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Comparative Markedness and Induced Opacity*

Daniel A. Dinnsen,
Department of Linguistics, Indiana University Memorial Hall 322, 1021 E. Third Street Bloomington, IN 47405, U.S.A. dinnsen@indiana.edu

Judith A. Gierut, and
Department of Speech and Hearing Indiana University 200 South Jordan Avenue Bloomington, IN47405, U.S.A. gierut@indiana.edu

Ashley W. Farris-Trimble
Spence Labs of Psychology, University of Iowa 11 Seashore Hall E Iowa City, IA 52242, U.S.A. ashley-trimble@uiowa.edu.

Abstract

Results are reported from a descriptive and experimental study that was intended to evaluate comparative markedness (McCarthy 2002, 2003) as an amendment to optimality theory. Two children (aged 4;3 and 4;11) with strikingly similar, delayed phonologies presented with two independent, interacting error patterns of special interest, i.e., Deaffrication ([tɪn] ‘chin’) and Consonant Harmony ([gɔg] ‘dog’) in a feeding interaction ([kik] ‘cheek’). Both children were enrolled in a counterbalanced treatment study employing a multiple base-line single-subject experimental design, which was intended to induce a grandfather effect in one case ([dɔg] ‘dog’ and [kik] ‘cheek’) and a counterfeeding interaction in the other ([gɔg] ‘dog’ and [tik] ‘cheek’). The results were largely supportive of comparative markedness, although some anomalies were observed. The clinical implications of these results are also explored.

Keywords

comparative markedness; opacity; learning; phonological delay; optimality theory; Deaffrication; Consonant Harmony

1. Introduction

This paper brings descriptive and experimental evidence to bear on the evaluation of comparative markedness (McCarthy 2002, 2003), which was put forward as an amendment to optimality theory (Prince & Smolensky 1993/2004). The evidence is drawn from the phonologies and learning patterns of two young children with phonological delays.

Comparative markedness elaborates the conventional interpretation of markedness by partitioning markedness violations into two distinct subsets: (a) those incurred by the fully faithful output candidate (FFC), and (b) those incurred by output candidates that differ from the FFC. Violations of the former type are considered ‘old’ ($_{O}$M) in the sense that the prohibited property is identical to what occurs in the input representation, and violations of the latter type are considered ‘new’ ($_{N}$M) in that the offending property would have been

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derived from some source other than the input representation. The proposed distinction embodied in comparative markedness can be illustrated by considering the familiar developmental error pattern of Velar Fronting. Children in the early stages of acquisition often exclude velars from their inventories and replace them with coronals (e.g., Smit 1993, Bernhardt & Stoel-Gammon 1996). A conventional markedness constraint associated with this error pattern, *k, would be violated by any candidate with a velar, whether it was supplied from the input or derived from some other error pattern such as Consonant Harmony. For example, then, the output candidate [kek] for ‘take’ would incur two of the same violations of the conventional markedness constraint *k. Comparative markedness, on the other hand, would distinguish among this candidate's violations—assigning one $_{O}$*k violation for the final velar because it is fully faithful and a separate $_{N}$*k violation for the initial velar because it would have been derived from some other process such as Consonant Harmony. The reason for elaborating markedness in this way was to account for opacity effects involving generalizations that are not surface-true.[1] Such underapplication opacity effects fall into two distinct categories. One category has been dubbed a ‘grandfather effect’. In these cases, a process applies to phonologically or morphologically derived representations (induced by violation of a highly ranked $_{N}$M constraint), but that process is blocked from applying to nonderived representations (protected by the dominance of a faithfulness constraint over an $_{O}$M constraint). Grandfather effects are quite common in fully developed languages and are identifiable in rule-based terms as a restriction on neutralization rules, applying exclusively to derived representations (e.g., Kiparsky 1976, 1982). For example, the English process of Velar Softening replaces /k/ with [s] when followed by a high front vowel with an intervening morpheme boundary (e.g., Chomsky & Halle 1968). This process operates in a morphologically derived context and accounts for the [k]/[s] alternation in ‘electric’ and ‘electricity’. However, this process is blocked (rendered opaque) in nonderived environments (when a morpheme boundary does not intervene), e.g., ‘kiss’. The other category of underapplication effects involves a counterfeeding interaction whereby a process applies to nonderived representations (induced by the violation of a highly ranked $_{O}$M constraint), but that process is blocked from applying to representations derived by some other process (protected by the dominance of a faithfulness constraint over a $_{N}$M constraint). These counterfeeding interactions are also quite common in fully developed languages and are typified by ‘chain shifts’ (e.g., Moreton & Smolensky 2002). For example, a common chain shift in young children's developing phonologies is the concomitant substitution of [f] for target /θ/ (Labialization) and [θ] for target /s/ (Dentalization) (e.g., Bernhardt & Stemberger 1998, Dinnsen & Barlow 1998). Importantly, [θ]'s derived from /s/ do not undergo Labialization. In rule-based terms, the underapplication opacity effect associated with these chain shift substitution patterns would have been accounted for by ordering Labialization before Dentalization, effectively preventing Labialization from applying to [θ]'s derived from Dentalization.

Like most other constraints, comparative markedness constraints are assumed to be freely permutable, yielding the predicted typology in (1).

Earlier conceptions of markedness and the current proposal of comparative markedness clearly overlap in some of their typological predictions. The overlap occurs with respect to the application of a process to both underlying and derived representations (1a) and the blocking of a process in both underlying and derived representations (1d). These two situations result in transparent outputs that are unmarked in the former case and both marked

[1]This class of opacity effects differs from overapplication cases where a generalization is not surface-apparent. Within rule-based theories, overapplication opacity can arise from the application of rules in a counterbleeding order. This paper and comparative markedness make no claims about overapplication opacity effects. However, for some optimality theoretic accounts of such opacity effects in acquisition, see Barlow and Keare (2008), Dinnsen (2008) and Dinnsen, McGarrity, O'Connor and Swanson (2000).

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and unmarked in the latter case. Both situations can be exemplified by considering again the common developmental process of Velar Fronting. This process would affect all velars, whether underlying or derived, and would result in the exclusion of velars from the inventory if a conventional markedness constraint (*k) or the comparative markedness versions of that constraint ($_{O}$*k and $_{N}$*k) were highly ranked. Similarly, if the conventional markedness constraint banning velars or the two comparative markedness constraints were low ranked, the Velar Fronting error pattern would be blocked in all contexts, thus allowing underlying and derived velars to occur. The critical difference between conventional markedness and comparative markedness resides in (1b) and (1c), where a faithfulness constraint is ranked between the comparative markedness constraints to yield different opacity effects.

The characterization of these opacity effects has long challenged optimality theory and has been met with varying degrees of success by other proposals, e.g., local conjunction of faithfulness constraints (Kirchner 1996, Moreton & Smolensky 2002), local conjunction of markedness and faithfulness (Łubowicz 2002), sympathy (McCarthy 1999), and optimality theory with candidate chains (McCarthy 2007), among others. Comparative markedness is to date the only proposal that has attempted to unify and relate grandfather effects and counterfeeding interactions and to do so with the same mechanisms that account for transparency.

Evaluations of comparative markedness have been limited to descriptive studies with standard typological considerations. While the above typological predictions have been amply supported by descriptive accounts from fully developed languages, little is known about how the typology and especially its opacity effects emerge in the course of acquisition. Additionally, most of the questions that have been raised about comparative markedness have focused on issues of observational and descriptive adequacy (cf. McCarthy 2003 and the various critiques in that volume). One of the issues that has come up is whether it might be necessary on empirical grounds to make even finer distinctions among derived representations than would be allowed by comparative markedness (e.g., Łubowicz 2003). This is important because a corollary of comparative markedness is that sounds that are merged by different processes (i.e., derived) should behave the same, although not necessarily the same as an identical nonderived underlying sound. In any case, it should not be necessary to distinguish identical sounds derived from different processes. This too is an empirical issue that has received little attention, but that bears on the evaluation of comparative markedness and local constraint conjunction. We hope to shed light on these issues here by extending the evaluative base for comparative markedness to include the results from an experimental study that was designed to induce the predicted opacity effects in two young children's developing phonologies.

Phonological acquisition is an especially informative venue for experimentally investigating the emergence of this typology. First, children are assumed to begin with a default ranking of markedness over faithfulness (e.g., Smolensky 1996). This assumption ensures an initial state with multiple error patterns that could potentially interact with one another and a highly restrictive (subset) grammar. Such an early stage of development would instantiate the typological prediction in which both an old and a new comparative markedness constraint are ranked above an antagonistic faithfulness constraint (1a). Moreover, if multiple error patterns were found to interact such that one error pattern derived sounds that were vulnerable to a further change by another error pattern, we would have an ideal test condition for comparative markedness. That is, one of those error patterns would have two or more sources of sounds that it could affect, i.e., one supplied by the input and the other(s) by one or more interacting error patterns. This situation would result in error patterns with

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transparent outputs, especially if the target language required the reverse ranking of faithfulness over markedness (1d).

Another reason for appealing to acquisition to evaluate comparative markedness is that opacity effects (most notably grandfather effects and counterfeeding interactions) have been observed to be abundant and naturally occurring in both typical and atypical acquisition, even when those opacity effects were not evident in the primary linguistic data to which the children were exposed (e.g., Dinnsen, Barlow & Morrisette 1997, Bernhardt & Stemberger 1998, Dinnsen & Barlow 1998, Dinnsen, O'Connor & Gierut 2001, Jesney 2005, Barlow 2007, Dinnsen 2008, Dinnsen & Farris-Trimble 2008a, c). We want to underscore this point because it runs counter to the longstanding assumption that opacity effects are hard to learn (e.g., Kiparsky 1971). The difference here would be that the emergent opacity effects were unintended.

It is hypothesized that the opaque instances of the typology emerge from the transparent initial-state ranking and represent intermediate stages of development with at least some markedness constraints demoted below faithfulness (1b and c). One reason behind this hypothesis is that both opacity effects introduce a contrast that would not have been evident in the presumably preceding transparent stage (1a), and that contrast may or may not be identical to the target language contrast (1d). For example, a grandfather effect (1b) would introduce target-appropriate productions, but only in some words. While a counterfeeding interaction (1c) would not introduce target-appropriate productions, it would at least introduce a distinction that corresponds to a target distinction. Finally, to achieve conformity with the target language, all relevant markedness constraints must be demoted below faithfulness (1d). Because these opacity effects emerge naturally, we should expect to be able to take an initial-state grammar and experimentally induce the demotion of either one of the old or new comparative markedness constraints ($_{O}$M or $_{N}$M) without demoting the other. The result of that demotion should yield a grandfather effect in one case (1b) and a counterfeeding interaction in the other case (1c). If the opaque instances of the typology do indeed represent intermediate stages of development, it would be important to know whether there is a preference for one or the other, and whether they are developmentally sequenced relative to one another. Comparative markedness predicts that the opaque instances of the typology represent intermediate stages of development and that either opacity effect is equally likely to emerge from an unmarked transparent stage of development. If these predictions can be substantiated, we would have strong support for the independent and permutable character of old and new markedness constraints.

Because children with phonological delays often require clinical intervention to eradicate their persistent error patterns, they offer researchers the unique opportunity to selectively induce and observe changes in the course of phonological development. With this in mind, two children with phonological delays and strikingly similar, interacting error patterns were selected for inclusion in an experimental treatment study. Treatment focused on different sources for a given error pattern in the two children's presenting phonologies: For one child, the treatment words/stimuli were designed to demote $_{O}$M, and for the other child, $_{N}$M. It will be argued that our results provide positive support for several aspects of comparative markedness and identify a number of other issues for future study.

The paper is organized as follows: In §2, we describe the two children's presenting phonologies and formulate an optimality theoretic account. We then go on to describe the rationale behind the individualized treatment experiments and the treatment procedures and stimuli. In §3, we present the results of that treatment through a consideration of the children's individual learning patterns and associated changes in their grammars. In §4, we consider the clinical implications of our findings. The paper closes with a brief summary.

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2. Participants and Methods

2.1. Participants

The two children of this study, Child 142 (age 4;3) and Child 195 (age 4;11), were identified through the Learnability Project at Indiana University and were found to be typically developing in all respects, except for a delay in their phonologies. They scored within normal limits on all standardized tests of hearing, nonverbal intelligence, oral-motor structure and function, receptive vocabulary, and expressive and receptive language. However, both children also scored at or below the 5th percentile on the *Goldman-Fristoe Test of Articulation* (Goldman & Fristoe 1986, Dinnsen & Gierut 2008). This means that 95% of other children of the same age and gender as these participants had phono-logical systems that were better developed. The table in (2) provides a summary profile of the children.

2.2. Pretreatment Error Patterns

The two children of this study were identified as having strikingly similar phonologies as determined from a comprehensive speech sample and standard phonological analysis procedures (Gierut 2008c). The speech sample was elicited in a spontaneous picture-naming task. The probe list consisted of 544 words that are known to children of that age and that sampled the full range of English consonants in initial, medial, and final position. The sessions were audio recorded and phonetically transcribed by a trained listener with 10% of all probes retranscribed for reliability purposes by an independent judge. The overall transcription reliability measure was at or above 95% agreement for both children.

In the immediately following subsections, we first describe those error patterns that were common to the two children's phonologies. Important individual differences are then described for each child separately.

2.2.1. Commonalities—Two error patterns of special interest were found to co-occur and interact in both children's phonologies. Illustrative data are given in (3) and (4) for each of the children. One error pattern, Deaffrication, replaced word-initial affricates with a simple alveolar stop (3a) and (4a). This is a commonly occurring error pattern in both typical and atypical phonological development (e.g., Smit 1993). The other independent error pattern, Consonant Harmony, replaced word-initial simple alveolar stops with a dorsal consonant when followed by a dorsal consonant later in the word (3b) and (4b). This too is a commonly occurring error pattern in both typical and atypical development (e.g., Smith 1973, Menn 1976, Macken 1978, Vihman 1978, Stemberger & Stoel-Gammon 1991, Stoel-Gammon & Stemberger 1994, Bernhardt & Stoel-Gammon 1996, Bernhardt & Stemberger 1998, Pater & Werle 2001, 2003).

These two independent error patterns also interacted in a perfectly transparent way when a target word began with an affricate and was followed by a dorsal consonant later in the word (3c) and (4c). In rule-based derivational terms, word-initial affricates would have undergone Deaffrication, yielding a simple alveolar stop as an intermediate representation, which then would have served as the input to Consonant Harmony, resulting in a word-initial dorsal consonant. There are several reasons for assuming that these two independent processes were both involved when affricates occurred in harmonizing contexts. The alternative assumption might be that Consonant Harmony is a more general process that directly targets any coronal consonant when a dorsal consonant follows. The problem with this latter assumption is that it must incorporate a Deaffrication process in the Consonant Harmony process, missing the generalization for these (and other) children that an independent Deaffrication process also occurs in nonharmonizing contexts. This point is reinforced by

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cross-sectional studies which have found that, when Consonant Harmony appears to affect consonants that are more marked than alveolar stops, those more marked sounds also tend to be vulnerable to error in other contexts (e.g., Macken 1978, Vihman 1978).

Another argument against the more general formulation of Consonant Harmony is the fact that these two children produced coronal fricatives correctly in both harmonizing and nonharmonizing contexts. That is, coronal fricatives resisted Consonant Harmony. This point will be expanded upon in our description of individual differences in §2.2.2.

That there were two separate processes in a feeding relation is also important to our evaluation of comparative markedness because, aside from underlying alveolar stops serving as one source for Consonant Harmony, Deaffrication also provided a phonologically derived source of alveolar stops that could also undergo Consonant Harmony. These two different sources for Consonant Harmony are relevant to the putative distinction between $_{\text{O}}$MARKEDNESS and $_{\text{N}}$MARKEDNESS, which is the focal point to be manipulated in our experiment.

2.2.2. Individual Differences—

This section describes some of the important ways in which these two children's phonologies differed.

2.2.2.1. Child 142: The data in (5a) reveal that coronal fricatives occurred in this child's inventory and were produced correctly. As shown in (5b), this fact also extended to contexts where Consonant Harmony might have induced a change in the initial consonant if, contrary to fact, that error pattern had affected all coronals that were followed by a dorsal consonant. This further supports our contention that the target of Consonant Harmony was restricted to alveolar stops (rather than all coronals). One fact that distinguished Child 142 from the other child of this study was his substitution pattern affecting labial fricatives. That is, he replaced labial fricatives with coronal fricatives, as shown in (5c). This error pattern involved a change in place from labial to coronal, but preserved the target manner of articulation. We will refer to this error pattern as Coronalization.

2.2.2.2. Child 195: A peculiarity of Child 195's pretreatment phonology (which distinguished her from Child 142) was the rather unusual replacement of word-initial labial fricatives with a coronal stop, as shown in (6a). For ease of reference, we will refer to this error pattern as Stopping (even though it also involved a change in place). Stopping also interacted with Consonant Harmony by providing an additional source for derived alveolar stops, feeding Consonant Harmony, as shown in (6b). This fact adds an important dimension to our evaluation of comparative markedness because, in addition to underlying (nonderived) alveolar stops that could and did undergo Consonant Harmony, there were two other, but different, derived sources of alveolar stops, one derived from Deaf-frication and the other derived from Stopping, both of which also could and did undergo Consonant Harmony. The forms in (6c) are similar to those for Child 142 in that target coronal fricatives were produced correctly and resisted Consonant Harmony.

2.3. Optimality Theoretic Account of the Pretreatment Facts

This section first presents an account of those facts that were common to the two children's phonologies. The account is then augmented for each child separately to address individual differences.

2.3.1. Account of Commonalities—

We begin with an account of the shared error pattern of Deaffrication. The two ranked constraints in (7) are minimally necessary to account for this error pattern.

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The markedness constraint *AFFR must be ranked above the antagonistic faithfulness constraint ID[manner] to compel Deaffrication. We assume that the change from an affricate to a simple alveolar stop represents a change in manner, even though other geometric structures are likely involved. The tableau in (8) shows how with this constraint ranking the faithful candidate (a) is eliminated in favor of the errored output (b). We assume here and throughout that these two children's underlying representations were target-appropriate. This assumption is consistent with richness of the base, which prohibits language-specific (or child-specific) restrictions on underlying representations (Prince & Smolensky 1993/2004, Smolensky 1996). It is, of course, still possible that the children might have incorrectly internalized these words, but it is the responsibility of the constraint hierarchy to yield the attested outputs from a rich base. Nevertheless, we will see in §3 that the children's learning patterns and the lack of overgeneralization errors support our assumption of target-appropriate underlying representations. For a fuller discussion of this issue, see Dinnsen (2002).

The other independent error pattern that was common to both children's phonologies, Consonant Harmony, requires the two additional constraints in (9).

AGREE is a context-sensitive markedness constraint that bans simple alveolar stops when followed by a dorsal consonant. This constraint is a particular instantiation of a general markedness constraint banning consonants with different place features within the word. (For an overview of optimality theoretic accounts of Consonant Harmony, see Goad (1997) and Pater and Werle (2003) and references therein.) The various restrictions on what can serve as the trigger and target of assimilation can be attributed to the interplay of other constraints in the hierarchy. For example, the fact that dorsals served as the trigger of assimilation can be attributed to either a fixed constraint ranking or stringently formulated constraints that give a greater preference to the preservation of dorsal place (ID[dorsal]) over labial and coronal place (ID[labial] and ID[coronal], respectively) (Prince & Smolensky 1993/2004, Kiparsky 1994, de Lacy 2006). Similarly, the fact that alveolars, rather than labials, were targets of assimilation can be attributed to that same hierarchy, which gives priority to the preservation of labial place over coronal place. The regressive direction of assimilation can be attributed to the prominence of rhymes in early phonological development (Dinnsen & Farris-Trimble 2008b). The dominance of AGREE over ID[coronal] causes simple alveolar stops to give way to a dorsal when a dorsal follows later in the word. This result is illustrated by the tableau in (10).

With the ranking we have established for these four constraints, we can now account for the transparent interaction of these error patterns in ‘cheek’-type words. The tableau in (11) illustrates a number of important points about our analysis. The fully faithful candidate (a) fatally violates *AFFR and is eliminated from the competition. Notice, however, that this candidate does not violate AGREE. There are several reasons for this. First, note that the initial and final consonants differ in both place and manner. This fact is relevant to the observation that Consonant Harmony processes tend to target sounds that have the same manner as the trigger or are less sonorous than the trigger (Macken 1978, Vihman 1978). Additionally, the relatively marked palatoalveolar articulation of the affricate does not fit the definition of AGREE, which requires that the target of assimilation be an unmarked alveolar stop. This restriction on targets of place assimilation is related to the observation that less-marked place features are most vulnerable to Consonant Harmony processes (Stemberger & Stoel-Gammon 1991, Stoel-Gammon & Stemberger 1994). Candidate (b) with a derived alveolar stop achieves sufficient similarity in manner between the trigger and target to violate AGREE and is eliminated. The assimilated candidate (c) thus survives as optimal, violating only the lower ranked faithfulness constraints ID[manner] and ID[coronal].

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Of the markedness constraints we have discussed thus far, AGREE is the one that can take advantage of comparative markedness. We saw that Consonant Harmony actually had at least two sources.[2] One source came from the violation of AGREE incurred by the fully faithful candidate (a) in tableau (10) for ‘dog’. That would represent an $_{O}$AGREE violation. The other source for Consonant Harmony came about from the violation of AGREE incurred by the unfaithful candidate (b), which was derived from Deaffrication in tableau (11) for ‘cheek’. That would represent a $_{N}$AGREE violation. The definitions for these comparative markedness constraints are given in (12).

Our analysis assumes that the conventional markedness constraint AGREE is replaced by these two comparative markedness constraints and that they occupy the same ranking in the hierarchy that had been held by AGREE.[3] The dominance of these two comparative markedness constraints in the children's pretreatment phonologies would have rendered both active, but would have also masked their presumed independence. Stated differently, if we had looked only at the children's pretreatment phonologies, we would have had no indication that there was any need or motivation to split AGREE into the two comparative markedness constraints. This, of course, was the point of our experiment, i.e., to determine whether that presumed independence could be manipulated by inducing the demotion of one comparative markedness constraint without demoting the other. This point will be elaborated in our description of the treatment experiment in §2.4 and in our discussion of the results in §3.

2.3.2. Individual Differences—In the next two subsections, we augment the above account by integrating the individual differences as set forth in §2.2.2.

2.3.2.1. Child 142: Recall that Child 142 exhibited the additional error pattern of Coronalization, which replaced labial fricatives with coronal fricatives. This ban on labial fricatives can be accounted for by a highly ranked markedness constraint abbreviated as *f. This constraint is drawn from a more general family of markedness constraints collectively banning all fricatives. This particular ban on labial fricatives is not uncommon because different children have been found to exhibit different restrictions on the fricatives that are allowed/prohibited in their inventories (e.g., Gierut 1998). Inasmuch as Coronalization involved a change from labial to coronal place, the faithfulness constraint preserving labial place, ID[labial], must be ranked below *f. However, because manner was preserved in the substitution pattern of Coronalization, ID[manner] must be ranked above ID[labial] to prevent the replacement of labial fricatives by labial stops. Until this point, we had had no evidence one way or the other about the ranking of ID[manner] relative to ID[coronal]. However, because we now know that ID[manner] must outrank ID[labial], and that ID[labial] must out-rank ID[coronal] to comply with the place preference scale, we now have a ranking argument to rank ID[manner] over ID[coronal]. Recall too that this child produced coronal fricatives correctly. This is relevant to the fact that coronal fricatives were resistant to Consonant Harmony. These facts are accounted for, in part, by the dominance of ID[manner] and ID[coronal] over the markedness constraint *s, which bans coronal fricatives. The definitions for these constraints and their ranking are given in (13).

The tableau for ‘foot’ in (14) illustrates our account of Coronalization. We have limited the candidate set to only the most likely competitors with an equally limited set of constraints. The fully faithful candidate (a) is ruled out by its violation of *f, and candidates (b) and (c) with a labial stop and a coronal stop, respectively, are eliminated by their violation of ID[manner]. Because candidate (c) also involves a change in place, it incurs a gratuitous

[2]Child 195 also provided an additional derived source for Consonant Harmony supplied by the Stopping error pattern.

[3]McCarthy (2002) assumes that all markedness constraints are, in fact, reinterpreted in comparative markedness terms.

violation of ID[labial]. Candidate (d) with a coronal fricative survives as optimal because it preserves manner from the input and only violates lower-ranked constraints.

We argued earlier that targets of Consonant Harmony needed to be restricted to alveolar stops to the exclusion of coronal fricatives. We include a tableau for ‘sick’ in (15) simply to show that the additional constraints and ranking arguments associated with Coronalization still correctly account for the resistance of coronal fricatives to Consonant Harmony.

The integrated pretreatment hierarchy for Child 142 as formulated thus far is given in (16). This hierarchy will be relevant to the comparison with the post-treatment hierarchy and the predicted demotion of $_{O}$AGREE.

2.3.2.2. Child 195: Recall that Child 195 exhibited a somewhat unusual Stopping error pattern, which replaced labial fricatives with coronal stops (e.g., ‘foot’ realized as [tʊʔ]). This Stopping error pattern can be attributed, in part, to the highly ranked markedness constraint *f, which is the same constraint that banned labial fricatives in Child 142's phonology. The fact that the substitute for labial fricatives did not retain labial place or manner indicates that ID[manner] and ID[labial] were lower ranked. To account for the specific repair adopted by Child 195 (which was different from that adopted by Child 142) requires appealing to other highly ranked constraints that would eliminate a labial stop or a coronal fricative as the substitute. Recall that both types of sounds occurred and were produced correctly, indicating that any markedness constraints banning those sounds were low ranked. Interestingly, comparative markedness offers an explanation for these facts by splitting the markedness constraints that ban labial stops (*p) and coronal fricatives (*s) into their ‘old’ and ‘new’ comparative markedness counterparts. The faithful realization of labial stops and coronal fricatives would, then, be accounted for by low ranked $_{O}$*p and $_{O}$*s, and the prohibition against labial stops and coronal fricatives as substitutes for any other sound would be achieved by high-ranked $_{N}$*p and $_{N}$*s. This is essentially a grandfather effect, although different from the one of primary concern to our experiment. The additional comparative markedness constraints that we are appealing to are given in (17).

The tableau in (18) shows how the relevant constraints interact to yield Child 195's Stopping error pattern.

The fully faithful candidate (a) is ruled out by its violation of undominated *f. Similarly, the undominated comparative markedness constraints $_{N}$*p and $_{N}$*s assign fatal violation marks to candidates (b) and (d), respectively. Candidate (c) with an initial alveolar stop survives as optimal, even though it violates ID[manner] and ID[labial].

Recall too that Stopping interacted with Consonant Harmony by providing an additional source of derived alveolar stops that could violate $_{N}$AGREE, feeding Consonant Harmony (e.g., ‘finger’ realized as [ki^{ŋ}ʊ]). These data further corroborate our original claim that $_{N}$AGREE was highly ranked at the pretreatment point in time. The tableau in (19) shows how the relevant constraints yield the feeding interaction between Stopping and Consonant Harmony.

Just as in the prior tableau, the fully faithful candidate (a) is eliminated by un-dominated *f. Candidates (b) and (c) are also ruled out by the undominated comparative markedness constraints $_{N}$*p and $_{N}$*s, respectively. Of the two remaining competitors, candidate (d) incurs a fatal violation of $_{N}$AGREE—allowing the assimilated candidate (e) to win despite its violations of ID[manner] and ID[labial].

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The integrated pretreatment hierarchy for Child 195 as formulated thus far is given in (20). This basic hierarchy will be compared with the child's post-treatment hierarchy and our predicted demotion of NAGREE.

2.4. Treatment Procedures

In the following subsections, we describe the intent of treatment, the treatment procedures, and the treatment stimuli for each of the children individually. We also describe how change in the children's grammars was to be assessed over time.

2.4.1. Child 142—The intent in the case of Child 142 was to induce a grandfather effect from his initial state of unmarked transparency. This means that Consonant Harmony would be expected to be suppressed in ‘dog’ words, resulting in target-appropriate realizations of those words, but Deaffrication and Consonant Harmony should persist in ‘cheek’ words, continuing to yield [kik]. While this clinical goal might seem modest, it is at least intended to result in some target-appropriate productions of some words, which could then potentially lead to more widespread changes following the experimental treatment period. To achieve this particular opacity effect, OAGREE must be demoted below ID[coronal]. Treatment stimuli were thus designed to highlight the simple fact that Consonant Harmony should not affect underlying alveolar stops in the harmonizing context, e.g., ‘dog’ words. The treatment stimuli consisted of the nonwords in (21).

The phonological characteristics of the nonwords were specifically designed to focus the child's attention on the legitimate occurrence of alveolar stops in the context before dorsals. Nonwords (rather than real words) were used for several reasons. First, this child was part of a larger experimental study in which it was important to control for individual differences in the words that children might know and for any potential influence of that knowledge on training and learning. Nonwords provide that control because all children were unfamiliar with the nonwords prior to treatment. Nonwords have also been shown to offer an advantage for sublexical processing (e.g., Vitevitch, Luce, Charles-Luce & Kemmerer 1997).

In an attempt to associate the nonwords with meaning, they were paired with pictures of storybook characters engaged in novel actions. (For an overview of similar treatment protocols, see Gierut 2008b.) The child was seen for one-hour sessions three times a week. Treatment proceeded in two phases, with corrective feedback provided about accuracy of productions. In the first phase, the child produced the nonwords in imitation of the adult model. The design of the experiment called for this phase to continue for a maximum of seven sessions or until 75% accuracy on the treated nonwords was achieved over two consecutive sessions, whichever occurred first. This child met the performance criterion in the first two days of treatment. In the second phase, treatment then shifted to spontaneous production of the nonwords in association with the picture; a model was not provided as a prompt. This phase was to continue for a maximum of 12 sessions or until 90% accuracy was achieved over three consecutive sessions, whichever came first. For this child, the performance criterion was met in the first three days. Consequently, the actual time that this child was in treatment totaled five hours.

2.4.2. Child 195—The treatment procedures for Child 195 were identical to those employed in the case of Child 142. However, the intent in the case of Child 195 was to induce a counterfeeding interaction between Deaffrication and Consonant Harmony. This means that, while Consonant Harmony was expected to persist in ‘dog’ words (realized as [gag]), that error pattern was predicted to be suppressed in ‘cheek’ and ‘finger’ words (realized as [tik] and [ti^{ŋ}ʊ], respectively). Note too that Deaffrication and Stopping were expected to persist. This treatment plan was not necessarily intended to result in target-

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appropriate productions of any words, at least during the experimental period, but it was certainly intended to move the child's phonology somewhat closer to English by demoting a markedness constraint below a faithfulness constraint. The clinical value of this plan was that a well defined class of words would be exempted from a previously pervasive error pattern (Consonant Harmony), even if those same words continued to be affected by another error pattern (e.g., Deaffrication and Stopping). This can be considered a clinical form of approximation. To achieve this opacity effect from an initial state of unmarked transparency, NAGREE must be demoted, and OAGREE must remain highly ranked.

Selecting appropriate treatment stimuli in this case posed a special challenge because there are no word types in English that we could present to the child that would demonstrate that Consonant Harmony should be blocked in words that have undergone Deaffrication (i.e., a process that does not occur in English). The next best tactic was to present the child with target-appropriate renditions of words where both Deaffrication and Consonant Harmony could interact, e.g., ‘cheek’ words. The expectation was that, while the error pattern of Deaffrication might persist, the child would take note of the simple fact that Consonant Harmony does not occur in these words. Additionally, with the sustained dominance of OAGREE, we expected Consonant Harmony to persist in ‘dog’ words. The treatment stimuli consisted of the nonwords in (22).

Child 195 met the performance criterion in the last two days of the imitation phase of treatment and in the last three days of the spontaneous phase of treatment. She was thus enrolled in treatment for the full seven days in imitation and twelve days in spontaneous for a total of 19 hours of treatment.

2.4.3. Assessment of Learning—To assess change in these two children's phonologies, generalization probes of untreated real words were administered before treatment began, during treatment at phase shift, immediately following treatment, and then again at two-weeks posttreatment and two-months posttreatment. Generalization was defined as the transfer of learning from performance on treated nonwords to untreated real words. The probe list for each point in time included the same untreated real words that were elicited prior to treatment and that served as the basis for our pretreatment analysis. We were most interested in the children's performance relating to the error patterns described above. The children's productions of all words were elicited in a spontaneous picture naming task. A model was not provided to the children.

3. Results

The learning patterns that resulted from the treatment experiment are described for each child individually in the following two subsections. The associated changes in each child's phonology are also described relative to the predictions of comparative markedness.

3.1. Child 142

The results of treatment for Child 142 are shown in Figure 1. On the y-axis, separate functions are plotted to document the percent occurrence of each relevant error pattern in probe words. The sampling intervals for the probes are represented on the x-axis. The first interval represents baseline pretreatment performance. The second interval refers to the phase shift point in time during treatment. The remaining three intervals reflect posttreatment performance on the probes immediately following treatment and then again at two-weeks and two-months posttreatment. The *AFFR function refers to the percent occurrence of Deaffrication in ‘chin’ type words. Similarly, OAGREE refers to the percent occurrence of Consonant Harmony in ‘dog’ type words, and NAGREE refers to the combination of Deaffrication and Consonant Harmony in ‘cheek’ type words. This child's Coronalization

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error pattern associated with his avoidance of labial fricatives is represented by the *f function (‘foot’ words). A decline in an error pattern's function over time indicates simply that that particular error pattern was decreasing in its percent occurrence. This often corresponded with an increase in the percent occurrence of target-appropriate productions in previously affected words. However, in some cases, it corresponded to the introduction of a different realization from some other error pattern. Any value for a function below 100% and above 0% indicates variation within a class of words that could be affected by an error pattern. We are not attempting to account for that variation because it would take us too far afield of our main purpose, but see Anttila and Cho (1998), Boersma (1998), and Coetzee (2004) for some examples of alternative approaches to variation. We instead focus attention on the categorical presence versus absence of an error pattern. We take values at or below 25% occurrence of an error pattern to represent the suppression of that error pattern and values above 25% to represent the presence of that error pattern (e.g., McReynolds & Elbert 1981). Setting the cutoff criterion lower than 25% would severely limit the number of affected words, making it difficult to distinguish random errors from active processes. Specifically, the probe consisted of 35 ‘chew’ words relevant to Deaffrication alone, 20 ‘tiger’ words relevant to Consonant Harmony alone, and 9 ‘chicken’ words relevant to the applicability of both processes.

Note that, prior to treatment, all of the error patterns occurred in a high percentage of words, consistent with our description and account of the facts for that point in time. While the $_{N}$AGREE function for ‘cheek’ words started out at a lower percent occurrence relative to the $_{O}$AGREE function for ‘dog’ words, it is noteworthy that the other ‘cheek’ words not affected by Consonant Harmony were still produced in error, albeit by other unrelated processes. During the treatment period, both the $_{O}$AGREE and $_{N}$AGREE functions for Consonant Harmony declined gradually and did so in parallel. After treatment ceased and by the two-weeks posttreatment interval, the relationship between $_{O}$AGREE and $_{N}$AGREE was reversed with the $_{O}$AGREE function declining below the critical 25% cutoff criterion meaning that the process was now inactive. In contrast, the $_{N}$AGREE function for Consonant Harmony (‘cheek’ words) persisted in some words as did Deaffrication. It is at this two-week posttreatment interval that the independence of the two comparative markedness constraints $_{O}$AGREE and $_{N}$AGREE can be observed, revealing the emergence of the grandfather effect. It is not until the two-month posttreatment point in time that we can say that Deaffrication and Consonant Harmony were fully suppressed for ‘cheek’ words. The independence of the $_{O}$AGREE and $_{N}$AGREE functions is evident in two respects. First, the percent change from baseline to two-weeks posttreatment differed for the two functions. Additionally, the suppression of the $_{O}$AGREE function was achieved in a shorter time frame, resulting in correct productions of ‘dog’ words. On the other hand, the $_{N}$AGREE function declined at a slower rate, and at the two-week point in time 100% of the ‘cheek’ words were still produced in error by a combination of processes (including the grandfather effect). We will return to this point shortly. Finally, the Coronalization error pattern associated with the ban on labial fricatives (*f) did not interact with these other error patterns and persisted in a high percentage of words over the entire sampling period.

The productions in (23) from two-weeks posttreatment exemplify the observed grandfather effect.

The constraint ranking required for these posttreatment facts is given in (24). This hierarchy is identical to the pretreatment hierarchy, except for the demotion of $_{O}$AGREE below ID[coronal]. The constraints responsible for Coronalization (*f and its relation to ID[manner] and ID[labial]) are included for completeness, but Coronalization did not interact with the other facts of interest and will not be discussed further.

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For ease of comparison, the pretreatment hierarchy is repeated in (25).

The tableau in (26) shows the consequence of demoting $_{O}$AGREE below ID[coronal]. We have limited the candidate set to the two most likely competitors and have included only those constraints relevant to those candidates. Neither candidate violates $_{N}$AGREE, but the assimilated candidate (b) incurs a fatal violation of ID[coronal]. The winning candidate (a) does incur a violation of lower ranked $_{O}$AGREE, but that violation is less serious and allows the candidate to survive as the optimal output.

Our account for the persistence of Consonant Harmony in ‘cheek’ words is shown in the tableau in (27). The fully faithful candidate (a) with an affricate is eliminated by *AFFR. $_{N}$AGREE is active in eliminating the unfaithful candidate (b) with the derived alveolar stop. The assimilated candidate (c) thus wins, even though it violates the two lower ranked faithfulness constraints.

We take Child 142's learning patterns as support for comparative markedness. The complete eradication of Consonant Harmony in ‘dog’ words can be related directly to the treatment stimuli and shows that $_{O}$AGREE was demoted independently of $_{N}$AGREE. That demotion was consistent with the constraint demotion algorithm (e.g., Tesar & Smolensky 1998). Additionally, the persistence of Consonant Harmony in some ‘cheek’ words establishes that $_{N}$AGREE remained active and highly ranked. The combined result of these findings is the emergence of a grandfather effect from an initial state of transparent unmarkedness as predicted by comparative markedness.

3.2. Child 195

We now turn to the treatment and learning results for Child 195. Figure 2 plots the percent occurrence of the relevant error patterns over time (in the same way as for Child 142). One difference, however, relates to the *f function banning labial fricatives, which in this case resulted in a Stopping error pattern (‘foot’ realized as [tʊʔ]).

As this figure shows, the various error patterns all occurred in a high percentage of words prior to treatment, consistent with our description of the pretreatment facts. Stopping was the only error pattern of these to persist throughout the observation period. Deaffrication and all aspects of Consonant Harmony declined during treatment and were concurrently eradicated at the posttreatment point in time. The productions in (28) are from that posttreatment sampling interval.

These results are somewhat anomalous relative to the predictions of comparative markedness. On the one hand, the intent of treatment was simply to eradicate Consonant Harmony in those words that were similar to the treatment words, namely in those words that had been affected by both Deaffrication and Consonant Harmony (e.g., ‘cheek’ words). The decline of the $_{N}$AGREE function to 0% at posttreatment would seem to indicate that the goal of treatment was achieved. However, that conclusion is clouded by some of the other facts. That is, suppression of Deaffrication was not the focus of treatment, nor was suppression of Consonant Harmony in ‘dog’ words. The loss of these other error patterns raises a number of questions that we consider in detail below. Those questions include: Is it appropriate to claim that $_{N}$AGREE was demoted given that Deaffrication was also suppressed at the same time? What does the persistence of Stopping show about the ranking of $_{N}$AGREE at posttreatment? Why would Consonant Harmony in ‘dog’ words and Deaffrication in ‘chin’ words have also been eradicated? Why were we unable to induce the predicted counterfeeding interaction?

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The loss of Deaffrication had the unfortunate consequence (from the perspective of the experimental question) of eliminating a critical source for new derived alveolar stops that could violate $_{N}$AGREE. That is, while the declining $_{N}$AGREE function seems to indicate that that part of the error pattern was being lost, that fact alone cannot be taken as evidence that the markedness constraint associated with that error pattern, namely $_{N}$AGREE, was also being demoted. In the absence of any other evidence, $_{N}$AGREE could have remained undominated, consistent with the default ranking of markedness over faithfulness and the assumption that faithfulness constraints are ranked as low as possible (e.g., Hayes 2004, Prince & Tesar 2004). Thus, while $_{N}$AGREE might have remained undominated, it would have been rendered inactive due to the demotion of *AFFR. In one sense, then, Consonant Harmony in ‘cheek’ words might have been passively suppressed.

The facts about the persistence of Stopping and its interaction with Consonant Harmony provide additional crucial support for the claim that $_{N}$AGREE was in fact demoted at posttreatment. Recall that Stopping yielded alveolar stops that could undergo Consonant Harmony if $_{N}$AGREE were highly ranked, as was the case prior to treatment. It is striking that, immediately following treatment, Consonant Harmony was suppressed in ‘finger’ words, as shown in (30e). These facts show that $_{N}$AGREE was in fact demoted because alveolar stops derived from Stopping were no longer subject to Consonant Harmony and were instead the preferred substitute. These words changed from one incorrect realization to another incorrect realization, as we might expect if a counterfeeding interaction were being introduced.

Focusing for the moment just on the persistence of Stopping and the suppression of Consonant Harmony in phonologically derived contexts, only one constraint in the hierarchy would have had to change its ranking from pre- to posttreatment, namely $_{N}$AGREE. For ease of comparison, the relevant parts of the pre- and posttreatment hierarchies are given in (29). We have added to the hierarchies one constraint that has not yet been mentioned as relevant to these phenomena, namely *k, which bans dorsal consonants. This constraint was not mentioned earlier because it would have been low ranked in the pretreatment phonology and did not play a role then. That is, dorsals could occur and were the preferred substitute in those words that underwent Consonant Harmony. We will see, however, that this low-ranked constraint played a role (i.e., emergence of the unmarked) in the posttreatment phonology of Child 195.

The tableau in (30) illustrates the required posttreatment demotion of $_{N}$AGREE below *k in words that continued to undergo Stopping. The fully faithful candidate (a) is eliminated by its violation of *f. Candidates (b) and (d) are also eliminated by their violations of the comparative markedness constraints $_{N}$*p and $_{N}$*s, respectively. The remaining two candidates both violate ID[manner] along with the next lower ranked constraint ID[labial], passing the choice down even further. The harmonized candidate (e) incurs a violation of *k not incurred by the competitor candidate (c), yielding candidate (c) as the winner. Note that we have excluded the extra violation marks for *k that would have been contributed by the dorsal consonant later in the word (trigger) because all candidates would have violated that constraint equally.

In one sense, then, it can be concluded that our treatment was effective and achieved the desired result, i.e., the demotion of $_{N}$AGREE and the eradication of Consonant Harmony in phonologically derived contexts. However, this does not completely match our predictions of inducing an opacity effect because Consonant Harmony was also eradicated in nonderived ‘dog’ words. The loss of Consonant Harmony in ‘dog’ words entails the demotion of $_{O}$AGREE.

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The hierarchy that resulted from Child 195's treatment is formulated as in (31). The change in the constraint hierarchy from pre- to posttreatment that needs to be explained at this point is the demotion of the two other markedness constraints, i.e. $_{\mathrm{O}}$AGREE and *AFFR.

The tableau in (32) focuses exclusively on the effect of demoting $_{\mathrm{O}}$AGREE, accounting for the suppression of Consonant Harmony in ‘dog’ words. The fully faithful candidate (a) only violates $_{\mathrm{O}}$AGREE, but the lower ranking of that constraint allows the fully faithful candidate to win out over the assimilated candidate (b), which fatally violates the higher ranked faithfulness constraint ID[coronal].

The tableau in (33) shows how Consonant Harmony was also suppressed in ‘cheek’ words due to the demotion of *AFFR below ID[manner]. The assimilated candidate (c) violates both faithfulness constraints and is eliminated. The deaffricated (but unassimilated) candidate (b) fatally violates ID[manner] (along with its gratuitous violation of $_{\mathrm{N}}$AGREE), allowing the fully faithful candidate (a) to win. We have excluded those extra *k violations that would be associated with the final dorsal consonant because all candidates fare the same on this point. To properly evaluate comparative markedness in this instance, it was necessary for some process/error pattern (e.g., Stopping or Deaffrication) to persist, creating unfaithful candidates that could in turn violate $_{\mathrm{N}}$AGREE. Because Deaffrication was eradicated (i.e., *AFFR was demoted below ID[manner]), our test was partially circumvented. However, because Stopping persisted, the crucial test conditions remained available and supported the claim that $_{\mathrm{N}}$AGREE was in fact demoted, consistent with the intent and design of the treatment for this child.

While some of Child 195's results go beyond what we expected, the extensions make sense on a number of fronts, and they provide valuable support for another aspect of comparative markedness. Let us first consider the corollary of comparative markedness, which maintains that it should only be necessary to distinguish between derived and nonderived (FFC) representations; no further distinctions should be necessary among unfaithful derived representations. This means, for example, that $_{\mathrm{N}}$AGREE should not have needed to distinguish between alveolar stops derived from Deaffrication versus those derived from Stopping. We saw that this prediction was borne out by Child 195's pre- and posttreatment facts where both derived sources of alveolar stops behaved the same. That is, both derived sources were vulnerable to Consonant Harmony pretreatment, and both were immune to Consonant Harmony posttreatment.

Returning now to the question of why Child 195 would have demoted *AFFR (even though that was not the intent of her treatment), the fact is that she was exposed to treatment stimuli with an initial affricate. Her attention to that fact would have been sufficient to motivate her demotion of *AFFR below ID[manner], eradicating Deaffrication (and a fortiori Consonant Harmony in ‘cheek’ words). Consequently, of the observations that Child 195 might have made from the treatment stimuli alone, she can be credited with having made the clinically more efficacious observation, which was that affricates could occur in word-initial position. If, on the other hand, she had simply observed that ‘cheek’ words did not undergo Consonant Harmony (as we intended), $_{\mathrm{N}}$AGREE alone might have been demoted, and all the other processes would have persisted. That is, Consonant Harmony should have persisted in ‘dog’ words, Deaffrication should have persisted in ‘chin’ and ‘cheek’ words, and Stopping should have persisted in ‘foot’ and ‘finger’ words. What this shows, at the very least, is that there are potentially two ways to eradicate Consonant Harmony in phonologically derived words. One way is to demote the markedness constraints responsible for creating new derived sources for Consonant Harmony (i.e., *AFFR and *f); the other is to demote the comparative markedness constraint responsible for Consonant Harmony in derived words

(NAGREE). Child 195 adopted both strategies by demoting *AFFR and NAGREE, which may be the preferred means for eradicating an error pattern that affects derived words.

Let us now return to the question of why OAGREE would have been demoted in the case of Child 195, despite the fact that it was not the focus of her treatment. One possibility is that this child viewed OAGREE and NAGREE as a single, unified constraint equivalent to the conventional markedness constraint AGREE. Under this approach, the demotion of either comparative markedness constraint would have entailed the concomitant demotion of the other. Consequently, the motivated demotion of NAGREE (which was the intent of treatment) would have forced the demotion of OAGREE. This implies that there is some developmental process or option that allows constraints to be exploded, or not, into their component parts (Gierut 2008a), and that Child 195 had not yet exploded her conventional markedness constraint AGREE into its comparative markedness counterparts.[4] Child 142, on the other hand, would have had to explode the constraint, allowing the comparative markedness constraints to be demoted independently. This approach preserves the universality of constraints, but allows for different developmental options in the interpretation of those constraints. One prediction of this proposal is that Child 195's results would have been exactly the same even if she had received the same treatment as Child 142. A fuller evaluation of this proposal must await further study. However, the obvious challenge will be to identify and distinguish those children who have and have not exploded their constraints prior to treatment.

We still need to consider why, in the case of Child 195, we were unable to induce a counterfeeding interaction between Deaffrication and Consonant Harmony. There are several possible answers to this question. One reason may relate to a point originally noted by McCarthy (2002: 59). In his discussion of counterfeeding chain shifts, he raised a question about the facts of the target language that would ever motivate a child to demote a new markedness constraint. Stated differently, there is no fact in the available input to the child that would force the demotion of a constraint that allows for the realization of unfaithful segments. Recall that we had exactly this problem in designing the treatment stimuli for Child 195. The constraint demotion algorithm would have preferred that we expose the child to ‘cheek’ words that had undergone Deaffrication but that had not undergone Consonant Harmony, e.g., [tik] ‘cheek.’ English obviously does not have such words, and ethical considerations prevented us from teaching the child to mispronounce words. So, it is quite possible that the limits imposed by the target language on the set of available treatment stimuli prevented us from inducing the desired counterfeeding interaction.

If the available treatment stimuli were indeed the problem in not being able to induce a counterfeeding interaction, how then might we otherwise induce such an opacity effect? We know that counterfeeding interactions are actually quite common, and that they emerge naturally in the course of phonological development (Jesney 2005, Dinnsen 2008). Possibly, if more children were included with the same error patterns and were put in the same treatment condition as Child 195, one of those children might choose the option of demoting NAGREE alone. Interestingly, Dinnsen and Farris-Trimble (2008a) describe a child with a phonological delay, Child 5T (age 4;3), whose pretreatment phonology included exactly these same error patterns of Consonant Harmony and Deaffrication in a counterfeeding relation. In the absence of any other evidence, we can only assume that Child 5T's phonology prior to that point in time included these same processes in a transparent feeding interaction.

[4]Note, however, that our account of Child 195 assumed that the conventional markedness constraints *p and *s had already been exploded into their associated comparative markedness constraints.

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It is also quite possible that more frequent sampling intervals of the generalization probes would reveal the missing stage with a counterfeeding interaction. This was certainly a potential concern in the case of Child 195 with her protracted treatment and the longer time intervals between the administration of the generalization probes. Nevertheless, we are still left with a question about what facilitates the natural emergence of counterfeeding interactions and what seems to inhibit their emergence in clinical efforts to induce such opacity effects. In other work (e.g., Dinnsen & Farris-Trimble 2008c), it was speculated that the emergence of counterfeeding interactions vis-à-vis the demotion of a new markedness constraint is probably not motivated by the child's recognition of some specific fact of the target language per se, but rather is simply an initial, minimal response to the learning situation that allows maximal compliance with the default ranking of undominated markedness constraints. The idea is that some children might recognize that there is something about their speech that does not quite fit with the primary linguistic data to which they are being exposed, but they remain unclear about the exact focal point of the problem. That minimal recognition alone may be sufficient to induce the demotion of a new markedness constraint because such a response would move a child's phonology somewhat closer to the target system without disturbing anything else about the constraint hierarchy. This suggests that the highly focused nature of most clinical treatment may cause the child to go well beyond that minimal recognition that seems to occur naturally without intervention. Successful treatment plans certainly intend to help children identify which constraints could most effectively be demoted. A clinical setting thus may not be the best venue to induce a counterfeeding interaction, unless of course standard treatment were purposely withheld during an extended sampling and observation period. This too may pose some ethical concerns.

While we were apparently unable to induce the counterfeeding interaction in Child 195's phonology (at least as could be determined from the generalization probes), it should be noted that the other child discussed in this study actually exhibited a counterfeeding interaction between Deaffrication and Consonant Harmony in several words during treatment and at the point the grandfather effect was emerging. Recall from his learning patterns in Figure 1 that the process of Consonant Harmony in ‘cheek’ words declined in its occurrence at a slower rate than it did in ‘dog’ words. During that decline, some ‘cheek’ words continued to undergo Consonant Harmony, while other words of the same type were still being produced in error, but with a different error pattern. That is, some of those words were produced with a word-initial deaffricated alveolar stop, and some ‘dog’ type words were continuing to exhibit Consonant Harmony, as shown in (34) for the immediate posttreatment point in time.

While we are not attempting to account for the variation that occurred during treatment within a class of words, the observed counterfeeding interaction in those words in (34) would require NAGREE to be demoted below ID[coronal] while OAGREE remained active. At the very least, then, Child 142 also serves as a fleeting example of a clinically induced, but experimentally unintended counterfeeding interaction. These facts also underscore the value of administering generalization probes more frequently and with shorter intervals between probes if we are to capture the crucial facts. Recall that Child 142's generalization probes were administered on the second and fifth days of treatment and then again two weeks after treatment. This is in contrast to Child 195, whose generalization probes were administered on the seventh and nineteenth days of treatment.

In sum, while Child 195's treatment achieved its intended goal of demoting NAGREE, suppressing Consonant Harmony in phonologically derived words, our results for this child are less probative for comparative markedness, for we were unable to induce a clear-cut counterfeeding interaction. However, this lacuna has several possible explanations,

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including the limits imposed by English on available treatment stimuli, the timing and frequency of sampling, and finally the highly focused nature of clinical treatment itself. Nevertheless, we did see that we were able to induce the predicted counterfeeding interaction in the phonology of the other child in this study during treatment, even if unintended and only in a few words for a brief period of time. Finally, Child 195 provided valuable support for another fundamental claim of comparative markedness, namely that there is no need to distinguish between different sources of derived representations. Unfaithful candidates incurred one and the same violation of NAGREE whether derived from Deaffrication or Stopping. Recall that Stopping and Deaffrication were entirely independent processes.

4. Clinical Implications

Our evaluation of comparative markedness yielded a number of promising clinical insights that warrant further study. For example, we found that, while it was relatively quick and easy to induce a grandfather effect in the phonology of Child 142, inducing a clearly discernable counterfeeding interaction in the phonology of Child 195 met with more difficulty, especially with regard to the availability of appropriate treatment stimuli. However, in our attempt to induce the counterfeeding interaction, we found that Child 195 had completely suppressed both Deaffrication and Consonant Harmony by the close of treatment. This is in contrast to Child 142, who did not suppress Deaffrication or Consonant Harmony until two months after treatment ended. Note that Child 142's treatment focused on just the one part of the Consonant Harmony process that related to the fully faithful candidate, whereas Child 195's treatment affected the Deaffrication process which fed Consonant Harmony. The clinical implication from our findings is that, when a child whose pretreatment error patterns are both transparent and in a feeding interaction, it may be more efficacious to focus treatment on the eradication of the one error pattern that feeds the other. It remains to be determined whether this clinical insight extends to other interacting error patterns in a feeding relation. A relevant test case might be a child with two independent, interacting error patterns affecting different places of articulation. For example, then, the common error pattern of Velar Fronting, which replaces dorsals with alveolar stops, might feed a particular version of Consonant Harmony, which replaces alveolar stops with labials when followed by a labial later in the word. If treatment were successful at eradicating Velar Fronting, the expectation might be that untreated Consonant Harmony would also be suppressed. We might also expect that any child with a Consonant Harmony process that appeared to target velars and was triggered by a following labial would also have an independent Velar Fronting process. Further clinical research of the sort employed in this study should help to answer these questions.

5. Conclusion

In closing, our investigation of children's clinically induced learning patterns has provided a novel source of experimental evidence for the evaluation of comparative markedness and more generally for other theoretical proposals involving the characterization of opacity effects. Our findings provided support for several aspects of comparative markedness. Specifically, Child 142's induced learning patterns supported the predictions of comparative markedness in that OAGREE was demoted independently of NAGREE to yield a grandfather effect from an initial state of transparent unmarkedness. Additionally, at the point the grandfather effect emerged, NAGREE was shown to be active in eliminating derived alveolar stops in the harmonizing context. Our results were less conclusive regarding the prediction of a counterfeeding interaction. That is, while treatment achieved its goal of demoting NAGREE in the case of Child 195, we were unable to induce (or failed to observe) the predicted counterfeeding interaction. While these latter results did not support comparative

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markedness, they also cannot be taken as a counterexample because the anomalous results had other possible explanations. The predicted counterfeeding interaction did, however, garner some surprising support from the unlikely source of Child 142, who (in addition to his emerging grandfather effect) also exhibited the critical counterfeeding interaction in at least a few words during treatment. It was, thus, possible to experimentally induce both grandfather effects and counterfeeding interactions, even if we did not fully understand what triggered the demotion of the NMARKEDNESS constraint. The findings from Child 195 provided further valuable support for an additional fundamental claim of comparative markedness, namely that there was no need to distinguish between different derived sources of a sound (cf. Farris 2007).

Our results also brought to light a number of issues that warrant further study. For example, a conundrum of this study is why documented cases of clinically induced counterfeeding interactions appear to be so few and ephemeral, especially given that they are otherwise so abundant in naturalistic settings. It is also still unclear how grandfather effects and counterfeeding interactions relate to one another as intermediate stages of development. That is, are they alternative disjunctive paths to an end-state grammar in which faithfulness would come to dominate markedness (as predicted by comparative markedness), or are they developmentally sequenced? These issues will have to await further longitudinal studies that compare naturalistic development with clinically induced learning. These and other issues considered here underscore an element of acquisition studies which adds another dimension to the evaluation of theoretical proposals, namely the need to account for typological facts in a way that also provides for continuity in the transition from an initial-state to the end-state.

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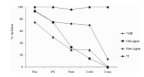

Figure 1.
Learning patterns for Child 142.

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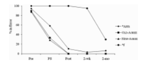

Figure 2.
Learning patterns for Child 195.

(1)

Typological predictions from permutable constraint rankings

	Ranking	Prediction
a.	$_{O,N}M >> F$	Unmarked transparent
b.	$_{N}M >> F >> {}_{O}M$	Opaque, grandfather
c.	$_{O}M >> F >> {}_{N}M$	Opaque, counterfeeding
d.	$F >> {}_{O,N}M$	Fully faithful

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(2)

Participants' profiles

Child	Age	Sex	GFTA
142	4;3	M	5th %ile
195	4;11	F	2nd %ile

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(3)

Child 142's pretreatment error patterns

a. Deaffrication			
[tɪn]	'chin'	[dip]	'jeep'
[tɛʊ]	'chair'	[dɛt]	'jet'
[dʌmp]	'jump'		
b. Consonant Harmony			
[gɔg]	'dog'	[gʌks]	'duck'
[gɔgi]	'doggie'	[gʌki]	'duckie'
[kaɪgoʊ]	'tiger'	[kɪkɪt]	'ticket'
c. Interaction of Deaffrication and Consonant Harmony			
[kik]	'cheek'	[kɔk]	'chalk'
[kɪkɪn]	'chicken'	[gækɛt˺]	'jacket'

(4)

Child 195's pretreatment error patterns

a. Deaffrication			
[tɪn]	'chin'	[dip]	'jeep'
[tɛʊ]	'chair'	[dɛt]	'jet'
[tiz]	'cheese'	[dʌp]	'jump'
b. Consonant Harmony			
[gag]	'dog'	[gʌk]	'duck'
[gagi]	'doggie'	[gʌki]	'duckie'
[kaɪgə]	'tiger'	[kɪkɪt]	'ticket'
[kʌ ŋ]	'tongue'	[gɪgin]	'digging'
[kʌk]	'truck'	[kiki]	'twinkie'
[kʊkʊtit]	'trick-or-treat'		
c. Interaction of Deaffrication and Consonant Harmony			
[kik]	'cheek'	[kak]	'chalk'
[kɪkɪn]	'chicken'	[gʲækɪt]	'jacket'
[goʊkin]	'joking'		

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Child 142's pretreatment coronal and labial fricatives

a. Coronal fricatives realized correctly			
[sæni]	'Santa'	[sʌn]	'sun'
[soʊp]	'soap'	[sup]	'soup'
b. Coronal fricatives resisted Consonant Harmony			
[sɪk]	'sick'	[sək]	'sock'
c. Labial fricatives replaced by coronal fricatives (Coronalization)			
[sʊt]	'foot'	[seɪs]	'face'
[saɪz]	'five'	[ɡusi]	'goofy'
[wus]	'roof'	[kɔᵊs]	'cough'

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(6)

Child 195's pretreatment Stopping and Consonant Harmony

a. Labial fricatives replaced by coronal stops (Stopping)			
[tʊʔ]	‘foot’	[dæn]	‘van’
[toʊwᵊ]	‘floor’	[taɪ]	‘fly’
[taɪjə]	‘fire’	[tadʊ]	‘father’
b. Stopping fed Consonant Harmony			
[kiᵑʊ]	‘finger’	[kæk]	‘flag’
[kaɡ]	‘frog’	[kaɡi]	‘froggie’
c. Coronal fricatives resisted Consonant Harmony			
[sak]	‘sock’	[sɪk]	‘sick’
[saki]	‘sock-i’	[sɨkin]	‘sucking’
[mjusɪk]	‘music’	[sɔᵑ]	‘song’

(7)

Constraints and ranking for Deaffrication

*AFFR: Affricates are banned
ID[manner]: Manner features must be preserved
*AFFR >> ID[manner]

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Deaffrication

/ʧɪn/ ‘chin’	***AFFR**	**ID[manner]**
a. FFC ʧɪn	*!	
b. ☞ tɪn		*

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Constraints and ranking for Consonant Harmony

AGREE: Simple alveolar stops are banned when followed by a dorsal consonant
ID[coronal]: Coronal place must be preserved
AGREE >> ID[coronal]

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Consonant Harmony

/dɔg/ 'dog'	AGREE	ID[coronal]
a. FFC dɔg	*!	
b. ☞ gɔg		*

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Transparent interaction of Deaffrication and Consonant Harmony

/ʧik/ 'cheek'	***AFFR**	**AGREE**	**ID[manner]**	**ID[coronal]**
a. FFC ʧik	*!			
b. tik		*!	*	
c. ☞ kik			*	*

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Comparative markedness constraints for Consonant Harmony

$_{\text{O}}$AGREE: Simple alveolar stops that are shared with the fully faithful candidate (FFC) are banned when followed by a dorsal consonant
$_{\text{N}}$AGREE: Simple alveolar stops that are not shared with the FFC are banned when followed by a dorsal consonant

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(13)

Constraints and ranking for Coronalization

*f: Labial fricatives are banned
*s: Coronal fricatives are banned
ID[labial]: Labial place must be preserved
ID[coronal]: Coronal place must be preserved
ID[manner]: Manner features must be preserved
Ranking: *f >> ID[manner] >> ID[labial] >> ID[coronal] >> *s

(14)

Coronalization

/fʊt/ 'foot'	*f	ID[manner]	ID[labial]	*s
a. FFC fʊt	*!			
b. pʊt		*!		
c. tʊt		*!	*	
d. ☞ sʊt			*	*

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Coronal fricatives resisted Consonant Harmony

/sɪk/ 'sick'	AGREE	ID[manner]	ID[coronal]	*s
a. FFC ☞ sɪk				*
b. tɪk	*!	*		
c. kɪk			*	

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Child 142's integrated pretreatment hierarchy

*AFFR, $_{O}$AGREE, $_{N}$AGREE, *f >> ID[manner] >> ID[labial] >> ID[coronal] >> *s

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Additional comparative markedness constraints

$_{O}$*p: Labial stops that are shared with the FFC are banned
$_{N}$*p: Labial stops that are not shared with the FFC are banned
$_{O}$*s: Coronal fricatives that are shared with the FFC are banned
$_{N}$*s: Coronal fricatives that are not shared with the FFC are banned

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Stopping

/fʊt/ ‘foot’	**$_N$*p**	**$_N$*s**	***f**	**ID[manner]**	**ID[labial]**
a. FFC fʊʔ			*!		
b. pʊʔ	*!			*	
c. ☞ tʊʔ				*	*
d. sʊʔ		*!			*

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Transparent interaction of Stopping and Consonant Harmony

/fiᵑʊ/ 'finger'	$_N$AGREE	$_N$*p	$_N$*s	*f	ID[manner]	ID[labial]
a. FFC fiᵑʊ				*!		
b. piᵑʊ		*!			*	
c. siᵑʊ			*!			*
d. tiᵑʊ	*!				*	*
e. ☞ kiᵑʊ					*	*

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Child 195's integrated pretreatment hierarchy

*AFFR, $_{O}$AGREE, $_{N}$AGREE, $_{N}$*p, $_{N}$*s, *f >> ID[manner] >> ID[labial] >> $_{O}$*p, ID[coronal] >> $_{O}$*s

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Treatment stimuli for Child 142

[təgu]	[dɛkoʊ]
[tɪgəm]	[dakəb]
[dæk]	[tuk]
[tig]	[deɪg]

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Treatment stimuli for Child 195

[ʧɔgu	[ʤɛkoʊ]
[ʧɪgəm]	[ʤeɪkən]
[ʧæk]	[ʤug]
[ʤik]	[ʧag]

(23)

Emergence of grandfather effect

a. Underlying alveolar stops were immune to Consonant Harmony			
[dɔg]	'dog'	[dʌk]	'duck'
[dɔgi]	'doggie'	[taɪgu]	'tiger'
[tɪkɪt]	'ticket'	[tɪkɪn]	'ticking'
b. Deaffrication persisted			
[tɪn]	'chin'	[dusi]	'juicy'
[teɪn]	'chain'	[dɛt]	'jet'
[tɪʊ]	'cheer'	[dɔz]	'jaws'
c. Derived alveolar stops continued to undergo Consonant Harmony			
[kik]	'cheek'	[kɔk]	'chalk'

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(24)

Constraint ranking for Child 142's grandfather effect

*AFFR, $_{N}$AGREE, *f >> ID[manner] >> ID[labial] >> ID[coronal] >> *s, $_{O}$AGREE

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(25)

Pretreatment hierarchy

*AFFR, $_O$AGREE, $_N$AGREE, *f >> ID[manner] >> ID[labial] >> ID[coronal] >> *s

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Consonant Harmony suppressed in ‘dog’ words

/dɔg/ ‘dog’	**NAGREE**	**ID[coronal]**	**OAGREE**
a. FFC ☞ dɔg			*
b. gɔg		*!	

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Consonant Harmony persisted in ‘cheek’ words

/ʧik/ ‘cheek’	***AFFR**	**NAGREE**	**ID[manner]**	**ID[coronal]**	**OAGREE**
a. FFC ʧik	*!				
b. tik		*!	*		
c. ☞ kik			*	*	

(28)

Child 195's posttreatment productions

a. Deaffrication suppressed in ‘chin’ words			
[ʧɪn]	‘chin’	[ʤip]	‘jeep’
[ʧir]	‘cheer’	[ʤus]	‘juice’
[ʧiz]	‘cheese’	[ʤʌʤ]	‘judge’
b. Consonant Harmony suppressed in ‘dog’ words			
[dɔg]	‘dog’	[dʌk]	‘duck’
[dɔgi]	‘doggie’	[dʌki]	‘duckie’
[tʌ^{ŋ}]	‘tongue’	[tɪkɪʔ]	‘ticket’
[dɪgɪn]	‘digging’	[trikoʊrtit]	‘trick-or-treat’
c. Deaffrication and Consonant Harmony suppressed in ‘cheek’ words			
[ʧik]	‘cheek’	[ʧak]	‘chalk’
[ʧɪk]	‘chick’	[ʧɪkən]	‘chicken’
[ʤækɪʔ	‘jacket’	[ʤoʊkin]	‘joking’
d. Stopping persisted			
[tuʔ]	‘foot’	[d^{j}æn]	‘van’
[toʊr]	‘floor’	[taɪ]	‘fly’
[taɪjʊr]	‘fire’	[tadʊr]	‘father’
e. Consonant Harmony suppressed in ‘finger’ words			
[tɪ^{ŋ}gʊr]	‘finger’	[tæg]	‘flag’
[tag]	‘frog’	[tagi]	‘froggie’

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Pre- and posttreatment hierarchies for Stopping and Consonant Harmony

Pretreatment: $_N$AGREE, $_N$*p, $_N$*s, *f >> ID[manner] >> ID[labial] >> ID[coronal] >> *k	
Posttreatment: *f, $_N$*p, $_N$*s >> ID[manner] >> ID[labial] >> ID[coronal] >> *k >> $_N$AGREE	

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Consonant Harmony suppressed in contexts derived from Stopping

/fi^{ŋ}gʊr/ ‘finger’	***f**	**$_{N}$*p**	**$_{N}$*s**	**ID[manner]**	**ID[labial]**	***k**	**$_{N}$AGREE**
a. FFC fi^{ŋ}gʊr	*!						
b. pi^{ŋ}gʊr		*!		*			
c. ☞ ti^{ŋ}gʊr				*	*		*
d. si^{ŋ}gʊr			*!		*		
e. ki^{ŋ}gʊr				*	*	*!	

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Posttreatment constraint hierarchy for Child 195

$_N$*p, $_N$*s, *f >> ID[manner] >> ID[labial], *AFFR >> ID[coronal], $_O$*p >> *k, $_O$AGREE, $_O$*s >> $_N$AGREE

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Consonant Harmony suppressed for ‘dog’ words

/dɔg/ ‘dog’	**ID[coronal]**	**OAGREE**	**NAGREE**
a. FFC ☞ dɔg		*	
b. gɔg	*!		

(33)

Suppression of Consonant Harmony for ‘cheek’ words

/ʧik/ ‘cheek’	**ID[manner]**	***AFFR**	**ID[coronal]**	***k**	**OAGREE**	**NAGREE**
a. FFC ☞ ʧik		*				
b. tik	*!					*
c. kik	*!		*	*		

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Child 142's unintended counterfeeding interaction

a. $_{O}$AGREE was active in some words			
[gɔg]	‘dog’	[gʌk]	‘duck’
[gɔgi]	‘doggie’	[kaɪgoʊ]	‘tiger’
b. $_{N}$AGREE was inactive in other words			
[tik]	‘cheek’	[tɪk]	‘chick’
[dækɪt]	‘jacket’		