AN OPACITY-TOLERANT CONSPIRACY IN PHONOLOGICAL ACQUISITION*

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This paper presents an example of a developmental conspiracy that interacted with another error pattern to yield opacity (i.e., generalizations that were not surface-true). The data were drawn from the Developmental Phonology Archive at Indiana University (Gierut 2008) and came from a female child (Child 5T, age 4;3) with a phonological delay. Our analysis revealed a conspiracy among several independent, commonly occurring error patterns that merged place and manner distinctions in word-initial position. An account is formulated in terms of optimality theory with candidate chains (McCarthy 2007) with the intent of exploring this new framework's implications for acquisition. Attention is also given to the question of how opacity effects are learned.

1. Introduction

Phonological conspiracies have been amply documented in the languages of the world (e.g., Bakovic 2000, 2001; Kiparsky 1976; Kisseberth 1970; Klein 2005; Pater 1999) and have played a significant role in support of optimality theory (e.g., McCarthy 2002a; Prince and Smolensky 1993/2004). Standard conceptions of conspiracies involve different processes that work together to achieve the same end, yielding transparent (surface-true) generalizations. In the optimality theoretic literature, conspiracies are often referred to by the phrase 'heterogeneity of process and homogeneity of target'. Conspiracies have been found to be at the heart of many young children's phonological error patterns (e.g., Barlow 1997; Gnanadesikan 2004; Kiparsky and Menn 1977; Łukaszewicz 2007; Pater 2002; Pater and Barlow 2003; Smith 1973). The developmental conspiracy described by Pater and Barlow (2003) for a child with a phonological delay (Child LP65, age 3 years;8 months), whose phonology effected a ban on fricatives in two different ways, serves as an especially apt illustration of heterogeneity of process and homogeneity of target. That is, one process changed singleton fricatives to stops; the other process deleted fricatives in clusters. The combined result of these processes was the transparent generalization that fricatives were absolutely banned from the child's inventory. Conspiracies have also been argued to reflect highly stable, preferred states that are presumably resistant to change (e.g., Crist 2001; Kiparsky 1976). The stability of conspiracies is attributed to the pressure to preserve transparency. This is an especially interesting claim with regard to developmental conspiracies, which must change or be suppressed if children are to ever acquire a phonology close to that of the target language.

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Surprisingly, however, little is known about the empirical and theoretical consequences of changing a conspiracy in the course of acquisition.

This paper presents an example of a developmental conspiracy with an interacting error pattern that introduced opacity, resulting in generalizations that were not surface-true. The association of an opacity effect with a conspiracy is an interesting, but unexpected, amalgamation of one of optimality theory's greatest challenges with one of its greatest successes. That is, while optimality theory offers a ready explanation for conspiracies, the theory has had to invoke special machinery to account for opacity effects. Some of those proposals have included local conjunction of faithfulness constraints (e.g., Kirchner 1996; Moreton and Smolensky 2002; Smolensky 1995), comparative markedness (McCarthy 2002b, 2003), and most recently, optimality theory with candidate chains, henceforth OT-CC (McCarthy 2007). The spontaneous emergence of an opacity effect in early stages of acquisition is also interesting on a couple of fronts. First, it has long been assumed that opaque generalizations are hard to learn (e.g., Kiparsky 1971). However, this assumption is especially difficult to reconcile with the growing body of evidence that has begun to show that opacity effects are actually quite common in early acquisition—even though those opaque generalizations are not observable in the target language (e.g., Dinnsen 2008 and references therein). We will argue that the conspiracy presented here is a natural developmental step forward in the acquisition of English and follows from recent proposals for characterizing such effects. Because OT-CC is a relatively new proposal with little attention given as yet to acquisition issues, we have chosen to formulate our account within this more recent framework, thus providing further grounds for its evaluation.

The paper is organized as follows: In §2, the facts of the case study and the basic conspiracy are presented and accounted for. The opacity effect associated with the conspiracy is then introduced in §3. In §4, we consider how this opacity effect could have been acquired. The paper closes with a brief summary and discussion.

2. The conspiracy

The data for this study were drawn from the Developmental Phonology Archive at Indiana University (Gierut 2008) and came specifically from a female child (Child 5T, age 4;3) with a phonological delay. It should be emphasized that this child was 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, because she produced 15 target singletons and all clusters in error on the *Goldman-Fristoe Test of Articulation* (Goldman and Fristoe 1969), she was diagnosed as having a severe phonological delay relative to age-matched peers.

The general methodologies employed in studies associated with the Archive are described in Gierut (2008). Briefly, however, for this specific case, a comprehensive speech sample was elicited in a spontaneous picture-naming task. The probe list consisted of several hundred 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 reli-

ability purposes by an independent judge. The overall interjudge transcription reliability measures were at or above 97% agreement.[1]

Our analysis of the child's speech identified four error patterns that participated in a conspiracy to prohibit marked lingual place and manner features in word-initial position. Each of the error patterns in the conspiracy is described and accounted for in turn in this section. We then go on in §3 to consider the interaction of the error patterns that yielded the opacity effect. It is specifically the opaque interaction that will require special theoretical machinery. To address that need and to maintain theoretical consistency, our account will employ OT-CC throughout (even for those transparent aspects of the phonology where standard optimality theory would suffice).

We will be assuming that this child's underlying representations were target-appropriate (as has been assumed for many other children; see, e.g., Gnanadesikan 2004; Smith 1973; cf. Fikkert 2006). This assumption accords well with a basic tenet of optimality theory, namely richness of the base, which precludes language-specific (or child-specific) restrictions on underlying representations (e.g., Prince and Smolensky 1993/2004). This should not be taken to mean that this child could not have had (some) underlying representations that were identical to her errored phonetic outputs. It simply means that the constraint hierarchy must be held responsible for yielding the attested outputs from a base that is at least as rich as English. It should also be kept in mind throughout that all of these error patterns are commonly occurring in both typical and atypical phonological development (e.g., Smit 1993).

Before describing the individual error patterns of the conspiracy and their restriction to word-initial position, we want to establish first that the place and manner distinctions of interest to us could and did occur elsewhere. More specifically, labial, coronal and dorsal consonants all occurred and contrasted in place of articulation postvocalically. The data in (1) illustrate this place contrast.

(1) Postvocalic place contrast preserved

[dɪpoʊ^{r}]	'zipper'	[bæt]	'fat'	[bæk]	'back'
[doʊp]	'soap'	[dʌt]	'cut'	[bʊk]	'book'
[dʌb]	'tub'	[mʌd]	'mud'	[bɪg]	'big'
[dibə]	'zebra'	[bɛd]	'bed'	[hʌg]	'hug'

[1] Inasmuch as these transcriptions were based on impressionistic judgments, it is, of course, possible that finer-grained instrumental analyses of purported mergers might have revealed subtle, systematic acoustic differences that could be taken as evidence of covert contrasts. Instrumental analyses of other developing and fully developed languages have in many cases succeeded in identifying covert contrasts (e.g., Cohn and Kishel 2003; Dinnsen and Charles-Luce 1984; Forrest et al. 1990; Maxwell and Weismer 1982; Port and O'Dell 1985; Scobbie et al. 1997; Slowiaczek and Dinnsen 1985; Warner et al. 2003; Weismer 1984). However, because these covert contrasts tend not to be perceptible, they effectively result in mergers. They would nonetheless support the claim that those children maintained a distinction in their underlying representations. It should also be kept in mind that our appeal to impressionistic transcription judgments accords with standard practices for research on fully developed languages. The high level of transcription reliability in our study adds a further measure of confidence in the transcriptions.

A full range of obstruent manner distinctions was also evident in postvocalic contexts. Stops, fricatives and affricates all occurred and contrasted in manner of articulation in that context, as shown in (2).

(2) Postvocalic manner contrast preserved

[tʌp]	'cup'	[wʊf]	'roof'	[wɔtʃ]	'watch'
[bæt]	'fat'	[dɛs]	'dress'	[bitʃ]	'peach'
[gʌk]	'duck'	[bæθ]	'bath'	[bɪdʒ]	'bridge'

While the data in (1) and (2) exemplify this child's contrastive use of place and manner distinctions postvocalically, they also preview some of the errors that were restricted to word-initial position, not all of which will concern us. One of those error patterns that we will be setting aside replaced initial voiceless consonants with seemingly voiced stops (while maintaining a voice contrast postvocalically, as can also be seen in many of the above words). We have chosen to ignore this error pattern here because of the inevitable questions that arise about the phonetic interpretation of the voiced transcription symbols in affected words. For our purposes, it will suffice to assume throughout that those sounds were voiced, recognizing that it may ultimately be more appropriate to described them as voiceless unaspirated. Either way, the transcription reflects the percept of a laryngeal merger in word-initial position and adds to the larger conspiracy to merge distinctions in that context.

The target-appropriate realization of sounds postvocalically along with the restriction of any error pattern to word-initial position is acknowledged to be at odds with widely held assumptions about fully developed languages and the contexts that are considered strong and resistant to change versus those that are weak and vulnerable to change (e.g., Beckman 1998; Lombardi 1999; Smith 2005). However, we have shown elsewhere (Dinnsen and Farris-Trimble 2006, 2008a) that many young children exhibit contextual strength relations that are just the opposite of what is observed in fully developed languages. That is, the default is for children to judge final position and syllable rhymes to be prominent—the context where contrasts will first be acquired. Accordingly, word-initial position and syllable onsets are judged to be weak at that stage and are vulnerable to error. We have argued further that, in the course of development, prominence shifts to conform to the contextual strength relations that we see in fully developed languages. We have hypothesized that the shift in prominence may be related to the lexical restructuring that goes on as new words are added to the lexicon (e.g., Metsala and Walley 1998). This disparity between developing and fully developed languages can be resolved without appealing to different constraints for children and adults, if (as we have argued) a family of conflicting universal markedness constraints assigns prominence to different contexts. The default ranking of those prominence-assigning constraints ascribes prominence to rhymes and final position, and the later reranking of those constraints results in initial prominence.

With this background and these assumptions in mind, we can now move on to a consideration of the error patterns associated with the conspiracy. While we will be describing each error pattern separately, it is our contention that these error patterns share properties that are suggestive of a more general, unifying process. As we will see, the combined effect of these error patterns is to prohibit marked lingual place and marked manner features in the same word-initial context. This resembles the frequently observed restriction on codas in

fully developed languages, namely, Coda-Condition, which maintains that codas cannot directly license place (and manner) features (e.g., Itô 1986; cf. Beckman 2004). The difference here, of course, is that the restriction we are considering does not relate to codas, but rather to word-initial onsets. The fact that a young child's word-initial onsets might behave the same way codas do in fully developed languages should not be surprising in light of our findings concerning developmental differences in contextual strength relations (e.g., Dinnsen and Farris-Trimble 2006, 2008a). What unifies these licensing restrictions is the weakness of the respective prosodic constituents: Codas are weak in fully developed languages, and word-initial onsets are weak in young children's developing phonologies. This thus allows us to subsume Coda-Condition under the more general Weakness-Condition as formulated in (3).

(3) Weakness-Condition

WEAK-COND: Weak contexts cannot directly license marked place and manner features

We will see that the Weakness-Condition is the driving force behind each of the following error patterns. The first error pattern of interest is Velar Fronting. This error pattern replaced marked dorsal consonants in word-initial position with an unmarked alveolar stop. The data in (4) illustrate this error pattern for this child.

(4) Word-initial dorsals replaced by alveolar stops

[dʌt]	'cut'	[dɔlɪŋ]	'calling'
[dæːtʃ]	'crash'	[dætʃɪŋ]	'crashing'
[dɛːtʃ]	'catch'	[dɛtʃɪŋ]	'catching'

This error pattern can be accounted for by ranking WEAK-COND above an antagonistic faithfulness constraint ID[dorsal], which demands that dorsal place be preserved, as shown in (5). While this lower-ranked faithfulness constraint would be inactive with regard to Velar Fronting, it would be active in retaining dorsal consonants in contexts not affected by WEAK-COND, namely in postvocalic contexts, as was shown in (1).

(5) Constraints and ranking for Velar Fronting

ID[dorsal]: Dorsal place must be preserved

Ranking: WEAK-COND >> ID[dorsal]

The tableau in (6) illustrates our account of Velar Fronting for this child. It also reflects one of the innovations of OT-CC, namely, the enriched conception of a candidate. That is, each candidate is a chain that begins with the fully faithful candidate and is followed by 0 or more unfaithful mappings, with each step in the chain being minimally different from the preceding step and harmonically improving based on the constraint hierarchy of the language. The requirements for a valid chain have the consequence that, for any given input, there will now be only a small, finite set of candidates for evaluation. The markedness con-

straints evaluate the terminal element of a chain. There are thus only two candidate chains for this input. Candidate chain (a) includes the fully faithful candidate alone and is assigned a fatal violation by WEAK-COND because of the associated marked dorsal place in the weak word-initial position. This assumes that what serves as a weak context follows from other factors relating to the prominence-assigning constraints. Consequently, for this and all following tableaux, it will be assumed that a highly ranked prominence-assigning constraint in this child's phonology renders word-initial onsets weak. Candidate chain (b) is a two-step chain, which begins with the fully faithful candidate and ends with a minimally different unfaithful, unmarked candidate. It violates only ID[dorsal], but the lower ranking of that constraint allows this candidate to win. We assume here and throughout that unmarked alveolar stops do not violate WEAK-COND. However, even if it were alternatively assumed that they do violate WEAK-COND, an argument could be made along the lines of Parker (2001) that an undominated constraint demands that consonants have some place and manner, thus tolerating the least marked place and manner for a consonant. We also assume as uncontroversial that harmonic scales for place and manner will prefer coronal stops over other places and manners, even if those markedness constraints were low ranked (e.g., de Lacy 2006).

(6) Velar Fronting

/kʌt/ 'cut'	WEAK-COND	ID[dorsal]
a. <gʌt> faithful	*!	
b. ☞ <gʌt, dʌt> <ID[dorsal]>		*

This child also exhibited another common error pattern, Stopping, which replaced marked fricatives with an unmarked stop in word-initial position. This error pattern affected labial and coronal fricatives. The data in (7) illustrate this error pattern. Notice that place of articulation was preserved in the errored output.[2]

(7) Word-initial fricatives replaced by stops

[du]	'zoo'	[dɛm]	'them'	[bæn]	'van'
[dibʌ]	'zebra'	[dɛ:ə]	'there'	[beɪʃ]	'vase'
[dæntə]	'santa'	[dæt]	'that'	[beɪθ]	'face'
[dʌn]	'sun'	[dʌm]	'thumb'	[bæt]	'fat'

[2] The only exception to this related to target labial fricatives, which varied in their realizations between labial stops and alveolar stops. This variation in place would likely require something along the lines of variable rankings among certain constraints (e.g., Anttila and Cho 1998). For example, because the markedness constraint WEAK-COND also bans marked labial place in initial position, it might be allowed to vary in its ranking relative to a faithfulness constraint preserving labial place. We will not attempt to incorporate this variation in our overall account, but we do find it interesting because it suggests that at an earlier stage of development, this child's conspiracy and the merger of place distinctions in word-initial position might have been broader, including all place distinctions in that context.

The constraints and ranking needed for this error pattern are given in (8). The ban on marked fricatives in a weak context could be achieved by WEAK-COND if it were ranked above the antagonistic faithfulness constraint that preserved manner features (ID[manner]). In the absence of any other highly ranked constraints compelling a change in place, place would be preserved in the errored outputs. The lower-ranked faithfulness constraint ID[manner] would exercise its influence in stronger postvocalic contexts, as was shown in (2).

(8) Constraints and ranking for Stopping

ID[manner]: Manner features must be preserved

Ranking: WEAK-COND >> ID[manner]

The tableau in (9) illustrates our account of the Stopping error pattern. The fully faithful candidate (a) fatally violates WEAK-COND because a marked fricative should not appear in the weak word-initial position, being eliminated in favor of the less marked candidate (b) with an alveolar stop.

(9) Stopping

/zu/ 'zoo'	WEAK-COND	ID[manner]
a. <zu> faithful	*!	
b. ☞ <zu, du> <ID[manner]>		*

This child also exhibited another common error pattern affecting a different manner of articulation, namely Deaffrication, which replaced marked affricates with unmarked alveolar stops in word-initial onsets. The data in (10) illustrate this error pattern.

(10) Word-initial affricates replaced by an alveolar stop

[dɛli]	'jelly'	[dɪp]	'chip'
[dʌmp]	'jump'	[diːʒ]	'cheese'
[duʂ]	'juice'	[dɛːə]	'chair'

The constraints and ranking associated with Deaffrication are the same as those for Stopping. That is, to compel the change from a marked affricate to an unmarked alveolar stop, WEAK-COND must outrank the antagonistic faithfulness constraint that would preserve manner. We are making the simplifying assumption that stops, fricatives and affricates differ in manner, but we recognize that the actual features and geometric structures associated with these sounds may require more specific faithfulness constraints.

The tableau in (11) illustrates our account of the Deaffrication error pattern. The fully faithful candidate (a) with an initial affricate is eliminated due to its violation of WEAK-

COND. Candidate (b) with an initial alveolar stop survives as optimal because it violates only the lower-ranked faithfulness constraint.

(11) Deaffrication

/dʒɛli/ 'jelly'	WEAK-COND	ID[manner]
a. <dʒɛli> faithful	*!	
b. ☞ <dʒɛli, dɛli> <ID[manner]>		*

A fourth error pattern associated with this child's conspiracy, Consonant Harmony, differed from the others in several respects and might even seem to be at odds with the conspiracy. That is, while the other error patterns favored unmarked alveolar stops in word-initial position, this error pattern dispreferred alveolar stops in that context, but only when the word contained a following lingual consonant with a different place feature, namely, dorsal place. Under those circumstances, a seemingly unmarked alveolar stop was replaced by a dorsal stop, presumably as a result of primary place assimilation. Illustrative data for this child's Consonant Harmony error pattern are given in (12).

(12) Word-initial alveolar stops assimilated to a following dorsal

[gʌk]	'duck'
[gɔʷg]	'dog'
[gɔgi]	'doggie'

The dilemma posed by Consonant Harmony is that it produced dorsal consonants, which are generally considered to be marked relative to coronals, and WEAK-COND should not tolerate marked place features in the weak word-initial context. However, if those more marked dorsal consonants received their licensing indirectly from the trigger of assimilation, which was itself in a strong context that directly licensed marked features, then Consonant Harmony would be perfectly consistent with the conspiracy.

The assimilatory nature of Consonant Harmony was clearly one factor that distinguished it from the other error patterns. The fact that an assimilatory process would yield seemingly marked sounds, and that the other, nonassimilatory processes would yield unmarked sounds is entirely consistent with standard expectations about such processes (e.g., Houlihan and Iverson 1979). However, the nonlocal character of the assimilation between the trigger and target must be regarded as a peculiarity of early phonological development. Nevertheless, Consonant Harmony is widely attested in early stages of acquisition (e.g., Stemberger and Stoel-Gammon 1991; Stoel-Gammon and Stemberger 1994; Vihman 1978). For accounts that attempt to reconcile this particular disparity between developing and fully developed languages, see Goad (1997), Pater (2002), and Dinnsen and Farris-Trimble (2008a).

The constraints that are most relevant to our account of Consonant Harmony are given in (13). AGREE is a particular instance of a more general context-sensitive markedness constraint that disfavors more than one place feature within a word and compels Consonant

Harmony. Many of the particulars of the constraint definition can ultimately be attributed to other constraints in the larger hierarchy and assumptions about harmonic scales for place. While dorsal consonants were usually prohibited in initial position due to the dominance of WEAK-COND over ID[dorsal], we see in this instance that a dorsal consonant was actually preferred over an alveolar consonant when in an assimilatory context. There are in principle at least two different ways to comply with AGREE if the target of assimilation were to be retained. One way would be to change the place feature to a directly licensed [dorsal] feature. That repair would, however, violate WEAK-COND. The other way to comply with both AGREE and WEAK-COND is to autosegmentally associate the [dorsal] place feature of the trigger with the initial consonant. This is how the conspiracy chose to deal with the pressure to enforce Consonant Harmony. The ranking of these two markedness constraints over the place-faithfulness constraints predicts the absence of a lingual place contrast in word-initial position.[3] The faithfulness constraint that preserves coronal place must be low ranked if coronals are to give way to dorsals in assimilatory contexts. The dominance of ID[dorsal] over ID[coronal] would, moreover, be consistent with harmonic scales for the preservation of place (e.g., de Lacy 2006).

(13) Constraints and ranking for Consonant Harmony

AGREE: Alveolar stops are banned when followed by a dorsal consonant within the word
ID[coronal]: Coronal place must be preserved

Ranking: AGREE, WEAK-COND >> ID[dorsal] >> ID[coronal]

The tableau in (14) illustrates our account of Consonant Harmony. Of the two possible candidate chains, we see that the fully faithful candidate (a) incurs a fatal violation of AGREE. It does not, however, violate WEAK-COND because the initial consonant is unmarked. The winning candidate (b) with a word-initial dorsal consonant would not violate WEAK-COND if it receives its licensing indirectly from the following trigger of assimilation. The winner thus violates only the lowest-ranked constraint, ID[coronal].

(14) Consonant Harmony

/dʌk/ 'duck'	AGREE	WEAK-COND	ID[coronal]
a. <dʌk> faithful	*!		
b. ☞ <dʌk, gʌk> <ID[coronal]>			*

The net result of these various error patterns and the conspiracy was that marked lingual place and marked obstruent manner features could not be directly licensed in word-

[3] While lingual places of articulation were not contrastive word-initially, target labial stops retained their labial place in that context and contrasted with lingual place. This is a common property of early phonological development (e.g., Fikkert 2006) and would require that ID[labial] outrank WEAK-COND.

initial position. The hierarchy that we have arrived at thus far for the constraints in the conspiracy is spelled out in (15).

(15) Summary hierarchy of the conspiracy

AGREE, WEAK-COND >> ID[manner], ID[dorsal] >> ID[coronal]

The data presented thus far have independently motivated the processes behind each of the error patterns, revealing a conspiracy against marked lingual place and marked obstruent manner features in word-initial position. This represents a conspiracy whether we were to formulate the account in rule-based or optimality theoretic terms. In a rule-based theory, it would be recognized as a conspiracy (but not accounted for in a unified way) because four separate rules (Velar Fronting, Deaffrication, Stopping and Consonant Harmony) would be needed, all of which would have to be formulated to operate in the same word-initial context. Despite the contextual convergence of these rules, the structural differences among them (especially their structural changes) would prevent them from being conflated into a single process that captures the functional unity among the rules. That is, these rules were working together to achieve the transparent generalization that lingual place and manner distinctions are not directly licensed word-initially.

Our account in (15) also corresponds with the optimality theoretic schema for conspiracies as described by Kager (1999) and McCarthy (2002a). That is, a conspiracy typically includes two or more ranked faithfulness constraints that are dominated by one or more markedness constraints. The hierarchy in (15) instantiates this schema most notably by the ranking of the two markedness constraints, AGREE and WEAK-COND, over the two ranked faithfulness constraints, ID[dorsal] and ID[coronal]. This translates to a general ban on dorsals in a weak context, except when they can be indirectly licensed by the trigger of Consonant Harmony. Moreover, the dominance of WEAK-COND over the other antagonistic faithfulness constraint, ID[manner], adds to the conspiracy by banning marked manner features in the same context where place distinctions are not licensed. Importantly, the markedness-over-faithfulness hierarchy predicts transparent outputs.

In the next section, we take up the interaction of Stopping and Deaffrication with Consonant Harmony and consider its implications for the conspiracy.

3. The opacity effect

Building on the above analysis, we now turn to the interaction of Consonant Harmony with Stopping and Deaffrication. The data in (16) show that alveolar stops derived from Stopping and Deaffrication did not undergo Consonant Harmony when a dorsal consonant followed in the same word. These forms thus represent apparent exceptions to Consonant Harmony, rendering that process opaque. The opaque interaction introduced a superficial lingual place contrast in assimilatory contexts. No data were available for 'cake'-type words, which might have allowed us to determine whether alveolar stops derived from Velar Fronting would also have been exempted from Consonant Harmony. Our hierarchy predicts that 'cake'-type words would likely have been produced target-appropriately, but not because of any demand to preserve word-initial dorsal place. Instead, an initial target dorsal could receive indirect licensing from the final dorsal within the same word.

(16) Derived alveolar stops immune to Consonant Harmony

[dɪgi]	'ziggy'
[dæŋktʃju]	'thank you'
[dɔwk]	'chalk'
[dɪkɨn]	'chicken'

The expectation of our account would have been that the words in (16) would not only have undergone Stopping and Deaffrication, but also Consonant Harmony as a result of a feeding interaction, yielding perfectly transparent outputs with indirectly licensed word-initial dorsals. The tableau in (17) illustrates this (erroneous) prediction with the hierarchy we established in (15) above. We have included in the tableau only those constraints from the hierarchy that are most relevant.

(17) Incorrect prediction of transparent output

/zɪgi/ 'ziggy'	AGREE	WEAK-COND	ID[manner]	ID[coronal]
a. <zɪgi> faithful		*!		
b. ☞ <zɪgi, dɪgi> <ID[manner]>	*!		*	
c. ☜ <zɪgi, dɪgi, gɪgi> <ID[manner], ID[coronal]			*	*

Notice that top-ranked AGREE incorrectly eliminates the attested opaque candidate (b). The other top-ranked markedness constraint (WEAK-COND) correctly eliminates the fully faithful candidate (a). Unfortunately, this leaves the assimilated transparent candidate (c) as the unintended winner. A similar incorrect prediction would obtain for those attested words with a deaffricated (and unassimilated) consonant followed by a dorsal consonant (e.g., 'chalk' words).

Interactions of this sort constitute an all-too-familiar problem for standard optimality theory. No single ranking of these constraints can block derived alveolar stops from undergoing Consonant Harmony while at the same time allowing Consonant Harmony to operate on underlying alveolar stops. Phenomena of this sort pose little difficulty for rule-based frameworks that allow extrinsic rule ordering (e.g., Chomsky and Halle 1968). For example, Stopping and Deaffrication could be ordered after Consonant Harmony in a counterfeeding relation, as the derivation in (18) shows.

(18) Counterfeeding derivation

UR	/dʌk/ 'duck'	/zɪgi/ 'ziggy'	/tʃɔwk/ 'chalk'
Harmony	gʌk	----	-----
Stopping	----	dɪgi	-----
Deaffrication	----	----	dɔwk
PR	[gʌk]	[dɪgi]	[dɔwk]

Notice that Consonant Harmony is permitted to effect a change in 'duck', but it is correctly blocked from applying to 'ziggy' and 'chalk' because at that point in the derivation those two words do not begin with an alveolar stop. After Consonant Harmony has been checked for its applicability, Stopping and Deaffrication are then permitted to apply. No ordering relationship can be established between Stopping and Deaffrication. Importantly, the alveolar stops produced by Stopping and Deaffrication cannot be fed back through the derivation, effectively blocking Consonant Harmony from applying to derived representations. Counterfeeding interactions of this sort are often referred to as "chain shifts" and are abundant in both developing and fully developed languages (e.g., Dinnsen 2008; Jesney 2005; Moreton and Smolensky 2002).

A number of proposals have been put forward within optimality theory to account for this counterfeeding type of opacity, including local conjunction of faithfulness constraints (e.g., Kirchner 1996; Moreton and Smolensky 2002; Smolensky 1995), comparative markedness (e.g., McCarthy 2002b; 2003), and most recently OT-CC (e.g., McCarthy 2007). While we are adopting OT-CC in this case, it should be noted that these other proposals can also account for the facts at hand. However, for a critical review of precursors to OT-CC, see McCarthy (2007). Also, for a consideration of the developmental implications of these other proposals, see Dinnsen (2008).

One of the important innovations of OT-CC is the introduction of a new family of PREC(EDENCE) constraints. These constraints evaluate the order of unfaithful mappings within a candidate chain. The relevant PRECEDENCE constraint is given in (19).

(19) PRECEDENCE constraint

> PREC(ID[coronal], ID[manner]): Every violation of ID[manner] must be preceded by a violation of ID[coronal] and must not be followed by a violation of ID[coronal]

If we return to the candidate chains in tableau (17) above, we can see how this constraint is interpreted. Candidate chain (a) does not include a violation of ID[manner], so PREC is not relevant and is vacuously satisfied. However, chains (b) and (c) both include violations of ID[manner], and that violation is not preceded in the same chain by a violation of ID[coronal]. Consequently, both chains incur one violation of PREC. Importantly, however, candidate chain (c) incurs a second violation of PREC because the ID[manner] violation is followed by a forbidden ID[coronal] violation. This makes the assimilated chain (c) worse than the unassimilated chain (b), all other things being equal. Ranking is, however, still important. AGREE cannot be ranked as high as we have been assuming. In fact, it must be ranked below PREC because it is PREC's second violation that will eliminate the assimilated candidate that would have been preferred by AGREE. It is thus more important to comply with PREC than it is to harmonize.

The tableau in (21) integrates PREC into the hierarchy and illustrates the counterfeeding effect for words that are subject to Stopping. One further comment is necessary regarding the ranking of constraints, and that is that a metacondition of OT-CC requires in this instance that ID[manner] outrank PREC. We have included in this tableau only those constraints that are helpful in illustrating the workings of OT-CC, but the fuller hierarchy is given in (20).

(20) Summary ranking for the opacified conspiracy

WEAK-COND >> ID[manner] >> PREC >> AGREE >> ID[dorsal] >> ID[coronal]

(21) Correct prediction of opaque output with OT-CC

/zɪgi/ 'ziggy'	WEAK-COND	ID[man]	PREC	AGREE	ID[cor]
a. <zɪgi> faithful	*!				
b. ☞ <zɪgi, dɪgi> ID[man]		*	*	*	
c. <zɪgi, dɪgi, gɪgi> ID[man], ID[cor]		*	**!		*

A similar result would obtain for 'chalk' words with WEAK-COND ranked above ID[manner], correctly selecting as optimal the deaffricated, but unassimilated candidate. While we can dispense with a tableau for 'chalk' words, it might be useful to consider the tableau for 'duck' words in (22), simply to show that PREC does not play an adverse role when a nonderived alveolar stop is in a harmonizing context and the assimilated candidate is the desired winner. PREC does not assess any violations in these cases because no valid chain includes a violation of ID[manner]. Again, we have limited the tableau to just those constraints that are most helpful to our exposition of the theory.

(22) Transparent output correctly predicted with OT-CC in nonderived contexts

/dʌk/ 'duck'	WEAK-COND	ID[manner]	PREC	AGREE	ID[coronal]
a. <dʌk> faithful				*!	
b. ☞ <dʌk, gʌk> ID[coronal]					*

Summing up to this point, we have shown that Child 5T's conspiracy was associated with an opacity effect by virtue of the interaction of Consonant Harmony with Stopping and Deaffrication and that OT-CC was able to account for both the opaque and transparent aspects of this child's conspiracy. Despite the opacity effect, the driving force of the conspiracy was still fully intact. That is, marked lingual place and manner features were not directly licensed in weak contexts. While this is the account that would be required within OT-CC, it is appropriate to ask how or why this opacity effect might have been acquired. The next section considers this question.

4. Opacifying a conspiracy

Our account of Child 5T's opacity-tolerant conspiracy involved at least one markedness constraint (AGREE) being dominated by faithfulness. This suggests—consistent with assumptions about the initial-state and the default ranking of markedness over faithfulness (e.g.,

Smolensky 1996)—that one or more stages of development with at least as many error patterns preceded the observed stage. It seems likely, then, that a prior stage would have had AGREE ranked above ID[manner], which would have yielded the same four error patterns, except that they would have interacted to yield perfectly transparent outputs. This means that both derived and nonderived alveolar stops would have undergone Consonant Harmony (a result we briefly entertained in (17)), and marked lingual place and manner features would also have been banned in word-initial position. The feeding interaction of Stopping and Deaffrication with Consonant Harmony in that earlier stage would, moreover, conform to standard conceptions of fully transparent conspiracies, and similar feeding interactions involving some of the same error patterns have been documented in other children's early speech (e.g., Dinnsen et al. 2007). The hypothesized hierarchy with the markedness constraints highly ranked and PREC now integrated for that earlier stage of development is given in (23). PREC is included in the hierarchy on continuity grounds and on the assumption that it is a member of the universal constraint set, but its violations would have been inconsequential because the higher ranking of AGREE would have ruled out the unassimilated candidate preferred by PREC.[4]

(23) Hypothesized hierarchy for the transparent stage

AGREE, WEAK-COND >> ID[manner] >> PREC >> ID[dorsal] >> ID[coronal]

For Child 5T to progress from the hypothesized transparent stage (23) to the attested stage with the opacity effect (20), she would have had to demote AGREE below PREC. The issue for OT-CC—and, for that matter, any of the other proposals for dealing with counterfeeding opacity effects—is that there is no observable fact in the target language that could ever motivate that particular demotion. More specifically, given the constraint demotion algorithm (e.g., Tesar and Smolensky 1998), Child 5T would have had to observe from the available input that alveolar stops derived from Stopping or Deaffrication did not harmonize. Stated differently, she would, for example, have had to observe that 'ziggy' was produced as [dɪgi] rather than as [gɪgi]. However, because English does not have Stopping or Deaffrication processes that derive alveolar stops, there are none to observe. Consequently, something else must motivate the demotion in these cases. We have argued elsewhere (e.g., Dinnsen et al. 2007; Dinnsen and Farris-Trimble 2008b) that counterfeeding opacity effects of the sort considered here emerge naturally in the course of acquisition as a result of imperfect partial learning. That is, a child might recognize that something about her pronunciation of a word does not quite match that of the target language, but she has not given sufficient weight to the fuller details of that mismatch. This does not have to mean that the child misperceived the target form. Instead, it simply means that the child recognized that her pronunciation of a word differed from the actual target form without committing to how those pronunciations differed (similar to a same/different discrimination judgment). Under those circumstances, some learning is still possible, but it will be minimal, resulting in only a minimal change in pronunciation. Importantly, however, the minimal change in the hierarchy that is called for will not be sufficient to eradicate prior error patterns.

[4] McCarthy (2007) makes no specific claim about the universality of PREC constraints; in the absence of evidence to the contrary, we will adopt the strong position that they are universal.

Let us now consider how Child 5T's demotion of AGREE below PREC fits with this view of imperfect learning. Any other change in her hierarchy would have corresponded to full and accurate recognition (i.e., both discrimination and identification) of some fact about the target language and would have resulted in at least some target-appropriate productions. For example, if AGREE had been demoted any further, i.e., below ID[coronal], Consonant Harmony would have been completely eradicated.[5] Alternatively, the demotion of WEAK-COND below ID[dorsal] would have completely suppressed Velar Fronting, Stopping and Deaffrication, introducing a target-appropriate lingual place and manner contrast in nonassimilatory contexts. On the other hand, if WEAK-COND had been demoted below ID[manner], a target-appropriate manner contrast would have been introduced, and the relevant words would not have been subject to Consonant Harmony. However, Velar Fronting would have persisted. Each of the above scenarios is typologically plausible and would undo part of the conspiracy. However, the demotion associated with the emergence of the opacity effect is, in fact, the only reranking that would have preserved all the same error patterns and still not have resulted in any new correct productions. Recall that the only change in pronunciation that resulted from this reranking was in 'ziggy' and 'chalk' words, which still were not produced correctly. This demotion is the only reranking that kept intact the conspiracy driven by WEAK-COND. That is, while derived alveolar stops violate AGREE and render Consonant Harmony opaque, they still comply with WEAK-COND because they represent the least marked place and manner. This must nevertheless be deemed a step forward because a superficial place contrast was introduced in assimilatory contexts (even though it was not manifested as in English). It also diminished (but did not eliminate) the pervasive application of Consonant Harmony. That is, Consonant Harmony continued to affect underlying alveolar stops, but no longer operated on derived alveolar stops. Also, while the opaque forms were still produced in error, they did at least come closer to the target by retaining the coronal place of the input. Consequently, Child 5T's opacity effect associated with the conspiracy can be seen as a minimal and positive (albeit imperfect) type of learning that maximally preserved her prior phonology.

But what contributes to imperfect learning and distinguishes it from learning that yields target-appropriate productions? It may be that conspiracies in general are at the heart of the problem. That is, drawing on Kiparsky's (1976) insight that conspiracies are resistant to change, the intertwined nature of the constraints in a conspiracy might hide from the child the facts of the target language that are most relevant to the suppression of any one error pattern in the conspiracy. The child's task is made even more difficult when one of the associated error patterns has multiple sources. This was especially relevant in the case of Child 5T's Consonant Harmony error pattern, which had several sources. That is, one of the sources was alveolar stops that were fully faithful. The other sources for alveolar stops came from the transparent feeding interaction of both Stopping and Deaffrication. The problem for the child is that, even if she recognized that some word(s) should not undergo Consonant Harmony, that fact alone would not be sufficient to guarantee the suppression of Consonant Harmony in words with different sources of alveolar stops. Even more importantly, a child's

[5] One other attested type of change not considered here would be for Consonant Harmony to be suppressed in 'duck' words while persisting in derived words such as 'ziggy' and/or 'chalk' (e.g., Child 142, Dinnsen 2008). All of the same error patterns would be active, but some correct productions would occur (e.g., 'duck' words). This would represent a different type of opacity effect, dubbed a 'grandfather effect' (e.g., McCarthy 2002b), and would require something along the lines of comparative markedness (ibid.).

recognition of a mismatch (discrimination) does not necessarily entail that she has also given equal weight to all of the details of that mismatch (identification). From the perspective of OT-CC, a child's recognition of a mismatch may simply motivate the demotion of the relevant markedness constraint to a point in the hierarchy where the candidate chain that is favored is the most harmonic failed candidate, i.e., the one that incurs one fewer faithfulness violation than the previous winner. Ultimately, the complete eradication of any conspiracy will require multiple constraints to be demoted because different markedness constraints conflict with different faithfulness constraints.

Other error patterns not associated with a conspiracy may be more amenable to complete suppression because fewer constraints would conflict or interact. Again, from an OT-CC perspective, there would be fewer competing candidate chains, and they would be shorter, making it more likely that even the most minimal demotion would result in target-appropriate productions. Standard conceptions of the constraint demotion algorithm may thus be sufficient to account for the full suppression of only some error patterns. This is not to say that children with conspiracies cannot come to make fully accurate judgments about the facts of the target language and demote the relevant constraints appropriately. We are simply saying that the constraint demotion algorithm as it has been conceived does not provide for imperfect learning of the sort illustrated here. We suggest that imperfect learning occurs naturally (without instruction) when a child has a conspiracy and recognizes only that there is a nonspecific mismatch between her speech and that of the target language. Under those circumstances, demotion can occur, but the constraints that are targeted for demotion and the extent of demotion follow from the requirement that all associated constraints in the conspiracy must remain active—even if opacity is introduced.

5. Conclusion

In closing, our analysis of Child 5T's developing phonology identified the four error patterns of Stopping, Deaffrication, Velar Fronting and Consonant Harmony to be participating in a conspiracy against the direct licensing of marked place and manner features in word-initial position. This conspiracy differs from other conventional conspiracies in that the error patterns interacted to yield some opaque outputs. More specifically, Consonant Harmony was rendered opaque due to the fact that alveolar stops derived from Stopping and Deaffrication did not undergo assimilation. Importantly, this opacity effect did not compromise the larger conspiracy, which was driven by the weakness-condition and prohibited the direct licensing of marked place and manner features in contexts that are presumed to be weak in young children's phonologies. These results confirm that conspiracies can and do change, but naturalistic change will be limited, favoring the emergence of opacity. The positive, but imperfect, learning observed in this case requires an expanded conception of the constraint demotion algorithm to allow learning to be triggered by a child's simple recognition of a mismatch between her speech and that of the surrounding speech community; the details of the mismatch may not be fully attended to. It remains to be determined whether the many other developmental counterfeeding chain shifts that have been documented also emerged from a fully transparent conspiracy, as we have argued here.

We have also shown that the underapplication opacity effects associated with this developmental conspiracy can be accounted for in terms of OT-CC. However, many questions are raised by our account and warrant further attention. For example, in terms of the theory

itself, the universality of PREC constraints remains an open question. It is equally unclear whether there are limits on the faithfulness constraints that serve as arguments in a PREC constraint. That is, are all, or only some, of the logically possible orders of unfaithful mappings legitimate arguments of PREC constraints? Additionally, from a developmental perspective, it will be important to establish the default ranking of PREC constraints. Our results may, however, begin to offer some insight into this issue. That is, the fact that opacity effects emerge naturally in the course of early acquisition suggests that in the initial-state, PREC constraints are ranked relatively high among the faithfulness constraints, which in turn are dominated by markedness constraints. Recall that a metacondition of the theory requires that each PREC constraint be dominated by its pivotal faithfulness constraint (i.e., the violated faithfulness constraint that must be preceded by and not followed by some other unfaithful mapping). As developed thus far, the metacondition tells us only that the PREC constraint cannot be ranked above its pivotal faithfulness constraint, but this leaves open a very large number of ranking options below the pivotal faithfulness constraint. However, if the PREC constraint were ranked immediately below its pivotal faithfulness constraint in the initial-state (as we have argued in the case of Child 5T), minimal demotion of a markedness constraint would enhance the prospects for the natural emergence of an opacity effect. Any lower ranking of the PREC constraint would inhibit the emergence of opacity effects, favoring transparency. We might even speculate that the presumed default ranking of PREC constraints is universally fixed (nonvarying). This would seem to allow for those cases where the PREC constraint needs to be active in some cases and inactive in others. That is, PREC constraints would be inactive if relevant markedness constraints did not compel unfaithful mappings or if those relevant markedness constraints were ranked above PREC. Any other view about the ranking of PREC constraints raises questions about the facts that would motivate their reranking. At the very least, our results and the questions they raise suggest that young children's developing phonologies offer a promising venue for the further investigation of OT-CC, conspiracies and the emergence and characterization of opacity effects.

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