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The predictive power of optimality theory for phonological treatment*

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Abstract

The phonology and clinically induced learning patterns of a female child with a phonological delay (age 4;11) were examined from the analytical perspective of Optimality Theory. The analysis revealed that a Consonant Harmony error pattern affected alveolar stops from two different sources—from underlying lexical representations and from representations derived by an interacting error pattern of Deaffrication. The implications of that analysis for the selection of treatment targets were explored in a treatment study. It was found that treatment aimed at the derived source of Consonant Harmony resulted in the suppression of both Consonant Harmony and Deaffrication. The explanation for these results was attributed to a fixed ranking among certain constraints.

Keywords

optimality theory; Consonant Harmony; Deaffrication; treatment; learning

1. Introduction

Identifying the source of a child's phonological error patterns is an obvious goal in the selection of a treatment target. This is a more challenging issue when an error pattern has multiple sources, and a decision needs to be made about which source to treat. Consider, for example, the commonly occurring error pattern of Consonant Harmony (e.g., Stoel-Gammon & Stemberger, 1994; Vihman, 1978), which replaces a word-initial alveolar stop with a dorsal consonant when a dorsal occurs later within the word (e.g., [gɔg] 'dog'). Word-initial alveolar stops associated with the underlying lexical representation of 'dog'-type words are thus vulnerable to error and constitute one source for Consonant Harmony. Treatment aimed at the suppression of Consonant Harmony might, then, focus on that source by teaching the child the correct production of word-initial alveolar stops in 'dog'-type words.

The sounds that result from other independent (but interacting) error patterns can also serve as sources for this error pattern. Consider, for example, the common error pattern of Deaffrication (e.g., Smit, 1993), which replaces affricates with a simple alveolar stop (e.g., [tɪn] 'chin'). When a word begins with an affricate and is followed by a dorsal, Deaffrication can create or derive a new source of sounds to which Consonant Harmony can and often does apply (e.g., [kik] 'cheek'). Different sources for error patterns such as Consonant Harmony pose a clinical question regarding which source to target for treatment. That is, if we want to eradicate Consonant Harmony, should treatment be focused on the lexical representation of word-initial

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alveolar stops in the harmonizing context (‘dog’ words) or on the Deaffrication source for alveolar stops, namely affricates in that same context (‘cheek’ words)? As we will show, optimality theory (e.g., Prince & Smolensky, 1993/2004) offers an answer to this question. The problem and solution will be illustrated by formulating an optimality theoretic account of the speech of a young child with a phonological delay, and then by evaluating the predictions of that analysis against the child’s learning patterns following clinical treatment.

The paper is organized as follows: In §2, we present some of the essentials of optimality theory that are most relevant to the analysis of this case study. Following that overview, §3 describes two interacting error patterns in the pretreatment phonology of a child with a functional (nonorganic) speech disorder and arrives at an optimality theoretic account with a specific recommendation for treatment. §4 presents the procedures and results from the recommended treatment study. The paper closes with a brief summary.

2. Sketch of optimality theory

Optimality theory has revolutionized conceptions of how language works and how it is acquired. It represents a radical departure from rule-based generative approaches (e.g., Chomsky & Halle, 1968), which dominated research on fully developed and developing phonologies for almost half a century. In brief, optimality theory is a theory of constraints and constraint conflict. (For a tutorial introduction to optimality theory with a focus on acquisition, see Barlow and Gierut (1999), Dinnsen (in press-a), Dinnsen and Gierut (2008), and Gierut and Morrisette (2005).) In contrast to earlier approaches, there are no rules and thus no rule-ordering restrictions. This is an important difference because the presence/absence of a rule or process, the sounds affected by that process, the rule’s specific repair, and its order relative to other processes were all assumed to be language-specific (or child-specific). On the other hand, the constraints of optimality theory are assumed to be finite, universal, and violable and are of two fundamental types: markedness and faithfulness. Markedness constraints express a ban on typologically marked features, sounds, or sound sequences and are formulated exclusively in terms of output phonetic properties. For example, a number of languages exclude affricates from their phonetic inventories—such as French, Cairene Arabic, and Finnish (Maddieson, 1984)—as do many young children with a Deaffrication error pattern. This ban on affricates can be attributed to the markedness constraint *AFFR in (1a). Notice that the constraint specifies only that affricates are not allowed to occur; it does not specify how the ban is to be reconciled (e.g., by deletion or by changing the manner feature). We will see shortly that the actual repair follows instead from the ranking of the other constraints in the hierarchy.

1. Constraints

    a. Markedness

        *AFFR: Affricates are banned

    b. Faithfulness

        ID[manner]: Manner features must be preserved in the output

The other type of constraint, faithfulness, demands identity between the input (underlying) and output (phonetic) representations of a word. The faithfulness constraint ID[manner] in (1b) is a relevant example and illustrates the conflict that can occur among constraints—here, with the markedness constraint banning affricates. The conflict is resolved by ranking the constraints. For example, if a child learning English ranked *AFFR over ID[manner], affricates would be excluded from the phonetic inventory, resulting in an error pattern. Phonetic forms without affricates would thus be judged optimal, even though some would violate the faithfulness constraint. The lower ranking of that faithfulness constraint renders the violation less serious. However, English requires ID[manner] to outrank *AFFR, allowing affricates to occur phonetically in words that are represented underlyingly with an affricate. The markedness constraint would be violated by the occurrence of an affricate, but this ranking claims that it is more important to be faithful to the input.

While the constraints of optimality theory are assumed to be universal, the ranking of most constraints is language-specific. The typological prediction is that different rankings of constraints should yield different languages. Some constraints are, however, assumed to be universally fixed in their ranking, limiting the permissible range of variation. Fixed rankings of constraints are employed primarily to account for asymmetries involving implicational relationships among sounds or error patterns (e.g., Dinnsen, in press-b; Dinnsen & O'Connor, 2001; Gierut, in press-a; Pater & Barlow, 2003).

Fixed constraint rankings are especially helpful in explaining certain learning patterns. Within optimality theory, acquisition and the suppression of error patterns proceeds by constraint demotion (e.g., Tesar & Smolensky, 1998). More specifically, it is assumed that the initial state is characterized by a default ranking of markedness over faithfulness (e.g., Smolensky, 1996). This provides for the most restrictive subset grammar, with many error patterns in the early stages of development, and allows the superset target grammar to be learned on the basis of positive evidence. Thus, when the child recognizes that some property does in fact occur in the target language, the constraint that had banned that property is demoted minimally in the constraint hierarchy—just low enough to allow the observed property to occur in the child's speech. When two or more constraints are in a fixed ranking, the demotion of the top-ranked constraint forces the demotion of all lower-ranked constraints in that same fixed hierarchy. The clinical significance of this point is that treatment can be designed to focus on the demotion of that top-ranked constraint, bringing about the suppression of that and other related error patterns without directly treating those other error patterns. It is this element of optimality theory that we are especially interested in illustrating with this case study.

3. The pretreatment phonology

The child of this study, Child 195 (age 4;11), was identified through the Learnability Project at Indiana University (Gierut, in press-b). She was found to be typically developing in all respects, except for a delay in her phonology. She 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, she also scored at the 2nd percentile on the *Goldman-Fristoe Test of Articulation* (Goldman & Fristoe, 1986). This means that 98% of other children of the same age and gender had phonological systems that were better developed.

For the purposes of establishing the child's pretreatment phonology, a comprehensive speech sample was elicited in a spontaneous picture-naming task. The probe list consisted of almost 600 words that are known to children of her 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 above 95% agreement.

While this child exhibited many error patterns, two were of special interest because of their interaction. Illustrative data are given in (2).

(2) Child 195's pretreatment error patterns

a. Deaffrication

[tɪn] 'chin' [dip] 'jeep'

[tɛʊ] ‘chair’ [dɛt] ‘jet’

[tiz] ‘cheese’ [dʌp] ‘jump’

b. Consonant Harmony

[kaɪgə] ‘tiger’ [gɑg] ‘dog’

[kɪkɪt] ‘ticket’ [gɑgi] ‘doggie’

[kiki] ‘twinkie’ [gɪgin] ‘digging’

[kʌk] ‘truck’ [gʌk] ‘duck’

[kʊkʊtit] ‘trick-or-treat’ [gʌki] ‘duckie’

[kʌŋ] ‘tongue’

c. Interaction of Deaffrication and Consonant Harmony

[kik] ‘cheek’ [goʊkin] ‘joking’

[kɪkɪn] ‘chicken’ [gjækɪt] ‘jacket’

[kɑk] ‘chalk’

d. Coronal fricatives resisted Consonant Harmony

[sɑk] ‘sock’ [sɪk] ‘sick’

[sɑki] ‘sock-i’ [sɨkin] ‘sucking’

[mjusɪk] ‘music’ [sɔŋ] ‘song’

One of the above error patterns, Deaffrication, replaced affricates with a simple alveolar stop (2a). The other independent error pattern, Consonant Harmony, replaced word-initial alveolar stops with a dorsal consonant when followed by a dorsal consonant later in the word (2b).

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 within the same word (2c). 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 appeared to harmonize in place and manner with a dorsal consonant. The alternative assumption might be that Consonant Harmony was a more general process that directly targeted any coronal consonant when a dorsal consonant followed. The problem with this latter assumption is that it must incorporate a Deaffrication process in the Consonant Harmony process, missing the generalization that an independent Deaffrication process also occurred in nonharmonizing contexts (2a). This point is reinforced by cross-sectional studies of typical development 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 conception of Consonant Harmony is the fact that this child produced coronal fricatives correctly in both harmonizing and nonharmonizing contexts. That is, coronal fricatives resisted Consonant Harmony (2d).

Turning now to our optimality theoretic account of the pretreatment facts, we have already introduced in (1) the two constraints that would be necessary to account for the error pattern of Deaffrication. The markedness constraint *AFFR must be ranked above the antagonistic faithfulness constraint ID[manner] to compel Deaffrication. This ranking of markedness over faithfulness is consistent with the default ranking of constraints in the initial state (e.g., Smolensky, 1996) and is signified as *AFFR $\gg$ ID[manner].

The tableau in (3) is a conventional display showing how an output candidate is selected as optimal. The underlying input representation is given in the upper left corner, and the competing output candidates are listed below the input in the same column. To conserve space, we have limited the candidate set to the two most likely competitors; the many other possible candidates would be eliminated by other constraints. The constraints are arranged to the right of the input in accord with the required ranking. A candidate's violation of a constraint is indicated by an asterisk (*) in the intersecting cell, and the violation that eliminates a candidate from the competition is termed a fatal violation and is denoted by an exclamation mark (!) to the right of the crucial violation mark. The winning, or optimal, candidate is the one that best satisfies the constraint hierarchy and is identified by the manual indicator (☞). With *AFFR ranked above ID[manner], we can see that the faithful candidate (a) is eliminated in favor of the errored output (b). We assume here and throughout that this child's underlying representations were target-appropriate. This assumption is consistent with a basic tenet of optimality theory, namely ‘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 this child 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 that the child's learning patterns and the lack of overgeneralization errors support our assumption of target-appropriate underlying representations. For a fuller discussion of this general issue, see Dinnsen (2002).

(3) Deaffrication

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

The other independent error pattern, Consonant Harmony, requires the two additional constraints in (4).

(4) Constraints and ranking for Consonant Harmony

AGREE: Alveolar stops are banned when followed by a dorsal consonant

ID[coronal]: Coronal place must be preserved in the output

AGREE $\gg$ ID[coronal]

AGREE is a context-sensitive markedness constraint that bans 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 Pater and Werle (2001) 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 a universal place hierarchy that gives a greater preference to the preservation of dorsal place (ID[dorsal]) over labial and coronal place (ID[labial] and ID[coronal], respectively) (de Lacy, 2006; Kiparsky, 1994; Prince & Smolensky, 1993/2004). Similarly, the fact that alveolars, rather than labials, were targets of assimilation can be attributed to that same universal place 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, in press). The dominance of AGREE over ID [coronal] causes alveolar stops to give way to a dorsal when a dorsal follows later in the word. This result is illustrated by the tableau in (5).

(5) Consonant Harmony

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

The ranking we have established thus far for these constraints accounts for the interaction of these error patterns in ‘cheek’-type words. While it is clear that the two markedness constraints must outrank the faithfulness constraints, these data alone are insufficient to determine further rankings among the two markedness constraints or among the two faithfulness constraints. The relative ranking of the markedness constraints can, however, be inferred from other cross-sectional studies. More specifically, it has been found that children with error patterns involving manner features tend to have error patterns affecting coronal place (e.g., Dinnsen & O’Connor, 2001; Macken, 1978; Vihman, 1978). That finding is suggestive of a fixed ranking among constraints such that *AFFR is universally ranked above AGREE.[1] While this fixed ranking could not have been established based on this child’s pretreatment facts alone, we will see that it plays a significant role in the explanation of the treatment results. In the absence of any other evidence, the two faithfulness constraints are assumed to remain equally ranked or unranked relative to one another. The integrated pretreatment hierarchy resulting from our analysis is given in (6). The comma between the two faithfulness constraints indicates that those two constraints are unranked relative to one another.

(6) Child 195’s pretreatment hierarchy

*AFFR ≫ AGREE ≫ ID[manner], ID[coronal]

The tableau in (7) illustrates our account of the interaction of Deaffrication and Consonant Harmony in ‘cheek’-type words. The dotted vertical line separating the faithfulness constraints in the tableau indicates that those two constraints are unranked relative to one another; the solid vertical lines between constraints denote crucial rankings. 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, 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]. This tableau illustrates another important point about the selection of the winning output candidate within optimality theory, namely, that the number of violations incurred by a candidate matters less than the seriousness (ranking) of any single violation.

(7) Interaction of Deaffrication and Consonant Harmony

[1]While there are apparently some children who have errors in manner and no coronal place errors, this fixed ranking of the markedness constraints still holds if the ranking of the faithfulness constraints varies across children.

/tʃik/‘cheek’	*AFFR	AGREE	ID[manner]	ID[coronal]
a. tʃik	*!			
b. tik		*!	*	
c. ☞ kik			*	*

This account has immediate and direct implications for the selection of a treatment target in the attempt to suppress an error pattern. First of all, the suppression of any error pattern requires the demotion of a markedness constraint. If we want to suppress Consonant Harmony, AGREE must be demoted below the antagonistic faithfulness constraint ID[coronal]. There are two ways to ensure the demotion of AGREE. One way is to focus on that constraint alone by teaching the child to correctly produce word-initial alveolar stops in harmonizing contexts (e.g., ‘dog’-type words). The prediction would be that Consonant Harmony would be suppressed, but Deaffrication would likely persist due to the sustained dominance of *AFFR over ID[manner]. The other way to suppress Consonant Harmony is to focus treatment on the Deaffrication error pattern with the intent of demoting *AFFR below its antagonistic faithfulness constraint ID[manner]. This could be achieved by teaching the child to correctly produce word-initial affricates in ‘cheek’-type words. The rationale for targeting affricates in that context is that Deaffrication served as the other source for Consonant Harmony. Because of the fixed ranking of *AFFR over AGREE, the prediction would be that the demotion of *AFFR below ID[manner] would necessarily entail the demotion of AGREE below ID [manner]. Given further that ID[manner] and ID[coronal] are ranked in the same stratum, AGREE would also come to be ranked below ID[coronal], resulting in the suppression of both Deaffrication and Consonant Harmony. The predictions of this latter alternative are evaluated in the treatment study described in the next section.

4. Treatment study

Child 195 was enrolled in a treatment study that was designed to suppress Consonant Harmony by focusing on the derived source for that error pattern, namely Deaffrication. Treatment was structured around the set of eight nonwords in (8). The phonological characteristics of the nonwords were specifically designed to focus the child’s attention on the occurrence of affricates 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, given that all children were unfamiliar with these 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 (in press-a).)

(8) Treatment stimuli

[tʃɔgu] [dʒɛkoʊ]

[tʃɪgəm] [dʒeɪkən]

[tʃæk] [dʒug]

[tʃɑg] [dʒik]

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 study 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. In the second phase, treatment 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. This child 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.

To assess change in this child's phonology, 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 child's performance relating to the error patterns described above. The child's productions of all words were elicited in a spontaneous picture-naming task. Neither a model nor feedback about accuracy was provided to the child during probe administrations.

The results from the generalization probe are plotted in Figure 1. On the y-axis, separate functions are plotted to document the percent occurrence of each error pattern and their interaction in probe words. The sampling intervals for the probes are represented on the x-axis. The first interval (Pre) represents baseline pretreatment performance. The second interval (PS) 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 Deaffrication function refers to the percent occurrence of Deaffrication in 'chin'-type words. Similarly, Harmony refers to the percent occurrence of Consonant Harmony in 'dog'-type words. The interaction of Deaffrication and Consonant Harmony in 'cheek'-type words is represented in the Deaffrication-Harmony function. A decline in an error pattern's function over time indicates that that particular error pattern was decreasing in its percent occurrence. Any value for a function above 5% indicates that the error pattern occurred in at least some words. We take values below 5% to represent the complete suppression of that error pattern.

As Figure 1 shows, the error patterns all occurred in a high percentage of words prior to treatment, consistent with our description of the pretreatment facts. They also all declined in parallel during treatment and were concurrently eradicated at the posttreatment point in time.

The productions in (9) are from that posttreatment sampling interval.

(9) Child 195's posttreatment productions

a. Deaffrication suppressed in 'chin' words

[tʃɪn] 'chin' [dʒip] 'jeep'

[tʃir] 'cheer' [dʒus] 'juice'

[tʃiz] 'cheese' [dʒʌdʒ] 'judge'

b. Consonant Harmony suppressed in 'dog' words

[tɪkɪʔ] 'ticket' [dɔɡ] 'dog'

[trikoʊrtit] 'trick-or-treat' [dɔɡi] 'doggie' [tʌŋ] ‘tongue’ [dʌk] ‘duck’

[dʌki] ‘duckie’

[dɪgin] ‘digging’

c. Deaffrication and Consonant Harmony suppressed in ‘cheek’ words

[tʃik] ‘cheek’ [dʒoʊkin] ‘joking’

[tʃɪk] ‘chick’ [dʒækɪʔ] ‘jacket’

[tʃɪkən] ‘chicken’

[tʃɑk] ‘chalk’

These posttreatment facts reflect a change in Child 195’s phonology. Specifically, the pretreatment constraint hierarchy would have had to change by demoting *AFFR below ID [manner]. Additionally, because the two faithfulness constraints were unranked relative to one another in the same stratum and because *AFFR is universally fixed in its ranking over AGREE, AGREE was also demoted below its conflicting faithfulness constraint ID[coronal]. The resultant posttreatment hierarchy conforms to the hierarchy for English and is given in (10).

(10) Posttreatment constraint hierarchy

ID[manner], ID[coronal] ≫ *AFFR ≫ AGREE

The treatment plan recommended by our optimality theoretic analysis was clearly quite effective. While treatment focused on Deaffrication alone, the eradication of that error pattern also resulted in the complete suppression of Consonant Harmony (even though it was not directly treated). These results were to be expected within optimality theory because of the observed implicational relationship among these error patterns and the associated fixed ranking of *AFFR over AGREE. Alternative rule-based approaches to phonology would have difficulty explaining these results because, while rules can interact, they are presumed to be entirely independent of one another. In fact, the empirical prediction of a rule-based account would have been that the treatment plan presented here would have eradicated Deaffrication in ‘chin’- and ‘cheek’-type words, but that Consonant Harmony would have persisted in ‘dog’-type words. This prediction was certainly not supported by the facts of this case (nor any others of which we are aware).

5. Conclusion

Our analysis of this child’s phonology serves to illustrate the workings and clinical value of optimality theory—especially for the selection of treatment targets and the prediction of learning. The analysis revealed two independent, but interacting, error patterns: Deaffrication and Consonant Harmony. The markedness constraints responsible for these error patterns were argued to be fixed in their ranking, such that *AFFR universally outranks AGREE. When two or more markedness constraints are part of a fixed hierarchy, the suggestion is to select a treatment target that will demote the top-ranked of those constraints (i.e., the most marked property). The prediction that follows from the demotion of that top-ranked constraint is that the treated error pattern will be suppressed along with all untreated error patterns associated with the lower-ranked constraints in the same fixed hierarchy. This prediction was borne out in Child 195’s posttreatment learning patterns: Treatment focused on the demotion of *AFFR resulted in the suppression of both Deaffrication and Consonant Harmony.

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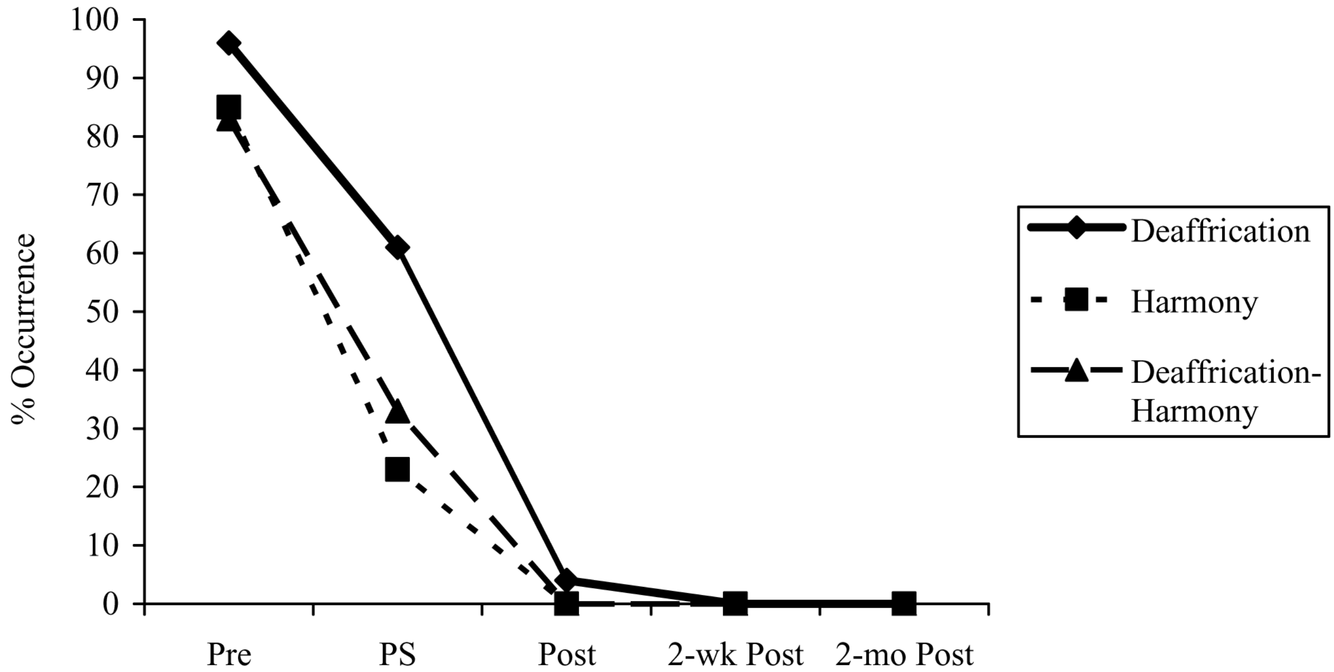

Figure 1.
Generalization learning patterns.