallels the nasal/fricative cluster effects detailed in Padgett (1994), which sometimes involve nasal, but never fricative, deletion. The constraints posited thus far assess obstruent and nasal deletion equally, as violations of MAX. How to formalize nasal-obstruent asymmetries in deletion, as well as in assimilation, remains unaddressed in Optimality Theory (and more generally, in phonology: see Mohanan 1993). One possibility is to introduce intrinsic rankings of the Faithfulness constraints. For example, the fact that nasals tend to assimilate in place to obstruents, rather than the other way around, could be captured by a fixed ranking of OBSPLACEIDENT >> NASPLACEIDENT (i.e. the identity requirement between an obstruent and its underlying correspondent is intrinsically higher ranked than that between a nasal and its correspondent). For deletion, a ranking of an obstruent specific MAX constraint (OBSMAX) above the nasal specific NASMAX achieves the desired result. Establishing the phonetic basis, and typological correctness of this presumed fixed ranking is beyond the purview of this study, but it can be noted that its univerality is supported by the observation that a few languages lack nasals, but none are without oral segments (Maddieson 1984, cited in McCarthy and Prince 1994, who provide a different explanation for this generalization).

The tableau in (14) demonstrates how an /NT/ cluster would be treated in a language

[8] In discussing these African languages I follow, for ease of exposition, Herbert (1986) and Padgett (1994) in treating derived prenasalized stops as segmental sequences (cf. Piggott 1992, and Steriade 1993 for other views on prenasalization). It should be emphasized, though, that 'segment' in Correspondence theory might well be understood as the equivalent to what in feature geometric terms is the root node and everything it dominates (i.e. a melodic element). Two root node theories of prenasalized stops have been proposed by Piggott (1988), Rosenthall (1989), Trigo (1993), and to some extent, Steriade (1993), and Piggott (1995).

such as Kelantan Malay, in which *NC dominates MAX (note that all other Faithfulness constraints, including LINEARITY, are also ranked above MAX):

**(14) Tableau for Kelantan-like languages**

| Input: $N_1T_2$ | *NC | OBSMAX | NASMAX |
|---|---|---|---|
| $N_1T_2$ | *! | | |
| $N_1$ | | *! | |
| $T_2$ ✓ | | | * |

In future tableaux, I will merge the two MAX constraints, and show only the candidate with the deleted nasal.

For some reason, languages seem not to make use of epenthesis to resolve *NC violations. One might stipulate that DEP universally dominates *NC, but without any independent motivation for this fixed ranking, such a formalization would remain in the realm of description, rather than explanation.[9] With this potential gap in the typology of NC effects duly noted, I will now turn to the featural changes that can be used to satisfy *NC, and propose constraints to rule them out in Indonesian. In these instances, we will see the predicted factorial typology is indeed fulfilled.

[9] One path to explanation may lie in the fact that NC sequences tend to be place assimilated, and thus resist epenthesis due to some version of geminate integrity. However, this explanation is difficult, if not impossible to formalize in Optimality Theory (why should place assimilation have precedence over *NC?), and faces the empirical challenge that NC effects do occur in the absence of place assimilation in several languages (see § 1.4.1).

## 1.3 *NC and Featural Faithfulness

### *1.3.1 Denasalization*

Instead of completely deleting the nasal, another way to meet the *NC requirement is to change the underlying nasal into an obstruent. There are at least three languages that take this route: Toba Batak[10] (Hayes 1986), Kaingang (Henry 1948; cf. Piggott 1995), and Mandar (Mills 1975). Mandar, a language spoken in South Sulawesi, is particularly interesting because it has a prefixation paradigm that differs minimally from that of Indonesian. A homorganic nasal appears before voiced obstruents (16a), but instead of nasal substitution with the voiceless ones, there is gemination (16b) (in Toba Batak and Kaingang, the resulting obstruent retains its place specification, and can be heterorganic with the following consonant).

(16) **Mandar maN- prefixation**

| | | | |
|---|---|---|---|
| a. | /maN+dundu/ | mandundu | 'to drink' |
| b. | /maN+tunu/ | mattunu | 'to burn' |

In Mandar, unlike Indonesian, the prohibition against NC extends throughout the language

(17) Nowhere in my material nor in Pelenkahu's extensive lists of minimal pairs is there a single instance of nasal plus voiceless stop.[11] Where such a cluster would be expected, because of cognate items or at certain morpheme boundaries, there is invariably a geminate voiceless stop. In this respect,

[10] In Toba Batak, the obstruents produced by denasalization fail to undergo the debuccalization that affects other obstruents in the same position. Hayes (1986) attributes this to a type of geminate inalterability, with the double linking of a [-Voice] feature spread from the following voiceless consonant inhibiting debuccalization. More plausibly, this a case of avoidance of neutralization. That is, underlying nasals fail to go all the way to glottals so as to avoid neutralizing the distinction between them and underlying obstruents. See Flemming (1995) for discussion of the formal issues involved in setting up contrast-maintaining constraints.

[11] Mills does not comment on nasal-/s/ clusters, but as far as I can tell from Pelenkahu et al. (1983), the same restriction holds as for the stops, since there are many examples of /-ss-/, but none of /-ns-/.

> [Mandar] is far more consistent than [Buginese]; perhaps it reflects greater freedom from outside influence (Mills 1975: 82).

There are number of potential constraints, or sets of constraints that could rule out denasalization in Indonesian, as well as in languages like Kelantan Malay that have nasal deletion. Before turning to them, a short discussion of featural Faithfulness within Correspondence theory is in order.

To replace the containment-based PARSE FEATURE (see e.g. Itô, Mester, and Padgett 1995) in Correspondence Theory, McCarthy and Prince (1994a, 1995) outline two approaches. One is to extend Correspondence into the featural domain, and require mappings between instances of features such as [voice] in the Input and Output. A less elaborate theory, and the one that McCarthy and Prince adopt, invokes a set of identity requirements between segmental correspondents. A general formulation for such constraints is given in (18):

(18) Featural Identity - IDENT-(F)
Correspondents are identical in their specification for F

Formulated in this way, featural Faithfulness is not violated if a segment is deleted, since if an Input segment has no Output correspondent, Identity constraints do not come into force. On the other hand, if there were a whole set of Correspondence constraints that examined features, then every time an underlying segment failed to be realized in the Output, all of the applicable Featural Correspondence constraints would be violated. This would force all of the Featural Correspondence constraints to be dominated by whatever constraint favoured deletion. Whether this is a fatal flaw, or a happy result,[12] can only be assessed through careful study of the relationship between segmental deletion and feature changing processes, but it is evident that Featural Identity has the advantage of analytic convenience, especially when considering reduplication, which often involves long strings of Correspondence violations.[13]

In cases of fusion, however, the simple statement of Featural Identity given in (18) does lead some complications. Consider the Input-Output mappings in (19):

```
(19)  Input    a. n t       b. n t
                  \/           | |
      Output      n            t t
```

Nasal substitution is represented in (19a), and denasalization in (19b).[14] One consequence of the symmetrical nature of Identity is that IDENT[NAS] is violated to the same degree in (19a) and (19b), since in both instances a nasal and a voiceless obstruent stand in correspondence

---

[12] Since this was first written, Lombardi (1995) has found a 'happy result' in one domain, while Alderete et al.(1996) find a 'fatal flaw' in another. Needless to say, the issue is far from settled.

[13] One could even imagine a hybrid theory. Features that display clear independence from segments, most prominently tones, might be subject to Correspondence requirements, while those that do not would be targeted by Identity. A theory incorporating only Correspondence (or PARSE FEATURE) would seem to predict that all features should behave quite independently. For instance, an ALIGN RIGHT constraint, combined with a constraint against multiple association, could make a feature leave its Input host at the left edge, and migrate to a segment at the right edge of the word. However, rather than a problem with Featural Correspondence, this might be a problem with the idea that ALIGN is the driving force behind harmony, instead of constraints on featural agreement (see Kiparsky's 1968 morpheme structure conditions, and the discussion in Kenstowicz 1994: 351, as well as Beckman 1995 against Alignment in Correspondence Theory). Further complicating the picture is the fact that there are strategies such as fusion for explaining some apparent featural stability effects, that do not require Featural Correspondence, so that the only incontrovertible evidence for featural independence would be examples in which the Input source of a particular feature is represented without that feature in the Output (though even this might be analyzed as <u>fission</u> in Identity theory).

[14] It should be noted that these diagrams do not represent autosegmental mappings; rather, they illustrate the set-theoretic relationship between the Input and Output sets of segments. In addition, there is no theoretical stance implicit in the representation of the geminated /t/ as a pair of segments. This representation is used because denasalization sometimes produces a non-assimilated segment (Kaingang and Toba Batak), and because the results in terms of Correspondence and Identity are the same if a single /t/ is used for a geminate. Different results in terms of LINEARITY might obtain depending on whether geminates were considered a single segment with a mora, or two segments with linked features.

with one another. Nasal substitution also violates LINEARITY, so in terms of the constraints considered thus far, it is impossible for a language to prefer (19a) over (19b), since the Faithfulness violations incurred by (19b) are a subset of those for (19a).

One might consider ruling out (19b) with constraints against coda obstruents, and/or gemination. By using a syllable structure constraint to rule out denasalization, however, the resulting prediction should be that languages that display nasal substitution have tight restrictions on possible codas. To some extent, this is borne out. However, Chamorro, which has nasal substitution in *man-* and *fan-* prefixation, also has geminates and coda obstruents (Topping 1973: 36-49), even in prefixes, such as *hat-*, *chat-*, and *tak-* (Topping 1973: 66). Thus, nasal substitution does not appear to be driven by a desire to avoid coda obstruents, or gemination.

Another response to this problem is to elaborate Identity somewhat, so that we have a way of stating that in nasal substitution an Input nasal maps to an Output one, while in denasalization an Input nasal maps to an obstruent. With this shift away from symmetry the theory of featural Faithfulness begins to look more like segmental Correspondence, which has separate MAX and DEP constraints. However, I will preserve the analytic advantage of Identity noted above by stating the constraint in such a way that featural Faithfulness is not violated in cases of deletion:

(20) IDENTI→O[F]
Any correspondent of an Input segment specified as F must be F

Nasal substitution does not violate IDENTI→O[NAS], while denasalization does. [NAS] here would refer to the feature [Nasal] in monovalent feature theory, or [+Nasal] if bivalent features were assumed. The choice is not crucial, but since the feature [-Nasal] seems not to be active in any phonological process, I will assume there is but a single monovalent feature [Nasal] (Piggott 1993, Rice 1993, Steriade 1993, Trigo 1993, cf. Cohn 1993). Note that if bivalent features were used, and Featural Identity were stated without any reference to the value of the feature (i.e. 'any correspondent of Input segment X must be identical to X in its specification for F'), then the the effects of this constraint would remain symmetrical, and the problem of differentiating I-O and O-I Identity would remain unresolved.

For a language like Mandar, IDENTI-O[NAS] is ranked beneath *NC and the rest of the Faithfulness constraints. In Indonesian, IDENTI-O[NAS] is ranked above LINEARITY, so that fusion is preferred over denasalization. A tableau for Mandar is given in (21):

(21) **Mandar denasalization: *NC >> IDENTI-O[NAS]**

| Input: $maN_1+t_2unu$ | DEP | MAX | LINEARITY | *NC | IDENTI-O [NAS] |
|---|---|---|---|---|---|
| a. $man_{1,2}unu$ | | | *! | | |
| b. $man_1t_2unu$ | | | | *! | |
| c. $mat_1t_2unu$ ✓ | | | | | * |
| d. $mat_2unu$ | | *! | | | |
| e. $ma\eta_1at_2unu$ | *! | | | | |

Some further motivation for the recognition of separate IDENTI-O[NAS] and IDENTO-I[NAS] constraints comes from the fact that there is at least one language in which a geminate nasal is created to avoid a *NC violation (the South Sulawesi language Konjo - Friberg and Friberg 1991: 88). To distinguish Konjo from its near neighbour Mandar, IDENTO-I[NAS] can be ranked beneath IDENTI-O[NAS], so that having an Output nasal in correspondence with an

Input obstruent (i.e. NT → NN) is a better resolution of *NC than having an Input nasal in correspondence with an Output obstruent (i.e. NT → TT). In Mandar, of course, the ranking between these constraints would be reversed.[15]

*1.3.2 Post-nasal voicing*

The most common, and most widely discussed NC effect is post-nasal voicing. A particularly relevant, and perhaps less familiar example is that of the Puyo Pungo dialect of Quechua (Orr 1962, Rice 1993). As shown in (22), post-nasal voicing only affects affixal consonants. Root-internally, post-nasal consonants can remain voiceless.

(22) **Puyo Pungo Quechua**

a. **Root-internal NC:**

šiŋki 'soot' čuntina 'to stir the fire' pampalʸina 'skirt'

b. **Suffixal alternations:**

| | | | |
|---|---|---|---|
| sinik-pa | 'porcupine's' | kam-ba | 'yours' |
| sača-pi | 'in the jungle' | hatum-bi | 'the big one' |
| wasi-ta | 'the house' | wakin-da | 'the others' |

Obviously, post-nasal voicing satisfies *NC. Again, the question of what it violates is not as straightforward as it might at first seem. Compare the I,O correspondences for nasal substitution and post-nasal voicing:

[15] This leaves a not insignificant problem unresolved. How do we distinguish between nasalization of the voiceless stop, and nasal substitution? In terms of the constraints considered thus far, nasal substitution incurs all the violations that nasalization does, plus a LINEARITY violation that is avoided by nasalization. One possibly key difference is that in fusion, one of the underlying correspondents of the Output nasal is a nasal, while in nasalization the second member of the cluster has as its sole correspondent a voiceless obstruent. I should also note here that Konjo nasalization is subject to considerable morphological conditioning. In fact, the prefix that causes nasalization has a homophonous counterpart that differs only in that it fails to nasalize the following voiceless obstruent.

```
(23)  Input    a. n t        b. n t
                   \/           | |
      Output       n            n d
```

If we assume full specification of the traditional set of features (i.e. those of Chomsky and Halle 1968), IDENT[VOICE] is the only constraint violated in (23b), yet it is also violated in (23a) since Input /t/ corresponds to Output /n/. Nasal substitution violates LINEARITY, while post-nasal voicing does not, so again, there is some difficulty in establishing how Indonesian could prefer (23a) over (23b).

In this case, it is pointless to consider constraints that would rule out the NC! configuration itself, since this does occur in Indonesian as the Output of an underlying NC! sequence. Nor does the problem lie in the symmetry of Identity, since in both cases a voiceless Input segment stands in correspondence with a voiced Output segment. Rather, it is due to the mistaken assumption that [Voice] on a sonorant, and on an obstruent, are equivalent in markedness. A clear explanation for why [Voice] is more marked in obstruents is provided by Kenstowicz (1994: 36) (see Chomsky and Halle 1968: 300):

(24) Vocal cord vibration is influenced by several factors; but the most important is airflow. The folds cannot vibrate if no air is passing through the glottis. In order for air to flow, the supralaryngeal pressure must be less than the sublaryngeal. The degree of stricture made during the articulation of a sound may increase the supralaryngeal pressure and hence tend to shut off voicing unless other adjustments are made. Stops and fricatives have a stricture that inhibits spontaneous voicing. The stricture associated with [+sonorant] segments does not disrupt airflow enough to inhibit voicing. Thus, the natural state for sonorants is [+voiced] and for nonsonorants...is [-voiced].

The usual way to formalize this difference in markedness is to assume that sonorants bear no underlying specification for [Voice] (i.e. are unmarked), and that [+Voice] is filled in during the derivation by a redundancy rule. Underspecification and respecification, however, requires the proliferation of derivational stages, which should rightly be anathema in a parallelist conception of Optimality Theory (see Mohanan 1991 and Steriade 1995 for extensive critical discussion, as well as Smolensky 1993).

An alternative, non-derivational method of capturing the markedness of obstruent voicing is to postulate that there is a feature borne by voiced obstruents, but not voiced sonorants, the presence of which violates a constraint, perhaps of the *STRUCTURE family (Prince and Smolensky 1993; Smolensky 1993). Based on the fact that obstruents do require an articulatory adjustment to produce voicing that is not required of sonorants (specifically, expansion of the supralaryngeal cavity), as well as on Trigo's (1991) work on consonant/vowel interactions, Steriade (1995) proposes that voiced obstruents are specified for both a feature [pharyngeally expanded] and a feature [vibrating vocal cords], whereas sonorants are only specified for the latter (cf. the proposal in Rice and Avery 1989, Piggott 1992 and Rice 1993 that sonorant voicing is marked with an SV node/feature). I will adopt Steriade's proposal, using [Voice] as the feature common to sonorants and obstruents, [Exp] as the feature specific to obstruents. Furthermore, I will assume an unviolable configurational constraint such that [Voice] on obstruents requires [Exp].[16]

With asymmetrical constraints on Featural Identity, as well as the assumption that a feature like [Exp] is monovalent (Steriade 1995), the constraint needed here is IDENTO–I[EXP]. This constraint ensures that any voicing present on an Output obstruent

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[16] An alternative to an unviolable constraint might be that it is basic structural requirement to have [Voice] dependent on either [Exp], or [Son] (cf. Piggott 1994, and Kawasaki to appear for a variant on this that assumes a Sonorant Voice node). The idea here is that plain [Voice], without sonorant stricture or [Exp], is uninterpretable phonetically, in much the same way as a non-coronal [-Anterior] specification might be.

must be present underlyingly, that is, it militates against the neutralization of the obstruent voicing distinction in the post-nasal position. As it targets only obstruent voicing, this constraint is not violated by nasal substitution. Indonesian thus has IDENTO-I-[EXP] >> *NC. In Puyo Pungo Quechua, there is a root specific version of IDENTO-I-[EXP] above *NC, while the general IDENTO-I-[EXP] ranks below *NC, thus producing affixal post-nasal voicing only. As this completes the analysis of nasal substitution, it is appropriate to provide an illustrative tableau:

(25) **Final tableau for nasal substitution**

| Input: /məN$_1$+p$_2$ilih/ | MAP O-I | IDENT I-O [NAS] | MAP I-O | ROOT LIN | IDENT O-I [EXP] | *NC | LIN |
|---|---|---|---|---|---|---|---|
| a. məm$_{1,2}$ilih ✓ | | | | | | | * |
| b. məm$_1$p$_2$ilih | | | | | | * ! | |
| c. məp$_1$p$_2$ilih | | * ! | | | | | |
| d. məm$_1$b$_2$ilih | | | | | * ! | | |
| e. məp$_2$ilih | | | * ! | | | | |
| f. məŋ$_1$əp$_2$ilih | * ! | | | | | | |

Noteworthy in this tableau is the fact that all of the non-optimal candidates, with the exception of the epenthetic (25f), do turn up as optimal in other languages, and that each of these cases can be generated simply by having one of the constraints fall beneath all the others. Candidate (25b) is generated if *NC ranks beneath the Faithfulness constraints, as in languages that permit NC clusters. With IDENTI-O[NAS] at the bottom of this hierarchy, candidate (25c) is made optimal, as we have seen in Mandar. Candidate (25d) is preferred when IDENTO-I[EXP] is lowest ranked, as in Puyo Pungo Quechua. Finally, candidate (25e) wins with MAX dominated by the others, as in Kelantan Malay.

With the introduction of constraints such as ROOTLIN that disallow one of the NC effects in a particular environment, we would also expect to see cases where an alternate process takes place in the environment in which the usual one is ruled out. Such conspiracies between NC effects can be modeled simply by having both of the relevant Faithfulness constraints ranked beneath *NC. It is a powerful argument for the *NC approach to NC effects, and against competing ones, that this expectation is indeed fulfilled.

### *1.3.3 NC fusion overruled by Featural Identity*

In this section, I show how a high ranking Featural Identity constraint can disallow fusion between particular segments. This discussion also serves to introduce evidence of a conspiracy between nasal substitution and nasal deletion. The data to be accounted for involve a parametric difference between Austronesian and African nasal substitution. In all the Austronesian examples of which I am aware, the fricative /s/ undergoes substitution:[17]

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[17] These examples also demonstrate the well-known complication that /s/ becomes a palatal nasal under substitution. The apparent oddness of this alternation is somewhat tempered by the independent evidence from a Javanese morpheme structure constraint that Austronesian /s/ is in fact itself phonologically palatal (Mester 1986). A related complication is that nasal substitution also often fails to occur with a /c/ initial root (/c/ is variously described as a palatal stop or an alveo-palatal affricate). Based on the fact that avoidance of homophony with /s/ initial roots seems to determine whether substitution with /c/ can occur or not, Onn (1980: 62) suggests that resistance to substitution arose as a property of the roots, rather than of /c/ itself, which is perhaps spreading to other /c/ initial roots by analogy (the generalizations about the occurrence of substitution with /c/ reported by Onn for Johore Malay were confirmed for Bahasa Indonesia by my consultant, Choirul Djamhari). Lexical exceptions such as these can be captured by means of lexically specific constraint rankings, for which we might extend the schema for Root-specific constraints, so that constraints apply to a specified subset of lexical items. For instance, these words might be subject to a lexically specific high ranking of a featural IDENTITY constraint, forcing all Input oral, voiceless consonants to be faithfully represented as such in the Output. See the next chapter for development of this approach to lexical exceptionality in the context of English stress.

| | | | | |
|---|---|---|---|---|
| (26) | /məN+sapu/ | [məɲapu] | 'to sweep' | (Indonesian) |
| | /man+saga/ | [maɲaga] | 'stay' | (Chamorro: Topping 1973: 50) |
| | /N+sambuŋ/ | [ɲambuŋ] | 'to connect' | (Javanese:Poedjosoedarmo 1982:51) |

African languages with nasal substitution demonstrate a split in behaviour between stops and fricatives, as in the following examples cited by Rosenthall (1989: 49) (see also Odden and Odden 1985 on Kihehe):

| | | | | |
|---|---|---|---|---|
| (27) | a. /N+tuma/ | [numa] | 'I send' | |
| | /N+seva/ | [seva] | 'I cook' | (Umbundu: Schadeberg 1982) |
| | b. /N+tabi/ | [nabi] | 'prince' | |
| | /N+supa/ | [supa] | 'soup' | (Si-Luyana: Givón 1970) |

As in Indonesian, fusion with the voiceless stops can be attributed to the ranking of LINEARITY beneath *NC and the rest of the Faithfulness constraints, including MAX. However, unlike Indonesian, deletion occurs with root-initial voiceless fricatives instead of fusion. This indicates that preservation of Input continuancy is more highly valued than preservation of the Input nasal segment in these languages, in other words, that IDENTI-O[CONT] dominates MAX. The fact that deletion does occur rather than a *NC violation places *NC above MAX. Combining these rankings, we get *NC, IDENTI-O[CONT] >> MAX >> LINEARITY. The following tableaux show how this hiearchy generates the different responses to *NC violations in fricative-initial and stop-initial roots:

(28) **Fusion with stops**

| Input: $N_1$+$t_2$abi | *NC | IDENTI-O [CONT] | MAX | LIN |
|---|---|---|---|---|
| a. $n_1t_2$abi | *! | | | |
| b. $n_{1,2}$abi ✓ | | | | * |
| c. $t_2$abi | | | *! | |

With a stop-initial root, IDENT[CONT] is satisfied in fusion, so MAX is free to choose fusion (28b) over deletion (28c) as the best alternative to a *NC violation (28a). When the root begins with fricative, as in (29), fusion creates a violation of IDENTI-O[CONT], since an Input fricative has a stop as an Output correspondent (assuming an undominated constraint against nasal fricatives in all these languages - cf. Cohn 1993, Padgett 1994, along with a dominant IDENTI-O[NAS] constraint that forces the realization of nasality). With IDENTI-O[CONT] >> MAX, the candidate with deletion (29c) becomes optimal in this instance:

(29) **Deletion with fricatives**

| Input: $N_1$+$s_2$upa | *NC | IDENTI-O [CONT] | MAX | LIN |
|---|---|---|---|---|
| a. $n_1s_2$upa | *! | | | |
| b. $n_{1,2}$upa | | *! | | * |
| c. $s_2$upa ✓ | | | * | |

Austronesian nasal substitution evinces the opposite ranking MAX >> IDENT[CONT], since loss of Input continuancy, as in (29b), is preferred to deletion.

As Kisseberth (1970) originally pointed out, cases like this in which two processes conspire to avoid a single configuration provide strong motivation for the formal recognition of output constraints.[18] Under a purely rule-based analysis of nasal substitution, such as the standard one of nasal assimilation followed by voiceless consonant deletion, the functional connection between nasal substitution and nasal deletion would have to be stated independently of the rules themselves. This contrasts with the present Optimality Theoretic analysis of African nasal substitution and nasal deletion, in which the functional motivation for these processes is directly incorporated into the formal explanation, thus allowing for a perspicuous account of the conspiracy between them.

### 1.4. Fusion vs. voiceless consonant deletion

One way to improve the standard analysis might be to treat voiceless consonant deletion as one of several repairs that can be used to fix violations of *NC, since this would at least formally express the relationship between the rule and the phonotactic constraint. However, besides the theoretical problem that the ordering between this repair and place assimilation would still have to be stipulated, there are two empirical reasons to abandon voiceless consonant deletion in favour of fusion: one is from typology, the other is internal to the phonology of Indonesian.

[18] To stem any suspicion that deletion before the fricatives is motivated solely by the markedness of nasal/fricative clusters (see Padgett 1994), I should note that voiced fricatives undergo post-nasal hardening in Kihehe (Odden and Odden 1985: 598). This shows that *NC is needed for deletion in a nasal/voiceless fricative sequence, since one would otherwise predict that /ns/ should surface as [nt].

### *1.4.1 Evidence from typology*

The first argument for fusion over voiceless consonant deletion comes from an examination of the typology of NC effects. As Stahlke (1976) notes, ordered rule analyses predict that each of the rules should be independently observable. While the first of the rules in the standard analysis, nasal assimilation, is of course extremely common, as far as I know there is not a single instance of post-nasal voiceless consonant deletion, without the prior assimilation of the nasal. There are examples of other NC effects applying without place assimilation, such as Zoque post-nasal voicing (Wonderly 1951, Kenstowicz and Kisseberth 1979:36, Padgett 1994), and denasalization in both Toba Batak (Hayes 1986) and Kaingang (Henry 1948, Piggott 1995). By using fusion rather than ordered rules, we avoid the 'false step' of voiceless consonant deletion.

### *1.4.2 Evidence from reduplication*

There is also evidence from within the phonology of Indonesian for the fusional analysis. Lapoliwa (1981: 110) notes that reduplication copies a substituted nasal (30a), while prefixal nasals preceding a voiced obstruent (30b), or a vowel (30c), fail to be copied:

| | | | |
|---|---|---|---|
| (30) | a. /məN+kata+RED+i/ | məŋataŋatai | 'to speak ill about someone' |
| | b. /məN+gerak+RED/ | məŋgerakgerak | 'to move something repeatedly |
| | c. /məN+əlu+RED+kan/ | məŋəluəlukan | 'to praise' |

Lapoliwa formulates the rule of nasal substitution as one of phonological and morphological coalescence, so that the substituted nasal in (30a) becomes part of the morphological stem, unlike the unassimilated nasal in (30c).

Building on work by Uhrbach (1987), Cohn and McCarthy (1994) propose an entirely prosodic approach to these facts. In addition to the reduplicative evidence, they provide several other reasons to believe that the prefixal nasal added to a vowel-initial root remains in coda position, outside of the prosodic word, rather than being incorporated as the initial onset of the prosodic word. This violation of the ONSET constraint is attributed to the operation of a higher ranked ALIGN-WD constraint, which in Correspondence terms, demands that the segment at the left edge of the Input root have a correspondent at the left edge of the Output prosodic word. As they note, it is also crucial to this prosodic account that the nasal resulting from substitution be formed by coalescence with the root-initial consonant. If nasal substitution were in fact the result of root-initial voiceless consonant deletion, then there would be no obvious way to explain the difference between (30a) and (30c).

### 1.5 *NC vs. redundant feature licensing

Itô, Mester, and Padgett (1995) propose an analysis of post-nasal voicing based on the licensing of redundant features. One might wonder whether redundant feature licensing could be extended to nasal substitution. In this section, I demonstrate that it cannot, and argue that this failure casts doubt on the suitability of redundant feature licensing as an analysis of post-nasal voicing itself, especially since post-nasal voicing and nasal substitution act in concert in OshiKwanyama to rid the language of NC sequences. I then go on to provide additional examples of NC conspiracies involving post-nasal voicing and each of nasal deletion and denasalization, which also resist treatment by redundant feature licensing. Further evidence of the inadequacy of redundant feature licensing as an explanation for post-nasal voicing comes from its ability to generate pre-nasal voicing, an unattested process.

*1.5.1 Post-nasal voicing*

The basic premise of Itô, Mester, and Padgett's analysis is that because [Voice] is redundant in sonorants, it cannot be licensed by sonorants. With this restriction, a nasal specified for [Voice] violates the constraint LICENSE[VOICE], as in the first candidate in the tableau in (31):

(31) **Post-nasal voicing as redundant feature licensing**

| Input: NT | LICENSE[VOICE] | SONVOI | FAITH |
|---|---|---|---|
| a. NT<br>\|<br>[VOICE] | *! | | |
| b. NT | | *! | |
| c. ND<br>\| /<br>[VOICE] ✓ | | | * |

As can be seen in (31b), the alternative of leaving the nasal unspecified for [Voice] runs afoul of the implicational constraint SONVOI, which demands that sonorants must be specified for [Voice]. The final candidate manages to satisfy both LICENSE[VOICE] and SONVOI by having a single [Voice] feature linked to both the nasal and the obstruent, the latter of which is able to license it. This candidate is optimal when the Faithfulness constraint that is violated by non-identity between the voicing specification on Input and Output obstruents, which I have simply labelled FAITH for present purposes, is ranked beneath LICENSE[VOICE] and SONVOI

*1.5.2 Nasal substitution?*

To understand why redundant feature licensing cannot deal with nasal substitution, consider the table in (32):

**(32) Nasal substitution and redundant feature licensing**

| Input: NT | LICENSE [VOICE] | SONVOI | LINEARITY |
|---|---|---|---|
| a. N<br>\|<br>[VOICE] | * | | * |
| b. N | | * | * |
| c. NT<br>\|<br>[VOICE] | * | | |
| d. NT | | * | |

In a language with nasal substitution, either (32a) or (32b) must be optimal. However, the violations incurred by each of those candidates are a superset of those of one of the faithful ones, (32c) and (32d) respectively. Therefore, fusion could not be the result of any ranking of this set of constraints.

Intuitively, one might think that nasal substitution and post-nasal voicing are in some way related, since both act to get rid of NC sequences. This intuition is borne out by the facts of OshiKwanyama, a western Bantu language discussed by Steinbergs (1985), which demonstrates a conspiracy between nasal substitution and post-nasal voicing. While there are no alternations, root-internal postnasal voicing is evidenced by the complementary distribution of [k] and [g] - [k] appears word-initially and intervocalically, while [g] occurs after nasals. Furthermore, loanwords are modified by voicing the postnasal obstruent. The following are borrowings from English:

(33) **Postnasal voicing in OshiKwanyama loanwords**

| | |
|---|---|
| [sitamba] | 'stamp' |
| [pelenda] | 'print' |
| [oinga] | 'ink' |

Root-initially, nasal substitution, rather than postnasal voicing, occurs to resolve underlying NC sequences (nasal/voiced obstruent clusters remain intact, though Steinbergs provides no examples):

(34) **Root-initial nasal substitution in OshiKwanyama**

| | | |
|---|---|---|
| /e:N+pati/ | [e:mati] | 'ribs' |
| /oN+pote/ | [omote] | 'good-for-nothing' |
| /oN+tana/ | [onana] | 'calf' |

A straightforward analysis of OshiKwanyama is obtained under the assumptions of the present study. As in Indonesian, root-internal nasal substitution can be ruled out by a Root-specific ranking of LINEARITY above *NC, while root-initial substitution is permitted because the general LINEARITY constraint is dominated by *NC. However, unlike Indonesian, IDENTO-I[EXP] is also ranked beneath *NC, so that post-nasal voicing occurs root-internally. Also crucial here is the ranking of IDENTO-I[EXP] >> LIN, since the reverse ranking would result in post-nasal voicing everywhere, as can be verified in the following tableau by comparing the violations incurred by candidates (35b) and (35c):

(35) **Root-initial nasal substitution**

| Input: $N_1\#T_2$ | ROOT-LIN | *NC | IDENTO-I [EXP] | LIN |
|---|---|---|---|---|
| a. $N_1\#T_2$ | | * ! | | |
| b. $N_1\#D_2$ | | | * ! | |
| c. $\#N_{1,2}$ ✓ | | | | * |

(36) **Root-internal post-nasal voicing**

| Input: $N_1T_2$ | ROOT-LIN | *NC | IDENTO-I [EXP] | LIN |
|---|---|---|---|---|
| a. $N_1T_2$ | | * ! | | |
| b. $N_1D_2$ ✓ | | | * | |
| c. $N_{1,2}$ | * ! | | | * |

Since redundant feature licensing cannot generate nasal substitution, it cannot express the OshiKwanyama conspiracy. This must be counted as serious inadequacy, especially within Optimality Theory, in which output constraints play such a central role.

*1.5.3 Other NC conspiracies*

The phonology of Greek dialects (Newton 1972)[19] provides us with examples of conspiracies between post-nasal voicing and each of nasal deletion and nasal deletion. This yields further

[19] Thanks to Adamantios Gafos for bringing Newton (1972) to my attention.

evidence for the treatment of NC effects as a unified phenomenon.

In Modern Greek, post-nasal voicing (37a&c) applies except when the post-nasal obstruent is itself followed by a voiceless obstruent (a fricative). In this situation, nasal deletion applies instead (37b&d):

| | | | |
|---|---|---|---|
| (37) | a. /pemp+o/ | [pembo] | 'I send' |
| | b. /e+pemp+s+a/ | [epepsa] | -aorist |
| | c. /ton+topo/ | [tondopo] | 'the place' |
| | d. /ton#psefti/ | [topsefti] | 'the liar' (Cypriot)[20] |

Here we have a transparent case of conflict: between post-nasal voicing, and a robust pattern of regressive obstruent voicing assimilation. As a proper analysis of voice assimilation lies beyond the reach of this chapter, I will simply posit a constraint VOICEASSIM that baldly demands regressive voicing assimilation between obstruents. This constraint is violated not only by MBS, but also by MBZ, which is in fact the Output for MPS in some dialects.

A ranking of VOICEASSIM and *NC above MAX and IDENTO−I[EXP] produces the Greek conspiracy between post-nasal voicing and deletion. VOICEASSIM has nothing to say about an Input that contains a single post-nasal obstruent, so ND is preferred as the Output for an NT cluster, as depicted in (38).

---

[20] In all dialects, the nasal is deleted within the word (5b), and in most dialects, including Cypriot, it is deleted in an article preceding a noun, except in 'slow, deliberate speech' (5d).

**(38) The Greek Conspiracy: VOICEASSIM, *NC >> MAX >>IDENTO-I[EXP]**

| Input: *MP* | VOICEASSIM | *NC | MAX | IDENTO-I [EXP] |
|---|---|---|---|---|
| a. MP | | * ! | | |
| b. _P | | | * ! | |
| c. MB ✓ | | | | * |

However, when the Input is MPS (TS clusters are independently illicit), deletion becomes optimal, as seen in (39):

**(39) The Greek Conspiracy: VOICEASSIM, *NC >> MAX >>IDENTO-I[EXP]**

| Input: *MPS* | VOICEASSIM | *NC | MAX | IDENTO-I [EXP] |
|---|---|---|---|---|
| a. MPS | | * ! | | |
| b _PS ✓ | | | * | |
| c. MBS | * ! | | | * |

To produce the deletion pattern for MPS, the only crucial ranking is for both VOICEASSIM and *NC to dominate MAX. The ranking between VOICEASSIM and *NC is inconsequential, as both are fully satisfied.

In contrast to the straightforward account that *NC affords, it appears that redundant feature licensing cannot capture the conspiracy between post-nasal voicing and nasal deletion. This is due to its inability to generate nasal deletion, as illustrated in the following tableau, which places MAX beneath LICENSE[VOICE] and SONVOI.

**(40) 'Nasal deletion' as redundant feature licensing**

| Input: *NVNT* | LICENSE[VOICE] | SONVOI | MAX |
|---|---|---|---|
| a. NVNT<br>    \|    \|<br>[VCE] [VCE] | * * ! | | |
| b. NV_T<br>\|<br>[VCE] | * ! | | * |
| c. NVNT | | * * ! | |
| d. NV_T | | * ! | * |
| e. _V_T ✓ | | | ** |

This ranking does in fact lead to a preference for nasal deletion over the violation of either LICENSE[VOICE] or SONVOI. However, the optimal outcome is for all nasals to be deleted (40e), not just those adjacent to voiceless obstruents (40b or d). If, as this result suggests, redundant feature licensing cannot generate NC nasal deletion, then it of course fails to express the Greek conspiracy.

The Greek dialect spoken on Karpathos (Newton 1972) displays a conspiracy between post-nasal voicing and denasalization. Post-nasal voicing applies except when the obstruent is word-initial, in which case denasalization occurs instead, as in (41):

| | | | |
|---|---|---|---|
| (41) | /tin+porta/ | [tipporta] | 'the door' |
| | /tin+kori/ | [tikkori] | 'the girl' |

There are at least two possible interpretations of initial blocking. One is to invoke Positional Faithfulness (Selkirk 1994; Beckman 1995; cf. Steriade 1993), so that a constraint on [voice] identity in initial position blocks post-nasal voicing. The other would be to pursue the following suggestion of Newton (1972:98), and provide an account in terms of paradigm uniformity:

(42) ...it is tempting to suppose that what we have is rather a failure of the stop to voice through analogical pressure of positions other than the postnasal one, followed by some process of gemination.

In McCarthy and Prince's (1995) Correspondence Theory, paradigm uniformity can be formalized in terms of a Faithfulness constraint that demands Identity in [voice] specification between correspondent Output segments (Benua 1995, McCarthy 1995; see also Burzio 1994, 1995, Kenstowicz to appear, Steriade 1994).

As the choice is of no immediate consequence, I will simply call the constraint that blocks initial voicing SPECIALFAITH. Following the general schema for conspiracies that we have seen in previous example, the ranking of SPECIALFAITH and *NC above IDENT[NAS] and IDENTO→I[EXP] captures the Karpathian conspiracy. As (43) shows, this ranking generates PNV medially.

(43) **SPECIALFAITH, *NC >> IDENT[NAS] >>IDENTO-I[EXP]**

| Input: *NT* | SPECIALFAITH | *NC | IDENT[NAS] | IDENTO-I [EXP] |
|---|---|---|---|---|
| a. NT | | * ! | | |
| b TT | | | *! | |
| c. ND ✓ | | | | * |

However, denasalization is favored at the word boundary:

(44) **SPECIALFAITH, *NC >> IDENT[NAS] >> IDENTO-I[EXP]**

| Input: *N#T* | SPECIALFAITH | *NC | IDENT[NAS] | IDENTO-I [EXP] |
|---|---|---|---|---|
| a. N#T | | * ! | | |
| b T#T ✓ | | | * | |
| c. N#D | * ! | | | * |

Any attempt to deal with this conspiracy in terms of redundant feature licensing would face the same problem as such an account of the post-nasal voicing/deletion conspiracy. When IDENT[NAS] is ranked beneath LICENSE[VOICE] and SONVOI, all nasals are deleted, not just those that abut voiceless obstruents:

(45) **'Denasalization' as redundant feature licensing**

| Input: *NVNT* | LICENSE[VOICE] | SONVOI | IDENT[NAS] |
|---|---|---|---|
| a. NVNT<br>    \|   \|<br>[VCE] [VCE] | * * ! | | |
| b. NVTT<br>  \|<br>[VCE] | * ! | | * |
| c. NVNT | | * * ! | |
| d. NVTT | | * ! | * |
| e. TVTT ✓ | | | ** |

*5.4 Pre-nasal voicing*

At least as problematic as the inability of redundant feature licensing to generate nasal substitution is its ability to generate pre-nasal voicing. The result of supplying an Input /TN/ cluster to exactly the same hierarchy that produces post-nasal voicing is illustrated in (46):

(46) **Pre-nasal voicing as redundant feature licensing**

| Input: TN | LICENSE[VOICE] | SONVOI | FAITH |
|---|---|---|---|
| a. TN<br>\|<br>[VOICE] | *! | | |
| b. TN | | *! | |
| c. DN<br>\\|<br>[VOICE] ✓ | | | * |

With just the three constraints discussed thus far, all sonorants would be [Voice]-linked to adjacent obstruents. Itô, Mester, and Padgett single out nasals as the only sonorant triggers of [Voice] spread by introducing a set of constraints that have the effect of prohibiting linkage between obstruents and segments that are more sonorous than nasals (the NOLINK constraints). However, both this solution, and the alternative of changing SONVOI to NASVOI (see Itô, Mester, and Padgett 1993, and the discussion in Itô, Mester, and Padgett 1995) would equally limit pre-sonorant voicing to nasals. Though post-nasal voicing is extremely widespread, there are no reported cases of regressive voicing triggered by nasals only. The progressive nature of nasal-obstruent voicing is particularly striking since more general forms of voicing assimilation tend to be regressive (Lombardi 1991; Mohanan 1993). This directional asymmetry, which is a fundamental property of post-nasal voicing (hence the name), completely escapes the redundant feature licensing analysis.[21]

[21] See however Kawasaki (1995), in which redundant feature licensing is supplemented by a principle of government that produces the required asymmetry in nasal-obstruent voicing.

*1.5.5 Lyman's Law and redundant feature licensing*

Redundant feature licensing was not designed solely as a means of voicing post-nasal obstruents. Its other job is to ensure that in other environments, sonorants remain unspecified for [Voice]. This is accomplished by the ranking LICENSE[VOICE] >> SONVOI, as shown in (47):

**(47) Underspecification by redundant feature licensing**

| Input: N | LICENSE[VOICE] | SONVOI |
|---|---|---|
| a. N<br>\|<br>[VOICE] | *! | |
| b. N ✓ | | * |

Without the adjacent obstruent as host for the parasitic licensing of [voice], the nasal without [voice] is optimal. The significance of this result within Yamato Japanese is that Lyman's Law, a morpheme structure constraint which allows only a single voiced obstruent in a root, can be stated as an OCP restriction against adjacent [voice] features, if sonorants lack [voice]. Furthermore, the fact that a post-nasal voiced obstruent is a target for Lyman's Law, which is problematic under a rule-based account, falls out naturally from redundant feature licensing.

The elegance of capturing post-nasal voicing and [voice] underspecification with the same small set of constraints is deceptive, however, since as we have seen, redundant feature licensing fails to properly characterize post-nasal voicing. Given the limited utility of underspecification elsewhere in Optimality Theory (see e.g. Smolensky 1993; cf. Inkelas 1994), it is well worth seeking alternative explanations for the invisibility of sonorants to Lyman's Law. Here I suggest two promising avenues for further investigation.

If the obstruent specific voicing feature [Exp] is accepted, there is no need for [Voice] underspecification, since Lyman's Law would then be a prohibition against multiple occurrences of [Exp] (Steriade 1995). Post-nasal voicing results in an obstruent specified for [Exp], so long as there is an implicational relationship between [Voice] and [Exp] on obstruents (see 1.3.2 above). Itô, Mester, and Padgett (1995: fn. 12) criticize this approach because post-nasal voiced obstruents involve 'little expansion of the pharynx, if any'. However, as Steriade (1995) notes, the feature [Pharyngeal Expansion] cannot be identified with a particular articulatory adjustment, as languages vary in how they compensate, when producing voicing, for the increase in supralaryngeal pressure in obstruents (see also Westbury 1979 for evidence of such variation within English). It is not surprising that the adjustment in the post-nasal context is relatively minor, given the overlapping of the opening of the velum into the obstruent portion of the cluster (see section 1). In fact, the very presence of an open velum on the obstruent may be considered the phonetic correlate of [Exp] in post-nasal voiced obstruents.

Even if we retain the traditional feature set, the work on segmental interaction that informs the sonority driven NoLink constraints proposed by Itô, Mester, and Padgett (1995) provides a means of dealing with Lyman's Law without resorting to sonorant underspecification. Morpheme structure constraints that prohibit identical place specifications are often sensitive to sonority, permitting sonorants homorganic to obstruents, but ruling out both homorganic sonorants and obstruents (see e.g. Selkirk 1988, 1993, Yip 1989, Pierrehumbert 1993, Padgett 1995b). Similarly, long distance place assimilations often apply between members of a particular sonority class only. Since the structural properties encoded in a feature geometry offers little insight into these facts (cf. Yip 1989), Padgett (1995b) suggests that the OCP is directly influenced by the sonority of segments, such that 'interaction in place between two segments is more likely as they are more similar in stricture/sonority'. While the formal details of this analysis remain to be worked out, nothing would seem to rule out extending it to the fact that Lyman's Law only targets [Voice] on obstruents, or that only obstruents interact in Russian voicing assimilation.[22]

### 1.6 Conclusions

I have argued that nasal substitution is best analyzed as fusion of a nasal and voiceless obstruent, driven by a phonotactic constraint against this sequence, *NC, which can also be satisfied by nasal deletion, denasalization, and post-nasal voicing. The traditional analysis of nasal substitution, and the recent analysis of post-nasal voicing in Itô, Mester, and Padgett (1995), were shown to capture both too much, and too little, when cross-linguistic possibilities are taken into consideration. In contrast, the factorial typology predicted by the permutation of the ranking of *NC and the Faithfulness constraints is nearly completely fulfilled.

The fact that languages exercise a range of options in dealing with *NC violations,

[22] Jaye Padgett (p.c.) notes the following complication. Though voicing interactions are perhaps sonority sensitive in making a distinction between obstruents and sonorants, they do not appear to divide the sonority scale in the same way as place interactions. Cases in which only fricatives interact in voicing, for instance, seem rather unlikely.

along with the existence of conspiracies between these NC effects, provides strong support for the Optimality Theoretic program of decoupling phonotactic constraints from Faithfulness constraints, and allowing them to be freely ranked with respect to one another. However, the apparent lack of NC epenthesis raises an intriguing question for future research: Is it the case that every phonotactic constraint is satisfied in all of the ways predicted by the permutation of the rankings between it and the Faithfulness constraints? Gaps in factorial typologies often serve as indications that constraints must be reformulated, but persistent links between marked configurations and the processes used to repair them would seem to force a more fundamental shift in theoretical assumptions. Either that, or we could settle for a theory of grammar that is in some respects only 'exegetically adequate', as opposed to 'explanatorily adequate', that is, we could rest content with having 'made some progress in understanding the facts as they are, though not in the sense of showing that they could not be otherwise' (Anderson 1979: 18). Such resignation would be disappointing though, in light of the strides that Optimality Theory has made toward predictive explanatory adequacy in many areas of phonology.

There are also some broader conclusions to be drawn from these data. The asymmetry of nasal-obstruent voicing discussed in §1.5.4 shows the futility of attempting to construct a restrictive theory of segmental phonology on the basis of a restrictive set of features freely combined with operational parameters (or constraint-based reformulations thereof). If nasal [voice] can spread right, then why could it not spread left? At least this apparent case of spreading must be attributed to a substantive constraint. Furthermore, the NC conspiracies can be added to the evidence for a theory of phonology based on output constraints (starting with Kisseberth 1970: see §1 of Prince and Smolensky 1993). Since substantive output constraints (along with Faithfulness constraints) are the building blocks of Optimality Theoretic grammars, it should not be surprising that Optimality Theory handles these facts in an elegant fashion.

# Preface to Chapter 2

The examination of NC effects in the preceding chapter served to provide arguments for two aspects of a constraint-based theory of phonology. First, the fundamental point that output constraints must be formally recognized; the evidence for this came from the conspiracies between NC effects, which cannot be captured by a purely rule-based theory. The second point is the importance of substantive, as opposed to purely formal, criteria in the determination of what constitutes a marked configuration (see e.g. Chomsky and Halle 1968: §9, Archangeli and Pulleyblank 1994). A great deal of evidence was found for the constraint *NC, while evidence of its putative symmetrical counterpart *CN was entirely lacking. Formally, these constraints are equivalent, but only *NC appears to have any substantive phonetic motivation.

Both phonologists, and acquisitionists, have long recognized the importance of substantive constraints, but have disagreed on how (and to some extent whether) they are to be formally incorporated (see Prince and Smolensky 1993: chapter 1 in the context of phonological theory, and Menn 1980 in acquisition). Optimality Theory is therefore far from unique in its use of constraints to account for phonological patterns. What does separate Optimality Theory from other constraint-based theories, though, is its claim that a constraint can be at the same time active, and violated. In most theories, there is a usually implicit assumption that when a linguistic principle is in force, it is unviolated. This tenet can be referred to as inviolability, or full satisfaction. In Optimality Theory, full satisfaction is replaced by *minimal violation* (Prince 1993): Under minimal violation, a constraint can be violated if and only if it conflicts with a higher ranked constraint. Crucially, the lower ranked constraint remains active, even though it is violated in situations where its satisfaction would entail the violation of a higher ranked constaint.

In the study of NC effects in the previous chapter, it can be seen that minimal violation played a crucial role in the account of conspiracies. In these cases, the structural constraint *NC is fully satisfied, but the means by which violation is avoided depends on the context. For example, in Greek, postnasal voicing is the usual way to resolve underlying NC sequences (see §1.5.3). This indicates not only that *NC ranks above the Faithfulness constraint demanding obstruent [voice] identity (IDENT-EXP), so as to allow the obstruent to become voiced, but also that other Faithfulness constraints, like MAX, dominate IDENT-EXP, so as to rule out deletion. However, in situations in which post-nasal voicing is blocked by higher ranked constraints, the nasal is deleted. In this example, MAX is violated when it is necessary to satisfy *NC, but is nonetheless active in blocking deletion when postnasal voicing is possible. MAX is thus neither fully satisfied nor freely violable, but minimally violable.

Because Faithfulness constraints are particular to Optimality Theory, and because postnasal voicing normally gets a purely rule-based treatment in earlier analyses, it is impossible to contrast this analysis which invokes minimally violable constraints to one based on full satisfaction. Therefore, we turn next to a domain that provides numerous examples of minimally violated structural constraints, and is typically analyzed using a combination of fully satisfied constraints and rules.

The following chapter demonstrates that minimal violation allows for a more satisfactory account of English stress than was possible given the assumption of full satisfaction that underlies earlier analyses. Generally speaking, minimal violation permits an explanatory treatment of instances of nonuniform constraint application, where a constraint is satisfied in one environment, but not another (see Prince 1993, McCarthy 1996). Quantity Sensitivity, 'cyclic' stress preservation, and lexically based exceptionality all apply nonuniformly in English. These phenomena have resisted explanation in theories in which constraints are simply either on, or off, but can be dealt with elegantly in a theory in which constraint conflict is resolved through constraint ranking.

In the rest of the preface, I provide a short history of how the interaction between syllable quantity and stress has been treated in the previous literature on English, which serves as a background to the discussion in the text. English stress provides an excellent arena for theory comparison, since it has been the subject of intense empirical and theoretical scrutiny ever since the publication of Chomsky and Halle's 1968 *The Sound Pattern of English* (SPE). One of the many observations made in SPE, which have guided subsequent work, is that syllable weight plays a determining role in main stress placement. For example, nouns are stressed on the penultimate syllable if contains a long vowel (e.g. *aróma*), or a coda consonant (e.g. *agénda*). When the penult is light, consisting of only a short-voweled syllable (e.g. *Cánada)*, stress is antepenultimate.

The phonological framework presented in SPE does not actually make use of the notion "syllable weight" (or even the syllable). The fact that syllables with long (tense) vowels and those with coda consonants pattern together is simply stipulated in the formulation of the rules of stress placement (Chomsky and Halle 1968: §3).

That (C)V syllables act differently from (C)VV and (C)VC is by no means an idiosyncracy of the English stress system. Cross-linguistic surveys (e.g. Ohsiek 1978, Hayes 1995) show that heavy syllables attract stress in a large number of the world's languages, including many completely unrelated to English. In contrast, no language prefers to stress light syllables. There is no reason that an SPE-style rule could not be written that stresses a syllable only if it is light, so this asymmetry is not captured by the theory. More generally, SPE provides no characterization of what is a possible, and an impossible stress system, beyond the quite loose limits of what can be expressed by the rule formalism (see the discussion in Kaye 1989).

Starting with Liberman and Prince 1977, and Hayes 1981, 1982, recent theories of metrical phonology have aimed to more precisely restrict the set of possible stress systems (see Kenstowicz 1995 and Kager 1996 for useful theoretical overviews, Dresher and Kaye 1990 on learnability, Fikkert 1994 on L1 acquisition, and Archibald 1993 and Pater to appear on L2). In the principles-and-parameters framework (see e.g. Chomsky 1986), in which this work is usually cast, universal grammar contains fixed *principles* that hold true of all languages, and multi-valued (usually binary) *parameters* whose settings vary between languages. Under this view, the extent to which languages can vary is restricted by the available settings of the parameters. This restrictiveness has accompanying benefits in learnability, for the learner is no longer faced with the relatively complex task of inductively composing rules, but instead must only deductively choose from a limited set of parametric values.

In this framework, the propensity for heavy syllables to be stressed is usually captured by positing a parameter of Quantity Sensitivity, which for present purposes can be stated as in (1):

(1) Quantity Sensitivity {on/off}

Heavy syllables must be stressed

Languages that require heavy syllables to be stressed have an {on} setting for Quantity Sensitivity, while those that do not have it set to {off}. As there is no principle or parameter that forces light syllables to be stressed, the theory correctly rules out the existence of a language with a preference for light syllable stress.

Along with the change from a rule-based to a principle and parameters view of the grammar, metrical theory in the 1980's introduced a concomitant shift in the nature of representations. In SPE, representations are simply sequences of segments, composed of more basic features, along with word and morpheme boundaries. No phonological structure above the level of the segment was posited. In current theory, phonological representations are generally held to encode not only syllable structure, but also higher level prosodic structure. The principles and parameters determine how this prosodic structure is created, which in turn determines where stress falls.

Just as segments are grouped into syllables, syllables are grouped into feet, and feet themselves into a Prosodic Word.[1] This yields the prosodic hierarchy in (2):

[1] The literature contains a variety of proposals about the nature of metrical representations. Since the publication of Halle and Vergnaud (1987), it has generally been accepted that representations must encode both constituency and headship (which for present purposes is equivalent to prominence: cf. Hayes 1995). Exactly how this is done appears to be of no consequence to the matters at hand in this dissertation, so I retain the traditional vocabulary of prosodic theory (cf. e.g. Halle and Idsardi 1996).

(2) Prosodic Hierarchy (Selkirk 1980)

| | |
|---|---|
| PrWd | Prosodic Word |
| \| | |
| Ft | Foot |
| \| | |
| σ | Syllable |

Within each constituent (PrWd, Ft, σ), one of the elements is picked out as the head. The head of a foot is the syllable that receives stress. The head of the Prosodic Word is the foot that bears primary stress.

In the account of Hayes 1981, 1982, adopted in Dresher and Kaye 1990, and most principles-and-parameters based acquisition work, Quantity Sensitivity interacts with several other parameters to create the pattern of stress placement observed in English.[2] These parameters form maximally bisyllabic left-headed feet, starting from the right edge of the word, but skipping the final extrametrical syllable in nouns. When the penultimate syllable is light, a maximal bisyllabic foot is formed that incorporates both the penultimate and antepenultimate syllables, which places stress on the antepenultimate syllable. In the bracketed grid representation used here, parentheses indicate foot boundaries, angled brackets extrametricality, and x's prominence and headship.

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[2] In research subsequent to Hayes 1981, the existence of a parameter of Quantity Sensitivity has been questioned (see esp. Hayes 1987, 1995). It was discovered that languages with iterative, left-headed quantity sensitive feet are exceedingly rare, if not unattested. In the revised theory, the weight sensitivity of English main stress placement would be explained by positing a moraic trochee, which can take the form H, or LL (but not XH). This revision has no effect on the present arguments, however, since just as the Hayes 1981 parametric framework has difficulty with the partially quantity sensitive nature of secondary stress placement, so does that of Hayes 1987, 1995: it would have to explain why a moraic trochee is used for main stress placement, but something like a syllabic trochee is used for secondary stress, and also why this syllabic trochee displays partial quantity sensitivity. I retain the traditional Quantity Sensitivity parameter for ease of comparison with other work in learnability and acquisition, and also with Optimality Theoretic work incorporating a WEIGHT-TO-STRESS constraint.

(4)

```
   x
 (x x)<x>
 Cana da
```

If a word with a heavy penult were parsed in the same way as *Canada*, the heavy syllable would not be in head position, and would be stressless, in violation of Quantity Sensitivity. Instead, the rightmost foot incorporates only the penultimate syllable:

(5)

```
   x          x
 x(x)<x>    x(x)<x>
 agenda     aro ma
```

The rightmost foot becomes the head of the Prosodic Word, and hence the main stressed foot, due to a {right} setting for word level headedness. In a word with more than one foot, such as *Apalachicola*, this parameter setting makes the rightmost foot the most prominent:

(6)

```
          x
(x    x   x)
(x x)(x x)(x)<x>
apa lachicola
```

While this basic principles and parameters approach to English stress is adequate for primary stress placement, when we turn to secondary stress assignment, we must confront the problems raised by nonuniformity. If secondary stress placement were governed by the {on} setting of the Quantity Sensitivity parameter, then one would expect to find stress on all heavy syllables. That this is not the case has led to significant complications in prior analyses of English stress; the resolution of this problem is one of the main goals of the following chapter.

# Chapter 2

## On the nonuniformity of weight-to-stress and stress preservation effects in English

### 2.0 Introduction

Since Chomsky and Halle 1968, it has been agreed that syllable weight plays a determining role in main stress placement in English. Nouns, for example, are stressed on the penultimate syllable if it is heavy, where either a long vowel (1a), or a coda consonant (1b) makes a syllable heavy. When the penult is light (1c), stress is antepenultimate.

(1) a. aróma balaláika hiátus horízon aréna Minnesóta angína

b. agénda uténsil appéndix placénta synópsis amálgam

c. Cánada América cínema ársenal análysis jávelin vénison

The relationship of syllable weight to secondary stress is less straightforward, and so has been the subject of more dispute. As Halle and Kenstowicz (1991) emphasize, it is to some extent arbitrary whether heavy syllables bear secondary stress or not.[1] Corresponding to the stressed heavy syllables in (2a) are the unstressed heavies in (2b).

(2) a. incàrnátion òstèntátion chimpànzée Hàlicàrnássus ròdomòntáde

b. Pènnsylvánia rèpercússion sèrendípity Kilimanjáro Nèbuchadnézzar

---

[1] I take the standard view that a syllable with a reduced vowel or a syllabic sonorant consonant is unstressed, and one with a full vowel is stressed, modulo the effects of word-finality (see Burzio 1994 for another stance). I will not discuss finer distinctions between levels of stress than secondary, primary, and the complete lack of stress because neither syllable weight, nor stem stress, seem to determine whether a syllable has tertiary or secondary stress (on the non-determination of the secondary/tertiary distinction by stem stress, see Halle and Vergnaud 1987 and Kager 1989; cf. Kiparsky 1979).

Although the existence of these near minimal pairs does indicate that the lexicon has a role to play in the stressing of heavy syllables, the weight-to-secondary stress relationship is not entirely arbitrary. A clear demonstration of this comes from the fact that syllable weight does unequivocally determine secondary stress placement in some environments (more subtle arguments against simply arbitrary weight-to-stress for even the words in (2) are presented in §2.1 and §2.3). For example, the "initial dactyl" effect (3a; see Prince 1983:49), in which a ternary string of light syllables receives initial stress, is blocked when the second syllable is heavy, as in (3b) (Chomsky and Halle 1968: 114 and many subsequent others).

**(3)** a. Tàtamagóuchi àbracadábra Kàlamazóo Wìnnepesáukee Wàpakonéta

b. Monòngahéla Valènciénnes geròntophília Belùchistán

Stress preservation yields a strikingly similar pattern of sometimes arbitrary, and sometimes unequivocal determination of secondary stress placement. Whether or not stem stress is preserved on medial pretonic heavy syllables is basically arbitrary, as a comparison of the words in (4a) with those in (4b) bears out.

**(4)** a. àdvàntágeous àugmèntátion àuthènticity còndèmnátion còndènsátion

b. infòrmátion làmentátion cònservátion fràgmentátion trànsportátion

However, stress preservation, like weight-to-stress, consistently overrides the preference for initial dactyls (Hammond 1989, Burzio 1994):

(5) accrèditátion imàginátion originálity medicinálity divisibilty phenòmenólogy

This brief sketch of English secondary stress is sufficient to show that principles of weight-to-stress, and stress preservation are not uniformly active or inactive, on or off. Nor is their application determined purely lexically (cf. Halle and Kenstowicz 1991); such an account would predict arbitrary variation in the application of these principles to the words in (3b) and (5), where none in fact exists.

To the extent that it has been dealt with, this *nonuniformity* (Prince 1993) of weight-to-stress and stress preservation effects has created tremendous complications in prior analyses of English stress.[2] For example, in the standard treatment of weight-to-stress nonuniformity, instituted by Liberman and Prince 1977 and Hayes 1982 (see also Halle 1973), primary stress is first assigned in a quantity-sensitive fashion, then secondary stress assignment proceeds without regard to quantity, followed by a set of very specific quantity-sensitive destressing rules (cf. Kager 1989).

Nonuniformity is problematic because of the usually implicit tenet of full satisfaction, or inviolability, which claims that when a linguistic principle is in force, it is never violated. A theory based on this tenet often has little to say about a principle that is only satisfied in

[2] Burzio (1994) avoids the complications of these patterns of nonuniformity by denying that the syllables in (2a) and (4a) are in fact stressed, in conformance with his basic theoretical premise that a foot made up of a single heavy syllable is universally ill-formed (a premise which should rightly be attributed to Kager 1989: 129). This premise is at odds with most other work in metrical theory, and requires a number of equally idiosyncratic assumptions to maintain (e.g. that words like *bandana* have a null initial vowel, that vowel reduction is far more context-sensitive than usually assumed). This is not necesarily a criticism of Burzio's extremely thorough account of English stress; it is internally consistent, and contains a number of important descriptive and theoretical advances that have been made use of here. These idiosyncracies do, however, seriously impede any attempt to systematically compare Burzio's analysis with other analyses of English, as well as situate it in the wider cross-linguistic typology of stress systems (see e.g. Hayes 1981, Halle and Vergnaud 1987, Idsardi 1992, Hayes 1995).

certain contexts. Under full satisfaction, nonuniformity in the data tends to lead to the following theoretical consequences:

i. the proliferation of otherwise unmotivated derivational stages or levels between which the principle (rule/constraint/condition) is turned on and off

ii. a lack of generality in constraint or rule formulation: nonuniformity is simply stipulated

iii. descriptive gaps: nonuniformity is simply ignored

As will be detailed below, the particular cases of nonuniformity examined in this paper have in fact inspired instances of each of these less than elegant analytic moves.

As brought out most forcefully by Prince (1993), and McCarthy (1995), nonuniformity is an expected consequence of Optimality Theoretic constraint ranking and violability, instead of an unwelcome burden. The basic distinguishing characteristic of Optimality Theory (Prince and Smolensky 1993) is that it abandons full satisfaction in favor of minimal violation: a constraint is violated only to the extent necessary to satisfy a higher ranking one. In a theory based on minimal violation, nonuniformity receives an absolutely direct treatment. A constraint is violated in a particular environment because its satisfaction would conflict with the satisfaction of a higher ranked constraint. If in another context the higher ranked constraint makes no conflicting demands, the lower ranked one is obeyed.

The ease with which Optimality Theory handles cases of nonuniformity suggests that applying it to the domain of English stress may lead to a more principled treatment of the massively nonuniform effects of syllable weight and stress preservation on secondary stress.

In what follows, I show that constraint ranking does in fact permit explanatory gains on a number of fronts.

## 2.1 Weight-to-secondary stress

### *2.1.1 The 'Arab' rule*

I will start with a particularly complex case of nonuniformity which has to this point defied principled analysis, and which can in fact be reduced to the ranking of a handful of basic metrical constraints. Kager 1989 cites data such as the following to show that an obstruent-final syllable ($\sigma_o$) is unstressed if it is preceded by a light syllable (2a), but stressed if preceded by a heavy syllable (2b):

| | | |
|---|---|---|
| **(2)** | a. **L** $\sigma_o$- | àlexánder ànaptýxis àrithmétic (adj.) còllectánia Èpictétus Èrechtétum rèsignátion sùrreptitious Màzatlán mòlybdénum |
| | b. **H** $\sigma_o$ - | dèlèctátion càòutchóuc incògnito (*alt.*) ticktàcktóe Timbùcktóo |

Post-tonically, this behavior of $\sigma_o$'s produces what has been called the 'Arab' rule, due to the covariance of final syllable stress with the length of the initial vowel in two idiolectical pronunciations of *Arab* (i.e. [æ]rab vs. [ey]ràb; see Fidelholtz 1967; Ross 1972).

Also relevant here are the following near minimal pairs:

| | | | |
|---|---|---|---|
| **(3)** | a. ànnexátion | àdaptátion | àffectátion |
| | b. indèxátion | rèlàxátion | èxpèctátion |

Though the stems of the vertically aligned words display nearly identical stress patterns, the derived words with initial light syllables (3a) can have stressless medial heavy syllables, while those with heavy initials (3b) must have stress on both of the first two syllables.[3]

Words in which the first two syllables are parsed as a single leftheaded foot, which I will notate as '$(L\sigma_o)$', are in violation of Quantity Sensitivity when the second syllable is heavy, since the heavy syllable is unstressed. The Optimality Theoretic equivalent of Quantity Sensitivity is the WEIGHT-TO-STRESS constraint, which Prince and Smolensky (1993:53) state as in (4).

(4) WEIGHT-TO-STRESS
Heavy syllables are prominent in foot structure and on the grid

This constraint requires that a heavy syllable be the head of a foot, and dominated by an accentual grid mark indicating stress. In most cases, prominence and headship are coextensive, and for present purposes can be regarded as equivalent (cf. Kager 1989, Prince and Smolensky 1993, and Hayes 1995 on prominence without constituency within frameworks that grant a role to constituency).

In Optimality Theory, variation between languages is captured not by parameterization, but by constraint ranking. The constraints themselves are held to be fixed and universal, but languages vary in how they are ranked. Since under minimal violation, constraint violation must be compelled by some higher ranking constraint(s), English must

---

[3] Kenyon and Knott 1953 gives *annexation*, *adaptation*, and *affectation* with either a full or a reduced vowel in the second syllable. See section 2.3 for discussion of variation in this domain.

have at least one other constraint ranked above WEIGHT-TO-STRESS, which the (L$\sigma_o$) parsing manages to satisfy, and which would be violated if WEIGHT-TO-STRESS were respected.

One such constraint is PARSE-$\sigma$, which demands exhaustivity of constituent construction (see McCarthy 1993, Prince 1993, Mester 1994, Cabré and Kenstowicz 1995, and especially Prince and Smolensky 1993 on Latin for closely related PARSE-$\sigma$ effects in other languages). In contrast with Halle and Vergnaud (1987), Halle and Kenstowicz (1991), and earlier work, Exhaustivity of constituent construction is in one way or another regarded as violable in most recent work in metrical phonology (see Kager 1989, Idsardi 1992, Halle and Idsardi 1995, Hayes 1995, and especially Burzio 1994, where it plays an active role in determining the well-formedness of metrifications). As a minimally violable constraint, PARSE-$\sigma$ can be stated as in (5).

**(5)** PARSE SYLLABLE (PARSE-$\sigma$):

Syllables must belong to feet

Syllables not parsed by feet are parsed by the Prosodic Word (see Itô and Mester 1992, McCarthy and Prince 1993a).

If PARSE-$\sigma$ is ranked above WEIGHT-TO-STRESS, the fully parsed (L$\sigma_o$) is preferred to L($\sigma_o$), in which the heavy syllable is the head of the foot and bears stress. The tableau in (6) illustrates this result for the pretonic string *Alex-* of *Alexander* (as primary stress placement is discussed in §2.2, until then violations will be assessed only for the underlined pretonic string of syllables).

(6) PARSE-σ » WEIGHT-TO-STRESS

| Input: *Alexander* | PARSE-σ | WEIGHT -TO-STRESS |
|---|---|---|
| a. (Àlex)(án)der ✓ | | * |
| b. A(lèx)(án)der | * ! | |

Constraints separated by a solid line in the tableau are ranked with respect to one another, and those separated by a dashed line are unranked. In this case, the solid line between PARSE-σ and WEIGHT-TO-STRESS shows that the former dominates the latter. Constraint violations are indicated by an asterisk, and an exclamation mark shows the violation that rules out a particular candidate. Here, (6a) violates WEIGHT-TO-STRESS, and (6b) violates PARSE-σ. Because of the ranking between these constraints, the violation of PARSE-σ rules out **A(lèx)(án)der*. The optimal candidate, *(Àlex)(án)der*, which is the grammatical form, receives a check mark in the tableau.

The analysis is not complete, because there are other candidates and other constraints to consider. As things stand, nothing discriminates against the parsing (L)($\sigma_o$), where the two syllables form separate feet, fulfilling the requirements of both constraints. What rules this out is FOOT BINARITY (P&S 1993: 47; see also McCarthy and Prince 1986 and 1993a):

(7) FOOT BINARITY (FTBIN):

Feet are binary at some level of analysis ($\mu$, $\sigma$).

The mora ($\mu$) is the unit of syllabic weight: a light syllable is monomoraic, and a heavy syllable bimoraic. The requirement that a foot must be binary disallows the (L) foot needed for the (L)($\sigma_o$) parsing, since it is neither bimoraic nor bisyllabic.

All of FTBIN, PARSE-$\sigma$, and WEIGHT-TO-STRESS could be satisfied by parsing (L$\sigma_o$) as a single right-headed foot (e.g. *Alèxánder*). However, this would violate a constraint demanding left-headed feet. which could be formulated as either aligning the head syllable of a foot with its left edge (McCarthy and Prince 1993b) or as Rhythmic Type = Trochaic (Prince and Smolensky 1993, McCarthy and Prince 1993a). As the exact formulation is of no consequence here, I will simply call the constraint 'TROCH'.

With FTBIN, PARSE-$\sigma$, and TROCH ranked above WEIGHT-TO-STRESS, left-headed (L$\sigma_o$) is chosen as optimal (8a), instead of L($\sigma_o$) (8b), (L)($\sigma_o$) (8c), or right-headed (L$\sigma_o$) (8d).

**(8) FTBIN, PARSE-$\sigma$, TROCH » WEIGHT-TO-STRESS**

| Input: *Alexander* | FTBIN | PARSE-$\sigma$ | TROCH | WEIGHT -TO-STRESS |
|---|---|---|---|---|
| a. (Àlex)(án)der ✓ | | | | * |
| b. A(lèx)(án)der | | *! | | |
| c. (À)(lèx)(án)der | *! | | | |
| d. (Alèx)(án)der | | | *! | |

Since the heavy syllable in the optimal form is unstressed, this candidate violates WEIGHT-TO-STRESS. As shown by the other candidates, the satisfaction of WEIGHT-TO-STRESS requires the violation of one of the higher ranking constraints – FTBIN, PARSE-$\sigma$, or TROCH.

When the initial syllable is heavy, the conflict between WEIGHT-TO-STRESS and FTBIN disappears. Because of this, stress on the pretonic syllable is correctly generated, as tableau (9) shows.

**(9) Tableau for H$\sigma_0$**

| Input: *Timbucktoo* | FTBIN | PARSE-σ | TROCH | WEIGHT -TO-STRESS |
|---|---|---|---|---|
| a. (Timbuck)(tóo) | | | | * ! |
| b. Tim(bu̇ck)(tóo) | | * ! | | * |
| c. (Timbu̇ck)(tóo) | | | * ! | * |
| d. (Tim)(bu̇ck)(tóo) ✓ | | | | |

The difference here is that the initial syllable contains a coda consonant, so that it can be parsed alone as a bimoraic foot, without causing a violation of FTBIN. This eliminates the conflict between FTBIN and WEIGHT-TO-STRESS satisfaction, allowing the lower ranked WEIGHT-TO-STRESS to choose the candidate with heavy syllable stress. Thus, this complex case of nonuniformity, in which the weight of the preceding syllable determines whether a $\sigma_0$ gets stressed or not, is reduced to the ranking of three extremely well-motivated constraints above WEIGHT-TO-STRESS.

The difficulty this case poses for a theory based on full satisfaction is attested to by the fact that in pre-Optimality Theoretic analyses, this generalization has either been left unaccounted for (see Prince 1985: 486 for an explicit discussion of the inability of then current theories to cope with it), or simply stipulated (amongst metrical theorists, see Hayes 1982: 256 and Kager 1989).

*2.1.2 Sonorant-final syllables*

As the obstruent-specific formulation of the Arab rule implies, sonorant-final syllables ($\sigma_s$) behave differently. The stressing of a $\sigma_s$ does not depend on the weight of the preceding syllable. This is demonstrated by the data in (10), in which pretonic $\sigma_s$'s preceded by both light and heavy syllables are uniformly unstressed.

(10) a. **L$\sigma_s$** àffirmátion làmentátion dissertátion rèpercússion sèrendípity simultáneous tàrantélla

b. **H$\sigma_s$** còmpensátion informátion ùsurpátion Pènnsylvánia Mòzambíque gòrgonzóla cònsultátion

With just the constraints introduced above, the string **H$\sigma_s$** would be treated like **H$\sigma_o$**, and parsed as **(H)($\sigma_s$)**. However, the productivity of pretonic **(H$\sigma_s$)** is demonstrated not only by the vast numerical superiority of **(H$\sigma_s$)** over **(H)($\sigma_s$)** (Kager 1989: 123), but also by the existence of derived words in which a syllable that is stressed in the stem becomes stressless, so as to conform to the **(H$\sigma_s$)** pattern (e.g. *infọrmátion* and *cònsultátion* from *infórm* and *consúlt* – see further §2.3).

To rule out **(H)($\sigma_s$)**, there must be an active constraint that disfavours stress on the pretonic syllable. Such a constraint can be derived from the "Stress Well" environment of Halle and Vergnaud 1987: 238, which is used to target stressed syllables adjacent to the main stress for destressing and shortening (see also Liberman and Prince 1977: 285 and intervening work on English stress for similar notions). I assume the formulation in (11).

(11) STRESSWELL

No stressed syllable may be adjacent to the head syllable of the Prosodic Word

This constraint may be regarded as a slightly more specific instantiation of the general prohibition against adjacent stresses, or stress clash (Prince 1983, Hammond 1984). The evidence from within English for this specific formulation is that adjacent stresses *per se* are well tolerated. Words like *Ticònderóga* show no tendency toward becoming clash-less; examples parallel to **Ticonderóga* are in fact completely unattested (see §2.3.3). Further exemplification of the strong dispreference for pretonic stress, and the lack of a parallel intolerance of mere adjacency, is provided in §2.3.2.

It is not easy to marshall cross-linguistic evidence for this constraint, as its effects are often indistinguishable from simple *CLASH. However, Hayes (1995: 157) notes that Maithili has specifically pretonic shortening, which could be reduced to the combined effects of STRESSWELL and WEIGHT-TO-STRESS, as pretonic shortening would result in the satisfaction of both of these constraints.

Before proceeding to rank STRESSWELL so as to produce **(H$\sigma$,)**, it must be ensured that its introduction does not alter the results obtained for obstruent-final syllables. The fact that a $\sigma_o$ is usually stressed when adjacent to a primary stress, in defiance of STRESSWELL, can be attributed to the ranking of WEIGHT-TO-STRESS above STRESSWELL:

**(12) WEIGHT-TO-STRESS » STRESSWELL**

| Input: *Timbucktoo* | WEIGHT -TO-STRESS | STRESSWELL |
|---|---|---|
| a. (Timbuck)(tóo) | *! | |
| b. (Tim)(bùck)(tóo) ✓ | | * |

This tableau shows that the heavy syllable stresslessness required to satisfy STRESSWELL leads to a violation of the higher ranked WEIGHT-TO-STRESS, and is thus ruled out.

The ease with which a $\sigma_s$ is unstressed relative to a $\sigma_o$ may at first seem unexpected, given the cross-linguistic generalization that if a subset of consonants contributes a mora to the syllable, it is composed of the sonorants, rather than the obstruents (Prince 1985; see Prince 1983: 57, Zec 1988 on the typological facts). However, the shedding of a mora is not the only means by which the demands of WEIGHT-TO-STRESS can be escaped. The key here is the longstanding observation that in English, post-vocalic sonorants are incorporated into the nucleus when unstressed (see recently Liberman and Prince 1977: 299, Travis 1983, Piggott and Singh 1985, Kager 1989: 166). As such, a $\sigma_s$ is monomoraic (13a),[4] rather than bimoraic (13b):

```
(13) a.   σ           b.   σ
          |                |\
          μ                μ μ
          |\               | |
        (V) C              V C
```

[4] The fact that the V is enclosed within parentheses means that I am taking no position on whether the schwa here is present phonologically, or is inserted phonetically.

Being a light syllable, a stressless $\sigma_s$ then incurs no WEIGHT-TO-STRESS violation, and STRESSWELL is free to choose pre-tonic stresslessness.

**(14) Tableau for H$\sigma_s$**

| Input: *Pennsylvania* | WEIGHT -TO-STRESS | STRESSWELL |
|---|---|---|
| a. (Pènnsl)(vá)nia ✓ | | |
| b. (Pènnsyl)(vá)nia | * ! | |
| c. (Pènn)(sỳl)(vá)nia | | * ! |

Following Liberman and Prince (1977), a sonorant nucleus is indicated by the omission of the vowel in the spelling.

From this perspective, the greater attraction of stress to $\sigma_o$'s than to $\sigma_s$'s can be derived from the cross-linguistic generalization that sonorants make better nuclei than do obstruents (Prince and Smolensky §8). To express this generalization, I will invoke a pair of constraints, and a universally fixed ranking between them (cf. Prince and Smolensky §8) If *SONNUC is violated by a nuclear sonorant consonant, and *OBSNUC by a nuclear obstruent, then the fixed ranking *OBSNUC » *SONNUC creates a universal dispreference for obstruent nuclei relative to sonorants. So long as *OBSNUC dominates WEIGHT-TO-STRESS and STRESSWELL, obstruents will resist integration into the nucleus, even at the cost of violating the latter two constraints. With *SONNUC ranked beneath these constraints, they will continue to compel sonorant nuclei. The tableau in (15) shows how this ranking stops obstruents from behaving like sonorants in the face of a STRESSWELL violation.

(15) *OBSNUC » STRESSWELL

| Input: *Timbucktoo* | *OBSNUC | WEIGHT -TO-STRESS | STRESSWELL |
|---|---|---|---|
| a. (Timbck)(tóo) | * ! | | |
| b. (Timbuck)(tóo) | | * ! | |
| c. (Tim)(bùck)(tóo) ✓ | | | * |

The ranking *OBSNUC » STRESSWELL rules out a nuclear obstruent, as in (15a), in favor of pretonic stress, as in (15c). The final candidate would remain optimal if *OBSNUC and WEIGHT-TO-STRESS were unranked, since all that is necessary to rule out the second candidate is the ranking of WEIGHT-TO-STRESS » STRESSWELL. The necessary dominance of *OBSNUC is displayed only in a situation in which WEIGHT-TO-STRESS is violated by the optimal candidate:

(16) *OBSNUC » WEIGHT-TO-STRESS

| Input: *Alexander* | *OBSNUC | WEIGHT -TO-STRESS |
|---|---|---|
| a. (Àlx)(án)der | * ! | |
| b. (Àlex)(án)der ✓ | | * |

Sonorant nuclei, on the other hand, continue to be preferred over pretonic stress, since STRESSWELL dominates *SONNUC:

(17) StressWell » *SonNuc

| Input: *Pennsylvania* | StressWell | *SonNuc |
|---|---|---|
| a. (Pènnsl)(vá)nia ✓ | | * |
| b. (Pènn)(sỳl)(vá)nia | * ! | |

Before turning to further data and analysis, it is worth noting the contribution of the theoretical assumption of *Parallelism* (see Prince and Smolensky 1993, McCarthy 1993, Cohn and McCarthy 1994, McCarthy and Prince 1995) to this treatment of the $\sigma_s/\sigma_o$ asymmetry. It appears to be crucial that syllabification and stress assignment be evaluated in parallel, rather than established and evaluated in sequence (see P&S 1993: §3.2 for arguments to this effect for Tongan). Whether the second syllable in a Hσ- pretonic sequence is unstressed depends upon whether the syllable-final consonant can be parsed as a nucleus. Whether a sonorant is parsed as a nucleus in turn depends upon whether it is unstressed. This sort of interdependence between the well-formedness of stress and syllable structure is extremely difficult to express in a theory in which syllabification derivationally precedes stress placement.

### *2.1.3 Odd-parity strings*

Combining the rankings motivated thus far, the complete hierarchy stands as follows:

**(18)** FtBin, Parse-σ, Troch, *ObsNuc » Weight-to-Stress » StressWell » *SonNuc

An interesting and encouraging property of this hierarchy is that it needs very little embellishment to generate the correct results for odd-parity pretonic strings of syllables. In accounting for the stressing of bisyllabic strings, we have established that PARSE-σ dominates WEIGHT-TO-STRESS (✔*(Àlex)(án)der*, **A(lèx)(án)der*) and that WEIGHT-TO-STRESS dominates STRESSWELL (✔*(Tìm)(bùck)(tóo)*, **(Tìmbuck)(tóo)*). This means that by transitivity, PARSE-σ dominates STRESSWELL, which leads to the prediction that a single pretonic syllable should be parsed, even at the expense of a STRESSWELL violation.

This prediction is borne out in the difference between a single pretonic $\sigma_s$, and one that is preceded by another syllable. As we saw in the last sub-section, when a $\sigma_s$ follows another syllable, light or heavy, it is parsed as the weak member of a bisyllabic foot, in obedience to STRESSWELL. However, when there is but a single syllable, PARSE-σ forces it to be parsed alone, and stressed, in contravention of STRESSWELL. Illustrative data appear in (19), and an illustrative tableau, in (20).

**(19)** bàndána Nàntúcket pòntóon càntéen cèntúrion càntánkerous

**(20) Tableau for $\sigma_s$-**

| Input: *bandana* | PARSE-σ | WEIGHT-TO-STRESS | STRESS WELL | *SON NUC |
|---|---|---|---|---|
| a. (bàn)(dána)✓ | | | * | |
| b. bn(dána) | * ! | | | * |
| c. ban(dána) | * ! | * | | |

Notice that the availability of a nuclear sonorant (20b) as an alternative to a WEIGHT-TO-STRESS violation (20c) has no effect on the outcome, because in this instance, PARSE-σ, rather than WEIGHT-TO-STRESS, is the constraint motivating heavy syllable stress.

When a $\sigma_s$ is the last member of a trisyllabic pretonic string, it also usually receives stress, as the examples in (21) illustrate.

**(21)** a. $\sigma\sigma\sigma_s$ Hàlicàrnássus ròdomòntáde pìthecànthrópus

b. $\sigma\sigma\sigma_s$ àrgumèntátion instrumèntátion sàcramèntátion sèdimèntátion èlephàntíasis

The words in (21b) are based on roots without stress on the final syllable, which precludes an analysis in which the stress is stored underlyingly, and points to the productivity of this pattern of secondary stress assignment (Kager 1989: 123). The productivity of pretonic stress in this environment also follows from the dominance of PARSE-σ:

**(22) Tableau for $\sigma\sigma\sigma_s$**

| Input: *Halicarnassus* | PARSE-σ | WEIGHT-TO-STRESS | STRESS WELL | *SON NUC |
|---|---|---|---|---|
| a. (Hàli)(càr)(nássus)✓ | | | * | |
| b. (Hàli)car(nássus) | *! | * | | |
| c. (Hàli)cr(nássus) | *! | | | * |
| d. Ha(licr)(nássus) | *! | | | * |

Here too, leaving a syllable unparsed is fatal, due to the dominance of PARSE-σ over the other constraints (22b-d). A fifth candidate, not shown in this tableau, in which all of the pretonic syllables are grouped into a single foot, would violate FTBIN, since such a foot is neither moraically nor syllabically binary (more on this below).

In this environment, a $\sigma_o$ behaves in the same way as a $\sigma_s$:

**(23)** bàctéria Òctóber èxtrínsic cògnítion àpothègmátic ànimàdvérsion

This is as expected, since there is nothing in this analysis that differentiates $\sigma_o$ and $\sigma_s$ in relation to PARSE-σ. And as we will see in the next subsection, pretonic long vowels are also stressed in this environment, and stressless when preceded by a single syllable.

### *2.1.4 Pretonic long vowels*

We have yet to examine the stressing of pretonic open syllables. Syllables with underlying long vowels for the most part pattern with $\sigma_s$'s. Halle and Vergnaud (1987: 240) observe that long vowels usually retain their length and are stressed in initial position (24a), but surface as stressless and reduced medially, after both heavy and light syllables (24b).

(24) a. privátion vòcátion citátion èjéction gràdátion

b. dèprivátion invocátion èxcitátion rèvelátion dègradátion

There are, however, no reported monomorphemic words that have a pretonic long vowel in the same position as the stressed $\sigma_s$ in *Hàlicàrnássus*. Given the small number of underived words with trisyllabic pretonic strings, it is difficult to know if this is an accidental gap. In derived words, at least, we do find such pretonic long vowels (see further §2.3, and Appendix B):[5]

(25) rètrogràdátion civilizátion stàndardizátion pàrasitólogy

To account for the patterning of long vowels with $\sigma_s$'s, the constraint requiring the preservation of input vowel length in the output form can simply be placed in the same position in the hierarchy as *SONNUC: at the bottom. Constraints requiring a match between input and output are referred to as *faithfulness* constraints. Following McCarthy (1995) and Urbanczyk (1995), a formulation of this constraint in terms of McCarthy and Prince's (1995) Correspondence Theory of faithfulness is provided in (26).

---

[5] As will be discussed in §2.3, these words do have variant pronunciations in which the pretonic vowels are reduced. In this respect too, long vowels parallel $\sigma_s$'s (e.g. the underlined syllable in *rèpresentátion* can be either stressed or not).

(26) WEIGHT-IDENT
If $\alpha$ is bimoraic, then $f(\alpha)$ must be bimoraic,
where $f$ is the correspondence relation between input and output

This constraint states that if an input vowel is bimoraic, then the corresponding vowel in the output must also be bimoraic. In the following tableaux, vowel length is indicated by subscripted moras. When the long-vowelled syllable is preceded by another syllable, they are parsed together, so as to satisfy STRESSWELL (27a). The satisfaction of WEIGHT-TO-STRESS by the optimal candidate is even more obvious than in parallel $\sigma_s$ cases (e.g. *Pènnsylvánia*), since the vowel surfaces as short and reduced. That vowel length is lost in this environment indicates that WEIGHT-IDENT, like *SONNUC, is dominated by STRESSWELL:

**(27) STRESSWELL » WEIGHT-IDENT**

| Input: *depri$_{\mu\mu}$vation* | WEIGHT-TO-STRESS | STRESS WELL | WEIGHT-IDENT |
|---|---|---|---|
| a. (dèpri$_{\mu}$)(vá)tion✓ | | | * |
| b. (dèpri$_{\mu\mu}$)(vá)tion | * ! | | |
| c. (dè)(pri$_{\mu\mu}$)(vá)tion | | * ! | |

Again, as tableau (28) shows, the stressing of a single pretonic syllable is due to the requirement that it be parsed (PARSE-$\sigma$), rather than the need for heavy syllables to be stressed (WEIGHT-TO-STRESS), or for vowel length to be preserved (WEIGHT-IDENT):

**(28) Tableau for V:**

| Input: *pri$_{\mu\mu}$vation* | PARSE-σ | WEIGHT-TO-STRESS | STRESS WELL | WEIGHT-IDENT |
|---|---|---|---|---|
| a. (prì$_{\mu\mu}$)(vá)tion✓ | | | * | |
| b. pri$_{\mu\mu}$(vá)tion | *! | * | | |
| c. pri$_{\mu}$(vá)tion | *! | | | * |

*2.1.5 Pretonic light syllables and left alignment*

So far, the dominance of PARSE-σ has played a central role in the analysis. It causes both the lack of stress on obstruent-final syllables when they are preceded by light syllables, and the presence of stress on lone pretonic heavies. That two apparently unrelated, and in some sense contradictory, phenomena can be motivated by the same constraint is a positive, and intriguing result.

Even this robustly satisfied constraint is not uniformly satisfied, however. Single light pretonic syllables, as exemplified by the words in (29), are almost always unstressed, and hence unparsed:

**(29)** L  banána América terrific cerámic Fellíni lagóon gorílla Jamáica crevásse

Satisfaction of PARSE-σ in these instances would lead to a violation of FOOTBIN, as the resulting foot consists of a single monomoraic syllable. With FOOTBIN » PARSE-σ, these syllables remain unparsed:

(30) FOOTBIN » PARSE-σ

| Input: *banana* | FOOTBIN | PARSE-σ |
|---|---|---|
| a. ba(nána)✓ | | * |
| b. (bà)(nána) | * ! | |

It is in fact possible to avoid violations of both of these constraints, by altering the segmental composition of the word. For instance, the initial syllable could be truncated, leaving a fully footed (nána), which would violate neither FOOTBIN nor PARSE-σ. To rule out this possibility, a faithfulness constraint demanding that input segments be preserved in the Output, must be ranked above PARSE-σ, so that the candidate with an unparsed initial syllable is correctly chosen over a candidate in which the initial syllable is not realized at all.[6] A tableau including this constraint, dubbed MAX by McCarthy and Prince (1995), is provided in (31):

(31) MAX, FOOTBIN » PARSE-σ

| Input: *banana* | MAX | FOOTBIN | PARSE-σ |
|---|---|---|---|
| a. ba(nána)✓ | | | * |
| b. (bà)(nána) | | * ! | |
| c. (nána) | **! | | |

[6] Also needed here, and anywhere else that FTBIN is invoked to rule out a non-final monomoraic foot, is a high ranking ONSET constraint, which would rule out bàn.ána, and, if ambisyllabicity is permitted, a constraint to rule out ambisyllabicity across a foot boundary. See McCarthy and Prince (1993b), and Pater (1994) for relevant discussion. See also section 2.3 for an account of penultimate vs. antepenultimate stress in *banana* vs. *Canada*.

Though candidate (31c) satisfies PARSE-σ, the higher rank of MAX renders it ungrammatical in adult English. The ranking between MAX and FOOTBIN cannot be ascertained, as we have no examples in which either is violated, so they are left unranked. In the next chapter, we will see that (31c) is in fact the optimal candidate in early child English, which will be taken to be evidence of a low ranking MAX constraint in the early grammar.

Just as there is a parallel between the behaviours of lone pretonic heavy syllables in initial and medial positions, so is there one between light syllables in these contexts. In (32) appears a list of examples of medial unstressed light syllables that parallel the initial ones in (29).

**(32) LLL** Tàtamagóuchi àbracadábra Kàlamazóo Winnepesáukee Wàpakonéta dèlicatéssen Lòllapalóoza

With the first two syllables parsed into a binary foot, the third, pretonic syllable is left stranded. For it to be parsed would require a violation of FOOTBIN, so it remains unparsed, in conformity with the ranking FOOTBIN » PARSE-σ.

Yet to be explained, however, is why the first two, rather than the second two syllables, are paired into a foot. Either parsing would fair equally well on the constraints discussed thus far. In McCarthy and Prince (1993b), the initial stress in these words is ascribed to one of a family of Align constraints, which in this case forces the alignment of the left edge of the Prosodic Word with the left edge of a foot:

(34) ALIGN (PRWD, L, FT, L) - ALIGN-LEFT

'Align the left edge of the Prosodic Word with the left edge of a foot.'

When the initial string is made up of three light syllables, FTBIN demands that one of them must remain unparsed. This is because FTBIN states simply that a foot must be binary, so that constituents must be not only minimally binary at either the syllabic or moraic level, but maximally binary at one of these levels as well (P&S 1993: 47 - this restates the principle of Strict Binarity of foot size proposed by Prince 1985; see also Itô and Mester 1992). The job of ALIGN-LEFT is to ensure that the unparsed syllable is not the initial one:

**(35) Left-Alignment**

| Input: *Tatamagouchi* | FTBIN | PARSE-σ | ALIGN-LEFT |
|---|---|---|---|
| (Tàtama)(góu)chi | * ! | | |
| Ta(tàma)(góu)chi | | * ! | * |
| (Tàta)ma(góu)chi ✓ | | * ! | |

This tableau shows that ALIGN-LEFT can be ranked below PARSE-σ, and still force initial stress. To see why this ranking is necessary, we must consider other data, since left alignment in *Tatamagouchi*-type words will obtain under any ranking of these two constraints, as inspection of the above tableau should reveal. The data that motivate a low rank for ALIGN-LEFT are those in (36). Here we see that if the second syllable in a ternary pretonic string is heavy, it, rather than the initial syllable, is stressed. While there are few examples of this pattern, it appears to be exceptionless, and native speaker intuitions are strong on the unacceptability of initial stress for these words:

(36) L(HL) Monòngahéla Valènciénnes geròntophília Belùchistán

Since even a $\sigma_s$ or a long vowel in the second syllable inhibits left alignment, ALIGN LEFT must be ranked at the bottom of the hierarchy elaborated thus far. The tableau for *Monongahela* shows that the ranking between ALIGN LEFT and *SONNUC is crucial:

(37) *SONNUC » ALIGN-LEFT:

| Input: *Monongahela* | FTBIN | PARSE-σ | WEIGHT-TO-STRESS | *SON NUC | ALIGN-LEFT |
|---|---|---|---|---|---|
| a. (Mònnga)(héla) | * ! | | | | |
| b. (Mònon)ga(héla) | | * | * ! | | |
| c. (Mònn)ga(héla) | | * | | * ! | |
| d. Mo(nònga)(héla) ✓ | | * | | | * |

The topmost candidate is immediately ruled out by FTBIN. The remaining candidates all violate PARSE-σ, so evaluation is passed on to the next constraint, WEIGHT-TO-STRESS, which rules out (37b). With *SONNUC » ALIGN-LEFT, the candidate with left mis-alignment (37d) is correctly chosen over the one with the nuclear sonorant (37c). In sum, even though a $\sigma_s$ can behave as a light syllable in order to avoid a STRESSWELL violation, left alignment is not a sufficiently potent force in English to warrant the requisite violation of *SONNUC.

The addition of ALIGN-LEFT, WEIGHT-IDENT, and MAX, and of the ranking between FOOTBIN and PARSE-σ, is thus all that is needed to complete the account of the regular patterns of heavy syllable stress and stresslessness in secondary stress assignment (though see Appendix C on light syllable stress). The final hierarchy is as depicted in the tree diagram in

(38), which is used because FtBin and Max dominate Parse-$\sigma$, but all three are unranked with respect to Troch and *ObsNuc.

**(38)**

FtBin, Max    Troch, *ObsNuc

|    |

Parse-$\sigma$    |

\    |

Weight-to-Stress

|

StressWell

|

*SonNuc, Weight-Ident

|

Align–Left

At this point, it is worth drawing attention to how another nonuniform weight effect (besides the Arab rule) has been dealt with here in terms of constraint ranking and minimal violation, and contrasting this analysis with one based on full satisfaction.

The most obvious source of nonuniformity comes from the different behaviors of heavy syllables in initial, and medial position. In initial position, heavy syllables are regularly stressed (e.g. Sỳlvánia, prìvátion); in between initial and tonic position, abstracting from $\sigma_o$'s and the Arab rule, they are usually unstressed (e.g. Pènnsylvánia, dèprivátion). Here this positional difference is derived from the ranking of Parse-$\sigma$ » StressWell. StressWell demands pretonic stresslessness, but is overruled when it would lead to non-exhaustive parsing.

Halle and Vergnaud (1987: 240) explicitly discuss the long vowel cases. They do account for them without making their rule of stress deletion refer to the word-medial environment; this is done, however, by positing a rule of shortening that applies only medially. Thus, the existence of nonuniformity is accounted for by stipulating it in the formulation of a rule.

More generally, the absence of medial heavy syllable stress is attributed to the quantity insensitive nature of secondary stress assignment, as expressed in Strong Retraction (Hayes 1982), and the set of rules Halle and Vergnaud (1987) call "the Alternator". But as we have seen, in many environments, pretonic heavy syllables are regularly stressed. In fact, the only environment in which they are regularly unstressed is precisely the one under discussion: when they are adjacent to both the initial and tonic syllables. To produce the perhaps more usual cases of heavy syllable stress, Hayes (1982) invokes rules of pre- and post- stress destressing that are quantity sensitive (following in some respects Halle 1973 and Liberman and Prince 1977). Stress is assigned equally to bànána and bàndána, to Tàtàmagouchi and Mònòngahéla, but removed from only the light syllables.[7] Here we have the tack of positing a derivational stage during which the principle does not apply, and then turning it back on to trim back the misplaced stresses. Within a derivational theory, such a move is by no means illegitimate; it is actually the prime means by which both simple description, and descriptive gaps can be avoided in dealing with nonuniformity. However, we can surely count it as an advance if the facts can be accounted for more directly, and at the same time reduced to basic universal principles. By assuming minimal violation, instead of full satisfaction, just this sort

[7] An important step forward is made by Kager (1989), who assumes strictly bisyllabic foot construction, so that the light syllables are simply left unparsed, rather than stressed and then destressed. Kager's premise that (H) feet are impossible prefigures Burzio's (1994) theory, though their approaches to dealing with apparent cases of (H) feet are quite different. Whereas Burzio posits empty syllable structure, Kager invokes a Weight-to-Stress principle that grants stress to unfooted heavy syllables.

of advance in the analysis of the nonuniform weight effects in English secondary stress is possible.

## 2.2 Weight-to-primary stress

### *2.2.1 Basic Account*

An even more obvious source of nonuniform weight effects in English comes from the distinction between primary stress placement and secondary stress placement. A complete analysis of main stress placement, dealing with complexities such as stress retraction, and lexically and morphologically determined stressing, is beyond the scope of this chapter (see Kager 1989 and Burzio 1994 for comprehensive discussion and references). However, in this section, I will discuss the basic pattern of main stress placement on nouns outlined in (1), because with WEIGHT-TO-STRESS, and related constraints, such as WEIGHTIDENT and *SONNUC, ranked so low in the hierarchy, one might wonder how quantity sensitive primary stress placement is to be explained.

To see why this could be a problem, recall that in words such as *agénda*, *synópsis*, and *aróma*, primary stress falls on the heavy penultimate syllable, but when the penult is light, as in *Cánada*, stress is antepenultimate. That stress is antepenultimate in *Canada* is usually explained by a rule of Extrametricality (Hayes 1982), or a constraint of NONFINALITY (P&S 1993) that disallows the footing of the final syllable, so that the parsing *(Cána)da* occurs instead of *Ca(náda)* (cf. Burzio 1994). The apparent dilemma can be summarized in the following question: If PARSE-σ is ranked above WEIGHT-TO-STRESS and the other weight related constraints, then why aren't *a(gén)da*, *sy(nóp)sis*, and *a(ró)ma* more exhaustively parsed, and footed like *(Cána)da*?

To answer this question, we must consider the interaction of the constraints responsible for main stress placement with the hierarchy established for secondary stress placement. McCarthy and Prince (1993b) invoke the following constraint for English main stress placement:

**(39)** Align (PrWd, R, Head(PrWd), R) - ALIGN-HEAD

'Align the right edge of the Prosodic Word with
the right edge of the head of the Prosodic Word'

McCarthy and Prince (1993b) discuss only the interaction between this constraint and ALIGN-LEFT, and are not concerned with quantity sensitivity. In what follows, I will show that the formulation of ALIGN-HEAD allows for a straightforward treatment of main stress specific quantity sensitivity.

Following Prince and Smolensky (1993), I take headship to be transitive, so that 'head of the Prosodic Word' is fulfilled not only by the foot that bears main stress, but also by the syllable that is the head of that foot. Under this interpretation, an undominated ALIGN-HEAD constraint would force the head syllable of the Prosodic Word to be the rightmost syllable, resulting in final main stress.

That English does not have final main stress indicates that ALIGN-HEAD is dominated. NONFINALITY, formulated as 'the head of the Prosodic Word must not be final' (Prince and Smolensky 1993:52; cf. Hung 1994, Buckley 1995) is in direct competition with ALIGN-

HEAD, and when ranked above it, forces main stress, and the main stressed foot, off the final syllable.

A second crucial assumption, besides transitivity of headship, is that ALIGN-HEAD is gradiently violable (see Prince and Smolensky 1993: 57, McCarthy and Prince 1993b, Prince 1993). This means that the constraint is not merely satisfied or violated, but that there is a measure of degree of violation. In this case, a gradiently violable ALIGN-HEAD constraint demands that the main stressed syllable be as close as possible to the right edge of the word, with each syllable intervening between the head syllable and the edge counting as a violation. The minimal violation of ALIGN-HEAD, which satisfies NONFINALITY, is to have main stress on the penultimate syllable.

The ranking NONFINALITY » ALIGN-HEAD thus is all that is needed to place main stress on the correct syllable of *agenda*, and the other words with bimoraic penults:

**(40) NONFINALITY » ALIGN-HEAD**

| Input: *agenda* | NONFINALITY | ALIGN-HEAD |
|---|---|---|
| a. a(gén)da✓ | | * |
| b. (ágen)da | | ** |
| c. (àgen)(dá) | * ! | |

With but a single violation of ALIGN-HEAD, (40a), with penultimate stress, is optimal. As noted above, a candidate like (40a), with initial stress, fares better in terms of exhaustivity than the optimal one does, as it leaves only the final syllable unparsed. This shows that ALIGN-HEAD is ranked above PARSE-σ.

Now that the penultimate stress on *agenda* is accounted for, our original question is reversed. Why does *Canada* have antepenultimate stress? The answer is that penultimate stress would violate constraints whose high rank we have already established: either FTBIN, or TROCH.[8] If these constraints, along with NONFINALITY, outrank ALIGN-HEAD, antepenultimate stress is optimal:

**(41) FTBIN, TROCH, NONFINALITY » ALIGN-HEAD**

| Input: *Canada* | FTBIN | TROCH | NONFINALITY | ALIGN-HEAD |
|---|---|---|---|---|
| a. (Cána)da✓ | | | | ** |
| b. Ca(náda) | | | *! | * |
| c. Ca(ná)da | *! | | | * |
| d. (Caná)da | | *! | | * |

"Quantity sensitive" primary stress placement is thus achieved by simply placing the independently necessary constraints of NONFINALITY and ALIGN-HEAD in the hierarchy established for secondary stress placement.[9] Crucially, ALIGN-HEAD dominates PARSE-σ, so

[8] See Cohn and McCarthy (1994) and Kenstowicz (1994) for analyses of Indonesian in which an iambic foot is formed to place stress rightmost in the root, even though trochaic feet are preferred elsewhere.

[9] The facts of primary stress retraction do introduce some complications (see especially Kager 1989 for thorough discussion and references). When there is final stress, the main stress usually occurs on the next foot to the left. This is presumably an effect of NONFINALITY. With no elaboration, the present account would predict that main stress should land on the next legitimate foot, either a heavy

that primary stress does not shift to the left to incorporate a stray syllable, but is itself dominated by FTBIN, TROCH, and NONFINALITY, so as to ensure antepenultimate stress with a light penult. This yields the hierarchy in (42).

**(42)**
```
FTBIN, TROCH, NONFINALITY
            |
MAX   ALIGN-HEAD
   \        |          *OBSNUC
      PARSE-σ        /
            |        /
   WEIGHT-TO-STRESS
            |
     STRESSWELL
            |
*SONNUC, WEIGHT-IDENT
            |
      ALIGN-LEFT
```

It is important to note that the rankings needed for the account of primary stress placement are consistent with those required for secondary stress. Crucial to the analysis of primary stress placement is a ranking of ALIGN-HEAD below FTBIN and above PARSE-σ. For ALIGN-HEAD to be ranked in between these two constraints, FTBIN must dominate PARSE-σ. This was established on independent grounds in §2.1.5 (*✓ba(nána)*, **(bà)(nána)*). The ranking of ALIGN-HEAD above PARSE-σ also entails, by transitivity, that ALIGN-HEAD

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syllable (e.g. staláctite), or pair of lights (e.g. acétylène). However, main stress often ends up further to the left, skipping the heavy syllable (e.g. désignàte) or **LL** sequence (e.g. cátamaràn). One way to capture these cases of 'strong' and 'long' retraction would be to use a constraint demanding the alignment of the right edge of the Prosodic Word with a foot head (rather than the head of the Prosodic Word) to place the rightmost stress, and position the ALIGN-HEAD constraint much lower in the hierarchy, so that it cannot affect the placement of the other feet in the word. As both stress retraction, and the weight-to-stress behavior of final syllables are quite complex, and rife with exceptionality, I abstract from these aspects of the English stress system in the present analysis.

dominates ALIGN-LEFT. This is in fact the ranking that McCarthy and Prince (1993b) invoke to explain the preference for rightmost main stress placement over left alignment, as demonstrated in a word like *A(méri)ca*. This account of primary stress quantity sensitivity also goes beyond being compatible with the analysis of secondary stress placement proposed in the previous section: it has significant advantages over prior analyses.

### *2.2.2 Comparison with previous analyses*

The integration of primary and secondary stress assignment achieved here can be contrasted with the analysis in Halle and Vergnaud 1987: 228, in which an entirely separate rule stratum is set up for secondary stress assignment, which differs from primary stress assignment almost exclusively in its lacking the weight-to-stress rule (the Accent Rule) that causes quantity sensitive primary stress placement. The present analysis is an improvement not only because it avoids the redundancy of positing two levels of stress assignment, but also because it provides an explanation for why only primary stress placement should be quantity sensitive, as well as a tighter characterization of the cross-linguistic scope of this phenomenon.

This account is explanatory in that it reduces the observed facts to more basic principles. ALIGN-HEAD is independently needed to choose which foot is to bear main stress. Here I have shown that by ranking it beneath FTBIN, the effect of quantity sensitive main stress placement can also be derived. This makes for an interesting claim: that heavy syllables in English bear primary stress not because of the attraction of stress to heavy syllables, but because of the general delimitive quality of stress placement (that is, the tendency for stress to mark the edges of domains, which is arguably the substantive motivation for many

Alignment constraints; see Kager 1994). In contrast, by saying that the Accent Rule applies only in primary stress placement, and not in secondary stress placement, Halle and Vergnaud (1987) do not go much beyond simply stating the generalization.[10]

This analysis is also predictive in a way that the one of Halle and Vergnaud 1987 is not. The pattern of having a single quantity sensitive foot for main stress, followed by iterated quantity insensitive feet, is fairly common (relatively clear examples are Spanish: Harris 1982, Halle and Vergnaud 1987, Hayes 1995, and Inga: Levinsohn 1976, Hayes 1995). What unites these cases is that the single quantity sensitive foot is found at the right edge of the word (abstracting from extrametricality and exceptionality). Trochaic languages that have primary stress on the leftmost foot do not apparently display this sort of main stress specific quantity sensitivity. In fact, the opposite scenario is sometimes observed. In Finnish (Kiparsky 1991, Kager 1992), for example, secondary stress placement avoids left-headed (LH) feet, while the main stress foot is strictly initial and bisyllabic, even at the cost of creating an LH foot. Here only secondary stress is sensitive to syllable weight. As far as I know, this main stress specific quantity *in*sensitivity has never been attested of trochaic languages with rightmost primary stress.

The cross-linguistic picture that emerges, then, is that in trochaic languages, the position of the main stress is closely tied to how it can differ in quantity sensitivity from the secondary stress: quantity sensitivity can be restricted to the main stress foot only if it is at

[10] Though this aspect of English has not been addressed in the Hayes 1987, 1995 framework, Hayes (1995) does analyze Spanish as having a single moraic trochee for main stress, followed by syllabic trochees for secondary stress (the English main stress foot, at least, is claimed to be a moraic trochee). This analysis shares the same deficiencies as that of Halle and Vergnaud 1987, since there is no reason that a language could not have a syllabic trochee for main stress, and a moraic trochee for secondary stress.

the right edge of the word, while quantity insensitivity can only be restricted to a main stress at the left edge. No prior account of main stress specific quantity sensitivity (i.e. Halle and Vergnaud 1987, Dresher and van der Hulst 1993, Hayes 1995) captures this correlation. It is however, just what would be expected in view of the present Alignment based analysis, as I will explain.

Recall that in English, when the penult is heavy, ALIGNHEAD places stress on that syllable, but when the penult is light, the dominance of FOOTBIN forces a violation of ALIGNHEAD, and stress appears on the antepenultimate syllable. There is however, no such conflict between FOOTBIN and the version of ALIGN-HEAD that places main stress on the leftmost syllable ('Align the left edge of the Prosodic Word with the left edge of its head'). No matter how far an intial left-headed foot stretches to the right, ALIGN-HEAD(LEFT) will be fully satisfied, since the head rests at the left edge. For instance, (mánda) violates ALIGN-HEAD(RIGHT), but not ALIGN-HEAD(LEFT). Because of this, ALIGN-HEAD(LEFT) has nothing to say about the size of an initial trochaic foot, whereas ALIGN-HEAD(RIGHT) can affect the size of the final one. ALIGN-HEAD(LEFT) is thus incapable of creating the apparent quantity sensitivity achieved with ALIGN-HEAD(RIGHT).

With an LH sequence, there is also a crucial difference between ALIGN-HEAD(RIGHT), and ALIGN-HEAD(LEFT). Above, we noted that ALIGN-HEAD(RIGHT) prefers L(H) to (LH), when the foot is trochaic. ALIGN-HEAD(LEFT), on the other hand, is better satisfied by (LH), and can thus override the general dispreference for LH feet seen in trochaic languages. In Finnish and similar languages (see Kager 1992 for others), LH sequences are usually stressed on the heavy syllable, rather than on the light one, even though other bisyllabic sequences receive stress on the first member of the pair. If an LH sequence is initial in the word, however, the main stress falls on the light syllable. This can be explained by the domince of ALIGN-HEAD over the constraint disfavouring such feet. In this way, at the left edge, we get main stress specific quantity *in*sensitivity.

### *2.2.3 On the treatment of exceptionality*

As mentioned at the outset of this section, primary stress placement is subject to a number of lexical and morphologically-based irregularities that cannot be dealt with properly here, so this account remains in some respects incomplete. Here I will examine but one case of lexically based exceptionality, to show how this account might be extended to cope with the rest of the data. This discussion serves also to provide some background for the more in-depth examination of secondary stress exceptionality that appears in section §2.3.

One might have noted that some of the nouns used as examples in §2.1 do not have the antepenultimate stress that would be expected of words with light penults. Instead, *banána*, and other words like it, have stress on the penultimate syllable. The examples in (43) demonstrate that this phenomenon is not confined to words with /æ/ in the penultimate syllable (see Pater 1994 for a relatively exhaustive list):

**(43)** vanílla Mississíppi Kentúcky confétti abscíssa Philíppa

These exceptions are well known, and the literature contains a variety of ways of dealing with them.

The proposals can be broadly divided into two groups: representational (more properly, *underlying representation*-al, but this is cumbersome, to say the least), and grammatical. The earliest treatment of these exceptions, found in Chomsky and Halle (1968), is a representational one. The *SPE* solution is to posit underlying 'double consonants' between the last two vowels of these words, so that the penultimate syllables are made heavy for the purposes of the stress rules. Following the assignment of stress, a degemination rule applies to create the surface single consonant. In this account, the locus of the difference between the exceptional words and the regular ones is at the level of the underlying representation. The underlying geminate analysis has also recently been championed by Burzio (1994) and Hammond (1994). Halle and Vergnaud (1987) take a slightly different representational tack by directly supplying these words with an underlying line 1 asterisk, which marks prominence in their framework. The rules of metrical constituent construction are constrained to respect the placement of the asterisk, and form an exceptional monosyllabic foot on the penultimate syllable.

In grammatical approaches, on the other hand, the locus of exceptionality is in the rule or constraint system. To deal with these instances of exceptional penultimate stress, Selkirk (1984), Kager (1989), and Jensen (1993), propose that *banána* et al. are exceptions to extrametricality, so that foot construction groups the final two final syllables together.[11]

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[11] Selkirk's (1984) proposal is in fact not truly a grammatical one, since in her account the final syllable in a word like *América* is marked as extrametrical in the lexicon, and *Kentúcky* is stressed according to the normal rules of stress placement. This proposal is somewhat unusual, as it is at odds with the general practice of metrical theory, and phonology in general, to capture generalizations by rule, and to reserve lexical markings for exceptions.

In Optimality Theory, the burden of phonological explanation has generally shifted from representations to constraints, and from underlying and intermediate levels of derivation to the output. However, both representational and grammatical approaches to exceptionality have continued to be proposed within this framework. Representational treatments of exceptionality appear in Inkelas (to appear), Inkelas, Orgun and Zoll (1994) and in McCarthy (1996), while grammar-based accounts can be found in Itô and Mester (1995b), Hammond (1995), Inkelas (to appear), and Inkelas, Orgun and Zoll (1994) . In §2.3, I will demonstrate that though there is some overlap between the devices of representational and grammatical exceptionality, both must be incorporated into the theory (a conclusion reached on other grounds by Inkelas to appear, and Inkelas, Orgun and Zoll 1994).

For the case at hand, Pater (1994) proposes an Optimality Theoretic recapitulation of the Selkirk/Kager/Jensen 'exceptionally non-extrametrical' analysis, and defends it against arguments that have been put forth against that approach. Here I adopt a slightly modified version.[12]

For antepenultimately stressed words like *(Cána)da*, it is the ranking NONFINALITY, FTBIN » ALIGN-HEAD that rules out penultimate stress. With ALIGN-HEAD ranked above NONFINALITY, penultimate stress becomes optimal. To create a grammar that has this ranking only for certain words, we can introduce a lexically specific version of the ALIGN-HEAD constraint that ranks above NONFINALITY. By lexically specific, I mean that this constraint applies only to a subset of the lexicon, which could be delimited either by dividing up the

[12] A plausible representational treatment could also be provided, though it appears somewhat difficult to reconcile the ranking needed for that analysis with the one proposed for exceptional secondary stress in §2.3.

lexicon in the set-theoretic manner proposed in Itô and Mester (1995a, b), or by supplying words with lexical diacritics like the '+Latinate' of Chomsky and Halle (1968). The lexically specific version of the constraint will be referred to as ALIGN-HEAD-S, where S is the set of all words to which it applies. The lexically specific version of the constraint will be referred to as ALIGN-HEAD-$\mathcal{S}$, where $\mathcal{S}$ is the set of all words to which it applies. To show with maximal perspicuity the effect of adding this constraint to the hierarchy, I provide in (44) a tableau that contains both a word to which this constraint applies (*banana*), and one to which it does not (*Canada*).

(44) **FTBIN, ALIGN-HEAD-$\mathcal{S}$ » NONFINALITY » ALIGN-HEAD**

| | FTBIN | ALIGN-HEAD-$\mathcal{S}$ | NONFINALITY | ALIGN-HEAD |
|---|---|---|---|---|
| a. ba(nána)✓ | | * | * | * |
| b. (bána)na | | **! | | ** |
| c.(bàna)(ná) | *! | | | * |
| a. (Cána)da✓ | | | | ** |
| b. Ca(náda) | | | * ! | * |
| c. Ca(ná)da | *! | | | * |

In the next section, we turn to exceptional secondary stress caused by the idiosyncracies of the English lexicon, and by the influence of stem stress on derived words. There, once again, a high ranking FTBIN constraint plays a central role, this time in controlling the extent to which lexical and stem stress can disturb the usual patterns of secondary stress. In addition, the relative rankings of other constraints in the hierarchy, such as ALIGN-HEAD, STRESSWELL, and ALIGN-LEFT, finds further support.

### 2.3 Special secondary stress

The generalizations about weight-to-secondary stress outlined in §2.1 are upset by two sets of words: lexical exceptions, and derived words that retain stress from their stems. In this section, I argue for a treatment of these special cases in terms of exactly two formal mechanisms: prosodic faithfulness, and lexically specific ranking. In this domain as well, minimal violation allows a principled account of nonuniformity that has been lacking from prior analyses.

#### *2.3.1 Lexical and 'cyclic' stress as prosodic faithfulness*

A classic example of cyclic stress preservation is *còndènsátion,* which conflicts with the clearly productive tendency for a pretonic $\sigma_s$ to be unstressed and reduced in this environment (see §1.2). Since Chomsky and Halle 1968, the pretonic stress in *condensation* has generally been assumed to be due to the stress on the corresponding syllable of *condénse* (cf. *còntempláte -> còntemplátion*). In Chomsky and Halle's analysis, primary stress is assigned to *condense* on the first cycle, and preserved as a secondary stress when *-ation* is added on a subsequent cycle. Some additional examples of stem based exceptions like *condensation* are provided in (45).

**(45)** àdvàntágeous àugmèntátion àuthèntícity còndèmnátion

As pointed out by Halle and Kenstowicz (1991:460), parallel lexical exceptions also occur:

(46) incàntátion incàrnátion òstèntátion chimpànzée

Since there are no independent stems of the form *incánt*, *incárn*, *ostént*, or *chimpán*, the pretonic stress in these words cannot be due to cyclicity (though cf. Fidelholtz 1967: 7). Halle and Kenstowicz (1991) draw attention to these cases in proposing a radically novel treatment of *condensation*-like words: that they too are simply lexical exceptions, subject to a lexically conditioned weight-to-stress rule.

However, using a lexically conditioned weight-to-stress rule for apparent cases of stress preservation, and denying that the stress pattern of the stem plays any role, leads to a missed generalization. As Liberman and Prince (1977: 299) note, while a $\sigma_s$ can be productively destressed in this environment (e.g. *infórm* -> *informátion*), there are no instances of such a syllable becoming stressed in a derived word. That is, there are no words like *còntempláte* that become *còntèmplátion*, with a stressed pretonic syllable (compare *árgument* -> *àrgumèntátion*, discussed in §2.1.2, and further in §2.3.2 below). Thus, while the presence of stress on the corresponding stem syllable does not ensure stress in this position, a lack of stress on the stem syllable does guarantee stresslessness. This generalization shows that contra Halle and Kenstowicz (1991), Chomsky and Halle (1968) were in fact correct in assuming that the stress patterns of *condénse* and *còntempláte* influence the stressing of *còndènsátion* and *còntemplátion*.

We can thus conclude that this secondary stress pattern is unproductive, not only because underived words with pretonic stress like those in (46) are extremely rare, but also because derived words productively destress (e.g. *informátion*), but never stress syllables in this position (e.g. **còntèmplátion*). I will now advance an analysis of these instances of lexical and "cyclic" stress preservation that relies on a single mechanism of prosodic faithfulness, which applies between lexical and surface forms, and between morphologically related items (cf. McCarthy 1996). One benefit of this analysis is that it is consistent with the unproductive nature of this pattern.

First of all, I assume that the lexical form of a word like *incantation*, or *chimpanzee*, includes stress on the pretonic syllable. In order for this stress to be preserved in the output, there must be a faithfulness constraint that outranks STRESSWELL, since STRESSWELL usually forces such syllables to be stressless (see the tableau in (22) above). McCarthy (1996) shows that prosodic faithfulness constraints can take at least two forms in the Correspondence Theory of faithfulness, which as expounded in McCarthy and Prince (1995), premises correspondence relationships between segments only. The edge of the foot can be kept in the same place by requiring the correspondent of any edgemost segment to be edgemost itself (cf. Idsardi 1992), or else stress can be kept in the same place by requiring the correspondent of a segmental head of prosodic category to have the same role (cf. Halle and Vergnaud 1987). As either formulation, or indeed, any of a score of others, would suffice for present purposes, I will assume the relatively informal (47) (though see Appendix A for some evidence that English requires a formulation slightly different from those which McCarthy proposes).

**(47)** STRESSIDENT

If $\alpha$ is stressed, then $f(\alpha)$ must be stressed

As for the related WEIGHTIDENT constraint in (34), here *f* is the correspondence relation between input (lexical) and output (surface) strings of segments (see McCarthy and Prince 1995, McCarthy 1995 for formal details). The ranking STRESSIDENT » STRESSWELL leads to the preservation of underlying stress, even adjacent to the main stress:

**(48) STRESSIDENT » STRESSWELL: Lexical stress preservation**

| Input: *chimpànzee* | STRESSIDENT | STRESSWELL |
|---|---|---|
| (chimpn)(zée) | *! | |
| (chìm)(pàn)(zée)✓ | | * |

With the added assumption that a correspondence relationship also exists between a stem and its derivative (Benua 1995; McCarthy 1995; cf. also Burzio 1994, Steriade 1994, Kenstowicz to appear), then an unstressed pretonic syllable in *condensation* also violates STRESSIDENT, and STRESSIDENT » STRESSWELL generates stem stress preservation as well as lexical stress preservation:

**(49) STRESSIDENT » STRESSWELL: Stem stress preservation**

| Input: *condensation* | STRESSIDENT | STRESSWELL |
|---|---|---|
| (còndn)(sá)tion | *! | |
| (còn)(dèn)(sá)tion✓ | | * |

Because stress on these pretonic syllables is driven by faithfulness to prosodic structure in either the lexicon, or in the stem of a derived word, stress will not emerge in this position when it is absent underlyingly, or in the stem of derived word. This analysis thus captures the similarity between lexical and stem based stress that prompted Halle and Kenstowicz (1991) to use a lexically specific weight-to-stress rule for both types of exceptionality, without sacrificing the generalization that words like *còntèmplátion* do not exist. For the data considered thus far, one could equally proffer an analysis in terms of traditional derivational assignment and preservation of stress. However, in the next few subsections, which focus on nonpreservation, or 'unfaithfulness', the advantage of formalizing stress preservation in terms of a minimally violable constraint will become clear: it allows a precise and concise account of the circumstances under which preservation does and does not occur.

### *2.3.2 Unfaithfulness I: Lexically Specific Ranking*

The first case of nonpreservation that we will examine is displayed in words like *informátion*, that do not preserve the stress of their stems. To explain the destressing of these syllables, we need a way of formalizing the idea that STRESSIDENT exerts a greater influence on *condensation* than it does on *information*. I will discuss two possibilities: morphological reanalysis, and lexically specific ranking, and show that only the latter appears to be adequate.

An explanation based on morphological reanalysis would be that *information* has been (diachronically) reanalyzed as an independent word, and no longer stands in correspondence with *inform* (cf. Chomsky and Halle 1968: 112[13]; H&V 1987: 251). STRESSIDENT would not apply, and *information* would be free to obey STRESSWELL instead.

The chief flaw of this explanation is that it generates regularization through reanalysis in another environment, where none actually occurs. Transitivity of ranking entails that since STRESSWELL is dominated by STRESSIDENT, so is the lower ranked ALIGN-LEFT. The ranking STRESSWELL » ALIGN-LEFT produces the preference for stress preservation over left alignment that is exhibited by the words in (50), in which the non-aligned leftmost stress corresponds to a stressed syllable in the stem (i.e. *accrédit*, *imágine*, *oríginal*, etc.).[14]

**(50)** accrèditátion imàginátion orìginálity medicinálity divìsibílity phenòmenólogy

That stress preservation is at work here can be clearly seen in the contrast between *àcademícian*, as derived from *àcadémic*, and *acàdemícian*, from *acádemy* (Fidelholtz 1967; Kager 1987: 170).

[13] Chomsky and Halle (1968: fn. 64) claim that *information* does not preserve the stress of its stem because "*information* is not the nominalized form of *inform*, but rather a single noun presumably represented as /inform+At+iVn/. Thus we cannot have phrases like **his information of my friend about the lecture* related to *he informed my friend about the lecture*, as we have *his relaxation of the conditions* related to *he relaxed the conditions*." Note, however, that *their conservation of the forest*, and *his lamentation of the loss* can be related to *they conserved the forest*, and *he lamented the loss*, even though the pretonic syllables of *lamentation* and *conservation* are reduced. A rejection of the idea that there is a correlation between the morpho-syntactic facts of nominalization, and stress preservation, is implicit in Halle and Vergnaud (1987:251)

[14] Lexical exceptions to left alignment also occur: *apòtheósis*, *Apòllináris*, *Epàminóndas* (Halle and Kenstowicz 1991: 492). By treating these as bearing a lexical stress, we must assume, contra Halle and Kenstowicz, that the vowel-initiality of these words is a coincidence. In connection with this, note that not all vowel initial LLL pretonic strings lack initial stress (e.g. *àbracadábra*), and that there is at least one exception to left-alignment that has an onset (an alternate pronunciation of *Navràtilóva* attested to by Alan Prince in personal communication).

The fact that this instance of stress preservation falls out from rankings motivated on other grounds provides a welcome indication that our analysis is on the right track. However, what is of interest at present, and remains to be accounted for, is the complete lack of derived words that value left alignment over stress preservation (Burzio 1994). If correspondence could simply be 'turned off' by reanalysis, then one would expect to find that just as words like *information* obey STRESSWELL when reanalyzed, words like *imagination* could be reanalyzed and left aligned.

This conundrum is avoided if instead of morphological reanalysis for *information*, we invoke a lexically specific version of STRESSIDENT for *condensation*.[15] Designating the set of words, including *condensation*, and *chimpanzee*, that are subject to the lexically specific version of STRESSIDENT as '$\mathcal{L}_2$', this constraint can be referred to as STRESSIDENT-$\mathcal{L}_2$. By placing STRESSIDENT-$\mathcal{L}_2$ above STRESSWELL, and the general version of STRESSIDENT between STRESSWELL and ALIGN-LEFT, we generate lexically based variation in stress preservation for the *information/condensation* cases, and strict obedience to STRESSIDENT for *imagination* and similar words. To show the effects this ranking has on these various sets of words, an example of each is placed in the single tableau in (51):

[15] Lexically specific constraints appear to handle the same range of data as the constraint domains, or co-grammars, proposed in Itô and Mester (1995a&b), and discussed in Inkelas, Orgun, and Zoll (1994), and Pater (1994). I prefer the tack of proliferating constraints over that of proliferating grammars because I believe that it gives a clearer view of the limits that a language imposes on reranking, and especially because the proliferation of lexically specific constraints seems independently necessary (e.g. Alignment constraints that express the prosodic subcategorization requirements of specific morphemes; see McCarthy and Prince 1993b).

(51) STRESSIDENT-$\mathcal{L}_2$ » STRESSWELL » STRESSIDENT » ALIGN-LEFT

| Input: *condensation information imagination* | STRESS IDENT-$\mathcal{L}_2$ | STRESS WELL | STRESS IDENT | ALIGN-LEFT |
|---|---|---|---|---|
| (còndn)(sá)tion | * ! | | * | |
| (còn)(dèn)(sá)tion ✓ | | * | | |
| (infr)(má)tion ✓ | | | * | |
| (in)(fòr)(má)tion | | * ! | | |
| i(màgi)(ná)tion ✓ | | | | * |
| (ima)gi(ná)tion | (*!) | | * ! | |

As *condensation* is subject to STRESSIDENT-$\mathcal{L}_2$, its ranking above STRESSWELL renders the stress preserving *còndènsátion* optimal, even with the attendant STRESSWELL violation. When STRESSIDENT-$\mathcal{L}_2$ does not apply, as in *information*, the ranking STRESSWELL » STRESSIDENT creates a preference for pretonic stresslessness over stress preservation, leading to the grammaticality of *ìnformátion*. Finally, no matter whether a word like *imagination* is targeted by the lexically specific version of STRESSIDENT or not, stress preservation, as in *imàginátion*, is always more highly valued than left-alignment, as in *ìmaginátion*, because of the dominance of STRESSIDENT over ALIGN-LEFT.

The addition to the hierarchy of the prosodic faithfulness constraint STRESSIDENT, and a lexically specific version of the same constraint, allows us to capture the fact that pretonic stress preservation is subject to lexical conditioning, while stress preservation on syllables not adjacent to the main stress occurs without exception. This case of nonuniformity has never been explained before, except by denying that *còndènsátion* is an example of stress preservation (Burzio 1994: 185).[16]

In the present analysis, the lower bound of preservation is determined by the ranking of STRESSIDENT above ALIGN-LEFT: preservation is always valued over left alignment. The question to be addressed now is whether there is an absolute limit to faithfulness. Contrary to Liberman and Prince's (1977:286) claim that "the reluctance...to obscure the shape of unfamiliar words...can inhibit any reduction process in English", it turns out that there is an upper bound to stress preservation, which is provided by a constraint that rests at the top of the hierarchy established for regular stress: FOOT BINARITY.

### *2.3.3 Unfaithfulness II: FOOT BINARITY*

In the vast majority of situations in which STRESSIDENT conflicts with FTBIN, FTBIN always triumphs. This can be seen both in the complete absence of lexical stress, and in the consistent failure of stem stress to be preserved, in certain environments. In particular, a light syllable is never stressed when it is the final member of a bisyllabic or trisyllabic pretonic string. Lexical stress never turns up on the underlined syllable of words like *Mònte̲béllo*, or *Tàta̲m̲a̲góuchi* (Selkirk 1984), and in derived words, these syllables are always destressed (Kager 1989). Corresponding to the absence of words like **Mòntèbéllo* are the following alternations:

---

[16] It is in fact not entirely clear whether this denial constitutes an explanation. Burzio (1994) claims that *condensation*-like forms are instances of vowel quality preservation, rather than the stress preservation seen in *imagination* et al. However, he does not provide a formal account of vowel quality preservation, and hence provides no reason why vowel quality preservation should be variable, and stress preservation consistent.

(52) phonétic, phònetícian; còsmétic, còsmetícian; pathólogy, pàthológical; specífic, spècifícity telépathy, tèlepáthic; mechánic, mèchanístic; philátely, philatélic; diámeter, diamétric

And to the **Tàtamàgóuchi* gap:

(53) àcadémic, àcademícian; thèorétic, thèoretícian; màthemátic, màthematícian; hèmatólogy, hèmatológic; militáry, militarístic; Ìndiána, Ìndianápolis

As we saw in §2.1.5, the same absence of stress usually occurs in pretonic light syllables in word-initial position, such as in *banána*. Here too, we have productive destressing:

(54) grámmar, grammárian; órigin, oríginal; médicine, medícinal; nóvel, novélla; cívil, civílian; májesty, majéstic; próphecy, prophétic; míracle, miráculous

Word-initially, though, we find some well-known lexical exceptions (e.g. *ràcóon*) as well as some usually unrecognized instances of stem stress preservation (e.g. *fàscístic*). I refer the reader to the Appendix A for a discussion of the somewhat complex challenges these "exceptional exceptions" present.

In §2.1.5, the lack of pretonic stress on words like *banána*, and *Tàtamagóuchi*, was attributed to the ranking of FTBIN above PARSE-σ. The parallel blocking of lexical and stem based stress preservation described here can likewise be ascribed to the high ranking of FTBIN, so long as it dominates STRESSIDENT. Since the general version of STRESSIDENT is dominated by STRESSWELL, which itself is several rungs lower in ranking than FTBIN, the tendency for monomoraic syllables to be destressed is already built into the hierarchy. However, that they are always destressed establishes a new ranking: FTBIN dominates the lexically specific STRESSIDENT-$\mathcal{L}_2$. With STRESSIDENT-$\mathcal{L}_2$ intervening between FTBIN and STRESSWELL, lexically based pretonic stress preservation is possible for words like *condensation* and *chimpanzee*, but impossible for words like *phonetician* and *Montebello*, or *mathematician* and *Tatamagouchi*, as well as *majestic* and *banana*. The following tableau compares *condensation* and *phonetician*; the other word-types would be treated just like *phonetician*:

**(55) FTBIN » STRESSIDENT-$\mathcal{L}_2$**

| Input: *condensation* *phonetician* | FTBIN | STRESS IDENT-$\mathcal{L}_2$ | STRESS WELL |
|---|---|---|---|
| (còndn)(sá)tion) | | *! | |
| (còn)(dèn)(sá)tion ✓ | | | * |
| (phòne)(tícian) ✓ | | * | |
| (phò)(nè)(tícian) | *! | | * |

Because words like *còndènsátion* incur no violation of FTBIN, stress preservation is possible. However, in a word like *phonetician*, stress preservation creates a violation of FTBIN. As STRESSIDENT-$\mathcal{L}_2$ is ranked beneath FTBIN, stress preservation is impossible in this context.

Since this analysis also applies to the distinction between possible exceptional monomorphemic words like *chìmpànzée*, and impossible ones like **Mòntèbéllo*, a useful comparison can be made to the discussion of such cases in Kager 1989: 140. Kager also posits lexical stress on the pretonic syllable of *chìmpànzée*. This lexical stress blocks the rule of 'Closed Syllable Adjunction', which would ordinarily form a foot by adjoining the medial syllable with a preceding one. However, to express the absence of words like **Mòntèbèllo*, Kager is forced to invoke a bald restriction against lexical stress on light syllables, presumably because there is no principled reason why lexical stress should block 'Closed Syllable Adjunction', but not 'Open Syllable Adjunction'. When preservation of underlying stress is formalized as an Optimality Theoretic constraint, however, the extent to which lexical stress can override the usual stress phonotactics of the language can be expressed with no such added stipulation. This comparison serves to again highlight the difficulties nonuniformity poses for a theory based on full satisfaction, and the ease with which it is dealt with under minimal violation.

### *2.3.4 Unfaithfulness III: ALIGN-HEAD*

The approach taken to ruling out stress preservation when it conflicts with FTBIN carries over to an account of a couple of central facts left undiscussed until now. The instances of stress preservation discussed here are what is referred to in the literature as *weak preservation*: the primary stress of the stem corresponds to a secondary stress in the derivative. Weak preservation is not complete faithfulness – the segment bearing stress in the stem is the head of the Prosodic Word, and its correspondent is but the head of a foot. A separate, but obviously related observation, is that preservation of the stem stress does not interfere with main stress placement – stress is not preserved at all, instead of forcing the displacement of main stress. Similarly, lexical stress does not force main stress placement to the left.

I will start with the second observation. An example of how stress preservation might interfere with main stress placement can be found in the cases we have just looked at. If

FtBin » StressIdent-$\mathcal{L}_2$ disallows **gràmmárian*, then what rules out **grámmarian*? This would satisfy both FtBin and StressIdent. The problem with **grámmarian*, of course, is that main stress is too far to the left. Assuming that these, and other stress placing suffixes, are incorporated into the Prosodic Word (see Lamontagne and Sherer 1993), a ranking of Align-Head » StressIdent-$\mathcal{L}_2$ will ensure that main stress placement is unresponsive to the demands of stress preservation:

**(56) Align-Head » StressIdent-$\mathcal{L}_2$**

| Input: *grammarian* | Align-Head | Stress Ident-$\mathcal{L}_2$ |
|---|---|---|
| gram(mári)an ✓ | ** | * |
| (grámma)rian | ***! | |

As discussed in §2.2, the dominance of Align-Head by FtBin, and NonFinality, entails that the minimal number of Align-Head violations is the two incurred by the optimal candidate. The third violation rules out **grámmarian*, due to the ranking of Align-Head over Stress-Ident. Similar results obtain if one posits preantepenultimate lexical stress.

The same ranking can account for the subordination of the preserved stress to the primary stress. To distinguish between strong and weak preservation, let us assume that StressIdent is a gradient constraint: it is satisfied if the correspondent of the head of the Prosodic Word is itself the head of the Prosodic Word (i.e. strong preservation), one violation is caused if the head of the Prosodic Word is in correspondence with only the head of a foot (weak preservation), while two violations result if the head of the Prosodic Word is in correspondence with a non-head (non-preservation). An attempt to better satisfy

STRESSIDENT by making the preserved stress the head of the Prosodic Word, will automatically increase the number of violations of the higher ranked ALIGN-HEAD:

**(57) ALIGN-HEAD » STRESSIDENT: Stress subordination**

| Input: *imagination* | ALIGN-HEAD | STRESS IDENT |
|---|---|---|
| i(màgi)(ná)tion✓ | * | * |
| i(mági)(nà)tion | ***! | |

Here the minimal ALIGN-HEAD violation is but a single one, since the vowel is bimoraic, and FTBIN is obeyed. If the stem stress is preserved as a primary stress, the additional ALIGN-HEAD violations are fatal. I have omitted a candidate with two main stresses: this would be ruled out by an independent constraint against joint headship.

To wind up the discussion of prosodic faithfulness, it is striking that the distribution of exceptional and stem based stress requires high ranking FTBIN and ALIGN-HEAD, a low ranking ALIGN-LEFT, and an intermediate STRESSWELL, all of which are provided by the analysis of regular stress. This provides strong support for the approach taken here of accounting for these special cases by interspersing STRESSIDENT constraints into the hierarchy of constraints established for the usual patterns. Moreover, the close parallels between the distribution of lexical and stem based stress fall out nicely from the use of a single mechanism of prosodic faithfulness for them both (though cf. Appendix B). And above all, we have accounted for a wide array of facts by simply adding one constraint, and its lexically specific instantiation, to the independently motivated hierarchy. The resulting hierarchy is as in (58).

```
(58)          FTBIN, TROCH
                    |
               ALIGN-HEAD-ℒ
                    |
               NONFINALITY
                    |
               ALIGN-HEAD
            /       |        *OBSNUC
          /     PARSE-σ     /
STRESSIDENT-ℒ₂      |      /
          \   WEIGHT-TO-STRESS
           \        |
             STRESSWELL
             /      |
  STRESSIDENT    *SONNUC, WEIGHT-IDENT
             \      |
              ALIGN–LEFT
```

In the following sub-section, we turn to some more exceptions to the generalizations of §2.1, which this time fall outside the domain of prosodic faithfulness, and so must be generated by the grammar. These cases serve to strongly motivate a grammatical account of exceptionality, in addition to a purely lexical one, as well as to highlight the differences between "productive exceptions", and the nonproductive ones discussed in this last section.

### *2.3.5 Lexical exceptionality as lexically specific ranking*

As discussed in §2.1.3, odd-parity pretonic strings contrast with bisyllabic ones in that the final pretonic syllable of those strings is usually stressed if it is heavy, as in *bàndána*, *Hàlicàrnássus*, and *àrgumèntátion*. This was explained by the ranking PARSE-σ » STRESSWELL, which creates a preference for parsing the lone syllable into a foot, over the stresslessness that STRESSWELL demands of a syllable adjacent to the main stress. This section examines the rather large set of exceptions to this pattern of heavy syllable stress. I will provide an account of these productive exceptions in terms of a lexically specific ranking of STRESSWELL » PARSE-σ, which creates, for these words, a preference for pretonic stresslessness over parsing.

The best-known exceptions to the usual pattern of initial pretonic heavy syllable stress are words that were historically formed with Latinate prefixes (see e.g. Chomsky and Halle 1968:121, Liberman and Prince 1977: 284, and H&V 1987: 239). The prefixes often surface as stressless when pretonic, whether they end in a sonorant (59a), an obstruent (59b), or have a long vowel in other (often related) words (59c). It was in their discussion of these words that Liberman and Prince pointed out the special markedness of stress adjacent to the main stress, as opposed to simple adjacency (cf. *prèsèntátion*, *pròlòngátion*, and *rèlàxátion*):

**(59)** a. condémn condénse embárrass embráce engáge engráve enjóy

b. absólve admíre advántage extréme extínguish obsérve obstrúct

c. precócious presént prolóng recúrrent refórm reláx

It is not the case, though, that these prefixes always reduce in the pretonic environment. Besides the fact that more semantically transparent cases of prefixation, especially with the very productive prefixes /pre-/, /re-/, /pro-/ and /de-/ , do not involve reduction (e.g. *recover* 'cover again' vs. *recover* 'get back'; *rebutter* 'butter again' vs. *rebutter* 'one who rebuts', *preconscious* vs. *precocious* – the consistent long vowels are likely due to a restriction that 'true' prefixes in English must be bimoraic; see McCarthy and Prince 1994b), there is a great deal of variation in whether words with opaque Latinate prefixation have stressed or stressless initial pretonic syllables. In general, more common words have stressless initials, while more learned words have stressed initials (Fidelholtz 1975). To give a sense of the sort of variation that occurs, the lists in (60) provide examples of words with historical Latinate prefixes that are transcribed by Kenyon and Knott (1953) as stressless, stressed, or with both stressed and stressless variants. I have indicated in brackets instances in which Webster's 1981 disagrees with Kenyon and Knott. A plus sign (+) means that Webster's transcribes the initial syllable of the word as stressed, a minus sign (−) stressless, and an equal sign (=) both stressed and stressless:

**(60)** **a. Stressless:**
administer, admire, absolve, admonitory, advance, advantage, adversity (+), advise, combat (v.), combust, companion, compassion, compose, compress, compulsion, concur, concern, condemn, conduct, confection, confer, conflate, conflict (v.), congressional, controller, convenient, convention, embarrass, embody, embrace, endeavour, endow, engage, enjoin, enjoy, enlarge, enlighten, entice, entire, exact, example, exceed, except, excoriate, excrete, excursion, excuse, executive, exhume, expose, express, extend, extinguish, extravagance, extraneous (+), extreme, object (v.), obsequious (=), observe, obsess (=), obstetric, obstruct, obtain, obtrude, obtuse, obvert, proceed, produce, profess, profound, project, prolong, promote, propel, propose, protect, propose

**b. Stressless or stressed:**
abdominal, abduct (+), abhor (−), absorb (−), abstemious (+), abstract (v.), abstruse, absurd (−), abnormal (+), accelerate, accentuate, accept, accessible, accessory, acknowledge, adhere, admit (−), admixture (+), admonish (+), adverse (+), adverbial, concelebrate, concoct, concordance, eccentric, emphatic, exhale (+), obscene, obscure, obverse, pronomial (+)

**c. Stressed:**
abjure, abscise, abscissa, abscond, access (v.), admeasure, adsorb, advection, agnomen, concrete (v.), concretion (=), conglobate (=), concur (=), empiric (−), emporium (=), enteric, excreta, excursus, exogamy, expropriate, exsect, extrinsic, obtest, obtund, progenitor, proliferate (−), proscenium, prosector, protract (=), protrude

Since the more common words tend to be reduced, for this set of words, it would seem that pretonic stresslessness is productive. This is confirmed by the existence of a number of derived words in which pretonic stresslessness occurs on syllables that are stressed in the stems:[17]

**(61)** áccèss, accéssible; ádverb, advérbial; cóncòrd, concórdance; cóngress, congréssional; émphasis, emphátic; éxecùte, exécutive, exécutor

The presence of full stressed vowels in the stems precludes an analysis of the pretonic stresslessness of these words in terms of faithfulness to any prosodic or segmental feature. These stressless heavy syllables must therefore be generated by the grammar. To capture the productivity of this pattern, we can posit a lexically specific version of STRESSWELL ('no stress/main stress adjacency'), which I will refer to as STRESSWELL-$\mathcal{L}_3$, that dominates PARSE-σ. For a typical speaker, the set '$\mathcal{L}_3$' would include most of the words in (60a), some of the words in (60b), but few of those in (60c).[18] The result of this lexically specific ranking is illustrated in (62):

[17] Liberman and Prince (1977: 285) note what might be another two cases of this type: "In the words *concave*, *convex*, the prefix retains stress; curiously, in the derivatives *concavity*, *convexity* it seems easily destressable." However, in Kenyon and Knott 1953, the stems and the derivatives are equally given with both stressed and stressless initial syllables, while in Webster's 1981, both *concave* and *concavity* have only stressed initials. Here, as well as for the rest of the special cases discussed in §2.3, careful study of the pronunciations of native speakers would be extremely informative (see in this regard the next footnote).

[18] I assume that variation in the pronunciation of individual words here and elsewhere in this section is due to interspeaker variation. That two competing productive patterns would produce a great deal of variation is to be expected. If closer study reveals that this variation occurs within individual speakers, then one might appeal to the "floating constraint" formalism proposed by Reynolds (1995), which is quite consistent with the approach to lexically based variation taken here.

**(62) STRESSWELL-$\mathcal{L}_3$ » PARSE-σ**

| Input: *advantage* | STRESSWELL-$\mathcal{L}_3$ | PARSE-σ |
|---|---|---|
| (àd)(ván)tage | * ! | * |
| ad(ván)tage ✓ | | ** |

For words that are subject to STRESSWELL-$\mathcal{L}_3$, pretonic stresslessness is preferred, even though this results in an extra PARSE-σ violation (that is, in addition to the one made necessary by the dominance of NONFINALITY). For words that are not targeted by STRESSWELL-$\mathcal{L}_3$ the extra PARSE-σ violation makes pretonic stresslessness ungrammatical, since as shown in §2.1.2, PARSE-σ dominates the general STRESSWELL constraint.

The effects of this ranking can also be seen outside of the domain of words based on Latinate prefixes. First of all, as one might expect, there are words with stressless initial heavy syllables that superficially resemble those in (60), but do not in fact contain Latinate prefixes:

**(63)** agnóstic, confétti, conquistador, obsídian

There are also some monomorphemic words that bear less of a resemblance to the words in (60), but yet can have stressless initial syllables. All of the words in (64) are given in either Kenyon and Knott 1953 or Webster's 1981 with at least a variant with a stressless initial:[19]

**(64)** ambássador, Atlánta, Atlántic, Kentúcky, Manháttan, Septémber, sincére

---

[19] I exclude from this list words like Vermont, and Berlin, since as Liberman and Prince (1977: 284) note, *[vɛrmánt] and *[bɛrlín] are impossible in English. There must therefore be some independent constraint that forces coalescence between /ɛ/ and /r/ in this environment, making these in effect light syllables.

Outside of Latinate prefixation too, initial heavy syllable stresslessness appears to be productively generated. Initial reduction of such closed syllables is "restricted to words of considerable frequency" (Kager 1989: 142, citing Fidelholtz 1975). This would seem an odd restriction on an entirely extrasystemic pattern (which is how it has usually been treated). Furthermore, there are examples of destressing in derivation. Most of these cases involve long vowels (65a), but there is at least one instance of each a sonorant-final (65b), and an obstruent-final syllable (65c) becoming destressed in a derived word. Again, variation runs rampant here.

**(65)** a. Pláto, platónic; phóne, phonólogy; vácàte, vacátion; schéma, schemátic; légal, legálity; démon, demónic; régal, regálity; fátal, fatálity; phótogràph, photógraphy

b. sénse, sensátion

c. spéctacle, spectácular

So far, we have looked only at initial syllables. However, the ranking STRESSWELL-$\mathcal{L}_3$ » PARSE-σ generalizes to medial environments as well. Recall that in the present account, the dominance of PARSE-σ over STRESSWELL also generates stress on the pretonic syllable of words like *Halicarnassus*. The productivity of stress in this environment was demonstrated by words like *argumentation*, in which a stressless syllable in the stem becomes stressed. There are, however, monomorphemic words that lack stress on such syllables:

**(66)** Kilimanjáro Nèbuchadnézzar èlecampáne

We also find instances of productive destressing here. Liberman and Prince (1977:298) note that *sèntimentálity* optionally occurs, though *sèntiméntal* bears a stress on the corresponding syllable. To this example we can add those in (67a) and (67b). All of them appear in Webster's 1981; all have variants with pretonic stress.

(67) a. instruméntal, instrumentálity; rècomménd, rècommendátion; óriènt, òrientátion; represent, rèpresentátion

b. rétrogràde, rètrogradátion; cívilize, civilizátion; stándardize, stàndardizátion; párasite, pàrasitólogy

This too results from StressWell-$\mathcal{L}_3$ » Parse-σ:

**(68) StressWell-$\mathcal{L}_3$ » Parse-σ**

| Input: *Kilimanjaro* | StressWell-$\mathcal{L}_3$ | Parse-σ |
|---|---|---|
| (Kìli)(màn)(járo) | *! | * |
| (Kìli)mn(járo) ✓ | | ** |

Finally, as Kager (1989:125) notes, there is one clear exception to the generalization that pretonic obstruent final syllables retain stress when preceded by a heavy syllable: *diagnósis*.[20] Since Parse-σ dominates Weight-to-Stress, by transitivity StressWell-$\mathcal{L}_3$ also does. Therefore, this exceptionally unstressed heavy syllable, whose superficial resemblance to a

[20] Kager (1989: 125) also cites *indignation* as a counter-example, though his transcription provides a stress on the pretonic syllable. The stressed version is in agreement with Kenyon and Knott (1953), and Webster's (1981). This example highlights the difficulties in attributing stress or stresselessness to [I] - note that [ɛ] and [iʸ] often reduce to something like [I], rather that schwa. The present study follows previous studies of English stress in abstracting from the difficulties of accounting for various realizations of the reduced vowel.

Latinate prefix is perhaps not entirely a coincidence, can also be attributed to the lexically specific ranking of STRESSWELL.

In sum, in this section I have shown that stresslessness on lone heavy syllables is productive, at least for a lexically restricted group of words. In §1.3, it was demonstrated that for the bulk of the vocabulary, stress on such syllables is the norm and is productive. Stress in this context is produced by the ranking PARSE-σ » STRESSWELL, while stresslessness is induced by a lexically specific ranking of STRESSWELL-$\mathcal{L}_3$ » PARSE-σ. The difference between the unproductive exceptions like *chìmpànzée*, which were accounted for via faithfulness, and these productive exceptions, is well captured by a model in which unproductive exceptions are encoded with phonological structure in the lexicon, and an appropriate ranking of a faithfulness constraint, while productive exceptions are accounted for entirely in the grammar, through reranking (Inkelas, Orgun, and Zoll 1994, Inkelas to appear). Though there is some overlap between the empirical coverage of these formal mechnisms, and though criteria of productivity are notoriously contentious and difficult to define, it seems clear that lexically specific ranking, and exceptional lexical specification, have separate roles to fulfill, and that neither one can be eliminated from the theory.

### *2.3.6 Remarks on special secondary stress*

The most important point about the analysis of special secondary stress presented here is that it does not overgenerate. This contrasts with the account of lexical variation in Halle and Kenstowicz 1991, which invokes lexically conditioned rules of weight-to-stress and Stress Copy. Instead of completely shutting down weight effects, as the lexically specific weight-to-stress rule does, the lexically specific ranking of STRESSWELL alters the relative strengths of some of the relevant constraints. Crucially, this reranking does not subordinate WEIGHT-TO-STRESS or *SONNUC to ALIGN-LEFT. Therefore, the grammar constructed here does not generate unattested forms such as **Mònongahéla*. Further, the lexically specific ranking of STRESSWELL does not favour **Ticonderóga* over the correct *Ticònderóga*, since adjacent stresses are not militated against by STRESSWELL, only stress adjacent to the primary stress. If secondary stress weight effects can be turned off arbitrarily, as in Halle and Kenstowicz 1991, then there is no reason why these unattested forms should not be generated alongside the perfectly regular *Tàtamagóuchi*.

Halle and Kenstowicz's (1991) use of the lexically conditioned Accent Rule for *còndènsátion*-type words is in part motivated by the observation that stem stress is not consistently preserved in this environment, as demonstrated by words like *infomátion*. Instead of denying that stem stress plays any role, as that analysis implies, the lexically specific STRESSIDENT constraints allow faithfulness to stem stress to vary somewhat between words. Because faithfulness, rather than syllable weight, is called upon to motivate the pretonic stress in *còndènsátion*, pretonic stress in a word like *còncentrátion*, in which the stem lacks stress on the corresponding syllable, is ruled out. Also, since STRESSIDENT is ranked above ALIGN-LEFT, left alignment of words like *imàginátion* is impossible, though it is predicted to occur under the assumption either of a lexically conditioned rule of Stress Copy (Halle and Vergnaud 1987; Halle and Kenstowicz 1991; cf. Burzio 1994: 192), or of morphological reanalysis (Chomsky and Halle 1968; Halle and Vergnaud 1987).

It appears that here too, it is the *all or nothing* characteristic of full satisfaction that is at the root of the empirical shortcomings of these prior analyses. The precision of the present account of the lexical influences on the weight-to-secondary stress relationship is not bought at the cost of generality. As we have seen, the lexically specific ranking of STRESSWELL provides a unified account of a number of exceptional patterns of heavy syllable stresslessness. And by placing the faithfulness constraint STRESSIDENT and its lexically specific counterpart into the hierarchy established for regular stress, the same principles that determine regular prosodification are used to control the extent to which stem and underlying stress can alter the usual pattern of secondary stress.

### 2.4 Final Hierarchy and Conclusions

The hierarchy now stands as in (69). Underneath the hierarchy are examples from the sets of words targeted by the lexically specific constraints.

```
(69)        FTBIN, TROCH
                 |
            ALIGN-HEAD-ℒ
                 |
             NONFINALITY
                 |
            ALIGN-HEAD
             /   |
            / STRESSWELL-ℒ_3
           /     |        *OBSNUC
          /   PARSE-σ     /
STRESSIDENT-ℒ_2  |       /
          \  WEIGHT-TO-STRESS
           \     |
            STRESSWELL
            /    |
 STRESSIDENT *SONNUC, WEIGHT-IDENT
            \    |
            ALIGN-LEFT
```

Where $\mathcal{L}$ = {vanilla, Manhattan, Mississippi, banana, spaghetti ...}
$\mathcal{L}_2$ = {chimpanzee, condensation, creativity, contestation...}
$\mathcal{L}_3$ = {admire, companion, entire, expose, present, Atlanta, Manhattan, Kilimanjaro, representation...}

Throughout this chapter, the difficulties that nonuniformity creates for analyses based on full satisfaction have been pointed out, and have been overcome through the adoption of minimal violation and constraint ranking. There is little novel in the constraints themselves; the main innovation here consists of the ways in which they are made to interact.

A crucial aspect of this analysis is that the relative rankings of the constraints are validated across the various domains investigated. For instance, the low rank of ALIGN-LEFT that is motivated by the non-aligned leftmost stress in words like *Monòngahèla* is also required to explain the preference for rightmost main stress (e.g. *Amèrica*), and for stress preservation (e.g. *imàginátion*), over left-alignment. A dominant FTBIN is an essential ingredient in the analysis of the lack of heavy syllable stress in words like *Alexánder*, as well as in the absence of initial light syllable stress in *banána*; its high rank is supported in primary stress by the violation of ALIGN-HEAD that it compels in words with light penults (e.g. *Cánada*), and in lexical and stem based stress by the non-preservation of stress in instances in which this would create a monomoraic foot (e.g. **Mòntèbéllo* and **phònètícian*). This sort of coherence provides added reason to believe that this approach to nonuniform weight-to-stress and stress preservation effects is on the right track.

## Appendix A: Initial monomoraic stress preservation

The analysis in the text succeeds in fully accounting for the distribution of regular and exceptional stress on pretonic heavy syllables. There is, however, a residue of exceptionally stressed light syllables that remain to some extent intractable to it. Examples of lexical stress are in (70):

**(70)** ràcóon bàbóon èffáce vàmóose sùttée sèttée èffête bàssóon
càfféine Èssène èrráta Còlléen fèllátio illúsion Hippócrates

And of stem-based stress in (71):

**(71)** fáscist, fàscístic; léprosy, lèprótic; ánarchy, ànárchic; gémma, gèmmátion
hérald, hèráldic; módern, mòdérnity; Áaron, Àarónic; ácid, àcídic; Ítaly, Ìtálian
rábbi, ràbbínical; éthic, èthícian; Héllène, Hèllénic; lípid, lipídic; clínic, clinícian
mámmal, màmmálian; métric, mètrícian; sùm, sùmmátion

It should be noted that many of the words in both (70) and (71) have alternate pronunciations with unstressed initial syllables. This is not unlike the situation for words like *condensation* and *condemnation*, both of which appear in Webster's 1981 with both full and reduced pretonic vowels (Kenyon and Knott 1953 give *condensation* with only a full pretonic vowel, and the rest of the words like it with full and reduced variants). The present pattern is also similar to the *condensation/chimpanzee* one in that monomorphemic words with stress in this position are grossly outnumbered by ones without, and that derived words productively destress, but do not stress, these syllables. All of these facts serve as diagnostics of the unproductive nature of this pattern, which as we have seen, is well captured by an analysis based on faithfulness to underlying or stem stress.

Another benefit of an analysis based on faithfulness is that the restriction of exceptionally stressed monomoraic syllables to initial position can be derived from principles active in the grammars of other languages. Work by Selkirk (1994) and Beckman (1995) (see also Steriade 1993; Flemming 1994) shows that faithfulness constraints are sensitive to the morphological or prosodic position of the targeted element. For example, in Shona, contrastive vowel height occurs only in the first syllable of a root. Beckman (1995) attributes this to a position-sensitive faithfulness constraint demanding identity in height values between correspondent segments in root-initial syllables, which is ranked higher than the general vowel height faithfulness constraint. Given the formal equivalence between featural faithfulness and prosodic faithfulness constraints, it is natural that prosodic faithfulness should also be position-sensitive. In the present case, by ranking a positional STRESSIDENT constraint above FTBIN, the restricted distribution of monomoraic feet can be generated.

While such analysis explains why monomoraic feet occur only initially, there are a couple of remaining problems. McCarthy and Prince (1986) ascribe the ill-formedness of words like */bæ/, */tɛ/, and */pɪ/ to their consisting of monomoraic feet, which violate Foot Binarity. If, however, initial monomoraic syllables can exceptionally be parsed, as the data in (70) and (71) taken at face value do imply, then there is no reason why a lone monomoraic syllable should not be exceptionally parsed, as it is of course initial. The bimoraic word minimum, however, is exceptionless. Note that one could not simply reinterpret word minimality as a restriction on the size of the head of a Prosodic Word, as exceptional monomoraic primary stresses also occur (e.g. *Sémìte*, and *éssày*).[21]

The tension between the existence of these exceptional monomoraic feet and the absoluteness of the bimoraic word minimum is a generally unresolved problem. One way of avoiding it is to deny that these initial syllables are parsed into feet, and treat them instead as accented but unfooted, or more radically, as unfooted and unaccented, but unreduced (cf. Kager 1989: 142, Burzio 1994). To make this consistent with the rest of the text account, we would need to introduce a violable constraint that demands that an accented syllable be the head of a foot, or for the more radical view, that a full vowel be stressed, so that in the usual cases discussed in the text, full vowels, accent, and headship are correlated. Initial accent preservation would then be generated by ranking positional stress (or vowel quality) faithfulness[22] above the head/accent correlation constraint (*✓rà(cóon)*), but below FTBIN

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[21] One way of generating these exceptional monomoraic main stresses is to have a lexically specific version of NONFINALITY that outranks FTBIN. Like the lexically specific STRESSWELL, this constraint would apply primarily, but not exclusively, to words containing bound affixes – in this case the suffixes *-ite*, *-oid*, and *-ode* (e.g. *Semite*, *cathode*, *lithoid* – see Liberman and Prince 1977: 305). This would not interfere with a FTBIN-based analysis of word minimality, since when the input is monosyllabic, NONFINALITY is rendered inactive by the dominance of LEX≈PR, that is, by the requirement that lexical words be prosodified (Prince and Smolensky 1993). An interesting related observation is that words of this shape (i.e. LH) are regularly end-stressed (Oehrle 1971; Liberman and Prince 1977: 299). This suggests that the regular pattern is for FTBIN to dominate NONFINALITY, and that these constraints are actively competing.

[22] One consequence of the stress-based version of this analysis, though, is that it would require an extension of the theory of prosodic faithfulness in McCarthy (1995) to handle direct preservation of prominence. In McCarthy (1995), prominence is only preserved indirectly, through faithfulness to the prosodic role of segments. Insofar as the patterns of 'stress preservation' discussed in this paper are idiosyncratic to English, which can only be established through further research, it may be in fact preferable to treat them as vowel quality preservation instead, and leave the theory of prosodic faithfulness alone. The prediction this would make is that English-like stress preservation should only occur in languages with vowel reduction.

(*(rà)(cóon)). The latter ranking would enable these facts to be brought in line with the aforementioned analysis of word minimality, since it requires FTBIN to dominate positional faithfulness.

## Appendix B: Differences between lexical and stem based stress

In the text, I emphasize the parallels between lexical and stem based stress, in order to motivate a unified analysis of them. There are, however, a series of fairly subtle differences between the distribution of these two types of special stress. Interestingly, the gaps are always in the area of lexical stress: in all of these cases, we find examples of stem stress preservation, but no parallel ones of lexical exceptionality.

First, there is a group of words which preserve stem stress on a pretonic syllable, and leave the preceding initial syllable unstressed. Here are two of the more robust examples (Kager 1989: 171):[23]

(72) apártment, apàrtméntal; seléctive, selèctívity

In these examples, faithfulness to stem stress causes a violation of PARSE-σ (or perhaps TROCH), as well as of the lower ranked STRESSWELL. There are no instances of similar PARSE-σ violations in underived words.

Second, monomorphemic words with a medial stressed pretonic long vowel, parallel to *cìvilìzátion*, do not seem to exist. Similarly, there is a rather long list of derived words with binary pretonic strings in which the second syllable retains a stressed long vowel:

(77) còmmùnálity, cònglòbátion, crèatívity, dènòtátion, èxcitátion, èxclùsívity, èxhùmátion, èxùdátion, ìmmòbílity, òsmòlárity, trìlòbátion

---

[23] A full account of words like those in (77) will also have to deal with the complications induced by the instances of apparent monomoraic feet (*àcòustícian*) and vowel lengthening (*dòmèstícity*) that seem to occur as alternatives to PARSE-σ violations (see Kager 1989: 171 for further examples).

There are no attested underived words with long vowels in this position.

The final difference between lexical and stem based stress of which I am aware involves pretonic *-Vs-* clusters. These often preserve stem stress:

(78) còntèstátion, dètèstátion, dòmèsticity, èlàsticity, incrùstátion, infèstátion, mòlèstátion, òbtèstátion, pròtèstátion

Again, there are no reported monomorphemic words with stress on a medial *-Vs-* cluster (Kager 1993: 124).

There are two possible reactions to these disparities between the two types of exceptional stress, and as the choice seems rather arbitrary, I leave it open. One alternative is to treat the absence of monomorphemic words in each case as an accidental gap, which is especially reasonable given that these patterns are subject to regularization – stress tends to disappear on these pretonic syllables as words become more frequent – and that English is generally a poor source of underived words with multisyllabic pretonic strings (note the prevalence of North American place names and Biblical names in example lists). If, on the other hand, these distributional differences between lexical and stem based stress are thought to merit a grammatical account, one could specify STRESSIDENT as applying to either lexical-surface correspondent pairs (STRESSIDENT-LS), or to stem-stem pairs (STRESSIDENT-SS), a move that is consistent with McCarthy's (1996) well-motivated use of separate lexical-surface, and stem-stem faithfulness constraints in his analysis of Rotuman. Under this account, a lexically specific STRESSIDENT-SS would outrank PARSE-σ (for the forms in (76)), as well as whatever constraints rule out monomorphemic words parallel to those in (77) and (78). STRESSIDENT-LS, on the other hand, would be dominated by these constraints.

## Appendix C: The Luxipalilla problem

As an account of regular pretonic secondary stress assignment, this analysis remains incomplete in only one respect. For words containing the pretonic string HLL-, like *Luxipalilla*, it incorrectly predicts *(Lùx)(ipa)(lílla), since this parsing respects all of PARSE-σ, FTBIN, and STRESSWELL. However, it appears that some relatively unorthodox representational assumptions are needed to deal properly with words of this type. In the text, I have employed more standard representations that allow attention to be focused squarely on the issues surrounding nonuniformity, because the evidence that motivates the unorthodox representations is somewhat orthogonal to the discussion of weight-to-stress and stress preservation.

The important, and often neglected fact about pretonic dactyls is that the onset of the final syllable is aspirated, and unflapped (in the case of [t]) (Withgott 1982: 146, Gussenhoven 1986: 133, Jensen 1993: 106). This contrasts with consonants that are onsets to a word-final syllable, even though the immediate environment is identical; in both cases, the consonants are flanked by reduced vowels (compare *Mèditerránean*, *Mánitowòc* and *Nàvratilóva* with *cápital* and *autómata*). In this respect, these consonants are behaving as if they are foot-initial (*potáto*), or Prosodic Word-initial (*tomáto*). Thus, while either violating PARSE-σ, as in (Lùxi)pa(lílla), or FTBIN, as in (Lùxipa)(lílla) would yield the correct distribution of stress, neither parsing is consistent with the consonantal allophony.

The simplest way to make these syllables foot-initial would be to posit an iambic foot. However, if iambicity is permitted here, then it is difficult to see how one would give an account of the usual pattern of antepenultimate noun stress. Furthermore, this would make the main stress non-initial in its foot, counter to the evidence from aspiration. Thus, it seems necessary to either set up another level of foot structure, as in the 'superfoot' of early metrical phonology, so that these syllables are incorporated as foot-initial (Prince 1980; cf. Itô and Mester 1992), or to posit recursive Prosodic Word structure (McCarthy and Prince 1993a Kager to appear), so that they are PrWd-initial.

Whatever the proper analysis of these initial dactyls turns out to be, there are two related facts that must be accounted for. First, weight related constraints, and stem stress preservation both consistently override the stresslessness of the second syllable in the HσL-sequence (e.g. *Ticònderóga* and *icònoclástic*). Second, flapping is preserved from the stem in this environment (e.g. *càpitalístic* vs. *militarístic*; Withgott 1982). As flapping is allophonic in English, this last fact may provide motivation for the Stem-to-Stem correspondence account of morphological relatedness assumed here (see Benua 1995, and McCarthy 1996), though it could also be that the flapping is derivable from prosodic differences between the words, which may or may not ultimately require Stem-to-Stem correspondence to explain (cf. Cohn and McCarthy 1994).

## Preface to Chapter 3

In this chapter, we turn from an examination of the interaction of prosodic constraints in the stress system of English, to the study of prosodic constraints in child English. In an early stage of development, words are maximally one foot in size, with longer words being truncated (e.g. spaghetti -> geti). Following work on Prosodic Morphology by McCarthy and Prince (1994), I provide an account of this word size maximum in terms of the interaction of a set of well-motivated prosodic constraints. I then show that the child system differs from the prosodic system of adult English in that these constraints are fully satisfied only in the former. In the final state, faithfulness constraints are ranked higher than the prosodic constraints, thus blocking truncation. However, the prosodic constraints continue to play a demonstrable role in the system. Thus, the constraints are outranked, not turned off.

The basic pattern of reduction to a single foot is well known and well described in the literature. However, when the adult target is an initially stressed trisyllable (e.g. elephant) it has been variously claimed that the stressed and the medial syllables, or the stressed and rightmost syllables, are usually preserved in a child's truncated production. An examination of the relevant forms in a large corpus of previously unpublished data on the acquisition of English shows unequivocally that the usual pattern is to preserve the stressed and rightmost syllables (Echols and Newport 1992), and that apparent exceptions are due to the selection of the least marked onset. This pattern of onset selection provides evidence of minimal violation in the child system itself, since marked onsets are elsewhere well tolerated.

The final section documents a case of minimal violation across developmental stages, this time in the gradual relaxation, or limitation, of a "consonant harmony constraint". The constraints limiting consonant harmony are also shown to play a role in onset selection.

# Chapter 3

## Minimal Violation and Phonological Development

### 3.0 Introduction

The chief innovation of the approach to phonology taken in Optimality Theory (Prince and Smolensky 1993) lies in its claim that constraints are *minimally violable*; that a constraint can be violated if and only if its satisfaction would interfere with the demands of a higher ranked constraint. This can be contrasted with the usually implicit view that an active constraint is inviolable at the level at which it applies. Prince (1993), as well as Chapter 2 above, specifically discuss the types of explanatory gains made possible by the adoption of minimal violation in analyses of phonological phenomena. Extensive discussion of the results of this shift in theoretical assumptions can be found in Prince and Smolensky (1993), in the work of McCarthy and Prince (1993a, 1993b, 1994a, 1994b, 1995), and in the papers collected in Beckman, Walsh, and Urbanczyk 1995, as well as in the Rutgers Optimality Archive (http://ruccs.rutgers.edu/roa.html).

The goal of the present paper is to show that minimal violation also leads to an improved understanding of phonological development. It is a common observation that the speech of young children is subject to strict constraints on the phonetic shape of utterances that are overcome in the course of development. If constraints must be fully satisfied, then to overcome one is to render it completely impotent.[1] If on the other hand constraints are minimally violable, a constraint that is overcome is not necessarily shut off. When a constraint is outranked by another, it will continue to be satisfied wherever it does not conflict with the

[1] See §3.3 below, as well as chapter 2, for discussion of the mechanisms by which the effects of inviolable constraints might be limited, rather than fully suppressed. For the present, suffice it to say that in a theory that assumes fully satisfied constraints, incomplete satisfaction requires some special explanation.

requirements of the dominating constraint. Under this view, the effects of a child language constraint that is overcome could persist in sometimes quite subtle ways through successive developmental stages and into the mature system.

One much discussed restriction on the phonetic shape of child language is a bisyllabic maximum on word size, which applies at about age two. When a child at this stage attempts words whose adult forms are larger, they are truncated, so as to conform to the size limit. This has been extensively documented in both child English and child Dutch (Holmes 1927: 224; Allen and Hawkins 1978; Ingram 1978; Echols and Newport 1992; Fee 1992, 1995; Fikkert 1994; Gerken 1994; Wijnen, Krikhaar and den Os 1994; Demuth 1995; and Demuth and Fee 1995). While the existing accounts of this restriction are quite varied in their theoretical premises and in the details of their analyses, they agree that whatever constraint is responsible for this word size maximum is unique to the child system, and disappears during development, so as to play no role in the adult language.[2]

Since words in Dutch and English routinely exceed two syllables in length, such a conclusion may seem inevitable. In the first section of this paper, I suggest that contrary to initial appearances, the constraints responsible for the word size maximum do indeed play a role in the adult language, in particular, in the English stress system. Adapting work on prosodic morphology by McCarthy and Prince (1994), I show that the child language restriction can be reduced to the satisfaction of several well-motivated prosodic constraints.

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[2] As will be discussed below, accounts that define the restriction in prosodic terms (Fee 1992, 1995; Fikkert 1994; Demuth 1995; Demuth and Fee 1995) draw a connection between the child language constraint and constraints active cross-linguistically. They mostly agree with other accounts, though, that the restriction is not part of adult English or Dutch (with the important exception of the discussion of hypocoristic formation in Fee 1992, 1995).

I then demonstrate that while two of these constraints are in fact violated in adult English, they continue to have effects in the English stress system. Instead of being freely violable, or turned off, they are minimally violable, or outranked.

Following the account of the word size maximum, I turn to the patterns of content preservation seen in the truncations of adult targets that exceed that size limit. The analysis of these patterns reveals an instance of minimal violation in the child system itself. To establish the empirical base for the analysis, I present previously unpublished data from an extensive corpus of spontaneous utterances produced by four English learning children (see Compton and Streeter 1977 for the method of data collection and preliminary analyses). These data provide strong support for Echols and Newport's (1992) contention that truncations of initially stressed trisyllables usually preserve the initial and final syllables, with the medial one being deleted (cf. Gerken 1994; Wijnen, Krikhaar and den Os 1994). All apparent cases of preservation of the medial rather than the final syllable can be attributed to the relative markedness of the onsets of these syllables: the medial syllable's onset is retained instead of the onset of the final syllable only when the former is less marked (i.e. less sonorous: e.g. [bʌfo] *buffalo*; cf. [ɛfɛ̃nt] *elephant*). This parallels better known cases of onset selection in initial truncation (e.g. [bun] for *balloon*). It is here that we find evidence of minimal violation. The constraint demanding unmarked onsets is violated at this stage of development, since marked (i.e. high sonority) onsets are usually well tolerated (e.g. [jɛwo] *yellow*). Its role in determining the output of truncation, however, shows that it is not turned off.

The third section of the paper is concerned with another well-known restriction on early child utterances: that within a word, and sometimes within a phrase (Donahue 1986), consonants must have the same place of articulation (Jespersen 1922: 109; Ferguson, Peizer and Weeks 1973; Smith 1973; Drachman 1976; Menn 1976, Cruttendon 1978; Vihman 1978; Spencer 1986; Stemberger and Stoel-Gammon 1991; McDonough and Myers 1991; Macken 1992, 1995; Levelt 1994, 1995; Stoel-Gammon and Stemberger 1994; Stemberger 1995; Dinnsen, Barlow, and Morrisette 1996; Goad 1996, to appear). This restriction, often described as consonant harmony, is usually not stated as simply demanding agreement in place specification, since its application is normally limited in one or more ways. For instance, it is often the case that only coronals assimilate, so that words with a combination of labials and velars would violate a condition on place agreement. The claim here is that the limitations on the effects of this constraint are caused by its being dominated by constraints favoring a match between Input and Output representations (the Faithfulness constraints of McCarthy and Prince 1995). Again drawing on the corpus described in Compton and Streeter (1977), I provide evidence of a developmental progression in which this constraint is first fully satisfied, and then violated when its satisfaction would require a non-coronal consonant to be altered (i.e. Stage 1: [gɔg] *dog*, [gak] *box*; Stage 2: [gɔg] *dog*, [bɔks] *box*). Following the presentation of this further evidence for the view of development as constraint reranking, the paper concludes with a discussion of some prospects and problems for further research within this framework.

### 3.1 The Prosody of Child and Adult English

Child language researchers have long recognized an early stage in which words are maximally bisyllabic, and longer adult targets are truncated. Perhaps the earliest record of this stage is in Holmes' (1927:224) description of his daughter Mollie's speech: "A word of more than two syllables seems to be consistently reduced to two. Presumably that was Mollie's syllable span."

Subsequent research has shown that the binary "syllable span" is not quite descriptively accurate. Bisyllables can be truncated as well, if they are finally, rather than initially stressed. The following near minimal pairs, produced by an English learning child, illustrate the difference between initially and finally stressed bisyllables (from Trevor's corpus; see §3.2 for details on the source, and for more truncation examples). Age is given in parentheses as *years;months.days*.

| | | | | |
|---|---|---|---|---|
| (1) | a. [gaːbɛʤ] | garbage (1;10.5) | [wæːdɪt] | rabbit (1;9.2) |
| | b. [gaːʤ] | garage (1;10.5) | [wæːf] | giraffe (1;9.1) |

As is typical of children at this stage, initially stressed bisyllables (1a) are produced intact, while finally stressed ones (1b) are reduced to monosyllables. This asymmetry between 'σσ and σ'σ sequences shows up again in truncated productions of trisyllables with medial stress. The final two syllables, which form the preferred 'σσ shape, are consistently retained. Here again are some examples from Trevor:

| | | |
|---|---|---|
| (2) | a. [teːdo] | potato (1;10.2) |
| | b. [gɛːdi] | spaghetti (1;9.2) |
| | c. [gɛːdɚ] | together (1;10.1) |

The 'σσ unit that is preserved in these utterances is in fact the canonical left-headed foot (or trochee) of the English stress system (Hayes 1982, Kager 1989, Chapter 2 above; cf. Burzio 1995). The maximum word size of early child English is thus properly characterized not as a bisyllable, but rather as a foot.

To formally express this child language word size maximum, Allen and Hawkins (1978), Gerken (1994), and Wijnen, Krikhaar and den Os (1994) invoke templates that restrict children's words to a single SW rhythmic sequence (Strong/Weak, i.e. stressed/unstressed), while Fee (1992) and Fikkert (1994) use a prosodically based Minimal Word template that imposes a single foot limit.

While based on somewhat different theoretical premises, these accounts share a common strength, and a common weakness. They all capture the convergence between the prosodic or rhythmic structure of child language, and that of the adult system, since under these analyses, children are making use of the basic prosodic or rhythmic unit of the mature language. The shared weakness, however, is that the child language limit of one foot, or SW unit, per word, is simply stipulated.

In what follows, I adopt the framework of Optimality Theory (Prince and Smolensky 1993) to show that the monopedal maximum of child language can in fact be derived from the interaction of independently motivated prosodic constraints, and that these constraints continue to play an active role in the stress system of adult English.

*3.1.1 The Size Restriction Derived*

The analysis of the size restriction to be presented here starts from the important observation that the maximal size of words in early child language is equivalent to the Minimal Word of many adult languages (Fee 1992, 1995; Fikkert 1994).

The cross-linguistic import of the Minimal Word was first demonstrated in McCarthy and Prince (1986). As its name implies, the Minimal Word usually sets a lower bound on word size. For example, in Diyari, bisyllabic *kaŋa* 'man' is well-formed, while monosyllabic lexical words such as **ka* are nonexistent (Austin 1981, McCarthy and Prince 1986). McCarthy and Prince (1986) derive this restriction from the interaction of the prosodic hierarchy (3) with a principle of Foot Binarity (Prince 1980).

(3) **Prosodic Hierarchy** (Selkirk 1980)

| | |
|---|---|
| PrWd | Prosodic Word |
| \| | |
| Ft | Foot |
| \| | |
| σ | Syllable |
| \| | |
| μ | Mora |

The prosodic hierarchy is a hierarchy of constituency, with members of each level being grouped into a constituent of the next level above. Morae are organized into syllables, syllables into feet, and so on. It appears to be a universal of prosodic representation that every constituent must have a head; that is, that it contain an element from the next level below (see Selkirk 1995). If every Prosodic Word must contain a foot, and if by the principle of Foot

Binarity feet must be binary at either the moraic or syllabic level, then it follows that every word must be bisyllabic or bimoraic. In a language like Diyari, which does not permit bimoraic syllables, the result is a bisyllabic minimum.

The Minimal Word sets an upper limit on size in much more restricted circumstances in adult languages. Conveniently, Diyari also provides an example of the Minimal Word as maximum. Reduplication fully copies bisyllabic words (4a). When the word is longer, only the first two syllables are reduplicated (4b).

(4) **Diyari Reduplication**

| *Stem* | *Reduplicated form* | |
|---|---|---|
| a. kanku | kanku-kanku | 'boy' |
| b. kukuŋa | kuku-kukuŋa | 'to jump' |

To explain this pattern of reduplication, McCarthy and Prince (1986) posit a Minimal Word template as the lexical form of the reduplicant.

The parallel between the shape of the Diyari reduplicant and children's early productions is interesting. However, to simply state that children's early words are Minimal seems insufficient: one would like an explanation for why this should be so. Demuth and Fee (1995) suggest two such explanations. The first is that the prosodic hierarchy becomes available gradually, and that children at this stage have access only to the foot, and not to the Prosodic Word. I refer the reader to Demuth and Fee (1995), and Goad (1996b), for further development of this idea.

Here I will take up Demuth and Fee's other suggestion, which they do not pursue in any detail: that the Minimal Word is the unmarked Prosodic Word. Under this view, the connection between Diyari, and child language, is that unmarked structures are characteristic both of reduplication (Steriade 1988, McCarthy and Prince 1994a), and of the early stages of acquisition. The violability of constraints in Optimality Theory permits a definition of markedness that is extremely simple to state but rich in its implications: a form is marked if it violates a constraint (Smolensky 1993, McCarthy and Prince 1994a). Since every structure in all likelihood violates some constraint, this standard of markedness never makes absolute judgements; structures are not simply marked or unmarked. Rather, structures are marked or unmarked with respect to various dimensions of well-formedness, and we can compare the markedness of one structure to another along each of these dimensions.

Demuth (1995) provides an Optimality Theoretic analysis of child truncation in which a constraint that demands a minimal Prosodic Word outranks Faithfulness constraints. However, because it takes the unmarkedness of the minimal Prosodic Word to be a primitive notion, this analysis yields no explanatory dividends beyond those that are accrued by a Minimal Word template account. A different line of attack is taken in McCarthy and Prince's (1994a) reanalysis of Diyari reduplication (see further McCarthy and Prince 1994b and Urbanczyk 1996 on this atemplatic approach to Prosodic Morphology). They show that unmarkedness of the Minimal Word maximum can be explained in terms of its satisfaction of a few basic prosodic constraints, much in the same way that the Minimal Word minimum is reduced to the interaction of the prosodic hierarchy with Foot Binarity in McCarthy and Prince (1986). By extending this analysis to child language, we gain an explanation for the unmarkedness of child truncations.

The first ingredient in the analysis is an ALIGNMENT constraint. McCarthy and Prince (1993b) show that alignment of the edges of prosodic and morphological domains is the motive force behind a number of phonological and morpho-phonological processes (see also Selkirk's 1986 edge-based theory of the interface between syntax and prosody). Of special interest in the present context is that constraints of this type formally recognize the functional importance of word edges (see esp. Kager 1994), which has long been noted by acquisitionists (e.g. Slobin 1973; Echols and Newport 1992). The constraint needed here is one which demands coincidence of the edges of feet with the edge of the Prosodic Word. I follow McCarthy and Prince (1994) in invoking ALIGNLEFT, but ALIGNRIGHT would do as well:

(5) ALIGNLEFT
Align(Ft, L, PrWd, L)
'Align the left edge of every foot with the left edge of the Prosodic Word'

When a Prosodic Word consists of a single foot, as in (6a), ALIGNLEFT is fully satisfied. Any additional feet will fail to be aligned with the left edge of the Prosodic Word, and will cause a violation of this constraint, as in the bipedal (6b).

(6) a. $[(\sigma\sigma)_{Ft}]_{PrWd}$ : ✔ ALIGNLEFT b. $[(\sigma\sigma)_{Ft}(\sigma\sigma)_{\underline{Ft}}]_{PrWd}$ : *ALIGNLEFT

Fully satisfied, this constraint serves to limit words to a single foot. However, for the bisyllabic (6a) to be optimal, we also need an active constraint that forces syllables to be incorporated into feet. Most recent work in prosodic theory allows foot parsing to be non-exhaustive; syllables not parsed into feet can under certain circumstances be parsed directly by the Prosodic Word (see Kager 1989, Idsardi 1992, Itô and Mester 1992 as well as most subsequent literature on metrical phonology). As (7) illustrates, the addition of such a syllable would not violate Align-Left, and would create a trisyllabic word:

(7) $[(\sigma\sigma)_{Ft}\sigma]_{PrWd}$: ✔ ALIGNLEFT

Prince and Smolensky (1993) propose PARSE-σ as the constraint that punishes this sort of non-exhaustive parsing (8):

(8) PARSE-σ
Every syllable must belong to a foot

Combining ALIGNLEFT, and PARSE-σ with FTBIN derives the effect of the "Minimal Word template", since in concert they demand that a word consist of a single binary foot. The child language size restriction can thus be ascribed to the satisfaction of these three prosodic constraints.

The satisfaction of these prosodic constraints comes at the cost of violating Faithfulness. Constraints in Optimality Theory can be broadly divided into two groups. *Structural constraints*, like the prosodic constraints that have just been discussed, evaluate the well-formedness of the Output form. *Faithfulness constraints* evaluate the relationship between Input and Output (for present purposes underlying and surface form, though they can also be used to assess the relationship between structures at other levels). Structural constraints demand an Output that is perfectly formed according to their requirements, while Faithfulness constraints demand a perfect match between Input and Output. Much of

Optimality Theoretic phonology involves the resolution of conflicts between these two sets of demands.

I take the fairly standard assumption (since Smith 1973) that in child phonology, the Input is equivalent to the adult surface form (minus any perceptual losses; see e.g. Macken 1980), while the Output is the child's production (see Hale and Reiss 1996 and Smolensky 1996 for discussion in the context of Optimality Theory). From this it follows that child truncation involves a mismatch between Input and Output. In the Correspondence theory of Faithfulness (McCarthy and Prince 1995, and most subsequent work in Optimality Theory), Faithfulness violations are assessed by directly examining the relationship between the Input and the Output (cf. Prince and Smolensky 1993). The constraint violated by truncation is MAXI-O, which demands a full realization of all Input elements in the Output. The formal statement of this constraint, which can be paraphrased as '*No deletion*', is given in (9).

(9) MAX-IO

Every element in the Input has a Correspondent in the Output.

The violation of MAX-IO is compelled by its being ranked beneath ALIGNLEFT, PARSE-σ,and FTBIN. To illustrate why this ranking leads to truncation, I provide an illustrative tableau in (10).

The tableau compares the violations incurred by possible Output realizations of the Input form, referred to as candidates. Candidates are eliminated when they violate a constraint that another candidate satisfies. This process of evaluation starts with the highest ranked constraint, and continues on down the hierarchy until all but one candidate is eliminated. The candidate that remains is the optimal, or grammatical one. The conventions of the tableau are the following. Constraints separated by a solid line are ranked with respect to one another, while those separated by a dashed line are unranked. Constraints are unranked when their ranking cannot be determined by the data at hand, or because they do not conflict. The constraints are rank ordered left-to-right. Constraint violations incurred by each candidate are indicated by asterisks in the appropriate column, and an exclamation mark shows the violation that rules out a particular candidate. The optimal candidate receives a check mark to highlight its grammaticality. As our concerns are prosodic here, rather than segmental, orthography suffices to indicate the retained syllables.

**(10)** ALIGNLEFT, PARSE-σ, FTBIN >> MAXI-O

| Input: *hippopotamus* | ALIGNLEFT | PARSE-σ | FTBIN | MAXI-O |
|---|---|---|---|---|
| a. [(hippo)(pota)mus] | * ! | * | | |
| b.[(pota)mus] | | * ! | | ** |
| c. [(potamus)] | | | * ! | ** |
| d. [(hippo)(pomus)] | * ! | | | * |
| e. [(pomus)] ✔ | | | | *** |

Candidates (10a) through (10d) violate one or more of ALIGNLEFT, PARSE-σ, or FOOTBIN, for the reasons detailed above. It is important to keep in mind that PARSE-σ only demands that syllables in the Output representation be incorporated into feet; it says nothing about the Input-Output relation, which is of concern only to MAXI-O. For simplicity's sake, MAXI-O violations are here assessed in terms of the number of syllables deleted, rather than segments (cf. McCarthy and Prince 1995; McCarthy 1996). Because the three structural constraints are ranked above MAXI-O, the last candidate is optimal.

As the optimal candidate violates none of the structural constraints, and incurs no marks under them in the tableau, it is *structurally unmarked*, in the sense of McCarthy and Prince (1994). Under this analysis, child truncation can now be understood as an instance of the broader unmarkedness of child phonology (Jakobson 1941/68; Stampe 1969; Gnanadesikan 1995), rather than as a product of a specialized template. Furthermore, the constraints invoked in the present analysis are of wide generality. Their effects in the languages of the world are well documented in Prince and Smolensky (1993), and McCarthy and Prince (1993, 1994, 1995) amongst others, and in the next section, we will see that they in fact play a role in the stress system of English.

### *3.1.2 Development as Reranking*

As Menn (1980: 35-36) emphasizes in the following passage, constraint-based theories of phonology have long held considerable appeal for child phonologists:

> ...the child's "tonguetiedness," that overwhelming reality which Stampe and Jakobson both tried to capture with their respective formal structures, could be handled more felicitously if one represented the heavy articulatory limitations of the child by the formal device of output constraints...The child's gradual mastery of articulation then is formalized as a relaxation of those constraints

It is hence not surprising that a number of researchers have embraced Optimality Theory as a framework for the study of child pronunciations. Several have pursued the idea that the difference between the sound systems of child and adult language lies in a difference in the relative ranking of structural and Faithfulness constraints. As in the truncation example above, a lower ranking of Faithfulness constraints in child language produces the observed structural unmarkedness of child utterances (see especially Gnanadesikan 1995, as well as Demuth 1995, Levelt 1995, Stemberger 1995, Velleman 1995, Goad 1996, to appear; see also Hale and Reiss 1995, 1996 and Smolensky 1996 for discussion of foundational issues).

The potential of Optimality Theory as a framework for examining phonological *development* has yet to be much exploited, however. In all the cases studied to date, structural constraints that are active in child language become completely inactive in the mature grammar. In terms of development, these scenarios could equally be characterized as the elimination, or turning off of constraints.[3] A comparison of the prosody of adult and child English contributes an example of development as constraint reranking, in that structural constraints that are fully satisfied in child language are minimally violated in the adult language.

If all of FTBIN, ALIGNLEFT, and PARSE-σ were fully satisfied in adult English, then words would be maximally bisyllabic, as in child English. That larger words are permitted shows that these structural constraints are dominated. First of all, let us consider the adult parsing of *banána*. In this word, there is an unstressed, unfooted syllable at the left edge

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[3] Gnanadesikan 1995 provides evidence of minimal violation in the child system itself, which will be discussed with other examples of this type in §3.2.6.

(Kager 1989; §2 above), which violates both PARSE-σ, and ALIGN-LEFT. To compel these violations, the Faithfulness constraint MAXI-O must be ranked above both of these structural constraints, in reverse of the child language situtation in which it is subordinated to them. The tableau in (11) illustrates this aspect of the adult grammar.

(11)MAXI-O >> PARSE-σ, ALIGN-LEFT

| Input: banana | MAXI-O | ALIGNLEFT | PARSE-σ |
|---|---|---|---|
| a. (nana) | *! | | |
| b.ba(nana)✔ | | * | * |

If either PARSE-σ, or ALIGN-LEFT were ranked above MAXI-O, candidate (11a) would be preferred to candidate (11b). However, with MAXI-O dominating these two constraints, (11b) is correctly chosen as optimal.

This particular difference between the child and adult grammar is of the type that could be equally captured by constraint elimination, or parameter resetting. In what we have seen thus far, PARSE-σ, and ALIGN-LEFT are fully obeyed by the child, and entirely disregarded by the adult, so that instead of saying that they are outranked by MAXI-O in the adult grammar, we could simply say that they are turned off. However, a closer look at the adult system shows that these constraints do play a role, that they are in fact minimally, not freely violated.

The role of ALIGN-LEFT in English is documented in McCarthy and Prince (1993). When a trisyllabic sequence precedes the main stress, secondary stress usually appears on the initial syllable (see § 2 for an account of the exceptions). The words in (12) exemplify this pattern:

(12) Tàtamagóuchi àbracadábra Kàlamazóo Wìnnepesáukee Wàpakonéta Lòllapalóoza

By having the initial foot aligned with the left edge of the Prosodic Word (i.e. *(Tàta)ma(góu)chi*), these words satisfy ALIGN-LEFT. A parsing which maintains an alternating rhythmic pattern (i.e. *Ta(tàma)(góu)chi*) would violate ALIGN-LEFT. This indicates that ALIGN-LEFT dominates ALIGN-RIGHT, since the latter is better satisfied by *Ta(tàma)(góu)chi*.

PARSE-σ is ranked much higher than ALIGN-LEFT in the grammar of English, and has a broader range of effects, which provide further evidence that these constraints are outranked, rather than turned off. First of all, to allow iterative footing, PARSE-σ must dominate ALIGN-LEFT:

(13) PARSE-σ >> ALIGN-LEFT

| Input: apalachicola | PARSE-σ | ALIGN-LEFT |
|---|---|---|
| a. (ápa)lachicola | ****! | |
| b. (àpa)(làchi)(có)la ✔ | * | ** **** |

A candidate with but a single foot, as in (13a), fully satisfies ALIGN-LEFT. PARSE-σ must rank above ALIGN-LEFT to compel more exhaustive footing, as in (13b), in which the sole PARSE-σ violation occurs to satisfy a higher ranked NONFINALITY constraint (AKA Extrametricality; see Prince and Smolensky 1993, Chapter 2). The two sets of ALIGN-LEFT violations are those incurred by the second and third feet respectively, counted in terms of the number of syllables separating them from the left edge.

A more subtle PARSE-σ effect can be seen in what is commonly referred to as the 'Arab rule' (Kager 1989; § 2.1.1 above). In a word like *Àlexánder*, the medial syllable is heavy, yet stressless, in violation of the WEIGHT-TO-STRESS constraint, which demands that heavy syllables bear stress. The dominance of PARSE-σ over WEIGHT-TO-STRESS motivates the creation of a bisyllabic foot, rather than a monosyllabic one that would respect WEIGHT-TO-STRESS:

(14) PARSE-σ >> WEIGHT-TO-STRESS

| Input: Alexander | PARSE-σ | WEIGHT-TO-STRESS |
|---|---|---|
| a. A(lèx)(án)der | **! | |
| b. (Àlex)(án)der ✔ | * | * |

More generally, PARSE-σ acts to incorporate syllables into feet wherever possible, where the limit on what is possible is defined not only by the higher rank of MAXI-O, but also by that of FOOTBIN. As we saw above, in a word like *banána*, the first syllable is left unparsed. In *bàndána*, by contrast, the initial syllable is footed. The difference between these words is that the initial syllable of *bàndána* is bimoraic, and can thus be the sole constituent of a foot without trangressing FTBIN, while the putative *(bà)(nána)* would violate FTBIN due to its possession of a monomoraic, monosyllabic foot.

In this account, the transition from the prosodic system of early child English, to that of adult English, involves not the shutting off of structural constraints, but their being outranked by Faithfulness constraints, and ranked with respect to one another. Both PARSE-σ and ALIGN-LEFT are unviolated in child language, but minimally violated in the adult grammar.[4]

In child truncations, there are two points of interest: the size restriction itself, and what is retained from an adult target that exceeds the size limit. Up to this point, we have been concerned solely with the former. In the next section, we turn to the patterns of content preservation displayed when children produce adult targets of various prosodic shapes. As well as fleshing out the account of child truncation, this section provides an example of an outranked structural constraint in the child system itself, thus adding to the evidence for the view of development as constraint reranking.

### 3.2 Content Preservation and Faithfulness

#### *3.2.1 The empirical base*

Though child truncations have been the subject of considerable study, there remains some lingering controversy over what exactly is preserved from adult targets. It is not a simple matter to resolve this data issue, because some of the relevant forms are fairly sparsely attested in child speech, and there is very little phonetically transcribed developmental data that is publicly available.[5] Here I address the issue by consulting a large corpus of previously

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[4] FTBIN, on the other hand, may well be inviolable in both, despite appearances to the contrary in very early stages of child language (see Goad 1996b, and cf. Chapter 2: Appendix A for discussion of some possible violations in the adult system).

[5] One important exception is the corpus of Dutch child language recently contributed to CHILDES (MacWhinney 1995) by Paula Fikkert and Claartje Levelt (see Fikkert 1994 and Levelt 1994).

unpublished data on the acquisition of English. As we will see, these data do allow us to clear up the some of the remaining ambiguities in the description of child truncation.

The data to be discussed here were originally collected by a team under the direction of A.J. Compton in the 1970's. The method of data collection, and some preliminary analyses, are presented in Compton and Streeter (1977). The project was undertaken to map out as precisely as possible the development of children's sound systems. With this goal in mind, a diary method of data collection was chosen, with parents keeping track of their children's utterances by recording them in notebooks, 'at least four days a week and scattered throughout the child's waking hours, covering about 4 hrs. a day' (Compton and Streeter 1977: 100). The parents were speech pathologists, and received additional training in the phonetic transcription of child speech prior to the study.

This method of data collection allowed for a particularly large and comprehensive sample to be gathered; for the four children to be discussed here, a total of over 25,000 utterances were transcribed (about 3371 for Derek, 5772 for Julia, 5258 for Sean, and 13351 for Trevor).[6] The transcriptions cover the ages of 1;0.6 to 3;2.1 for Derek, 1;2.21 to 3;1.3 for Julia, 1;1.25 to 3;2.20 for Sean, and 0;8 to 3;1.8 for Trevor. All of the children were learning American English as spoken in California; none had any language or learning related impairments.

The obvious disadvantage of the diary method is that there is no way to verify the accuracy of the transcriptions, since no tests of interrater reliability are usually possible (let

[6] These are the number of entries in the database. They only approximate the total number of utterances since some of the entries are the parents' comments, rather than transcribed utterances. It is a relatively close approximation, though, because there are relatively few comments.

alone instrumental study of the phonetic characteristics of the utterances). However, in this case, Compton and Streeter (1977) checked the reliability of samples of the parental transcriptions by comparing them with transcriptions done simultaneously by the principal investigator, and by taping some sessions, so that they could also be transcribed by both the parent and the principal investigator. Compton and Streeter (1977:100) note that "[t]hese reliability checks indicated a high agreement of the phonetic transcriptions and, particularly, for the consonants (approximately 90%) which are the primary focus of this research." In the present study, we will be concerned with phonetic detail only at the level of the basic place and manner features of the consonants, and to a minor extent vowel quality. Therefore, we can have a reasonable degree of confidence in the accuracy of the transcriptions.

With such a large corpus, pencil and paper analysis is extremely difficult. From its inception, the aim of Compton's project was to create a computerized database, and Compton and Streeter (1977) report on the progress of that work to that date. Unfortunately, due to the limitations imposed by the technology of the day, the computerized database was never completed, and the corpus remained mostly unanalyzed. To make use of the corpus for present purposes, I scanned a typewritten version of the transcripts to create computer readable images, and used Optical Character Recognition software (OmniPage Pro) to create text files. These were then checked and placed in a simple database format.

The database at present contains no indication of stress or syllable structure in the glosses. Therefore, I searched the transcripts manually for target words of particular prosodic shapes. In particular, I extracted all finally stressed bisyllables, and all medially and initially stressed trisyllables, since each of these groups of target words is of particular interest for the patterns of preservation displayed in children's truncated productions of them (longer words are quite rare, and were excluded, since they would yield such a small sample).[7] The gloss field of the database was then searched for all occurrences of these words. The Appendix to this chapter contains the compiled results of this search for each child. In the Appendix, both truncated and non-truncated instantiations are included, so as to illustrate in some detail the process of prosodic development, and the variation inherent to it.

In the following tables, I supply exemplars of the patterns of preservation displayed by each child for each word, and the ages at which the first and the last token was produced. Since they contain only truncated examples, these tables abstract somewhat from the actual developmental variation. They also abstract from some variation in the exact segmental makeup of the words, except where this is relevant to the issues of content preservation.

I will start with the medially stressed trisyllabic targets. As mentioned in the introduction, children's truncated productions of these words almost always preserve the stressed and rightmost syllables (see Smith 1973, Ingram 1978, Allen and Hawkins 1978, Echols and Newport 1992, Fikkert 1994, Gerken 1994, Wijnen, Krikhaar and den Os 1994, and Demuth and Fee 1995). This tendency is clearly evident in the data in (14) as well. In most cases, the initial syllable of the child's truncated production is headed by the stressed vowel from the second syllable of the adult target, while the final syllable in the target and the truncated form correspond. As a perusal of the table will show, there are just a few isolated exceptions, about which I will have nothing to say in the analysis: *another* and *gorilla* both

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[7] As the database is so large, there is the possibility that a few relevant words could be missed. However, any word that occurred frequently enough to be of much interest would in all likelihood be included.

have some truncated versions whose relationship to the target is particularly opaque ([jəwo], and [jə] for *another*, [wʌ:ga:] for *gorilla*), and *another* has a couple of variants that retain the initial syllable (e.g. [ənɚ]).[8] As for the onset of the child's initial syllable, it can correspond to either the onset of the medial or the initial syllable of the adult form. As has also been observed by Smith (1973) and Fikkert (1994), the initial onset is often chosen so as to replace a liquid ([dɪʃəs] *delicious*; [gʌ:wa] *gorilla*; [ma:kas] *maracas*) or a stop coronal ([bænə] *banana*; [pedo] *potato*), with the former seeming to be somewhat more consistent.

(14) Truncations of σ'σσ targets

| | | | | | |
|---|---|---|---|---|---|
| **another** | | | **apartment** | | |
| *Derek* | [nʌdɝ] | 2;2.23 ~ 2;5.11 | *Julia* | [partmɛnt] | 2;3.14 ~ 2;5.16 |
| *Julia* | [jəwo] | 1;10.12 | | | |
| | [jə] | 1;11.4 | | | |
| *Sean* | [ənə] | 1;9.15 | | | |
| | [əʊ] | 1;10.11 | | | |
| | [nʌdɚ] | 2;4.2 | | | |
| | [ʌə] | 2;4.22 | **baloney** | | |
| | [anʌ] | 2;4.24 | *Derek* | [bwoni] | 2;7.18 ~ 2;10.2 |
| | [nʌθɝ] | 2;10.13 | | | |
| *Trevor* | [nʌ:ɚ] | 2;5.17 | | | |
| | [nʌ:dɚ] | 2;5.17 | | | |
| | [ənɚ] | 3;2.0 | | | |

[8] The pronunciation of *gorilla* as [go:wæ ] may be initial nucleus preservation as well, or it may result from misperception or misproduction of [ɪ] due to the surrounding liquids.

| | | |
|---|---|---|
| **banana** | | |
| *Derek* | [nænə] | 2;3.0 ~ 2;4.0 |
| *Julia* | [mænə] | 1;7.16 ~ 1;10.8 |
| | [bænə] | 1;11.6 ~ 2;5.29 |
| | [blæna] | 2;3.20 ~ 2;4.5 |
| *Sean* | [nænə] | 1;8.28 ~ 1;11.19 |
| *Trevor* | [nænə] | 0;11.10 ~ 1;6.8 |
| | [nænæ][9] | 1;0.9 ~ 3;1.8 |
| **gorilla** | | |
| *Julia* | [graʊwə] | 2;2.21 |
| *Trevor* | [go:wæ ] | 1;11.12 |
| | [wʌ:ga:] | 1;11.14 |
| | [gʌ:wa] | 1;11.14 |
| **Modesto** | | |
| *Trevor* | [dɛsto] | 2;8.15 |
| **Nathaniel** | | |
| *Trevor* | [fæfue] | 2;1.0 |
| | [fæ:ŋo] | 2;1.17 |
| | [fæŋo:s] | 2;2.23 |
| **piano** | | |
| *Julia* | [pæno] | 1;9.19 ~ 2;4.17 |
| *Trevor* | [pæ:no] | 1;11.9 ~ 2;2.23 |
| **remember** | | |
| *Julia* | [mɛmə] | 1;10.8 ~ 3;0.1 |
| | [mɛmbə] | 2;1.18 ~ 2;7.29 |
| **delicious** | | |
| *Julia* | [dɪʃəs] | 1;11.27 |
| **eleven** | | |
| *Julia* | [dɛbən] | 1;9.10 |
| | [jɛbən] | 1;9.15 |
| | [jɛmɪn] | 1;9.20 ~ 1;10.7 |
| | [jɛvən] | 2;2.24 |
| **maracas** | | |
| *Trevor* | [ma:kas] | 2;0.27 |
| **museum** | | |
| *Trevor* | [zi:ʌm] | 2;7.27 |
| **pajamas** | | |
| *Julia* | [daməs] | 1;8.27 ~ 2;0.2 |
| *Sean* | [ʤæməʃ] | 1;11.15 ~ 2;0.23 |
| *Trevor* | [da:məs] | 1;7.11 |
| | [ʤa:mas] | 1;7.26 ~ 2;2.10 |
| **potato** | | |
| *Julia* | [pedo] | 2;0.25 ~ 2;1.20 |
| | [teto] | 2;5.16 |
| *Trevor* | [te:to] | 1;9.19 ~ 1;10.5 |
| **salami** | | |
| *Trevor* | [ma:mi] | 1;6.25 ~ 2;1.0 |

[9] This reduplicated form, by far the most common variant of *banana* in Trevor's corpus, is quite idiomatic: no other reduplication persisted to this extent. Trevor seemed to have a lot of fun with this word. When he was about 1 year old, *banana* served as the cover term for all fruit, and there are at least a dozen pronunciations attested during this time. To save space these have been left out of the present table, but see the Appendix for details.

| | | | | | |
|---|---|---|---|---|---|
| **spaghetti** | | | **Theresa** | | |
| *Julia* | [dɪbi] | 1;9.7 | *Trevor* | [ri:sə] | 2;11.10 |
| | [gɛbi] | 1;10.8 | | | |
| | [skɛbi] | 1;11.19 ~ 2;3.8 | | | |
| | [sketi] | 2;0.29 | | | |
| *Trevor* | [gɛdi] | 1;4.27 ~ 1;9.2 | | | |
| **together** | | | **tomato** | | |
| *Trevor* | [gɛ:dɚ] | 1;9.27 ~ 2;0.27 | *Julia* | [meno] | 1;9.22 ~ 1;10.27 |
| | | | | [meto] | 2;0.11 ~ 2;10.30 |
| | | | *Trevor* | [me:do] | 2;0.27 |
| **tomorrow** | | | **umbrella** | | |
| *Julia* | [mowo] | 1;7.16 ~ 2;0.17 | *Derek* | [bwɛa] | 1;11.30 |
| *Trevor* | [moro] | 1;8.12 ~ 2;1.14 | *Sean* | [bɛla] | 2;0.1 |
| | | | *Trevor* | [brʌ:gæ ] | 1;11.1 |
| | | | | [bre:wa] | 1;11.5 |
| | | | | [bʌwə] | 1;11.5 |
| | | | | [bwɛ:wəz] | 2;1.0 ~ 2;1.14 |
| **vagina** | | | | | |
| *Trevor* | [ʤai:nə] | 2;11.10 | | | |

Bisyllables with final stress are also truncated by deleting the initial syllable. Again, the onset from the initial syllable is often retained so as to replace a liquid. In fact, for *balloon*, *belong*, *garage*, *Marie*, and *police*, when only one of the two target onsets is realized, the liquid is always deleted in favour of the initial non-liquid onset ([bun] *balloon*; [[bɔŋ] *belong*; [ga:ʤ] *garage*; [mi] *Marie*; [pis] *police*). The one exception is Trevor's pronunciation of *giraffe* as [wæf], which will turn out to be of some interest. We also have one example of a nasal being replaced by a obstruent ([dis] *Denise*), as well as one of a velar overriding a coronal ([ga:r] *guitar*) and of a velar replacing a labial ([gu:s] *caboose*).

(15) Truncations of σ'σ targets

| | | | | | |
|---|---|---|---|---|---|
| **again** | | | **alone** | | |
| *Julia* | [gɛn] | 1;10.1 ~ 2;1.24 | *Derek* | [won] | 2;6.24 |
| *Sean* | [gɛ] | 2;5.21 | *Trevor* | [io:n] | 2;1.26 |
| | [gɛn] | 2;7.11 | | | |
| *Trevor* | [gɛ] | 0;10.28 ~ 1;0.8 | | | |
| | [gɛn] | 1;6.17~ 2;3.3 | | | |
| **apart** | | | **around** | | |
| *Trevor* | [part] | 1;9.29 | *Sean* | [ound] | 1;11.12 |
| | | | *Trevor* | [wau:n] | 2;0.8 |
| **away** | | | **balloon** | | |
| *Derek* | [we] | 2;2.30 | *Derek* | [bu] | 1;11.6 ~ 2;2.1 |
| *Julia* | [waɪ] | 1;8.24 ~ 2;0.19 | | [bun] | 2;2.25 ~ 2;4.26 |
| *Sean* | [we] | 2;1.25 ~ 2;8.23 | *Julia* | [bu] | 1;5.28 |
| | | | | [bʊn] | 1;9.18 ~ 1;10.23 |
| | | | *Sean* | [bʌ] | 1;3.21 |
| | | | | [bu] | 1;4 ~ 1;7.18 |
| | | | | [bum] | 1;11.0 |
| | | | *Trevor* | [bu] | 1;4.19 ~ 1;4.27 |
| | | | | [bu:m] | 1;4.27 ~ 1;6.25 |
| | | | | [bu:n] | 1;9.29 ~ 1;11.14 |
| **behind** | | | **belong** | | |
| *Derek* | [haind] | 2;3.24 | *Julia* | [bɔŋ] | 1;11.27 ~ 2;0.26 |
| *Trevor* | [hai:n] | 2;0.8 ~ 2;2.15 | *Trevor* | [ɔ:ŋ] | 2;1.5 |
| **caboose** | | | **cement** | | |
| *Trevor* | [gu:s] | 2;4.24 ~ 2;11.17 | *Derek* | [mɛnt] | 2;11.27 |
| **Denise** | | | **dessert** | | |
| *Trevor* | [dis] | 1;1.17 ~ 2;2.15 | *Julia* | [zɚt] | 2;8.7 ~ 2;9.24 |
| **enough** | | | **excuse** | | |
| *Trevor* | [nʌf] | 1;10.5 ~ 1;11.25 | *Trevor* | [ku::zə mi] (excuse me) | 2;2.10 ~ 2;6.6 |
| **garage** | | | **giraffe** | | |
| *Julia* | [gwa:dz] | 2;8.25 | *Julia* | [ʤwæf] | 2;2.7 |
| *Trevor* | [ga:ʤ] | 1;10.5 ~ 2;0.24 | | [dræf] | 2;2.17 ~ 2;6.10 |
| | [garʤ] | 2;1.5 ~ 2;1.26 | | [dwæf] | 2;2.22 |
| | [graʤ] | 2;3.3 | *Trevor* | [wæ:f] | 1;9.1 ~ 1;11.14 |
| | [gra:ʤ] | 2;3.22 | | | |

| | | | | | |
|---|---|---|---|---|---|
| **guitar** | | | **machine** | | |
| *Sean* | [tar] | 2;2.12 | *Trevor* | [ʃɪʃɪm] | 1;8.26 ~ 2;4.13 |
| *Trevor* | [gi] | 1;1.13 ~ 1;3.11 | | (sewing machine) | |
| | [ga] | 1;1.19 ~ 1;6.17 | | [o: ʃi:n] | 2;4.24 |
| | [ga:r] | 1;7.20 ~ 2;1.5 | | (sewing machine) | |
| | | | | [so:ə ʃi::m] | 2;8.5 |
| | | | | (sewing machine) | |
| **Marie** | | | **Merced** | | |
| *Trevor* | [mi] | 1;6.17 ~ 1;9.2 | *Trevor* | [sɛd] | 1;11.12 ~2;11.10 |
| **Michele** | | | **police** | | |
| *Trevor* | [ʃɛ:u] | 1;6.25 ~ 2;5.26 | *Julia* | [pismæn] | 2;1.10 ~ 2;5.3 |
| | | | | (policeman) | |
| | | | | [plis] | 2;6.5 |
| | | | *Trevor* | [pi:smæn] | 2;4.13 |
| | | | | (policeman) | |
| **pretend** | | | **surprise** | | |
| *Julia* | [tɛnd] | 2;1.20 ~ 2;3.30 | *Derek* | [pwaɪz] | 2;7.7 |
| **today** | | | | | |
| *Derek* | [de] | 2;8.19 ~ 3;2.0 | | | |

### *3.2.2 The 'elephant' data*

The constraints on word size introduced in § 3.1 account for the fact that the trisyllables and the finally stressed bisyllables are truncated, since a target-like production would exceed the one foot maximum that the constraints impose. However, they say nothing about which syllables are preserved. Two basic approaches have been taken in the recent literature to explaining why the initial syllables are deleted. Echols and Newport (1992) propose that children have a perceptual bias to the stressed and rightmost syllables, and so pick out these syllables from the speech stream to make up their lexical representations. Production-based accounts, on the other hand, assume that children's lexical representations include the syllables that are deleted in truncation, and posit a process of mapping to a template (Gerken 1994, Wijnen, Krikhaar and den Os 1994), or of circumscription of a prosodic unit (Fikkert 1994) to generate the output form.

For the target words we have looked at so far, choosing the final foot, or the stressed and rightmost syllables, would yield the same result. However, for initially stressed trisyllables, these two approaches make different predictions. If the target words are prosodified as ('σσ)σ (see Hayes 1982), the final foot consists of the first two syllables. Extraction of the final foot would thus preserve the first two syllables, while the stressed and rightmost syllables are the first and third.

Claims about what the observed facts are here seem to split along factional lines, but nowhere is sufficient data presented to assess those claims. While Echols and Newport (1992) present statistics to show that stressed and rightmost is the dominant pattern, their analyses lump together σ'σσ and 'σσσ words, so it is impossible to tell how 'σσσ words behave (especially since these seem to be the rarer of the two).

Wijnen, Krikhaar, and den Os (1994), on the other hand, claim that in the Dutch children's truncations that they studied, both patterns occur with about equal regularity. There are, however, two confounding factors which make it difficult to accept this claim at face value. First, the target words that Wijnen, Krikhaar, and den Os give as examples of targets for stressed and medial truncations are in fact suffixed (i.e. *andere* and *poppetje)*, so it is possible that in saying [ɑndə] and [pɔpə] the children were merely producing the bare stems.[10] Second, because the unstressed final syllables in these target words are schwa-final, when a child produces a truncated version of one of these words, one cannot be sure that the

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[10] Thanks to Janet Grijzenhout and Ruben van de Vijver for pointing this out.

medial schwa, rather than the final one, is being produced. The identity of the accompanying onset fails to provide an unambiguous clue to the source of the schwa, since an onset can be drawn from a preceding syllable, as we have already seen in forms like [dɪʃəs] for *delicious*, and as we will shortly see for 'σσσ truncations in English. In this respect, English data are potentially very revealing. Unstressed final syllables quite often end with coda consonants (e.g. *Margaret*), syllabic sonorants (*tricycle*), or tense vowels (*buffalo*). Words such as these can provide a clear indication of whether the medial or final rime is being preserved.

Gerken (1994: 579) states that "the S(W) production template hypothesis predicts that, in SWW words like *elephant* and *animal*, children should preserve the first weak syllable more frequently than the second." Recognizing that this prediction is not fully borne out in the relevant data that do exist, Gerken suggests that the preference for adjacent syllables is overruled by a CV(C) segmental template, which demands that syllables must possess an onset. In a word like *élephant*, the SW template would select the first two syllables. However, the second syllable does not fulfill the CV(C) template, given the additional assumption that the [l] of *elephant* is not the onset for the second syllable but instead closes the first syllable, due to its being incorporated into the stressed syllable (it must also be assumed that children are aware of this syllabification and cannot alter it). Since the final syllable possesses an onset, and it is weak, it is chosen, giving the pronunciation [ɛlfʌn] attested in Echols and Newport (1992). This account makes the interesting prediction that words that have a cluster following the stressed syllable, and hence an available onset in the second syllable (e.g. *ambulance*) should usually lose the final syllable in truncation. Gerken (1994: 581) finds some evidence in data from Klein (1978) to support a difference between words like *elephant* and *ambulance*, but notes that "a more extensive examination of children's early SWW word productions is necessary" to test the predictions of her model.[11]

It turns out that the data from the corpus under study here strongly support Echols and Newport's (1992) position that stressed and rightmost is the regular pattern, and argue against Gerken's alternative interpretation of *elephant*-type words. The truncated productions of initially stressed trisyllabic target words are presented in (16):

(16) Truncations of 'σσσ targets

| | | | | | |
|---|---|---|---|---|---|
| **abacus** | | | **Allison** | | |
| *Trevor* | [æ:ʃɪʃ] | 1;8.7 | *Trevor* | [ai:] | 1;3.5 |
| | [æ:tʃus] | 1;9.2 | | [aijə] | 1;3.10 ~ 2;2.7 |
| | [ækus] | 1;9.2 ~ 2;0.8 | | [æ:sʌn ] | 2;0.8 ~ 2;2.3 |
| | [æ:ʃʌʃ] | 1;9.2 | | | |
| **animal** | | | **bicycle** | | |
| *Derek* | [æmʊ] | 2;1.14 ~ 3;1.24 | *Julia* | [baɪko] | 1;8.4 ~ 1;10.13 |
| *Julia* | [amo] | 1;9.8 ~ 2;1.2 | | [baisko:] | 2;0.14 ~ 2;5.7 |
| *Trevor* | [nɔno] | 1;5.13 | *Trevor* | [gaiki] | 1;5.5 |
| | [amu:] | 1;7.20 ~ 2;3.4 | | | |
| **broccoli** | | | **buffalo** | | |
| *Julia* | [baki] | 1;7.6 ~ 2;0.19 | *Julia* | [bʌfo] | 2;0.14 ~ 2;3.9 |
| **camera** | | | **cinnamon** | | |
| *Sean* | [kæmʌ] | 2;0.13 | *Julia* | [sɪmɛn] | 1;11.15 |
| | [kæmrʌ] | 2;0.13 ~ 2;10.9 | | | |
| *Trevor* | [kæ:mə] | 1;5.6 ~ 1;11.25 | | | |
| | [kæ:mɚ] | 2;0.3 | | | |

[11] What Gerken in fact finds is that *elephant*-type words generally preserve the final syllable, while *ambulance*-type words vary between medial and final syllable retention. She claims that this is captured by her account, since in a word like *ambulance* 'either weak syllable might be inserted into the W slot of the metrical template' (1994: 581). However this contradicts her discussion of SWWS words earlier in the paper, in which a preference for the first weak syllable is crucial, as well as the quotation cited above in the text, in which the prediction of the S(W) production hypothesis is explicitly stated. We must conclude, then, that final-syllable preservation for the *ambulance* class of words is problematic for Gerken's analysis.

| | | | | | |
|---|---|---|---|---|---|
| **company** | | | **dominoes** | | |
| *Julia* | [kʌmpi] | 1;11.14 | *Trevor* | [da::nouz] | 2;2.23 |
| *Sean* | [kʌmpi] | 2;0.27 | | [da:mno:θ] | 2;4.3 |
| *Trevor* | [kumni:] | 2;2.23 | | | |
| **dungarees** | | | **elephant** | | |
| *Trevor* | [gʌŋgi: z ] | 1;10.1 | *Derek* | [ɛwfən] | 2;9.7 ~ 2;10.7 |
| | | | *Julia* | [ɔwo] | 1;8.0 |
| | | | | [apɛn] | 1;10.4 |
| | | | | [aʊfənts ] | 1;10.27 ~ 2;0.13 |
| | | | *Sean* | [adi] | 1;6.1 |
| | | | | [ɛfɛnt] | 2;1.19 |
| | | | | [ɛlfɪnt] | 3;1.18 ~ 3;1.27 |
| | | | *Trevor* | [ɛ:fɪnt ] | 1;11.14 ~ 2;6.15 |
| | | | | [ɛ:tʌnt] | 1;11.14 |
| **favorite** | | | **gallopey** | | |
| *Julia* | [fevət] | 2;0.25 ~ 2;6.1 | *Julia* | [gabi] | 1;9.14 |
| *Sean* | [fevrɪt] | 3;2.12 | | | |
| **medicine** | | | **sesame** | | |
| *Julia* | [mɛsɪn] | 1;11.12 | *Derek* | [sɛmə] | 2;2.8 |
| *Sean* | [wapi] | 1;7.14 | | [semi] | 2;6.26 ~ 3;1.28 |
| *Trevor* | [mɛ::sɪn] | 2;1.26 | *Sean* | [diduit] (Sesame Street) | 1;10.6 |
| | [mɛ:sɪn] | 2;11.10 | | [do dwit] (Sesame Street) | 1;10.17 |
| | | | | [sɛsi stwit] (Sesame Street) | 2;5.14 |
| **spatula** | | | **tricycle** | | |
| *Trevor* | [bæ:tʃʌ] | 1;11.23 | *Derek* | [twaɪkl] | 2;8.18 ~ 2;10.4 |
| **vitamin** | | | | | |
| *Trevor* | [ga:mɪn] | 1;5.30 | | | |
| | [bai:mi:ʃ] | 1;6.9 | | | |

This data set demonstrates a strong tendency for the rightmost rime to be preserved. Of the words in (16), only two end in schwa (*camera* and *spatula*). In all the other words, the final rime can be distinguished from the medial one. For most of these words, the only attested truncations are ones in which the final rime in the target clearly corresponds to the final rime in the child's production. Syllabic [l] in final position is produced intact, or as a non-schwa vowel (e.g. [twaɪkl] for *tricycle*, [amo] for *animal*), and tense vowels are retained (e.g. [bʌfo] for *buffalo*, [baki] for *broccoli*), as are coda consonants (e.g. [sɪmɛn] for *cinnamon*, [fevət] for *favorite*). For those few words that have truncated versions that show no evidence of final rime retention ([aijə] for *Allison*, [ɔwo] for *elephant*, [sɛmə] for *sesame*), there are also variants that do ([æ:sʌn], [ɛ:fɪnt], and [semi] respectively).

While the truncations almost always preserve the final rime, for a large set of the target words the onset of the medial syllable is chosen instead of the final one (e.g. [baki] for *broccoli*). *Broccoli*, *buffalo*, *camera*, *dungarees*, *favorite*, and *spatula*[12] are always truncated in that fashion, as are some instances of *sesame* and *company*. Most of these words have but a single consonant separating the stressed and medial vowels, which shows that such consonants are in fact eligible as onsets in children's truncations, contra Gerken's (1994) solution for the *elephant* problem. What seems to determine whether the onset of the medial syllable is chosen is not whether it is part of a cluster, but whether it is less sonorous than the final syllable's onset. The basic sonority scale is given in (17) (see e.g. Sievers 1881, Jespersen 1904, Hankamer & Aissen 1974, Hooper 1976, Steriade 1982, Selkirk 1984, Clements 1990, Rice 1992, Prince and Smolensky 1993, Blevins 1995, Gnanadesikan 1995):

(17) Vowel > Glide > Liquid > Nasal > Fricative > Stop

[12] Several of these words have alternate pronunciations in adult English in which the medial vowel is deleted. All of them, however, are also transcribed with the medial vowel intact in either Kenyon and Knott (1953) or Webster's (1981). In any case, the consonants surrounding the deleted vowel are retained in the syncopated adult form, so an account still must be given of why the child chooses one or the other.

The scale is given in (17) in order of decreasing sonority; vowels are the most sonorous segment type, and stops the least. The way that the sonority scale plays out in the data at hand is that the onset is taken from the target's medial syllable only when it is lower in sonority than the onset of the final syllable. In all of the cases of medial onset retention, an obstruent (i.e. a fricative or a stop) from the medial syllable is chosen instead of a sonorant (i.e. a liquid or a nasal) from the final one. This is fully parallel to the data from initial truncation examined in the previous section, in which obstruents usually replaced liquids, and sometimes replaced nasals.

One apparent difference between initial and medial syllable deletion is that in the latter there is no evidence of the place specification of the consonants playing any role. However, it turns out that there are no initially stressed trisyllabic targets with the relevant array of consonants (e.g. with a labial onset preceding a coronal onset, where they are equal in sonority). Note too that onset selection that is sensitive to place of articulation is less consistent even in initial syllable truncation.

In the account of these patterns that follows, I will first discuss the constraints responsible for the preservation of the stressed and rightmost syllables. I will then analyze the robustly attested pattern of sonority driven onset selection, and provide evidence that this is an instance of minimal violation in the child system itself. We will return to the onset choices based on place of articulation in §3.3.

*3.2.3 Stressed and rightmost preservation as Faithfulness*

The basic intuition underlying the approach to content preservation taken here is that certain kinds of phonological elements, in particular, those that are prominent, are heads of constituents, or lie at the edges of domains, have a special status. This is formalized in terms of Faithfulness constraints that specifically target such entities (Benua 1995, Itô, Kitagawa, and Mester 1995, and McCarthy 1996). STRESS-FAITH, for example, requires the preservation of stressed elements (see §2; cf. MAXFT-HEAD in Itô, Kitagawa and Mester 1995 and HEADMATCH in McCarthy 1996):[13]

(18) STRESS-FAITH

An Input stressed element must have as its Output correspondent a stressed element

This constraint plays an important role in explicating child truncations, since they almost always preserve the stressed syllable. Across the three word types we have examined, we have seen that the stressed nucleus is consistently preserved.

To ensure the preservation of the final syllable, we can invoke the notion of edge-anchoring introduced in McCarthy and Prince (1994, 1995). ANCHOR constraints are edge-specific Correspondence constraints, which like the Alignment constraints of McCarthy

[13] I use STRESS-FAITH, rather than a constraint on the preservation of the prosodic head because it makes no implicit claim about whether or not the child's Input representation is prosodified or not. Preservation of the stressed syllable could simply be preservation of the most acoustically salient syllable. Given that words with secondary stress on the initial syllable, like museum, show preservation of the main stressed syllable, this constraint might need to be relativized to level of headedness (Foot vs. Prosodic Word), or to degree of salience. On the other hand, Fikkert (1994) shows that the rightmost foot, rather than the most prominent one, is often chosen in her Dutch truncation data. A full discussion of the relevant cases would take us far off track, and would require considerable querying of the corpus, so I leave this issue for further research.

and Prince (1993), formally recognize the importance of the edges of domains.[14] The ANCHOR constraint relevant here is the one in (19).

(19) ANCHOR-RIGHT I-O
Elements at the right edge of the Input word and the Output word stand in correspondence

Assuming for the moment that "element" in the formulation of these constraints refers to syllables, with STRESS-FAITH and RIGHT-ANCHOR ranked above any competing constraints, the stressed and the rightmost syllables will be preserved in the truncated form.

As it stands, we have not introduced any constraints that do compete with STRESS-FAITH and RIGHT-ANCHOR. The one possible conflict arises in the case of the finally stressed bisyllables, which preserve only the stressed syllable, which also happens to be the rightmost one. Fikkert (1994: 209) reports that this type of word is sometimes augmented with an epenthetic vowel to form a bisyllabic foot. In present terms, this would be driven by the need to satisfy FOOTBIN at the syllabic level. Interestingly, epenthesis hardly ever occurs in the present data set (a similar finding in experimental data on child English is presented in Kehoe and Stoel-Gammon 1996). The only exception is [ku::zə mi] for *excuse me*, in which the epenthesis could well be serving to break up the [zm] cluster. The lack of epenthesis might indicate that RIGHT-ANCHOR dominates FOOTBIN, but it may also be that FOOTBIN is satisfied at the moraic level in these children's systems (cf. Fee 1992, 1995); recall that FOOTBIN

[14] McCarthy and Prince (1995:371) note that Alignment between prosodic categories can also be formulated in terms of ANCHOR if correspondence is taken to be reflexive. Under this interpretation, a constraint demanding that a segment at the edge of a foot have a correspondent at the edge of a Prosodic Word would be satisfied if a segment that is edgemost in a foot is itself edgemost in a Prosodic Word. I retain the version of Alignment in §3.1 not only for expository ease, but also to facilitate comparison with McCarthy and Prince (1994a).

requires syllabic *or* moraic binarity. Because vowel length does not appear to be very reliably transcribed in the present corpus, and the status of bimoraic syllables in these children's systems is therefore difficult to ascertain, I will leave the choice between these alternatives open.

*3.2.4 Constraints on onset preservation*

In this section, I will start by discussing the apparent exceptions to stressed and rightmost preservation seen in truncations of initially stressed trisyllables, which as demonstrated in §3.2.2, result not from free variation between the retention of final and medial syllables, but rather from the choice of a lower sonority onset. For words whose final syllables begin with obstruents, that consonant is always preserved in the truncated form.[15] In cases where the onset of the final syllable is a liquid and the preceding onset is an obstruent or nasal (e.g. *buffalo* and *camera*), when one of the onsets is deleted, it is always the liquid; if the onset of the final syllable is a nasal, it is sometimes lost if the preceding onset is an obstruent (*sesame* and *company*; though cf. *vitamin*), but not if it is another nasal (*animal*, *cinnamon*, and *domino*).[16] Since liquids are more sonorous than nasals, which are in turn more sonorous than

[15] Two apparent exceptions are [aijə] for Allison, and [ɔwo] for elephant. These were very early versions of the words, produced by Trevor and Julia respectively. They were later replaced by forms that did preserve the obstruent. These two tokens also stand out in that they don't preserve the final rime. It seems then, that these are representative of an earlier developmental stage.

[16] There is also no evidence for a preference of stops over fricatives. The only word with a stop onset in the medial syllable and a fricative in the final one is medicine, and the truncations preserved the fricative rather than the stop. Further evidence is needed to determine whther or not this division in the sonority hierarchy plays any role here.

obstruents, the choice of the medial onset appears to be motivated by a search for a less sonorous obstruent.

The markedness of high sonority onsets is well attested in both child language (Fikkert 1994,[17] Gnanadesikan 1995, 1996), and in the phonologies of the world's languages (see e.g. Clements and Keyser 1983). The connection between the two is made particularly explicitly in Gnanadesikan (1995). She shows a clear parallel between cluster reduction processes in Sanskrit reduplication, and in a stage of the phonological development of an English speaking child (age 2;3 to 2;9). In both instances, clusters are reduced by choosing the least sonorous member.[18]

In the analysis of the role of sonority in truncation, we must first account for the fact that where sonority considerations do not come into play, such as when the final onset is an obstruent, or both are nasals,[19] the onset is taken from the final syllable of the target ([ækus] for *abacus*, [sɪmɛn] for *cinnamon*). Above, I interpreted the constraint ANCHOR-RIGHT as requiring that a syllable at the right edge of the Input word have a correspondent at the right edge of the Output Prosodic Word. This is in fact based on an expository simplification. In

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[17] While sonority plays a relatively important role in the patterns of cluster reduction that Fikkert (1994) documents, as she points out, it cannot be the sole determining factor in order of acquisition of simple onsets, since nasals emerge consistently earlier than fricatives (Fikkert 1994: 68).

[18] There are instances of cluster reduction in child language which run counter to the predictions of sonority preference. Some children exhibit a stage in the development of obstruent+liquid clusters in which the liquid, rather than the obstruent, is selected. This occurs following the stage in which the clusters are reduced to obstruents, and prior to the stage in which the clusters are produced faithfully (Compton and Streeter 1977, Fikkert 1994). Fikkert refers to the choice of the liquid as a 'selection strategy' and does not provide a grammatical account of it. This stage is certainly worthy of further study.

[19] Unfortunately, there are no data on what happens when both syllables began with approximants, but based on the instances in which nasals occurred in both positions, it is likely that the rightmost approximant would be retained.

McCarthy and Prince's (1995) theory of Correspondence, the elements in Correspondence are not syllables, but rather segments (see also McCarthy 1996). Under this view, the constraint only requires that the rightmost segment of the Input and Output representations stand in Correspondence. Because it says nothing about segments internal to the word,[20] we do not yet have any explanation for why the default case is that the final syllable's onset is retained.

The relevant constraint here would appear to be the Faithfulness constraint CONTIGUITY, which is violated when non-adjacent elements in the Input become adjacent in the Output. McCarthy and Prince (1995: 371) state the version of CONTIGUITY that targets the Input string (I-CONTIG) as in (20).

(20) I-CONTIG
The portion of $S_1$ standing in correspondence forms a contiguous string.

$S_1$ refers here to the Input string. The diagram in (21) illustrates why [æbus] as the output for *abacus* runs afoul of I-CONTIG:

(21) I: $\underline{a_1 b_2} a_3 c_4 \underline{u_5 s_6}$ O: $a_1 b_2 u_5 s_6$

The subscripted numbers indicate the Correspondence relation between the strings, and the underlined segments in the Input string are those that stand in that relation with segments in the Output string. The break in the underlining signals that there is a violation of I-CONTIG.

[20] For the one case where the rightmost segment of the Input is deleted so as to yield a less marked coda (Derek's [ɛwfən] for elephant), we could assume that ANCHOR-RIGHT applies gradiently (Alderete, Beckman, Benua, Gnanadesikan, McCarthy, and Urbanczyk 1996), so that the rightmost segment in the Output lies in correspondence with an element as close to the right edge as possible, given the dominance of higher ranking structural constraints. The other possibility would be to assume that the final segment [n] is in fact in correspondence with both Input /n/ and /t/ (see the discussion of fusion in chapter 1), and that ANCHOR-RIGHT is in fact fully satisfied.

This purely segmental statement of I-CONTIG is not quite sufficient, however. As (22) shows, the optimal candidate also violates it:

(22) I: $\underline{a}_1 b_2 a_3 \underline{c}_4 \underline{u}_5 \underline{s6}$ O: $a_1 c_4 u_5 s_6$

Since the optimal candidate fares no better on this constraint, it cannot explain why it is chosen. This problem can be remedied by relativizing contiguity to prosodic category (Lamontagne 1995), in this case, to the syllable. The revised statement is given in (23):

(23) I-CONTIG-σ
The portion of $S_1$ standing in correspondence with the constituents of a syllable forms a contiguous string.

This constraint requires that the segments within a given syllable must be taken from a contiguous string within the Input. The ill-formed and the optimal candidate are compared with respect to this constraint in (24). Syllable boundaries are indicated with brackets.[21]

(24) a. I: $\underline{a}_1 b_2 a_3 \underline{c}_4 \underline{u}_5 \underline{s}_6$ O: $[a_1][c_4 u_5 s_6]$ ✓I-CONTIG-σ
b. I: $\underline{a}_1 \underline{b}_2 a_3 c_4 \underline{u}_5 \underline{s}_6$ O: $[a_1][b_2 u_5 s_6]$ * I-CONTIG-σ

In (24a), all of the elements within each syllable are drawn from a contiguous portion of the Input string, so I-CONTIG-σ is satisfied. In (24b), though, the constituents of the final syllable stand in correspondence with a non-contiguous input string, which incurs a violation of the constraint.

[21] I assume an unmarked CV syllabification here. I am not aware of any evidence bearing on the question of whether children's pronunciations possess the post-stress ambisyllabicity (Kahn 1976) or resyllabification (Selkirk 1982) claimed to exist in mature English. I also assume that the final consonant is incorporated as a coda, rather than being unsyllabified, or syllabified as the onset of an empty-headed syllable (cf. Goad 1996b).

The combination of ANCHOR-RIGHT, and I-CONTIG-σ yields the preservation of the final syllable, including its onset. We can now consider the cases in which the onset is taken from the medial syllable, in violation of I-CONTIG-σ. As we have seen, this occurs when the medial onset is less sonorous than the final one. The relative markedness of onsets of greater sonority can be captured by positing a set of constraints that penalize consonants of the various degrees of sonority, which are arrayed in a fixed ranking, with the degree of sonority correlating to the ranking of the constraint (see e.g. Prince and Smolensky 1993, Gnanadesikan 1995). Assuming that vowels and glides differ only in their syllabic position, the sonority scale in (17) yields the onset markedness hierarchy in (25):

(25) *V-ONS >> *L-ONS >> *N-ONS >> *F-ONS

*V-ONS is violated by a vocalic (glide) onset, *L-ONS by a liquid onset, *N-ONS by a nasal, and *F-ONS by a fricative.[22] Assuming that stops constitute perfect onsets, there is no constraint penalizing their appearance in that position. Because liquids are realized as glides in most of the child data we will be concerned with, the ranking between *V-ONS and *L-ONS is of no particular consequence. Therefore, I will henceforth collapse them into a single constraint *A-ONS (*APPROXIMANT-ONSET).

The ranking of I-CONTIG-σ with respect to this hierarchy will generate the pattern of onset selection seen in the data. The clearest pattern is the selection of the medial onset when

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[22] These constraints could be formalized without reference to a formal primitive 'Onset' (see Prince and Smolensky 1993, Gnanadesikan 1995 for two proposals), but the statements here are adopted for simplicity's sake.

the final one is a liquid, as this occurs without exception for a substantial number of target words. This indicates that *A-ONS ranks above I-CONTIG-σ:

(26) *A-ONS >>I-CONTIG-σ

| Input: buffalo | *A-ONS | I-CONTIG-σ |
|---|---|---|
| a. [bʌfo] ✔ | | * |
| b. [bʌwo] | *! | |

Candidate (26a) violates I-CONTIG-σ, but it avoids the violation of *A-ONS which rules out the competing (26b).

The ranking of I-CONTIG-σ relative to *N-ONS is less clearly determined by the data. *Sesame* and *company* have variants that indicate the dominance of *N-ONS ([sɛsi] and [kʌmpi]), but also others that attest to the reverse ranking ([kumni:] and [semi]), while the two truncations of *vitamin* both obey I-CONTIG-σ. For the one target word where it could have an effect, *F-ONS is always overruled by I-CONTIG-σ, producing [mɛ:sɪn] in all three tokens. I-CONTIG-σ thus varies somewhat in its ranking with respect to *N-ONS, but as far as can be told, dominates *F-ONS in the grammars producing these truncated forms. These rankings yield the hierarchy in (28).

(28) *A-ONS >> I-CONTIG-σ / *N-ONS >> *F-ONS

The slash in the hierarchy between I-CONTIG-σ and *N-ONS should be interpreted as indicating that the systems under consideration vary with respect to their ranking. It is impossible to know whether the ranking varies from stage to stage, or from word to word (see Chapter 2 on lexically specific constraints). Even though the data related to nasals and fricatives are far too sparse to support any firm conclusions, it is interesting that they are consistent with the presumed fixed ranking of the onset markedness constraints, which predicts that amongst these three constaints, the effects of *A-ONS should be the strongest, those of *F-ONS the weakest, and those of *N-ONS in between the other two. Similar evidence can be found in the data from initial truncation, to which we turn next.

### *3.2.5 Onset choice in initial truncation*

Just as ANCHOR-RIGHT targets only the rightmost segment when Input-Output Correspondence is mediated by segments, rather than syllables, STRESS-FAITH will only require the preservation of the vocalic nucleus bearing stress. Onset choice in initial truncation will thus be governed by the interaction of the same constraints that select the medial onset: I-CONTIG-σ and the onset markedness constraints. Here I will discuss the parallels between the data from intial and medial truncation.

As would be predicted by the ranking of *A-ONS over I-CONTIG-σ, the initial onset is almost always chosen to form a syllable with the stressed nucleus when one of the onsets is deleted, and the medial syllable starts with a liquid (e.g. [dɪʃəs] *delicious*, [gʌ:wa] *gorilla*, [ma:kas] *maracas*; [bun] *balloon*, [bɔŋ] *belong*, [ga:ʤ] *garage*, [mi] *Marie*, and [pis] *police*). The σ'σ example of [wæf] for *giraffe* will be discussed in the context of the evidence for minimal violation in the next subsection. In the σ'σσ data, there are two cases where the initial obstruent does not replace a following liquid onset, but these seem amenable to explanation. The first is [ri:sə] for *Theresa*, which Trevor produced at the relatively late age of 2; 11.10, at which point it may well be that I-CONTIG-σ has been promoted above *A-ONS. A similar developmental sequence can be seen in Julia's [pedo] for *potato* later being replaced by [teto], though this involves the interaction of I-CONTIG-σ with place sensitive constraints, which will be discussed in § 3.3 (see also Fikkert 1994:240, fig. 71).

The second σ'σσ case is [ma:mi] for *salami*, in which the liquid is replaced by a nasal. It seems quite possible that this process, widespread in Trevor's corpus, is in fact an alternate means of fulfilling the demands of *A-ONS, which is exploited when there is a nasal in the Input (cf. the description of 'phophylactic harmony' in Drachman 1976). In all the examples I have been able to find, the nasal replaces an onset approximant. Unfortunately, for most of the duration of this process, there are no approximants in coda position, since liquids are generally vocalized. Some other examples include [nona] for *Lorna* (1;4.2 ~ 1;7.26), [mɛmɛn] for *melon* (1;5.18 ~ 1;9.2), [mɪmə] (1;6.8 ~ 1;7.26) and [mɪmər] (1.9.1 ~ 1;9.2) for *mirror*, [niŋ] for *ring* (1;5.9 ~ 1;7.28), and [kainɪŋ]for *crying* (1;7.26 ~ 1;8.14). A description and account of the full set of facts surrounding this process is clearly the topic for another paper, but as far I can tell from preliminary investigation, obstruents participate neither as targets nor as triggers (cf. the liquid harmony in the Amahl corpus in Smith 1973, discussed in detail in Goad 1996a, to appear).

Another parallel with the data from medial truncation that can be observed in initial truncation is in the relatively weak effect of *N-ONS. Though *Denise* is consistently [dis], *banana* is produced as both [bænə] and [nænə], while *cement*, *tomato*, and *tomorrow* always appear with the nasal intact. This again provides indirect evidence for the fixed ranking of *N-ONS beneath *A-ONS, but the results must continue to be treated as preliminary, and not only because of the small number of examples. Here we must also parcel out the effect of the tendency, not seen in the medial deletion data, to preserve segments with particular places of articulation. Usually labials (and sometimes velars) replace coronals (see Smith 1973, Fikkert 1994: 239). Onset selection in all of *banana*, *cement*, *tomato*, and *tomorrow* could be affected by this labial preference.

### *3.2.6 Minimal violation in onset selection*

For the data we have looked at so far, *A-ONS could be taken to be fully satisfied. The only case in which we have seen it to be violated was in [ri:sə] for *Theresa*, which was claimed to be the product of a later stage, in which the ranking of *A-ONS and I-CONTIG-σ is reversed. However, this could equally be captured by eliminating *A-ONS from the grammar in this later stage. In this section, I present data that show that *A-ONS is in fact violated at the same time that it is determining the output of truncation; that it is not fully satisfied, but minimally violated. I will then provide an account of these facts.

One example is Trevor's pronunciation of *giraffe* as [wæf] (1;9.1 ~ 1;11.14). This pronunciation occurs at the same time as garage is being produced as [ga:dʒ] (1;10.5 ~ 2;0.24). In this case, the initial affricate [dʒ] in the target is itself a marked segment, for reasons independent of sonority. A nearby demonstration of its markedness is that [dʒ] surfaces as [d] in most of Julia's pronunciations of *giraffe*. Rather than alter the segment, Trevor deletes it and retains the approximant. Thus, the markedness of affricates is overriding the dispreference for approximants. The importance of this example to the current discussion is that even in the same context in which an approximant onset is generally discriminated against by replacing it with an obstruent, under certain circumstances it surfaces.

Approximant onsets can also appear in this position when the initial syllable provides no onset. For example, *eleven* surfaces as [jɛbən] (Julia 1;9.15), and *around* as [wau:n] (Trevor 2;0.8), which can be contrasted with *delicious* as [dɪʃəs] (Julia 1;11.27), and *garage* as [ga:ʤ] (Trevor 1;10.5 ~ 2;0.24). Here again, the fact that approximants are permitted in the same position from which they are eliminated when there is an available obstruent clearly shows that *A-ONS is not fully satisfied.

Returning to medial truncation, we can adduce similar evidence by comparing the truncated forms in which approximants are deleted, to bisyllabic targets with medial approximant onsets. The table in (31) shows the result of that comparison.

(31) 'σσσ vs. 'σσ targets

| | | | | | |
|---|---|---|---|---|---|
| **Julia** | | | *pillow* | [pɪwo] | 1;7.17 ~ 3:0.22 |
| *broccoli* | [baki] | 1;7.6 ~ 2;0.19 | *yellow* | [jɛwo] | 1;8.27 ~ 2;10.16 |
| *buffalo* | [bʌfo] | 2;0.14 ~ 2;3.9 | *carrot* | [kɛr/wɪt] | 1;9.18 ~ 1;10.10 |
| *favorite* | [fevət] | 2;0.25 ~ 2;6.1 | | [kɛrɪt] | 1;11.14 ~ 2;5.8 |
| **Trevor** | | | *berry* | [bɛri]/[bɛwi] | 1;4.23 ~ 2;5.4 |
| *camera* | [kæ:mə] | 1;5.6 ~ 1;11.25 | *yellow* | [jɛ:wow] | 1;8.6 ~ 1;8.7 |
| *dungarees* | [gʌŋgi: z ] | 1;10.1 | | [jɛ:jo] | 1;8.11 ~ 2;0.3 |
| *spatula* | [bæ:tʃʌ] | 1;11.23 | *pillow* | [pɪwo] | 1;5.19 ~ 2;6.1 |
| **Sean** | | | | | |
| *camera* | [kæmʌ] | 2;0.13 | *carry* | [kɛri] | 2;0.23 ~ 3;0.17 |

In the bisyllables on the right hand side of the table, we see that approximants occur in the very same position in which they are avoided in the truncated productions on the left.

These examples are analogous to ones that Gnanadesikan (1995) introduces in her discussion of onset reduction. In the stage that Gnanadesikan describes, when the target word supplies a single high sonority onset, it is represented faithfully in the child's production. It is only when the Input contains a cluster that the effects of the constraints demanding low sonority onsets are observed, in the selection of the least sonorous of the members of the cluster. This provides one of the instances of minimal constraint violation in the child language data that Gnanadesikan uses to argue for an approach to acquisition based on Optimality Theory.[23] She shows that the facts can be straightforwardly captured with outranked structural constraints, but cannot be dealt with in a principled fashion under the assumptions of fully satisfied constraints and/or ordered rules. The analysis to follow draws heavily on Gnanadesikan's account.

The first question I will address is, what permits the violations of *A-ONS in the non-truncated forms? In the truncation examples, the liquid is deleted. This means that MAXI-O, stated as "every Input segment has a Correspondent in the Output", must be dominated. In § 3.1.1, we saw that MAXI-O must be ranked below the constraints enforcing the one foot maximum, since if it were ranked above them, truncation would be blocked. Also dominating MAXI-O is the constraint *COMPLEX ("No complex onsets": Prince and

---

[23] Instead of "minimal violation", Gnanadesikan uses the term "emergence of the unmarked", following McCarthy and Prince (1994). The emergence of the unmarked refers to a scenario in which a language generally permits a marked structure, but the unmarked counterpart emerges in a particular environment in which the constraint forcing the appearance of the marked structure (usually a Faithfulness constraint) fails to apply. The "emergence of the unmarked" is one subset of the broader range of cases we can describe as instances of minimal violation, which would also encompass the "emergence of the marked", where a language generally respects a structural constraint, except in a particular context (see e.g. McCarthy 1996 on codas in Rotuman). The other case of the emergence of the unmarked, which Gnanadesikan discusses in more depth, is the existence of an OCP effect that applies only when there is a choice of onsets.

Smolensky 1993), which rules out a candidate in which the obstruent and the liquid form a single complex onset, as in [bʌfwo] for *buffalo*.[24] This type of Output does occur following the stage in which liquids are deleted, as in Julia's [plis] for *police* at 2;6.5, which would indicate the promotion of MAXI-O above *COMPLEX. In the following illustrative tableau, FTBIN, ALIGNLEFT, and PARSE-σ are merged into a single WORDSIZE constraint.

(32) WORDSIZE, *COMPLEX >> MAXI-O

| Input: buffalo | WORDSIZE | *COMPLEX | MAXI-O |
|---|---|---|---|
| a. [bʌfo] ✔ | | | ** |
| b. [bʌfwo] | | *! | * |
| c. [bʌfəwo] | *! | | |

In the case of a bisyllable with a single intervocalic consonant, neither the word size constraints nor *COMPLEX apply. Therefore, so long as MAXI-O is ranked above *A-ONS, it will choose the candidate without deletion:[25]

[24] Such clusters could also be heterosyllabic, in which case, a constraint other than *COMPLEX would be at work.

[25] A constraint demanding syllables with onsets (e.g. Prince and Smolensky's 1993 ONSET constraint) also favors this result, and could be invoked in addition to, or instead of MAXI-O to derive it. As Heather Goad points out, this would yield another case of minimal violation in development: ONSET is often fully satisfied at the outset of development, with epenthesis or reduplication filling empty onsets. At the stage(s) we are concerned with here, word-initial vowels are tolerated, in violation of the constraint.

(33) MAXI-O >> *A-ONS

| Input: *yellow* | WORD SIZE | *COMPLEX | MAX I-O | *A-ONS |
|---|---|---|---|---|
| a. [jɛwo] ✔ | | | | *! |
| b. [jɛo] | | | *! | |

This tableau shows that when the higher ranked constraints are satisfied by a faithful parsing, MAXI-O overrules the lower ranked onset markedness constraints. However, when the WORDSIZE constraints and *COMPLEX force violations of MAXI-O, the onset markedness constraint is given the opportunity to select the less marked onset:

(34) Activity of *A-ONS under domination

| Input: *buffalo* | WORD SIZE | *COMPLEX | MAX I-O | *A-ONS |
|---|---|---|---|---|
| a. [bʌfo] ✔ | | | ** | |
| b. [bʌfwo] | | *! | | * |
| c. [bʌfəwo] | *! | | | * |
| d. [bʌwo] | | | ** | *! |

The WORDSIZE constraint(s) and *COMPLEX each compel one violation of MAXI-O. Since (34a) and (34d) fare equally with respect to MAXI-O, evaluation is handed on to the lower ranked *A-ONS, which decides in favour of [bʌfo].

The other cases of minimal violation would be handled in a similar fashion. For the examples in which an approximant occurs in word initial position when the target does not supply an initial obstruent (e.g. *eleven* as [jɛbən]), the constraint hierarchy we have already established would generate the correct results: [jɛbən] is chosen over [ɛbən] due to the dominance of MAXI-O over *A-ONS. For *giraffe* as [wæf], *A-ONS must be dominated by a constraint against [dʒ], as well as an IDENTITY constraint that militates against changing the affricate to an obstruent (on the form of these constraints, see McCarthy and Prince 1995, and chapter 1 above). Note that IDENTITY is also needed in all of these cases to force the approximant to surface as such, rather than as an obstruent (see Fikkert 1994: 61-62 for examples in which target approximants do in fact become obstruents).

*3.2.7 Comparison with other approaches*

The most robust empirical finding in the area of onset selection is that when the medial syllable of 'σσσ target words, or the initial of σ'σσ or σ'σ words is truncated, the onset of the deleted syllable usually replaces the onset of following target syllable, when the latter is an approximant, and the former is a nasal or an obstruent. This was claimed to be driven by the markedness of approximant onsets relative to that of nasals and obstruents.

Fikkert (1994:240) sketches an analysis of initial syllable deletion facts in Dutch child language that is in some respects quite similar. She draws a parallel between the onset substitutions, and the fact that in her data, approximant onsets are in general late to emerge. This leads her to claim that examples in which approximants are replaced in truncation "are context-free substitutions, governed by the child's onset template." A template, as traditionally conceived, must be fully satisfied, and its effects should generally be context-free (though context sensitivity can of course be stipulated). However, we have seen that the replacement of approximants in the present data set is massively context-sensitive, which would argue against the extension of Fikkert's analyses to these cases. Approximant onsets do occur when no better onset is made available in the Input. With minimally violable constraints, we can capture the fact that an unmarked onset is selected when possible, but that a marked onset is otherwise allowed.

As we have seen, the use of STRESS-FAITH and ANCHOR-RIGHT produces an account of child truncation that in some respects mimics that of Echols and Newport (1992). Since the truncations of initially stressed trisyllables examined here overwhelmingly support the predictions of that model against the alternative presented in Gerken (1994), this can be considered a positive result. There are significant differences between the approach here, and that of Echols and Newport, though. First, there is no reliance here on the assumption that the syllables are lost due to misperception of the adult target. Most of the criticisms of this assumption that have emerged in the literature are based on the facts that the weak syllable is usually variably present in children's productions, which is amply demonstrated in the Appendix, and that material from the unstressed syllable is preserved (see Fikkert 1994, Gerken 1994, Wijnen, Krikhaar, and den Os 1994, but see also Paradis, Petitclerc and Genesee 1996). These observations suggest that the child perceives the unstressed syllable that is deleted in production, though Gerken (1994:568) does show that these facts could be reasonably interpreted in a perception based account.

A more important difference is that this analysis recognizes that there is more to truncation than simple retention of the stressed and rightmost syllables (see Fikkert 1994, Gerken 1994). The claim here is that the forces motivating the retention of these syllables interact with other types of well-formedness constraints, in particular, constraints that optimize syllabic structure. Crucially, these constraints are minimally violable, rather than fully satisfied. The insufficiency of fully satisfied constraints is clearly pointed to by the difficulties that the S(W) template model, and the perceptual bias account, have in dealing with the *elephant* data. In large part, the difficulties stem from the fact that these analyses are based on categorical claims that the mapping from adult to child form must choose stressed and adjacent syllables, or stressed and rightmost ones. However, once restrictions on mapping are taken to be minimally violable, constraints demanding preservation of adjacent elements from the Input (i.e. CONTIGUITY), and constraints demanding preservation of edge elements (i.e. ANCHORING) can be played off against each other, and against constraints demanding unmarked Output prosodic structures. The data and analyses supplied in this section illustrate some results of that interplay.

### 3.3 Minimal violation across development stages

The consequences of the novel view of child language, and especially of development, that minimal violation affords have only begun to be explored, even within phonology, let alone other areas, such as syntax. Working in the framework of Natural Phonology, which is in some important respects similar to the present one, Stampe (1969) claims that there are three ways that a child overcomes natural processes: they can be suppressed, ordered or limited.

Suppression is equivalent to shutting off a constraint; here minimal violation offers nothing new. The effects of rule ordering do overlap in certain ways with the effects of constraint ranking; it remains to be seen whether constraint ranking captures all that rule ordering does (see Gnanadesikan 1995 for child language evidence that the reverse is not true). To limit a process, Stampe (1969:443) says, is "to limit the set of segments it applies to or the set of contexts it applies in." In the rule-based system of Natural Phonology, the limiting conditions are specific to each process, and must be stipulated for each one. The same would be true in a theory of fully satisfied constraints; if a parameter is given intermediate settings between on and off, for instance, these intermediate settings must be stated separately for each parameter. It is here that minimal violation promises significant explanatory advances, since any constraint that serves to limit the effects of a lower ranked constraint can simultaneously outrank and limit any of a number of other constraints. And to the extent that limiting conditions are not specific to particular processes, but instead are of wider generality, the present framework will continue to find empirical support. In this section, I document a case in which the effects of the limiting constraints do in fact extend beyond the specific process in question. We will see that the constraints on place Faithfulness that serve to limit the scope of consonant harmony also play a role in the cases of onset selection that are motivated by place of articulation differences between the segments.

### *3.3.1 The consonant harmony constraint*

Consonant harmony in child language refers to a process by which non-adjacent consonants assimilate in place or manner. Here, we will be concerned exclusively with the assimilation of primary place features, the most prevalent and widely discussed form of child consonant harmony. Some examples from Trevor's corpus are presented in (35).

| | | | |
|---|---|---|---|
| (35) | a. [gɪgʊ] *tickle* (1;7.28) | b. [kʌ ] *tongue* (1;7.28) | c. [kog] *cold* (1;8.7) |
| | d. [piwi] *TV* (1;6.25) | e. [bop] *boat* (1;8.12) | f. [gɪgu] *pickle* (1;9.2) |

These examples show that consonant harmony can be regressive (35a,b,d,f) or progressive (35c,e), it can target coronals (35a,b,c,d,e) or non-coronals (35f), and it can be triggered by velars (35a,b,c,f) or labials (35d,e). They further demonstrate that the target and trigger can differ in manner (35b,d),[26] and that vowels with various place specifications can intervene.

Consonant harmony is rarely attested in a single child's corpus in the range of fashions illustrated in (35). It is usually limited in one or more ways: to regressive directionality (e.g. Smith 1973; Cruttenden 1978), to coronal targets (Smith 1973, Stoel-Gammon and Stemberger 1994), to velar triggers (Smith 1973), or to consonants with an intervening homorganic vowel (Levelt 1994). One consequence of constraint violability is that it is in principle possible to attribute different varieties of consonant harmony to a single motivating constraint, with the differences between them being captured by the ranking of that constraint with respect to others (cf. the discussion of "Color" harmony in Padgett 1995a: 390). Constraint violability also allows us to make formal use of the traditional idea that consonant harmony is itself a limited (or partial) form of the full reduplication that is so common in babbling and early speech (see e.g. Jespersen 1922: 109; Goad 1993: 296). It seems likely that for children at an early stage of development, there is an advantage to gestural repetition at

[26] Because [voice] is difficult to accurately transcribe in child speech (Macken and Barton 1980), examples in which the target and trigger differ in other features are more convincing.

some level of speech production (see Menn 1976, Vihman 1978). I suggest that this preference for repeated gestures is incorporated into the child's grammar as the constraint REPEAT (see Yip 1995 for a broader formulation):[27]

(36) REPEAT
Successive consonants must agree in place specification

The stipulation that the constraint applies specifically to the place specification of consonants is an expository simplification that could ultimately be replaced by the use of independent dominating constraints, so as to complete the connection with full reduplication. It should be emphasized that the exact nature of the constraint driving consonant harmony is to some extent independent of the line of argument here: what is crucial is how this constraint interacts with consonantal place Faithfulness (cf. Levelt 1995, Stemberger 1995, Goad 1996, to appear for other approaches). It is to that area that we now proceed.

### *3.3.2 The limitation of consonant harmony: the data*

Both Trevor and Sean display what may be referred to as velar dominant harmony, in that labials, and coronals assimilate to velars. A full list of the words that undergo coronal-to-velar, and labial-to-velar assimilation that I have extracted from Trevor and Sean's corpora are given in (37a,b) and (37c,d) respectively. Again, the ages at which the first and the last token of each form was produced are noted in parentheses, and the phonetic

[27] In § 3.4, however, it is suggested that REPEAT is in fact a child-specific constraint, because consonant harmony is a child-specific process. Yip (1995) uses her version of REPEAT to drive morphological reduplication in adult languages. It would appear that under certain rankings, Yip's REPEAT does in fact yield child-like consonant harmony. Theories of reduplication have yet to take on the task of generating only the attested cases of "pre-specification" (see Alderete et al. 1996), but not long distance consonant assimilation (see Gafos 1996).

transcriptions abstract across some variation across tokens, mostly in vowel quality and the voice specification of consonants.

(37) a. Trevor's coronal-to-velar assimilation

| | | | | | |
|---|---|---|---|---|---|
| [gɔg] | *dog* | (1;4.19 ~ 2;3.17) | [gʌk] | *duck* | (1;4.27 ~ 2;2.3) |
| [gʌŋgi:z] | *dungarees* | (1;10.1) | [gækɪt] | *jacket* | (1;4.19 ~ 1;10.11) |
| [kɪŋk] | *sink* | (1;7.6) | [gak] | *sock* | (1;5.25) |
| [gɪk] | *stick* | (1;7.26 ~ 1;8.14) | [kek] | *take* | (2;1.4 ~ 2;1.26) |
| [gægu] | *thank you* | (1;6.25 ~ 1;6.29) | [gɪgu] | *tickle* | (1;4.19 ~ 1;11.25) |
| [k(r)ʌk] | *truck* | (1;6.17 ~ 2;2.15) | [kʌŋ] | *tongue* | (1;4.19 ~ 1;7.25) |
| [kaʊg] | *cloud* | (1;8.27) | [kok] | *coat* | (1;5.18) |
| [kog] | *cold* | (1;6.29 ~ 1;9.2) | [rɛkɪk] | *record* | (1;7.20 ~ 2;0.8) |
| [gɛ:g] | *good* | (1;6.17 ~ 1;10.5) | [kɪkar] | *guitar* | (2;1.5 ~ 2;4.3) |
| [kɪk] | *kiss* | (1;5.18 ~ 1;7.20) | | | |

b. Trevor's labial-to-velar assimilation

| | | | | | |
|---|---|---|---|---|---|
| [gæk] | *back* | (1;9.1 ~ 1;11.2) | [ga(r)k] | *bark* | (1;8.14 ~ 1;10.9) |
| [gɪg] | *big* | (1;9.21 ~ 1;10.9) | [gaik] | *bike* | (1;5.4 ~ 1;10.11) |
| [gægi] | *blanket* | (1;3.1 ~ 1;6.25) | [gʊk] | *book* | (1;5.4 ~ 1;10.2) |
| [gak] | *box* | (1;5.25 ~ 1;9.24) | [gʌgɪt] | *bucket* | (1;7.20) |
| [gʌk+gu] | *buckle* | (1;8.12) | [gʌki] | *Bucky* | (1;6.25 ~ 1;8.2) |
| [gʌg] | *bug* | (1;5.13 ~ 1;8.2) | [gʌgi] | *buggy* | (1;6.17 ~ 1;10.11) |
| [kʌg] | *plug* | (1;6.17 ~ 1;10.2) | [gækʌm] | *vacuum* | (1;6.29 ~ 1;7.4) |
| [kʌk] | *cup* | (1;5.5 ~ 1;5.30) | [gak] | *Mark* | (1;5.13) |
| [kɪku] | *pickle* | (1;5.6 ~ 1;11.1) | | | |

c. Sean's coronal-to-velar assimilation

| | | | | | |
|---|---|---|---|---|---|
| [kɪkʌ] | *chicken* | (1;6.27) | [kʊko] | *circle* | (1;8.24 ~ 1;10.17) |
| [gɔgi] | *doggie* | (1;8.11 ~ 2;5.21) | [gwiŋk] | *drink* | (2;0.18 ~ 3;1.13) |
| [gʌk] | *duck* | (1;11.11 ~ 2;1.19) | [gækɪt] | *jacket* | (1;11.11 ~ 2;1.23) |
| [kwiŋ] | *string* | (1;10.6 ~ 2;2.13) | [gʌk] | *stuck* | (1;10.12 ~ 1;11.11) |
| [kek] | *take* | (2;2.22 ~ 3;2.19) | [kekiŋ] | *taking* | (2;9.11 ~ 3;1.0) |
| [kɔk] | *talk* | (2;0.18 ~ 2;5.14) | [kæŋk] | *thank* | (1;6.1 ~ 3;2.0) |
| [kɪkak] | *tick tock* | (1;6.22 ~ 2;1.11) | [kaigə] | *tiger* | (2;2.7) |
| [kʌŋ] | *tongue* | (1;10.10 ~ 2;9.20) | [krɪk] | *trick* | (2;11.17 ~ 3;0.20) |
| [k(r)ʌk] | *truck* | (1;9.17 ~ 3;0.8) | [kok] | *cold* | (1;10.29 ~ 1;11.6) |
| [gægi] | *glasses* | (1;4.2 ~ 1;4.6) | [kaik] | *kite* | (2;3.7) |

d. Sean's labial-to-velar assimilation

| | | | | | |
|---|---|---|---|---|---|
| [gʊk] | book | (1;9.21 ~ 1;10.8) | [gogɛn] | broken | (1;8.2 ~ 1;10.10) |
| [kok] | fork | (1;9.13 ~ 1;9.15) | [gauk] | milk | (1;9.15 ~ 1;11.11) |
| [gækɪk] | vacuum | (1;10.22) | [kaki] | coffee | (1;9.15 ~ 1;11.4) |

A comparison of the ages at which the last token of each form is produced shows that the assimilation of coronals persisted longer than that of labials. Neither child produced a word displaying labial-to-velar assimilation after the two-year mark, while both children produced examples of coronal-to-velar assimilation for some time thereafter, with Sean's harmony lasting until past the age of 3.

Particularly revealing in this respect is the development of the phrase *dog barking* in Trevor's corpus:

(38) *dog barking* through time

| | |
|---|---|
| [gɔgarkɪŋ] | (1;8.14) |
| [gɔga:kɪŋ] | (1;9.1) |
| [gɔ:ga:kɪŋ] | (1;9.2) |
| [gɔ:ga:kɪŋ] | (1;9.23) |
| [gɔg ga:kɪŋ] | (1;9.29) |
| [gɔg ga:kɪŋ] | (1;10.9) |
| [gɔg ba:rkɪŋ] | (1;10.13) |
| [gɔg barkɪŋ] | (1;11.1) |
| [gɔg ba:rkɪŋ] | (1;11.5) |

The initial labial of *barking* began to be produced at (1;10.9), while the coronal of *dog* continued to be assimilated to the velar. The unassimilated version of *dog* first appears at 2;1,[28] with free variation between it and [gɔg] lasting until 2;3.17.

To further illustrate the earlier disappearance of labial-to-velar assimilation, I provide in (39) a set of near minimal pairs of velar-harmonizing words with labial and coronal initial consonants that were recorded for Trevor at approximately the ages of 1;9 and 2;0.

[28] There is in fact one instance of [dɔg] at 1:4.23. which was noted to have been said twice that day. This contrasts with four occurrences of [gɔg] on the same day, six in preceding days. and at least fifty before the next instance of [dɔg] at 2:1.0.

| | | | | | | |
|---|---|---|---|---|---|---|
| (39) | a. | [gʌk] | *duck* (1;9.1) | | [gɔg] | *dog* (1;8.7) |
| | b. | [gʌg] | *bug* (1;8.2) | [kʌg] *plug* (1;9.27) | [gak] | *box* (1;9.1) |
| | c. | [gʌk] | *duck* (2;0.3) | | [gɔg] | *dog* (2;0.3) |
| | d. | [bʌg] | *bug* (1;11.9) | [pʌg] *plug* (1;11.1) | [bɔks] | *box* (1;11.5) |

At 1;9, the coronals (39a) and labials (39b) equally underwent velar harmony. At 2;0, the coronals continued to be targeted (39c), while the labials had already ceased to harmonize at the beginning of the previous month (39d).

### *3.3.3 REPEAT and Faithfulness*

The data presented in the previous subsection indicate that there are two stages in Sean and Trevor's consonant harmony data: in the first, both labials and coronals assimilate to velars, and in the second, only coronals assimilate. To account for these patterns, we must invoke along with REPEAT a set of constraints that control the relationship between the place specifications of Input and Output consonants. For present puposes, we can refer to them as FAITHLAB, FAITHDOR, and FAITHCOR: labial, dorsal (i.e. velar), and coronal Faithfulness respectively. They could either be conceived of as MAX constraints that target individual features, demanding that Input features have Output correspondents, or as featural Identity constraints that require segments in Correspondence to bear identical place specifications. The choice between the two is of no particular consequence here (see § 1.3.1 above, Lombardi 1995, McCarthy 1996, and Alderete et al. 1996 for discussion of differences between the two approaches).

In the first stage, in which the labials and coronals assimilate to the velars, REPEAT is fully satisfied.[29] When an Input word consists of segments that have different places of articulation, one of the segments is always altered. To determine which one, the place Faithfulness constraints come into play. For the words with coronal-to-velar assimilation, both REPEAT and FAITHDOR must dominate FAITHCOR. This ranking is illustrated in (40):

(40) FAITH(DOR), REPEAT >> FAITH(COR)

| Input: *duck* | FAITH(DOR) | REPEAT | FAITH(COR) |
|---|---|---|---|
| a. [dʌk] | | *! | |
| b. [dʌt] | *! | | |
| c. [gʌk] ✔ | | | * |

In the absence of any assimilation, REPEAT is violated (40a). With velar-to-coronal assimilation, FAITH(DOR) is violated (40b). If both of these constraints dominate FAITH(COR), the alternative of assimilating the coronal (40c) is chosen as optimal, since it violates only the outranked constraint. Note that we must also assume a dominant MAX constraint to block deletion. As this constraint is unviolated, and common to all the tableaux, I have left it out.

For the instances of labial-to-velar assimilation, the same sort of ranking is involved, with FAITH(LAB) replacing FAITH(COR):

[29] A caveat here is that this abstracts from some lexical exceptionality, as well as the effects of directionality: labial-to-velar assimilation is much less robust when the velar precedes the labial.

(41) FAITH(DOR), REPEAT >> FAITH(LAB)

| Input: *bug* | FAITH(DOR) | REPEAT | FAITH(LAB) |
|---|---|---|---|
| a. [bʌg] | | *! | |
| b. [bʌb] | *! | | |
| c. [gʌg] ✔ | | | * |

Here labial faithfulness is sacrificed (41c) so as to satisfy the higher ranked FAITH(DOR) and REPEAT.

Combining these rankings produces the hierarchy in (42).

(42) FAITH(DOR), REPEAT >> FAITH(LAB), FAITH(COR)

We have no evidence for a ranking between FAITH(DOR) and REPEAT, as both are fully satisfied in the data under consideration. We also have not seen anything that would fix the ranking between FAITH(LAB) and FAITH(COR). The dominance of FAITH(LAB) over FAITH(COR) could be established empirically within the present data set by looking at instances in which a labial and a coronal occur in a word. In both Trevor and Sean's corpora, these words go through a stage in which the coronal assimilates to the labial (e.g. Trevor's [piwi] *TV* and [bop] *boat*). This would be generated by the ranking REPEAT, FAITH(LAB) >> FAITH(COR).

However, motivation for the FAITHLAB >> FAITHCOR ranking goes far beyond the labial harmony data. It seems to be a universal of child consonant harmony systems that coronals are always included as targets; no process targets labials, or velars, to the exclusion of coronals, whereas coronals are quite commonly picked out as the sole targets (see Smith 1973; Stoel-Gammon and Stemberger 1994). This is parallel to what has been observed of place assimilation between adjacent consonants in the languages of the world. As Mohanan (1993: 76) puts it, if non-coronals undergo assimilation, so do coronals (see further Jun 1995; see also Avery and Rice 1989, and Rice 1994 for feature geometric approach to the facts).

The implicational relationship between noncoronal and coronal targets can be captured if the dominance of FAITH(DOR) and FAITH(LAB) over FAITH(COR) is universally fixed (Kiparsky 1994; cf. Gnanadesikan 1995, Jun 1995 for slightly different proposals). With this fixed ranking, any time that REPEAT compels the assimilation of labials or velars by being ranked above FAITH(DOR) or FAITH(LAB), it will necessarily cause coronals to assimilate. For example, whenever the ranking REPEAT, FAITH(DOR) >> FAITH(LAB) motivates labial assimilation, as in tableau (41), it will also lead to coronal assimilation, since this ranking, combined with the universal FAITH(LAB) >>FAITH(COR), will create the hierarchy REPEAT, FAITH(DOR) >> FAITH(LAB) >> FAITH(COR). Included in this full hierarchy is the ranking REPEAT, FAITH(DOR) >> FAITH(COR), which as demonstrated in tableau (40), assimilates coronals to velars.

The hierarchy for the first stage of Trevor and Sean's consonant harmony now stands as in (43).

(43) REPEAT, FAITH(DOR) >> FAITH(LAB) >> FAITH(COR)

In the second stage, the labials stop assimilating to the velars, while the coronals continue to undergo harmony. This pattern is produced by the ranking of FAITH(DOR) and FAITH(LAB) above REPEAT, with only FAITH(COR) below. Tableau (44) shows the blocking of assimilation that this ranking generates.

(44) FAITH(DOR), FAITH(LAB) >> REPEAT >> FAITH(COR)

| Input: *bug* | FAITH(DOR) | FAITH(LAB) | REPEAT | FAITH(COR) |
|---|---|---|---|---|
| a. [bʌg] ✔ | | | * | |
| b. [bʌb] | *! | | | |
| c. [gʌg] | | *! | | |

Both FAITH(DOR) and FAITH(LAB) are crucially ranked above REPEAT, so as to block labial-to-velar (44c) and velar-to-labial assimilation (44b).

With FAITH(COR) dominated by REPEAT and FAITH(DOR), coronal-to-velar assimilation still occurs:

(45) FAITH(DOR), FAITH(LAB) >> REPEAT >> FAITH(COR)

| Input: *duck* | FAITH(DOR) | FAITH(LAB) | REPEAT | FAITH(COR) |
|---|---|---|---|---|
| a. [gʌk] ✔ | | | | * |
| b. [dʌk] | | | *! | |
| c. [dʌt] | *! | | | |

The pattern of development is thus characterized as the outranking of REPEAT by place Faithfulness constraints. In the first stage REPEAT is dominant, and fully satisfied, in the second it is dominated, and minimally violated. Importantly, with the fixed ranking of FAITH(COR) beneath FAITH(LAB), it is predicted that the reverse developmental scenario, in which coronals are the first to stop assimilating, should be impossible. It should be noted because the ranking between FAITH(DOR) and FAITH(LAB) is not universally fixed (cf. Gnanadesikan 1995, Jun 1995), either labials or velars can dominate the other in assimilation. This seems consistent with the known child language facts: for evidence of velar-to-labial assimilation, see Cruttenden (1978), Gnanadesikan (1995:fn. 22), and Macken (1995:679). Labial-to-velar assimilation is reported in Menn (1976), as well as in the present study.[30] In the domain of adult phonology, only labial-to-velar assimilation is attested, but because the targets in the adult cases are codas, this may be due to the general preference for velar codas (see Jun 1995; cf. Rice 1994).

### *3.3.4 Place Faithfulness in truncation*

In this section I demonstrate that the constraints that limit the effects of REPEAT can be seen to play a role in determining the output of truncation. Recall that Trevor produced *caboose* as [gu:s] from 2;4.24 to 2;11.17, and *guitar* as [ga] or [ga:r] from 1;1.19 ~ 2;1.5. In these cases of onset selection, it is the place specification of the consonants, rather than their sonority, that is of import. Somewhat similar cases are reported in Smith (1973), and Fikkert (1994). However, in those data, coronals are the only segments to be replaced; as far as I know [gu:s] for *caboose* is the first attested instance in which a velar is chosen from initial position to replace a labial. Undoubtedly, the uniqueness of this instance of onset selection

[30] Stoel-Gammon and Stemberger (1994) cite 5 instances of labial-to-velar assimilation, and 9 cases of velar-to-labial. Because no information is given on individual children's patterns, and the source of the data for each of these cases is not mentioned, it is impossible to know whether some, or all, of the instances of apparent velar-to-labial assimilation are in fact accompanied by the total absence of velars in the child's data at the relevant stage, as in Donahue (1986).

is related to the unusualness of Trevor's labial-to-velar consonant assimilation: the survey in Stoel-Gammon and Stemberger (1994) notes only 5 children who displayed this type of harmony, as opposed to 19 who had coronal-to-velar assimilation.

The connection between these two processes falls out directly from the analysis of consonant harmony above. For the consonant harmony pattern we made crucial use of a ranking between FAITH(DOR) and FAITH(LAB); this same ranking chooses [gu:s] over [bu:s] in the case of truncation:

(46) FAITH(DOR) >> FAITH(LAB)

| Input: *caboose* | FAITH(DOR) | FAITH(LAB) |
|---|---|---|
| a. [gu:s] ✔ | | * |
| b. [bu:s] | *! | |

To get this result, we must also assume that FAITH(DOR) dominates I-CONTIG-σ, since I-CONTIG-σ would prefer to preserve the labial. This is straightforward, so I will not provide a tableau (see § 3.2.4 for relevant discussion).[31]

It is quite interesting that the effects of the ranking of FAITH(DOR) over FAITH(LAB) are seen at this late a date in Trevor's development. Labial-to-velar assimilation dies out before age two, while this truncation pattern is attested from 2;4.24 to 2;11.17. Thus, the high

[31] If the Faithfulness constraints are conceived of as Featural Identity constraints, we must also assume that this apparent case of deletion is in fact fusion. If the velar is deleted in (46a), for instance, no violation of FAITHDOR would be incurred, since Featural Identity only applies to segments in Correspondence, and a deleted Input segment lacks an Output correspondent. This problem is avoided if the Output onset is in fact in Correspondence with both Input onsets, so that the choice between the place features can be made by the Identity constraints (see Gnanadesikan 1995 for discussion).

ranking of FAITH(DOR) persists across developmental stages, even though its effects change due to the reranking of other constraints (in particular, FAITHLAB over REPEAT, which blocks labial-to-velar assimilation).

### 3.4 Conclusions

In this chapter, we have examined several cases which provide support for the position that when child language constraints are overcome, they are outranked, not shut off. In the domain of foot and word level prosodic structure, constraints that serve to limit child words to a single foot were shown to play a role in the adult English stress system. In the adult system, these constraints are not inviolable as they are in the child system, nor are they freely violable as they would be if they were turned off. Instead, they are minimally violable, asserting themselves whenever they are not fettered by the restrictions of higher ranked constraints In the domain of syllable structure, a constraint on onset markedness was shown to be minimally violable in the child system itself; it plays a crucial role in determining the output of truncation, yet in other cases it is violated. Finally, at the level of the segment, explicit evidence of the developmental process of constraint outranking was provided: a constraint causing consonant harmony is first unviolated, assimilating both coronals and labials to velars, and later minimally violated, assimilating only coronals.

Besides providing evidence for a view of development as constraint reranking, these cases demonstrate the fruitfulness of the view of markedness as constraint violation. As opposed to parochial theories of markedness that apply only to particular sub-domains within phonology (e.g. underspecification for segmental phonology, unmarked parameter settings for syllable structure), markedness in Optimality Theory is domain independent. The generality of this approach to markedness allows phenomena beyond the reach of traditional markedness theories, such as the word size maximum, to be formally treated as instances of the broad unmarkedness of child language. Given the wide scope of the framework, further progress along these lines appears readily achievable.

Some puzzles do remain to be addressed, of course. Chief among them is the fact that while consonant harmony is extremely common in child language, it is unattested in this form in adult languages, where primary place assimilation applies only locally, not across intervening vowels (see Shaw 1991 for discussion). Drachman (1976) points to this and other disparities between the domains of child and adult phonology in a challenge to Stampe's (1969) claim that the two areas are subject to the same set of natural processes, and in particular, that it is the application of natural processes in child language that is responsible for much of historical sound change. Putting the issue of the locus of sound change to the side, the problems that Drachman raises for the theory of Natural Phonology continue to apply equally to the almost any approach in which phonological theory is applied to child phonology, including the present one (see Macken 1995 for relevant discussion).

By following Jespersen (1922) and drawing a connection between consonant harmony and full reduplication, the position here is that the constraint REPEAT is constructed by the child in response to the pressures imposed by the developing production system, which entails that at least some constraints of child phonology are inductively learned, rather than innately given (see the discussion of consonant harmony and Stampean innateness in Menn 1976 and Vihman 1978; see also Hayes 1995 for other motivations for constraint construction). To explain the child/adult asymmetry, it would also have to be the case that REPEAT and other constraints like it are eliminated from the grammar, since if they were simply low ranked, their effects could be seen in "emergence of the unmarked" scenarios (McCarthy and Prince 1994a; see also fn. 23 above). Clearly, the introduction of child-specific constraints has implications for learnability theory that cannot be taken lightly. Not only would constraint reranking have to be shown to be computationally tractable (Turkel 1994, Smolensky and Tesar to appear), but an account would also have to be given of constraint genesis, and of constraint extinction. This is a considerable task, but one that appears worth undertaking, since it has the potential to contribute to a sufficiently restrictive theory of adult phonology, and to an explicit depiction of the relationship between developing and mature sound systems.

## Conclusions to the Thesis

To provide a perspective from which to discuss the results obtained in these three studies of the consequences of constraint ranking, I would like to return to Anderson's (1979) distinction between the explanatory and exegetic adequacy of phonological theories, first brought up in the conclusion to chapter 1. A theory that is explanatorily adequate is one that makes the right predictions: it allows for all and only the attested possibilities within the domain it covers (see also Chomsky 1986). A theory that is exegetically adequate, on the other hand, allows us to make "some progress in understanding the facts as they are, though not in the sense of showing that they could not be otherwise" (Anderson 1979: 18).[1]

In the first chapter, the concern was with explanatory adequacy, both within the framework of Optimality Theory, and across frameworks. It was shown that by treating the NC effects (nasal substitution, postnasal voicing, et al.) as resulting from the ranking of a substantive output constraint over various Faithfulness constraints, considerable strides toward explanatory adequacy could be made. The range of attested nasal-voiceless obstruent interactions were generated, with just a slight overgeneration in the area of epenthesis. Of the existing alternative conceptions of NC effects, the present Optimality Theoretic one best fits the facts.

The research presented in the second and third chapters, on the other hand, may be thought of primarily as studies in exegetic adequacy. In chapter 2, we examined a series of phenomena in the English stress system that exhibit nonuniform constraint application, that is, in which a constraint applies only in a particular context. These phenomena have not

[1] Anderson's contention is that the standard theory, embodied by Chomsky and Halle (1968) and subsequent work, was exegetically adequate, and that this was all we should expect of a theory of phonology. Most phonologists would agree, I think, that predictive explanatory adequacy is a desirable, if elusive goal.

necessarily eluded description in previous work, but the types of descriptive devices required can be characterized as stipulative. The general advantage of minimal constraint violation is that it often allows for a more principled description of nonuniformity, reducing it to the interaction of fundamental constraints. The main result of chapter 2 was that this sort of reduction was in fact possible within the study of English stress. Crucially, reduction to basic principles does not necessarily entail explanatory adequacy; in fact, these goals often conflict, since principles that extend beyond the case at hand may well extend too far, yielding unwanted results (see, for example, the discussion of Itô, Mester, and Padgett 1995 and prenasal voicing in chapter 1). Within the limited area of main stress-specific quantity sensitivity, it was shown that the analysis invoked for English does seem to make the right cross-linguistic predictions. However, whether this approach to metrical theory is more broadly consistent with the findings discussed in Hayes (1995) and other typological work remains to be seen.

Similarly, by focusing on minimal violation in child phonology in chapter 3, the main purpose was to "understand the facts as they are", not to "show that they could not be otherwise". It was demonstrated that minimally violable constraints allow for a more adequate description of the facts than do inviolable ones. The only way in which the analysis is predictive is in its postulation of a fixed ranking of non-coronal Faithfulness constraints above coronal Faithfulness, which correctly rules out a scenario in which coronals are the sole targets for harmony.

One way of obtaining a predictive theory of child phonology within the Optimality framework is suggested in Gnanandesikan (1995): assume that all constraints are innate, and that structural constraints outrank Faithfulness constraints at the outset of acquisition. However, it is far from clear whether the simple structural >> Faithfulness schema captures all and only the attested child language phenomena. Particularly striking evidence that it does match the facts is provided by Gnandesikan (1995), who shows that the pattern of onset cluster reduction in the speech of a two and a half year old English learning child replicate exactly the pattern of onset simplification in Sanskrit reduplication. In this dissertation, we have seen two more examples of parallels between child language and cross-linguistic unmarkedness. In §1.2.3, it was noted that the deletion of nasals before voiceless stops observed in Kelantan Malay and Maore is attested in child English, child Greek, and child Spanish. In chapter 3, we saw that the single foot maximum imposed on the Diyari reduplicant finds expression in the word size maximum of child English and child Dutch. However, we have also seen a child language process that is absent in adult languages: long distance assimilation of primary consonant place, also known as consonant harmony. An understanding of the basis of this and other child-adult mismatches, as well as a fuller cataloguing of attested, and unattested phenomena in child language, is clearly a priority for further research

In sum, this dissertation has shown that both explanatory and exegetic adequacy can be enhanced in various domains through the introduction of constraint ranking. The extent to which these gains can be further generalized, and the extent to which constraint ranking also results in explanatory and/or exegetic losses, will, as usual, be determined through further development and critical evaluation of the framework.

## Appendix to Chapter 3

## Prosodic Development Documented[1]

In what follows, I document the process of prosodic development by providing a list of both the truncated and non-truncated versions of the target words discussed in Chapter 3, and the order in which they appeared, as well as the age at which they were pronounced. To make the size of this Appendix as manageable as possible, I have omitted many sequential repetitions of particular pronunciations. However, I did make sure to include the first and last instances of each pronunciation, and when the pronunciation changed, I included the immediately prior instance of the first one. For instance, if the tokens of *banana* appeared in the corpus as follows:

| | | |
|---|---|---|
| (1) | 1;11.21 | næna |
| | 1;12.3 | næna |
| | 2;0.1 | næna |
| | 2;3.2 | bənænə |
| | 2;3.4 | bənænə |
| | 2;3.5 | bənænə |
| | 2;4.23 | nænə |

They would be given in this Appendix as:

| | | |
|---|---|---|
| (2) | 1;11.21- 2;0.1 | nænə |
| | 2;3.2 - 2;3.5 | bənænə |
| | 2;4.23 | nænə |

This saves considerable space, at the cost of losing information about the number of times

[1] This Appendix is intended for inclusion in the dissertation only, not in the published version of the paper.

particular forms occurred. But since the data were not collected in such a way that would support quantitative analysis, this seems of little consequence.

An inspection of the resulting compilation of child forms quickly reveals that the notion of a "stage" in prosodic development must abstract from a considerable amount of variation. This is not so much true of Derek's data, which shows little evidence of variation, data are quite but it is probably no coincidence that Derek's corpus is the smallest, and hence least detailed of the three. The variation that is seen in the other children's speech occurs both across words, and across instantiations of particular words; we can refer to these as lexical and free variation respectively. Lexical variation is evident in the occurrence of words larger than a single foot, at the same time that other words continue to be truncated. For examples, at 2;5.16 Julia produces *another* as [ənʌdə], and *apartment* as [patment]. Free variation is instantiated in words that vary between truncated and non-truncated versions. Many examples of free variation, often occuring on the same day, can be quickly found by scanning the data below.

The presence of lexical variation shows that prosodic development is not strictly across the board, but to some extent diffuses across the lexicon, while the free variation shows that during the transition from one stage to the next, words can be produced according to the norms of either the earlier or later stage. Neither free nor lexical variation is expected in a theory in which all words are subject to a single constraint ranking, and in which development consists simply of rearranging that ranking, just as they are unexpected in a theory in which the grammar is defined by parameter settings that apply to all words, or the ordering of rules is limited to a particular fixed state for the entire lexicon.

This does not necessarily argue, however, against a grammatical account of the data. In recent work in Optimality Theory, there has been a number of proposals about how to deal with the lexically based variation (e.g. Hammond 1995, Inkelas, Orgun, and Zoll 1995, Itô and Mester 1995, Pater 1994, Chapter 2 above) and with the 'free' variation[2] (e.g. Antilla 1995, Kiparsky 1993, Reynolds 1995) that is observed in 'steady state' grammars. These accounts could be straightforwardly adapted to the data at hand, though it is important to note that the introduction of unranked, or lexically ranked constraints, may have consequences for a theory of learnability. In any case, until we can be sure that child language variation is qualitatively different from that of adult languages (see Rice 1995 for arguments that it is not), the presence of variation in these data should not be seen as counter-evidence for a grammatical analysis.

[2] Scare quotes are used here because a major goal of these papers is to account for the limits on variation.

**Derek's data**

**σ'σσ words**

**another**

2;2.23 [nʌdɝ]

2;5.4 [nʌdɚ]

2;5.11 [nʌdɚ]

**baloney**

2;7.18 [bwani]

2;8.16 [bwoni]

2;10.2 [bwoni]

**banana**

2;3.0 [nænə]

2;3.0 [nana]

2.30 [nana]

2;4.0 [nana]

**umbrella**

1;11.30 [bwɛa]

**'σσσ words**

**animal**

2;1.14 [æmʌ]

2;1.15 [æmʌ]

2;1.16 - 2;5.24 [æmʊ]

2;5.24 [æmu]

2;9.11 [æml]

3;0.25 [æmʊ]

3;1.24 [æmʊ]

**elephant**

2;9.7 - 2;10.7 [ɛwfən]

**sesame**

2;2.8 [sɛmə]

2;6.26 - 3;1.28 [semi]

**tricycle**

2;8.18 - 2;9.2 [twaɪkl]

2;9.25 [twaɪsɪkl]

2;10.4 [twaɪkl]

**σ'σ words**

**again**

2;10.13 [ʌgɪn]

2;10.23 [əgɪn]

3;1.21 [ʌgɪn]

| | |
|---|---|
| 3;1.21 | [əgɪn] |
| **alone** | |
| 2;6.24 | [won] |
| **away** | |
| 2;2.30 | [we] |
| 2;6.5 | [ʌwe] |
| 2;7.20 | [awe] |
| 2;10.29 | [ʌwe] |
| 2;11.10 | [əwe] |
| **balloon** | |
| 1;11.6 | [bu] |
| 2;2.1 | [bu] |
| 2;2.25 | [bun] |
| 2;4.26 | [bun] |
| 2;6.2 | [bwun] |
| **cement** | |
| 2;11.27 | [mɛnt] |
| **enough** | |
| 2;2.9 | [anʌf] |
| **surprise** | |
| 2;7.7 | [pwaɪz] |
| **today** | |
| 2;8.19 | [de] |
| 3;2.0 | [de] |

**Julia's data**

**σ'σσ words**

| | |
|---|---|
| **another** | |
| 1;10.12 | [jəwo] |
| 1;11.4 | [yə] |
| 2;2.10 | [ənʌdə] |
| 2;2.16 | [ənʌδ/də] |
| 2;3.20 | [ənʌδa] |
| 2;5.16 | [ənʌdə] |
| 2;6.9 | [ənʌδə] |
| 2;8.28 | [ənʌdə] |
| **apartment** | |
| 2;3.14 | [partmɛnt] |
| 2;5.16 | [patment] |
| **banana** | |
| 1;7.16 | [mænə] |

| | |
|---|---|
| 1;7.26 | [manə] |
| 1;10.8 | [mænə] |
| 1;11.6 | [bænə] |
| 2;2.22 | [bænə] |
| 2;2.24 | [bænəs] |
| 2;3.20 | [blæna] |
| 2;4.1 | [bænə] |
| 2;4.1 | [bəbδænə] |
| 2;4.5 | [blænə] |
| 2;4.11 -2;5.29 | [bænə] |
| 2;5.13 | [bænə] |
| **delicious** | |
| 1;11.27 | [dɪʃəs] |
| **eleven** | |
| 1;9.10 | [dɛbən] |
| 1;9.15 | [jɛbən] |
| 1;9.20 | [jɪ/ɛmɪn] |
| 1;9.22 | [ɛjebən] |
| 1;9.26 | [ɛjɛmən] |
| 1;10.7 | [jɛman] |
| 2;2.24 | [jɛvən] |
| **pajamas** | |
| 1;8.27 | [daməs] |
| 1;10.7 | [dæməs] |
| 1;11.9 | [dæmis] |
| 1;11.11 | [dæməs] |
| 2;0.2 | [dæmis] |
| **piano** | |
| 1;9.19 | [pæno] |
| 1;11.15 | [pæno] |
| 2;4.17 | [pæno] |
| **potato** | |
| 2;0.25 | [pedo] |
| 2;1.20 | [peto] |
| 2;5.16 | [tet=o] |
| **remember** | |
| 1;10.8 | [mɛmə] |
| 1;10.22 | [memə] |
| 1;11.25 | [mɛmo] |
| 2;0.21 | [mɛmə] |
| 2;1.18 | [mɛmbə] |
| 2;4.0 | [mɛmə] |
| 2;4.9 | [mɛmbʌ] |

| | |
|---|---|
| 2;5.1 | [mɛmbə] |
| 2;7.29 | [mɛmbə] |
| 2;9.18 | [məmɛmbə] |
| 3;0.1 | [mɛmə] |
| **spaghetti** | |
| 1;9.7 | [dɪbi] |
| 1;10.8 | [gɛbi] |
| 1;11.19 | [skɛbi] |
| 2;0.2 | [skɛbi] |
| 2;0.23 | [skɛbi] |
| 2;0.29 | [sketi~skɛbi] |
| 2;3.8 | [skɛbi~ skɛdəbi] |
| **together** | |
| 2;10.1 | [təgɛδə] |
| **tomato** | |
| 1;9.22 | [mɪnos] |
| 1;9.23 | [menos] |
| 1;10.27 | [meno] |
| 2;0.11 | [meto] |
| 2;1.14 | [medo] |
| 2;1.20 | [meto] |
| 2;1.27 | [meto] |
| 2;5.13 | [medo] |
| 2;5.27 | [to+m3dos] |
| 2;6.4 | [met=o] |
| 2;8.14 | [met=o] |
| 2;8.14 | [tomet=o] |
| 2;10.30 | [met=o] |
| 2;10.30 | [təmet=o] |
| **tomorrow** | |
| 1;7.16 | [mowo] |
| 2;0.17 | [maʊwɔ] |
| 2;0.21 | [əmaʊwo] |

| | |
|---|---|
| **'σσσ words** | |
| **accident** | |
| 3;0.1 | [æksɪdɛnts] |
| **animal** | |
| 1;9.8 | [amos] |
| 1;9.19 | [amos] |
| 1;10.4 | [æməs] |
| 1;11.4 | [æmos] |
| 2;0.4 | [amos] |

| | |
|---|---|
| 2;1.2 | [æmos] |
| 2;2.23 | [ænimo] |
| 2;3.4 | [ænəməs] |
| 2;6.1 | [ænəmo] |
| **bicycle** | |
| 1;8.4 | [baɪko] |
| 1;9.14 | [baɪko] |
| 1;10.13 | [baɪko] |
| 2;0.14 | [baisko:] |
| 2;1.13 | [baisko] |
| 2;5.7 | [baisk=o] |
| 2;8.25 | [baisɪko] |
| **broccoli** | |
| 1;7.6 - 2;0.19 | [baki] |
| 2;6.10 | [brakəli] |
| 2;11.16 | [blakoi] |
| **buffalo** | |
| 1;1.10 | [bʌfəwo] |
| 2;0.14 | [bʌfo] |
| 2;1.15 | [bʌfo:] |
| 2;3.9 | [bʌfo] |
| 2;3.11 | [bʌfəwo] |
| 2;9.5 | [bʌfəlo] |
| **cigarette** | |
| 2;8.14 | [sɪgərɛts] |
| **cinnamon** | |
| 1;11.15 | [sɪmɛn] |
| **comfortable** | |
| 2;4.28 | [kʌmfəbo] |
| 2;8.17 | [kʌmfbəboʊ] |
| 2;10.24 | [kʌmfəboʊ] |
| 2;11.22 | [ənkʌfəbou] |
| 3;0.27 | [ənkʌmpbəbo] |
| **company** | |
| 1;11.14 | [kʌmpi] |
| **elephant** | |
| 1;8.0 | [ɔwo] |
| 1;10.4 | [apɛn] |
| 1;10.27 - 2;0.13 | [aʊfənts] |
| 2;2.11 | [ɔnəfənt ] |
| 2;2.24 | [ɛnəfʌnt'] |
| 2;3.5 | [ɛnəfʌnt] |
| 2;3.11 | [ɛnəɛnt] |

| | |
|---|---|
| 2;5.11 | [ɛnəfʌnt] |
| 3;1.3 | [ɛnəfɛnt] |
| **favorite** | |
| 2;0.25 | [febət] |
| 2;0.29 | [fe.vɪt] |
| 2;3.14 | [feɪ.vɪt] |
| 2;6.1 | [fevət] |
| **gallopey** | |
| 1;9.14 | [gabi] |
| **Jennifer** | |
| 2;1.19 | [ʤɛnəfə] |
| 2;5.16 | [ʣɛnəfʌ] |
| **medicine** | |
| 1;11.12 | [mɛsɪn] |
| 2;3.30 | [mɛdəsɪn] |
| 2;4.29 | [mɛdəsən] |
| **octopus** | |
| 3;1.3 | [ɔktɔpʊs] |
| **sesame** | |
| 2;11.13 | [sɛsəmi] |
| **tricycle** | |
| 2;8.7 | [traisɪko] |

**σ'σ words**

| | |
|---|---|
| **again** | |
| 1;8.4 | [agɪn] |
| 1;10.1 | [gɛn] |
| 1;10.3 | [əgɛn] |
| 1;10.12 | [gɪn] |
| 1;10.23 | [gɛn] |
| 1;10.26 | [ɛgɛn] |
| 1;11.9 | [gɛn] |
| 1;11.15 | [əgɛn] |
| 1;11.24 | [gɛn] |
| 1;11.24 | [əgɛn] |
| 1;11.25 | [gɛn] |
| 1;11.26 - 2;1.24 | [əgɛn] |
| 2;1.24 | [gɛn] |
| 2;2.3 - 2;3.10 | [əgɛn] |
| **around** | |
| 1;10.8 | [winəwaʊnəwaʊnə] (ring around a...) |
| 1;11.22 | [əw/raʊn] |
| 2;0.23 | [əraʊn] |

| | |
|---|---|
| 2;0.26 | [əwaʊnd] |
| 2;2.9 | [əw/raʊnd] |
| 2;2.11 | [əWraʊnd] |
| 2;3.6 | [əwaʊnd] |
| 2;3.25 | [əwaʊnd] |
| **away** | |
| 1;8.24 | [waɪ] |
| 1;11.14 | [waɪ] |
| 1;11.24 | [(ə)we] |
| 2;0.19 | [wai] |
| 2;1.15 | [əweɪ] |
| **balloon** | |
| 1;5.28 | [bu.] |
| 1;9.18 | [bʊn] |
| 1;10.23 | [bun] |
| **behind** | |
| 2;3.24 | [haind] |
| **belong** | |
| 1;11.27 | [bɔŋ] |
| 2;0.26 | [bɔŋs] |
| 2;4.24 | [blɔŋz] |
| 3;0.1 | [blɔŋ] |
| **cement** | |
| 2;8.18 | [sɪmɛnt] |
| **dessert** | |
| 2;8.7 | [zɚt] |
| 2;9.24 | [zɛ(ɚ)t] |
| **enough** | |
| 2;2.11 | [ənʌf] |
| 2;3.8 | [ənʌf ] |
| 2;3.29 | [ənʌf] |
| 2;6.13 | [ənʌf] |
| **garage** | |
| 2;4.5 | [gəwadz] |
| 2;8.25 | [gwa:dz] |
| **giraffe** | |
| 1;11.7 | [dəwæf] |
| 2;2.7 | [dʒwæf] |
| 2;2.17 | [dræf] |
| 2;2.22 | [dwæf] |
| 2;6.10 | [dræf] |
| **police** | |
| 2;1.10 | [pismɛ/æn] policeman |

2;1.12 [pismən] policeman
2;5.3 [pismæ/ɛn] policeman
2;6.5 [plis]

**parade**
2;9.18 [pəwed]

**pretend**
2;1.20 [tent/d]
2;3.29 [tend]
2;3.30 [tɛn]
2;5.23 [pətɛndiŋ]
2;6.5 [pətɛnd]

**Sean's data**

**σ'σσ words**

**another**
1;9.15 [ənə]
1;10.11 [əʊ]
2;4.2 [nʌdɚ]
2;4.2 [ʌnʌdɚ]
2;4.22 [ʌnʌdɚ]
2;4.22 [ʌə]
2;4.22 [ʌnʌθɚ]
2;4.24 [anʌ]
2;5.9 [ʌnʌɚ]
2;6.0 [ʌnʌdɝ]
2;6.12 [ʌnʌθɚ]
2;10.13 [ʌnʌθɝ]
2;10.13 [nʌθɝ]
2;10.17 [ʌnʌdɝ]
2;10.23 [ʌdʌɝ]
2;10.23 [ʌnʌdɝ]
2;10.29 [ʌnʌθɝ]
3;0.14 [ʌnʌdɚ]
3;0.17 [ʌnʌdɚ]
3;1.0 [anʌdɚ]
3;1.18 [ənʌdɚ]
3;2.0 [ənɚ]
3;2.12 [ənədɚ]

**bologna**
2;10.13 [bʌmoni]

| | |
|---|---|
| **banana** | |
| 1;2.7 | [na+na] |
| 1;2.12 | [nʌnʌ] |
| 1;2.28 | [næ+nʌ] |
| 1;4.4 - 1;6.25 | [nænʌ] |
| 1;7.25 | [bənænʌ] |
| 1;8.28 | [nænə] |
| 1;9.14 | [nænʌ] |
| 1;9.17 | [inænə] |
| 1;10.14 - 1;11.19 | [nænə] |
| 1;11.28 | [næni] |
| 2;0.13 - 2;8.5 | [bənænə] |
| **electric** | |
| 3;2.4 | [əlɛklɪk] |
| 3;2.4 | [əlɛkrɪk] |
| 3;2.4 | [alsklɪk] |
| **pajamas** | |
| 1;11.15 | [ʤæməʃ] |
| 1;11.19 | [dæməs] |
| 2;0.23 | [ʤæməs] |
| 2;11.27 | [piʤæmiz] |
| **potato** | |
| 2;0.15 | [pətedo] |
| 2;9.29 | [pʌteto] |
| 3;2.3 | [spət=edo] |
| **remember** | |
| 2;9.28 | [rimɛmba] |
| 2;10.17 | [mimɛmbɝ] |
| **salami** | |
| 2;6.23 | [sʌmami] |
| 2;10.13 | [slamami] |
| **spaghetti** | |
| 2;4.2 | [p=ʌgɛdi] |
| 2;4.2 | [sʌgɛdi] |
| 2;4.2 | [sʌgɛdi] |
| 2;4.3 | [fʌgɛdi] |
| 2;5.4 | [pʌgɛdi] |
| 2;11.27 | [skʌdɛdi] |
| **together** | |
| 2;6.9 | [ʌgɛdɝ] |
| 3;1.6 | [tugɛdɚ] |
| 3;1.10 | [tʌgɛd/ðɚ] |
| **tomato** | |

| | | | |
|---|---|---|---|
| 2;0.14 | [pəneno] | | |
| 2;5.13 | [pimed/to] | | |
| 2;9.23 | [pʌteto] | | |
| 3;0.20 | [pʌnedoz] | | |
| 3;2.5 | [pəteto] | | |
| 3;2.9 | [tamɪnedoz] | | |
| **tomorrow** | | | |
| 3;0.3 | [tumawo] | | |
| **umbrella** | | | |
| 2;0.1 | [bɛla] | | |
| | | | |
| **'σσσ words** | | | |
| **accident** | | | |
| 2;9.11 | [æzkʌdɛnt] | | |
| 2;10.14 | [æskʌdɛnt] | | |
| 3;1.5 | [æskʌkɛnt] | | |
| **animal** | | | |
| 1;11.16 | [animol] | | |
| 2;10.13 | [ænɪmʊls] | | |
| 2;10.24 | [æmɪnʊl] | | |
| 3;0.20 | [æmɪnʊl] | | |
| 3;1.6 | [æmɪnʊl] | | |
| **camera** | | | |
| 2;0.13 | [kæmʌ] | | |
| 2;0.13 | [kæm(r)ə] | | |
| 2;9.29 - 2;10.9 | [kæmrʌ] | | |
| **comfortable** | | | |
| 3;1.13 | [kəmftɚdul] | | |
| **company** | | | |
| 2;0.27 | [akʌmpi] | Electric Company | (TV program) |
| **elephant** | | | |
| 1;6.1 | [adi] | | |
| 1;11.11 | [ɛətə(n)t] | | |
| 2;0.23 | [ɛləfənt] | | |
| 2;1.19 | [ɛf ɛnt] | | |
| 2;3.25 | [ɛlʌfʌt] | | |
| 2;9.19 | [ɛlʌfənts] | | |
| 3;1.18 | [ɛlfɪnt] | | |
| 3;1.18 | [ɛlfɪnts] | | |
| 3;1.27 | [ɛlfənt] | | |
| **family** | | | |
| 3;0.8 | [flæməli] | | |
| **favorite** | | | |

| | |
|---|---|
| 3;2.12 | [fevrɪt/d] |
| **medicine** | |
| 1;7.14 | [wapi] |
| 2;1.2 | [b ɛdəsɪn] |
| 2;1.2 | [bɛdəsɪn] |
| **sesame** | |
| 1;10.6 | [diduit] Sesame Street |
| 1;10.17 | [do dwit] Sesame Street |
| 2;5.14 | [sɛsi stwit] Sesame Street |
| **spatula** | |
| 2;11.4 | [spæsʌlʌ] |
| **vitamin** | |
| 2;2.1 | [bətədən] |
| 2;6.16 | [badʌdɪnθ] |
| 2;8.5 | [baidʌnɪnz] |
| 2;8.5 | [baidʌdɪnz] |
| 2;8.6 | [baidʌdɪnz/s] |
| 2;9.11 | [baidʌdɪnz] |
| 2;9.20 | [baimʌnɪns] |

**σ'σ words**

| | |
|---|---|
| **again** | |
| 2;5.21 | [gɛ] |
| 2;5.19 | [ʌgcn] |
| 2;7.11 | [gɛn] |
| 2;8.23 -2;10.23 | [ʌgɛn] |
| **around** | |
| 1;11.12 | [ound] |
| 3;1.10 | [ʌwaund] |
| **away** | |
| 2;0.18 | [əwei] |
| 2;1.25 | [we] |
| 2;2.26 | [ʌwe] |
| 2;5.21 | [ʌwe] |
| 2;7.11 | [we] |
| 2;7.25 | [ʌwe] |
| 2;8.23 | [we] |
| 2;9.0 | [ʌwe] |
| 2;9.23 | [ʌwe] |
| 2;11.15 | [ʌwe] |
| 3;1.19 | [faɚ e faɚ e faɚ e] |
| 3;1.18 | [əwe:] |
| **balloon** | |

| | |
|---|---|
| 1;3.21 | [bʌ] |
| 1;4.4 | [bu:bu] |
| 1;4 - 1;7.18 | [bu] |
| 1;8.11 | [bʌum] |
| 1;9.21 | [baun] |
| 1;11.0 | [bum] |
| 1;11.19 | [bəum] |
| 2;2.24 | [balum] |
| 2;2.24 | [bəlum] |
| 2;2.24 | [bəwum:] |
| 2;11.15 | [balum] |
| 3;0.3 | [bʌlumz] |
| **cement** | |
| 2;7.25 | [sʌmɛnt] |
| **giraffe** | |
| 1;11.11 | [duæθ] |
| 2;0.27 - 2;1.19 | [ʤuwæf] |
| 2;2.1 | [duwæf] |
| 2;3.5 | [ʤɚræf] |
| **guitar** | |
| 2;2.12 | [tar] |
| 2;5.4 | [gʌtaɚ] |
| 2;5.4 | [gʌta:] |

**Trevor's data**

| | | |
|---|---|---|
| **σ'σσ words** | | |
| **another** | | |
| 2;1.14 | [əʌ:ɚ] | |
| 2;4.3 | [ʌnʌnɚ] | |
| 2;4.3 | [ənʌɚ] | |
| 2;4.3 | [ənʌ:d wan] | another one |
| 2;5.4 | [ənʌdɚ] | |
| 2;5.17 | [nʌ:ɚ] | |
| 2;5.17 | [nʌ:dɚ] | |
| 2;5.30 - 2;6.24 | [ənʌ:dɚ] | |
| 2;7.27 - 2;8.25 | [ənʌ:ɚ] | |
| **banana** | | |
| 0;11.10 | [nænə] | |
| 0;11.11 | [nænə] | |
| 0;11.11 | [nʌnʌnʌ] | |
| 0;11.18 | [anə] | |

| | |
|---|---|
| 0;11.18 | [nʌnʌnʌ] |
| 0;11.21 | [ænə] |
| 0;11.21 | [næna] |
| 0;11.21 | [nʌnʌ] |
| 0;11.21 | [anænə] |
| 0;11.25 | [anə] |
| 0;11.25 | [nænə] |
| 0;11.25 | [nanə] |
| 0;11.25 | [anæna] |
| 0;11.27 | [anə] |
| 0;11.27 | [nænə] |
| 0;11.27 | [nanə] |
| 0;11.27 | [anæ na] |
| 0;11.28 | [nænə] |
| 0;11.29 | [nænə] |
| 1;0.6 | [næ] |
| 1;0.6 | [nʌ] |
| 1;0.6 | [nænə] |
| 1;0.8 | [anæ] |
| 1;0.8 | [mana] |
| 1;0.9 | [nænæ] |
| 1;0.9 | [æna] |
| 1;0.9 | [anænə] |
| 1;0.9 | [ʌʌʌ] |
| 1;0.9 | [aaa] |
| 1;0.9 | [ææ] |
| 1;0.9 | [am:] |
| 1;0.9 | [an:] |
| 1;0.10 | [bæ] |
| 1;0.10 | [anæna] |
| 1;0.10 | [ənænə] |
| 1;0.10 | [nʌnʌnʌ] |
| 1;0.10 | [anʌnʌnʌ] |
| 1;0.10 | [ʌmʌmanæ] |
| 1;0.13 | [ænænə] |
| 1;0.13 | [ænanə] |
| 1;0.13 | [nʌnæna] |
| 1;0.13 | [nʌnʌnʌ] |
| 1;0.14 | [ænænə] |
| 1;0.14 | [nænænə] |
| 1;0.16 | [ænænə] |
| 1;0.17 | [nʌnænə] |
| 1;0.19 | [nænana] |

| | |
|---|---|
| 1;0.21 | [anænə] |
| 1;0.28 | [nʌnænə] |
| 1;0.29 | [nænænə] |
| 1;0.30 | [nanænə] |
| 1;0.30 | [anana] |
| 1;1.0 | [anana] |
| 1;1.0 | [anæna] |
| 1;1.0 | [anænə] |
| 1;1.2 | [anana] |
| 1;1.2 | [ananə] |
| 1;1.3 | [anænə] |
| 1;1.3 | [nənæn] |
| 1;1.3 | [nanana] |
| 1;1.7 | [næno] |
| 1;1.9 | [nænə] |
| 1;1.11 | [mæna] |
| 1;1.11 | [anænə] |
| 1;1.12 | [anænə] |
| 1;1.13 | [nʌnænə] |
| 1;3.10 | [nænæ ] |
| 1;3.11 | [anæna] |
| 1;3.11 | [nænæ ] |
| 1;3.12 | [næna] |
| 1;3.17 | [nænæ] |
| 1;3.25 | [nænæ] |
| 1;4.6 | [nænæ] |
| 1;4.19 | [hænæ] |
| 1;4.23 | [nænæ] |
| 1;4.27 | [nænæ] |
| 1;5.5 | [nænæ] |
| 1;6.8 | [nænæ] |
| 1;6.8 | [nænə] |
| 1;6.9 | [næna] |
| 1;6.9 - 2;6.6 | [nænæ], [næ:næ] |
| 2;7.15 | [bLænænæ] |
| 2;7.15 | [næ:næ] |
| 2;8.13 | [bLænæ] |
| 2;8.13 | [bænæ] |
| 2;8.13 | [bænænæ] |
| 2;8.15 | [blæ:næ] |
| 3;1.8 | [nænæ] |
| **electric** | |
| 2;4.3 | [ɪkɛkɚɪk] |

| | |
|---|---|
| 2;4.13 | [iɛkrik] |
| 2;8.13 | [əLɛkrɪk] |
| **gorilla** | |
| 1;11.12 | [go:wæ ] |
| 1;11.14 | [wʌ:ga:] |
| 1;11.14 | [gʌ:wa] |
| **maracas** | |
| 2;0.27 | [ma:kas] |
| **modesto** | |
| 2;8.15 | [dɛsto] |
| **museum** | |
| 2;7.27 | [zi:ʌm] |
| | |
| **Nathaniel** | |
| 2;1.0 | [fæfue] |
| 2;1.17 | [fæ:ŋo] |
| 2;2.17 | [əfæŋ0] |
| 2;2.23 | [fæŋo:s] |
| 2;2.23 | [əfæ:ɪ:ŋɔ:z ] |
| 2;2.23 | [əfæ:ɪ:ŋɔ:z ] |
| **pajamas** | |
| 1;7.11 | [da:məs] |
| 1;7.26 | [ʤa:mas] |
| 1;8.2 | [ʤa:ma:ʃ] |
| 1;8.2 | [ʤa:ma:ʃ] |
| 1;10.5 | [ʤamaz] |
| 2;2.10 | [ʤa:mɪs] |
| **piano** | |
| 1;11.9 | [pæ :no] |
| 2;1.26 | [bæ :no] |
| 2;1.26 | [pæ :no] |
| 2;2.23 | [bæ:no] |
| 2;3.3 | [pi:jæno:] |
| 2;4.3 | [piæ:no] |
| **potato** | |
| 1;9.19 | [te:toz] |
| 1;9.27 | [te:do] |
| 1;10.2 | [te:do] |
| 1;10.5 | [te:to:z] |
| **remember** | |
| 2;3.3 | [əmɛmɚ] |
| 2;4.13 | [əmɛmbɚ] |
| 2;5.8 | [ɛmɛmbɚ] |

| | | |
|---|---|---|
| **salami** | | |
| 1;6.25 | [ma:mi] | |
| 1;9.2 | [ma:mi] | |
| 1;10.9 | [ma:mi] | |
| 2;0.8 | [sæla:mi:t] | salami meat |
| 2;1.0 | [ma:mi] | |
| **spaghetti** | | |
| 1;4.27 | [gɛdi] | |
| 1;9.2 | [gɛ:di] | |
| 2;11.17 | [sɛgɛ:di] | |
| **Theresa** | | |
| 2;11.10 | [ri:sə] | |
| **together** | | |
| 1;9.27 - 1;10.1 | [gɛ:dɚ] | |
| 1;10.5 - 1;11.1 | [gɛ:dɪr] | |
| 1;11.9 | [dɛ:de:r] | |
| 1;11.12 | [gɛ:de:r] | |
| 1;11.12 | [ogɛ:dɚ] | |
| 2;0.27 | [gɛdɚ] | |
| 2;2.7 | [ugɛ:dɛr] | |
| 2;2.7 | [əgɛ:dɚ] | |
| 2;4.4 - 2;7.4 | [əgɛ:dɚ] | |
| **tomato** | | |
| 2;0.27 | [me:do] | |
| **tomorrow** | | |
| 1;8.12 | [moro] | |
| 1;8.26 | [mɔro] | |
| 1;9.22 | [mɔwro: w] | |
| 1;9.29 | [morou] | |
| 1;10.15 | [mouwou] | |
| 2;1.14 | [mo:ro] | |
| 2;3.22 | [təmo:ro] | |
| 2;3.30 | [əmo:ro:] | |
| 2;4.3 | [əmɔ:ɚo:] | |
| 2;4.13 | [əmoro] | |
| 2;4.24 | [əmo:rou] | |
| 2;5.30 | [əmo:r+ro:] | |
| 2;8.15 | [əmo:rou] | |
| **umbrella** | | |
| 1;11.1 | [brʌ:gæ ] | |
| 1;11.1 | [ʌmbrɛ:a] | |
| 1;11.1 | [ʌmbwɛ:wa] | |
| 1;11.5 | [bre:wa] | |

1;11.5 [bʌwə]
2;0.27 [əbɝwʌs]
2;0.27 [əbɝɛ:wə]
2;1.0 [bwɛ:wəz]
2;1.14 [bwɛwə]
2;3.3 [ʌ:bwɛla]

**vagina**

2;11.10 [ʤai:nə]

**'σσσ words**

**abacus**

1;5.30 [ka:ka]
1;8.7 [æ:ʃɪʃ]
1;9.2 [æ:tʃus]
1;9.2 [ækus]
1;9.2 [æ:ʃʌʃ]
1;10.2 [æ:kʊs]
2;0.8 [æ:ku:s]
2;2.15 [æ :sɪdɛ:s]
2;6.26 [æ:bɪgɛs]

**accident**

2;3.22 [æksɪsɛn]
2;4.24 [ækɪdɪn]

**Allison**

1;3.5 [ai:]
1;3.10 [aijɛ]
1;3.11 [aijʌ]
1;3.11 [aijɛ]
1;3.17 [aijə]
1;3.17 [aijɛ]
1;3.26 [ai:jə]
1;4.19 [aijə]
1;4.27 [aijə]
1;5.3 [aijə]
1;6.25 [ai:jə]
1;7.11 [ai:ja]
1;7.26 [ai:jə]
1;8.2 [ai:jə]
1;8.2 [ai:ja]
1;10.2 [ai:jæz]
1;10.5 [ai:ja]
1;10.5 [ai:ja:z]
1;10.5 [ai:jæ]

| | |
|---|---|
| 1;10.5 | [ai:ja] |
| 1;11.12 | [ai:ja] |
| 2;0.8 | [ai:ijʌn] |
| 2;0.8 | [æ:sʌn ] |
| 2;1.0 | [ai:jə] |
| 2;1.0 | [ai:jæ] |
| 2;1.0 | [ai:ja] |
| 2;1.14 | [a::sɪn] |
| 2;1.14 | [ai:ije] |
| 2;2.3 | [æ:ɪsɪn] |
| 2;2.3 | [æ:sɪn] |
| 2;2.3 | [ai:jə] |
| 2;2.7 | [æ:ɪsɪn] |
| 2;2.7 | [ai:ijə] |
| 2;2.7 | [ai:jə] |
| 2;3.4 | [æ:ɪsɪn] |
| 2;3.4 | [æ:wɪsɪn] |
| 2;3.4 | [æ:wɪsɪn] |
| 2;5.26 | [æ:ɪsɪn] |
| 2;5.30 | [æ:jɪsɪn] |
| **animal** | |
| 1;3.5 | [nænumæ] |
| 1;5.13 | [nɔno] |
| 1;7.20 | [amu:] |
| 1;7.20 - 1;8.12 | [a:mu] |
| 1;9.1 - 2;3.4 | [æ:mu:] |
| 2;3.22 | [æ:ɪmu:s] |
| 2;4.4 | [æ:nimu:θ] |
| 2;4.13 | [æ:mu:z] |
| 2;5.25 - 2;10.24 | [æ:mumu:] |
| **apricot** | |
| 1;5.30 | [ka+kat] |
| 1;5.30 | [nkagat] |
| 1;7.26 | [kækat] |
| 1;8.14 | [ka+kak] |
| 1;9.20 | [ka:kat'] |
| 1;10.2 | [kaka:ts] |
| 1;10.5 | [kakats] |
| 2;2.3 | [kaka:t] |
| 2;4.3 | [æ:bɪkatð] |
| 2;6.7 | [æ:prɪkat] |
| **bicycle** | |
| 1;5.5 | [gaiki] |

| | |
|---|---|
| 2;2.15 | [baisikəul] |
| **buffalo** | |
| 1;11.14 | [bʌfəo:] |
| **camera** | |
| 1;5.6 - 1;10.9 | [kæ:ma] |
| 1;11.25 | [kʌ:mæ ] |
| 1;11.25 | [kæ :mə] |
| 2;0.3 | [kæ:mɚ] |
| 2;3.17 | [kɛmɛrə] |
| 2;4.3 | [kæmɚɵ] |
| **comfortable** | |
| 2;8.5 | [kʌ:fordɪl] [kʌmfordɪl] |
| 2;8.13 | [kʌmfabʌl] |
| 2;8.25 | [kʌmfʌbiL] |
| 2;10.24 | [kʌmfətou] |
| 2;11.10 | [kʌmfɪtʌl] |
| **company** | |
| 2;2.23 | [kumni:] |
| 2;6.1 | [kʌmpæni] |
| **dominoes** | |
| 1;11.5 | [da:ɪ:no:z] |
| 2;2.3 | [da:ɪno:s] |
| 2;2.23 | [da::nouz] |
| 2;4.3 | [da:mno:θ] |
| **dungarees** | |
| 1;10.1 | [gʌŋgi: z ] |
| 1;10.5 | [dʌŋ:ari:z] |
| **elephant** | |
| 1;11.14 | [ɛ:fɪnt ] |
| 1;11.14 | [ɛ:fa:nt] |
| 1;11.14 | [ɛ:tʌnt] |
| 2;0.8 | [ɛ:fɪnts] |
| 2;4.13 | [ɛwɛfʌn] |
| 2;6.15 | [ɛ::fɪnt] |
| 2;10.13 | [ɛ:ufɛnθ ] |
| **family** | |
| 2;5.8 | [fæmɪli] |
| **Marion** | |
| 1;7.11 | [mɛimɛn] |
| 1;7.26 | [mɛiɪn] |
| 1;8.7 | [mɛiən] |
| 1;8.7 | [mɛiən] |
| 1;8.14 | [mɛriən] |

| | |
|---|---|
| 1;10.2 | [ma:ri:ən] |
| 1;10.9 | [mɛ:riʌn] |
| 2;0.3 | [me:rian] |
| 2;0.8 | [me:ri:æn] |
| 2;0.8 | [me:re:r pe:n] Marion airplane |
| 2;1.0 | [me:riæn] |
| 2;1.26 | [mer+riənz] |
| 2;2.23 | [me:riɛn] |
| 2;2.23 | [me:riɛn] |
| 2;2.23 | [me:riən] |
| **medicine** | |
| 2;0.8 | [mɛ+ɛsɪn] |
| 2;0.27 | [me:ɛsɪn] |
| 2;0.27 | [mɛ:ɪsɪn] |
| 2;0.27 | [me:ɛsɪn] |
| 2;1.0 | [mɛsedɪn] |
| 2;1.5 | [mɛsɛnɪn] |
| 2;1.26 | [mɛɛsɪn] |
| 2;1.26 | [mɛ::sɪn] |
| 2;11.10 | [mɛ:sɪn] |
| **spatula** | |
| 1;11.23 | [bæ:tʃʌ] |
| 1;11.23 | [ʃʌbæ:tʃʌ] |
| 2;0.8 | [bætʃuwa:z] |
| 2;9.18 | [səpætʃəʃ] [spæ:tʃu:La:ʃ] |
| **vitamin** | |
| 1;5.30 | [ga:mɪn] |
| 1;5.30 | [ga:mɪ:] |
| 1;6.9 | [bai:mi:ʃ] |
| 1;6.9 | [ba:mɪʃ] |
| 1;6.9 | [baiami:ʃ] |

**σ'σ words**

| | |
|---|---|
| **again** | |
| 0;10.28 - 1;0.8 | [gɛ ] |
| 1;6.17 | [gɪn] |
| 1;6.27 | [əgɛn] |
| 1;8.7 - 1;11.12 | [ngɛn ] |
| 1;11.25 | [əgɛ:n] |
| 1;11.25 | [ədɛ:n] |
| 1;11.25 | [dɛ:n] |
| 1;11.25 | [gɛ:n] |
| 2;0.24 - 2;1.26 | [əgɛn] |

| | |
|---|---|
| 2;2.15 | [gɛn] |
| 2;3.3 | [dɛn] |
| 2;3.4 | [ədɛn] |
| 2;3.4 - 2;8.23 | [əgɛ:n] |
| **alone** | |
| 2;1.0 | [ai o:n] |
| 2;1.0 | [æ o:n] |
| 2;1.14 | [awo:n] |
| 2;1.26 | [io:n] |
| 2;2.10 - 2;5.26 | [əwo:n] |
| 2;8.15 | [əLo:n] |
| **apart** | |
| 1;8.26 | [əpa:t] |
| 1;9.2 - 1;9.27 | [əpa:rt] |
| 1;9.29 | [part'] |
| 1;9.29 - 2;6.6 | [əpa:rt] |
| **around** | |
| 1;10.13 - 1;11.1 | [awau:nd] |
| 1;11.1 | [arau:nd] |
| 1;11.5 | [əwau:n] |
| 1;11.9 | [əmaund] |
| 1;11.9 | [əwaund] |
| 2;0.2 | [əwau:n] |
| 2;0.8 | [wau:n] |
| 2;0.27 | [əwau:n] |
| 2;1.23 | [əraun] |
| 2;3.3 | [əraun] |
| 2;3.22 | [əwau:nd] |
| 2;3.30 | [əraʊn] |
| 2;4.1 | [ərau=n] |
| 2;5.4 | [əraun] |
| 2;5.4 | [ərau::ndə ju:] around you |
| 2;5.30 | [əraun] |
| **away** | |
| 1;8.26 - 2;5.30 | [əwe:i] |
| 2;6 | [pu:pu wɛwei] pooh pooh away |
| **balloon** | |
| 1;4.19 | [bu] |
| 1;4.19 | [bau] |
| 1;4.19 | [bʊ] |
| 1;4.19 | [bʌʊ] |
| 1;4.20 | [bu:] |
| 1;4.27 | [bu] |

| | |
|---|---|
| 1;4.27 - 1;6.25 | [bu:m] |
| 1;9.29 | [bu:n] |
| 1;11.12 | [bu:nz] |
| 1;11.14 | [bu:n+θs] |
| 2;1.0 | [pæu:n pa:pt] |
| 2;1.14 | [bæ u:n] |
| 2;2.23 | [bʌu:n] |
| 2;2.23 | [bæwu:n] |
| **behind** | |
| 2;0.8 | [hai:n] |
| 2;0.24 | [bʌhai:n] |
| 2;0.27 - 2;1.0 | [əhain] |
| 2;1.0 | [ha:ʤu:] behind you |
| 2;1.14 | [əhai:nʤu:] |
| 2;2.15 | [hain] |
| 2;4.1 | [əhain dɝu:] |
| 2;6.15 | [e:hai:n] |
| **belong** | |
| 2;1.5 | [ɔ:ŋ] |
| 2;4.1 | [əlɔ:ŋz] |
| 3;1.6 | [ælɔ:ŋ] |
| **caboose** | |
| 2;4.24 | [gu:s] |
| 2;4.24 | [kæbu:s] |
| 2;5.26 | [gu::s] |
| 2;11.17 | [gu:θ] |
| **Denise** | |
| 1;1.17 | [ʤiʃ] |
| 1;4.2 - 1;4.23 | [ʒiʃ] |
| 1;4.27 - 1;5.6 | [dis] |
| 1;5.9 | [diʃ] |
| 1;5.14 | [ʤiʃ] |
| 1;5.18 | [di:s] |
| 1;6.8 | [diʃ] |
| 1;6.8 | [dis] |
| 1;7.4- 1;10.11 | [di:s] |
| 2;0.14 | [dɛi:s] |
| 2;0.23 | [di:s] |
| 2;1.26 | [di:ʃɪs] |
| 2;2.15 | [dɛi:s] |
| 2;2.15 | [dɛni:s] |
| 2;2.15 | [di:s] |
| 2;7.15 | [di:si] |

| | | |
|---|---|---|
| **dessert** | | |
| 2;7.15 | [əsɚt] | |
| **enough** | | |
| 1;10.2 | [ənʌf] | |
| 1;10.5 | [nʌf] | |
| 1;10.5 | [ənʌf] | |
| 1;10.9 | [nʌf] | |
| 1;11.9 - 1;11.25 | [ənʌf] | |
| 1;11.25 | [nʌf] | |
| 2;0.27 - 2;6.1 | [ənʌf] | |
| **excuse** | | |
| 2;2.10 | [ku::zə mi] | excuse me |
| 2;2.15 | [əku:sə mi] | excuse me |
| 2;2.23 | [kɪ: mi] | excuse me |
| 2;2.23 | [ku:sɛ mi] | excuse me |
| 2;3.4 | [ku:sə mɪ:] | excuse me |
| 2;3.22 | [əku:sə mi] | excuse me |
| 2;4.3 | [əku:zə mɪ:] | excuse me |
| 2;4.24 | [ku:zə mi] | excuse me |
| 2;5.8 | [skiu:zə mi:] | excuse me |
| 2;6.6 | [ku:z ə mɪ:] | excuse me |
| **garage** | | |
| 1;8.12 | [ga:ʃ] | |
| 1;9.2 | [ga+adʒ] | |
| 1;10.2 | [ga:dz] | |
| 1;10.5 | [ga:ʤ] | |
| 1;10.15 | [gerra:ʤ] | |
| 1;10.15 | [ga:ʤ] | |
| 1;11.5 | [garʤ] | |
| 2;0.23 | [ga:ʤ] | |
| 2;0.27 | [ga:ʤ] | |
| 1;11.25 | [ga:dθ] | |
| 2;0.24 | [ga:ʤ] | |
| 2;1.5 | [garʤ] | |
| 2;1.26 | [garʤ] | |
| 2;2.23 | [gɛwa:ʤ] | |
| 2;2.23 | [gawa:ʤ] | |
| 2;2.23 | [garaʤ] | |
| 2;3.3 | [graʤ] | |
| 2;3.7 | [garaʤ] | |
| 2;3.22 | [gra:ʤ] | |
| 2;4.24 | [garaʤ] | |
| 2;5.7 | [ga:raʤ] | |

| | |
|---|---|
| 2;6.6 | [ga:ra:ʤ] |
| **giraffe** | |
| 1;8.11 | [əwæ f] |
| 1;9.1 | [əwæ :f] |
| 1;9.1 - 1;11.14 | [wæ:f] |
| 1;11.25 - 2;0.14 | [əwæ :f] |
| 2;10.13 | [gɝæ:fθ] |
| **guitar** | |
| 1;1.13 - 1;1.17 | [gi:] [gi] |
| 1;1.19 | [kæga] |
| 1;1.19 | [kæ] |
| 1;1.19 | [ga] |
| 1;1.19 | [gɪ] |
| 1;1.19 | [gæka] |
| 1;3.1 | [ga] |
| 1;3.11 | [ga] |
| 1;3.11 | [gɪ] |
| 1;4.6 | [ga:] |
| 1;4.19 | [ga] |
| 1;5.3 | [ga:] |
| 1;5.4 | [ka] |
| 1;5.13 | [ka:] |
| 1;5.25 | [ka:] |
| 1;6.17 | [ka:] |
| 1;7.20 | [ka:r] |
| 1;11.12 | [ka:r] |
| 2;1.5 | [ga:r] |
| 2;1.14 | [kɪ:kar] |
| 2;1.14 | [ki:kar] |
| 2;1.14 | [ʃɪka:r] |
| 2;1.14 | [sɪka:r] |
| 2;2.15 | [tɪtar] guitar |
| 2;2.15 | [gita:r] guitar |
| 2;2.23 | [gi:ga:r] |
| 2;3.30 | [gɪ:ka:r] |
| 2;4.3 | [gɪka:r] |
| 2;4.3- 3;1.8 | [dɪtar] |
| **machine** | |
| 1;7.20 | [sʌmæʃin] sewing machine |
| 1;8.26 | [ʃɪʃɪm] sewing machine |
| 1;10.1 | [ʃɪʃi :m] sewing machine |
| 2;4.13 | [ʃiʃi:m] sewing machine |
| 2;4.24 | [o: ʃi:n] sewing machine |

| | |
|---|---|
| 2;8.5 | [ so:ə ʃi::m] |
| **Marie** | |
| 1;6.17 | [mi ] |
| 1;6.25 | [əmi] |
| 1;6.25 - 1;7.11 | [mi] |
| 1;7.20 | [məi:] |
| 1;7.26 | [mi:] |
| 1;7.26 | [mʌi:] |
| 1;8.2 | [mʊi:] |
| 1;8.7 | [mʊi:] |
| 1;8.26 | [mi:] |
| 1;8.26 | [məi:] |
| 1;9.2 | [mi] |
| 1;9.27 | [mʌi:] |
| 1;10.1 | [ma: ri] |
| 1;10.11 | [mu:ri] |
| 1;11.1 | [muri] |
| 1;11.5 | [mu:ri] |
| 1;11.9 | [mu:i:] |
| 1;11.12 | [mu:ri] |
| 2;0.3 | [muri:] |
| 2;0.3 | [mu:ri:] |
| 2;0.14 | [mu:ri] |
| 2;0.24 | [mu:ri] |
| 2;1.0 | [muri:] |
| 2;1.14 | [mu:ri:] |
| 2;1.14 | [mu:ri] |
| 2;1.23 | [mɝi:] |
| 2;1.23 | [mɝi:] |
| 2;2.3 | [muri] |
| 2;2.15 | [mu:ri:z] |
| 2;2.15 | [muri:] |
| 2;3.4 | [mu:ri] |
| 2;3.4 | [mu:ri:] |
| 2;3.7 | [muri] |
| 2;3.7 | [muri:s] |
| 2;3.22 | [muri:] |
| 2;4.24 | [muri:] |
| 2;5.30 | [mɝi:] |
| 3;0.29 | [məri:] [muri:] |
| **Merced** | |
| 1;11.12 | [sɛd] |
| 2;0.8 | [əsɛ:d] |

| | |
|---|---|
| 2;0.8 | [əʃɛ:d] |
| 2;0.8 | [əse:ɛd] |
| 2;.0.8 | [əse:ɛd] |
| 2;0.24 -2;2.7 | [əʃɛd] |
| 2;4.3 | [asɛd] to Merced |
| 2;5.17 | [a sɛd] to Merced |
| 2;5.26 | [a mɛrsɛd] |
| 2;11.10 | [sɛd] |
| **Michele** | |
| 1;6.25 - 2;5.26 | [ʃɛ:u] |
| **police** | |
| 2;4.13 | [pi:smæn] |
| **pretend** | |
| 2;6.15 | [pətɛ:n] |
| 2;11.0 | [ætɛ:nθ] |
| **surprise** | |
| 2;7.15 | [əprai:θ] |
| 2;9.18 | [a+prai:θ] |
| 2;10.13 | [əprai:θ] |
| **today** | |
| 2;5.26 | [ədei] |
| 2;11.10 | [ədei] |

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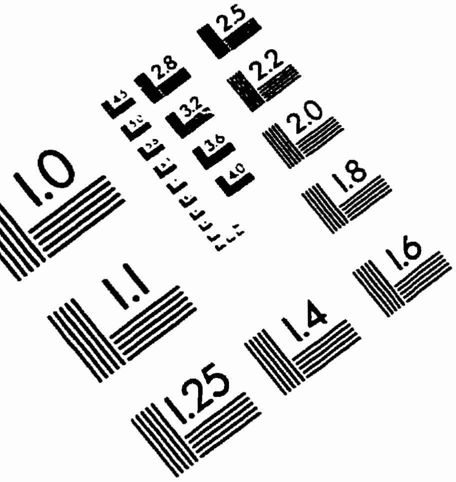
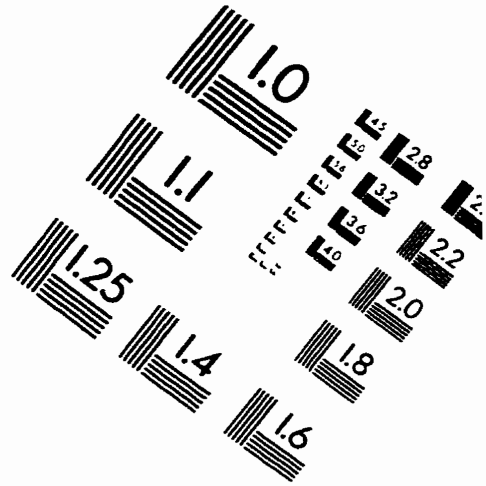
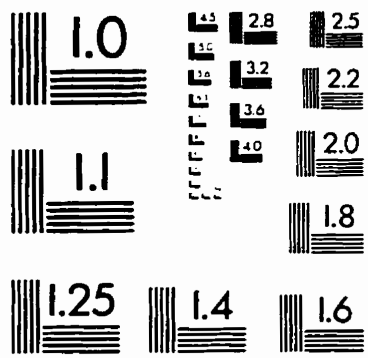
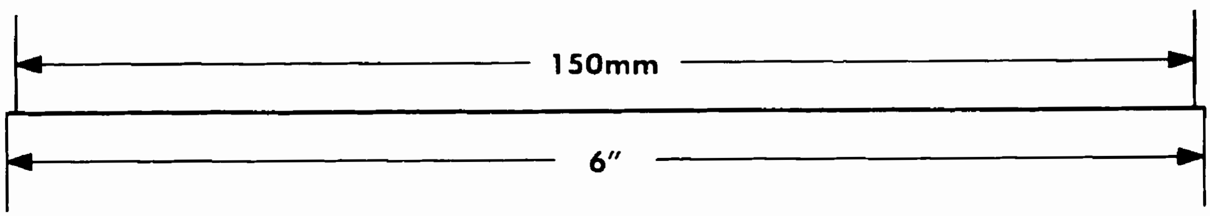
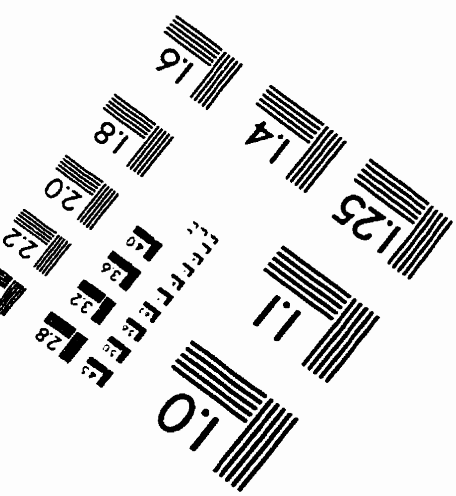
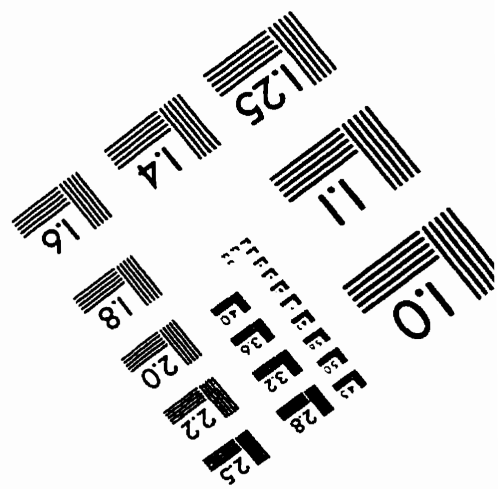
# IMAGE EVALUATION TEST TARGET (QA-3)

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