Direction of Assimilation in Child Consonant Harmony*
Joe Pater and Adam Werle, University of Massachusetts, Amherst

Abstract
In child language, consonants often assimilate in primary place of articulation across intervening vowels. In adult language, primary place assimilation occurs only between adjacent consonants. In both cases, the first consonant usually assimilates to the second. The standard analysis of directionality of local assimilation in Optimality Theory uses positional faithfulness to protect the second consonant. In this paper we argue that directionality in child language assimilation is due not to positional faithfulness, but to a markedness constraint that specifies that a consonant preceding a dorsal must agree in place of articulation with it. Along with directionality, this constraint accounts for cases in which dorsals, but not labials, trigger assimilation, which occurs in Korean as well as in child language. Differences between the attested types of assimilation in adult and child language can be explained by differences in how positional faithfulness applies in the two domains.

1. Introduction
Consonant harmony refers to the assimilation of one consonant to another across an intervening vowel. This paper focuses on harmony involving primary place of articulation, which seems to occur only in child language. Some examples from Trevor, a child learning American English, appear in (1) (Compton and Streeter 1977, Pater 1997):

(1) a. [ɡɔɡ] dog 1;5.14
b. [kɔk] coat 1;5.18
c. [kæɡ] cat 1;3.4
d. [ɡɪɡuː] tickle 1;7.26
e. [ɡɑɡ] bug 1;5.18
f. [kʌk] cup 1;5.13
g. [ɡɪɡu] pickle 1;9.2
h. [bɛp] bed 1;6.17
i. [bɑbo] butter 1;7.20
j. [pap] top 1;6.8

In (1), there are examples of velar harmony (a-g) and labial harmony (h-j), applying regressively (a, d, e, g, j) and progressively (b, c, f, h, i), targeting coronals (a-d, h-j) and non-coronals (e-g) across back vowels (a, b, e, f, i, j) and front vowels (c, d, g, h).

Primary place harmony is often pointed to as the prototypical instance of a child-specific phonological process. It is widespread in child language (Vihman 1978), but not a single case of

* Acknowledgements: Primary thanks go to A.J. Compton for sharing his data with us. Portions of this paper were presented at Holland Institute of Linguistics Phonology Conference, at the West Coast Conference on Formal Linguistics, and at New York University. Thanks to members of those audiences, Paul de Lacy, and especially to the reviewers and the editors for their comments on this work.

Pater (1997) adopts Kiparsky’s (1994) proposal that coronal targeting is the result of a fixed ranking of faithfulness constraints (see also Goad 1997; cf. Stoel-Gammon and Stemberger 1994). In this analysis, assimilation is driven by a markedness constraint ‘REPEAT’ demanding that consonants be homorganic (for alternative approaches see Goad 1997, 2003, Bernhardt and Stemberger 1998, Rose 2000, and Fikkert and Levelt 2002). Here we use the name ‘AGREE’, in line with current terminology (e.g. Lombardi 1999, Bakovic 2000).

(2) AGREE
Consonants agree in place of articulation

In child language, this constraint has a wider domain of application than in mature languages. In child language, it applies to successive consonants in a word, even across an intervening vowel, while in mature languages, it applies only under strict adjacency.

Faithfulness constraints regulate how the AGREE constraint is satisfied, and can also block its effects. The ranking of the constraints in (3) determines whether particular places of articulation will be changed in order to meet the demands of AGREE.

(3) FAITH(X)
An Input segment’s specifications of feature X must be preserved in its Output correspondent
Where X ∈ {DORSAL, LABIAL, CORONAL}

Kiparsky (1994) proposes the following fixed ranking to account for the susceptibility of coronals to assimilation in adult language:

(4) FAITH[DOR], FAITH[LAB] >> FAITH[COR]

Pater (1997) adopts this proposal to deal with the parallel facts in child language, as seen in

---

1 We use the term “Faith” as a cover term for either IDENT or MAX constraints that apply to features (McCarthy and Prince 1995, 1999). See Pater and Barlow (2003) for discussion of child language data bearing on the choice between different approaches to featural faithfulness.

2 See de Lacy (2002) for an account of cases in which only non-coronals undergo local assimilation in adult languages. His analysis relies on constraints in a stringency relation, an alternative to fixed rankings. As far as we know, no cases of this type have yet been reported in child language.
Trevor’s data in (1), in which coronals assimilate to labials and dorsals, rather than the reverse. This analysis is illustrated by the tableaux in (5) and (6), which also include the ranking of AGREE above FAITH[COR] that is needed to prefer assimilation over the fully faithful candidate.

(5) | /dɔɡ/ | AGREE | FAITH[DOR] | FAITH[COR] |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [ɡɔɡ]</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [dɔd]</td>
<td></td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>c. [dɔɡ]</td>
<td>!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(6) | /tæp/ | AGREE | FAITH[LAB] | FAITH[COR] |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [pap]</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [tæt]</td>
<td></td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>c. [tæp]</td>
<td>!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Since labials assimilate to dorsals, FAITH[DOR] and AGREE must also be fixed in rank above FAITH[LAB] in the grammar characterizing the relevant stage in Trevor’s development:

(7) | /bʌɡ/ | AGREE | FAITH[DOR] | FAITH[LAB] |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>a. [ɡʌɡ]</td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>b. [bʌb]</td>
<td></td>
<td></td>
<td>!</td>
</tr>
<tr>
<td>c. [bʌɡ]</td>
<td>!</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

While this accounts for the relative “strengths” of different places of articulation in terms of their resistance to assimilation, it deals with neither directionality asymmetries, nor does it fully account for differences between places of articulation in terms of their ability to trigger assimilation.

In this paper, we show that Trevor’s consonant harmony is subject to both a preference for regressive assimilation and for velar triggers (see Smith 1973, Stoel-Gammon 1996 for similar patterns in the productions of other English-learning children). The data in (1) show that progressive assimilation and labial-triggered assimilation are not absent from his productions. However, in Trevor’s longitudinal development they disappear before regressive and velar-triggered assimilation respectively. In its final stage, consonant harmony consists of regressive velar assimilation only, as exemplified by the forms in (8):

(8)  a. [ɡɒɡ] dog 1;11.12  
     b. [ɡʌk] duck 1;11.12  
     c. [dæː kɛk rt] Dada take it 2;1.14

3 In child Dutch consonant harmony, labials appear to be stronger triggers than dorsals (Levelt 1994, Fikkert and Levelt 2002). Neither the present analysis, nor that of Fikkert and Levelt 2002, provides an explanation for this difference between child English and child Dutch. In fact, the child Dutch data contradict the proposal in Pater (2002) that velars are universally preferred triggers (see also de Lacy 2002). It may be that the propensity for labial harmony in Dutch is related to the prevalence of vowel-to-consonant assimilation (Levelt 1994), which usually involves spreading of labiality.
Examples (8a-c) provide instances of regressive velar harmony, while (8d, e) show the non-application of progressive velar harmony, and (8f, g) show the absence of labial harmony.

Directionality asymmetries have usually been handled in Optimality Theory in much the same way as the target asymmetry: a faithfulness constraint protects the non-assimilating segment (e.g. Jun 1995, Beckman 1998, Lombardi 1999, Bakovic 2000, Steriade 2001). Another approach is to encode directionality in the formulation of the markedness constraint (e.g. Goad 1997, McCarthy 1997, Walker 2000). The advantage of the faithfulness-based approach is that directionality can be derived from independently needed constraints. For example, Lombardi (1999) analyzes regressive voice assimilation as being due to the interaction of AGREE[VOICE] with an onset-specific faithfulness constraint, stated here as IDENT-ONS[VOICE]:

\[(8) \text{AGREE[VOICE]}\]

Adjacent obstruents agree in specification of [Voice]

\[(9) \text{IDENT-ONS[VOICE]}\]

A consonant in onset position should be identical in [Voice] specification to its Input correspondent

The tableau in (10) shows how IDENT-ONS[VOICE] picks between two candidates that satisfy AGREE[VOICE], yielding regressive assimilation.

\[(10) \begin{array}{|c|c|c|}
\hline
\text{/atba/} & \text{AGREE [VOICE]} & \text{IDENT-ONS[VOICE]} \\
\hline
\text{a. [adba]} & \text{} & \text{} \\
\text{b. [atpa]} & \text{} & \text{!} \\
\hline
\end{array}\]

As Lombardi points out, IDENT-ONS[VOICE] can also be used to analyze coda voice neutralization, if it is ranked above a context-free *VOICE constraint:

\[(11) \begin{array}{|c|c|c|}
\hline
\text{/dab/} & \text{IDENT-ONS [VOICE]} & \text{*VOICE} \\
\hline
\text{a. [dap]} & \text{!} & \text{!} \\
\text{b. [tap]} & \text{!} & \text{!} \\
\text{c. [dab]} & \text{!} & \text{!} \\
\hline
\end{array}\]

Other contrasts, like major place of articulation, typically behave like voice in that they are neutralized in coda position, and undergo regressive assimilation. Particularly striking support for a unified account of neutralization and assimilation comes from Steriade’s (2001) observation that segments within the apical series (such as [+/retroflex]) pattern differently for both processes. Apical contrasts are preserved post-vocalically, and undergo progressive assimilation.
As Steriade shows, this pair of differences is accounted for if apical segments are targeted by a postvocalic faithfulness constraint, rather than the onset faithfulness constraints that target other features.

Because of its success in accounting for the adult language facts, it is tempting to extend the positional faithfulness account to child language. However, it is hard to see how a positional faithfulness approach could deal with directionality in child language assimilation (at least in English - see section 4 on French). Directly importing the onset faithfulness account will of course fail, since much of the child language data consists of assimilation of onsets to codas, as in the majority of the forms in (1). One might instead invoke a positional faithfulness constraint specific to the rightmost consonant, but this faces the difficulty that the rightmost consonant is not at the edge of the word in bisyllables like (1d, g). This places the consonant out of the scope of standard Anchoring constraints (McCarthy and Prince 1999), which have furthermore been argued not to target right edges (Nelson 2003).

In light of these difficulties (and others - see section 4), we take the approach of elaborating the simple AGREE constraint in (2) so that it can be used to produce directionality effects for child language assimilation (Pater and Werle 2001). With the markedness constraint in (12), directional assimilation can be derived without positional faithfulness:

(12) \text{AGREE-L-DOR}

A consonant preceding a dorsal must be homorganic with it

As the tableaux in (13) and (14) show, this constraint demands assimilation in words like dog, but not coat, which is what is required to deal with the data in (8). Assimilation of the dorsal to the coronal (e.g. /dɔg/ → [dɔd]) - is blocked by \text{FAITH[DOR] >> FAITH[COR]}, as shown in (5).

(13) \begin{array}{|c|c|c|}
\hline
\text{word} & \text{AGREE-L-DOR} & \text{FAITH[COR]} \\
\hline
\text{a. [gɔg]} & \cdot & \\
\text{b. [dɔg]} & * & \\
\hline
\end{array}

(14) \begin{array}{|c|c|c|}
\hline
\text{word} & \text{AGREE-L-DOR} & \text{FAITH[COR]} \\
\hline
\text{a. [kɔt]} & \cdot & \\
\text{b. [kɔk]} & * & \\
\hline
\end{array}

For AGREE constraints to produce directionality effects, they must also specify the trigger of assimilation. A constraint that demanded homorganicity of a consonant preceding all other consonants would have the same effect as the general AGREE constraint in (2). Specifying the trigger has the added benefit of yielding an account of assimilation that is triggered by velars only, as also occurs in the stage exemplified by the forms in (8). With only the general AGREE constraint, it is predicted that velar and labial assimilation must co-occur, contrary to fact. This use of elaborated AGREE constraints was independently developed by de Lacy (2002) to account for place-specific triggering of local assimilation in adult languages. In section 4 we discuss his analysis of Korean assimilation, which provides a striking parallel to patterns found in Trevor’s data.

In the next section, we provide a more thorough description of Trevor’s stages of
consonant harmony. Section 3 contains the analysis, which makes crucial use of the AGREE-L-DOR constraint. Section 4 shows how AGREE-L-DOR functions in Korean, and also highlights differences in directionality effects between child language and adult language, which correlate with the absence of right edge faithfulness in child language, and the robustness of onset faithfulness in adult language.

2. Stages in consonant harmony: data

These data were originally collected in a large-scale diary-style study by Compton and colleagues (Compton and Streeter 1977). Mothers, who were speech pathologists with special training in the transcription of child speech, transcribed their children’s utterances in notebooks at frequent, but non-regular intervals. For the period of Trevor’s development that we will discuss here (~ 2;4), there are over 10,000 transcribed utterances.

We extracted all of the words in Trevor’s database in which the adult targets contained a pair of oral stops that could produce assimilation. We excluded other manners of articulation so as to control for potential effects of manner on assimilation. Similarly, we included only monosyllables and initially stressed bisyllables so that the consonants in question always flanked a stressed syllable, so as to control for potential prosodic effects.\(^4\) In sum, the target words had the shape \(C_1(C)V_1(C)C_2(C)(V)(C)\), where:

\[
\begin{align*}
(15) \quad & a. \ C_1 \text{ and } C_2 \text{ are both oral stops} \\
& b. \text{ Either } C_1 \text{ or } C_2 \text{ is a velar or a labial} \\
& c. \text{ Only } V_1 \text{ is stressed}
\end{align*}
\]

There are six word types, based on the place of articulation of \(C_1\) and \(C_2\). The word types are given in (16), and monosyllabic examples of harmonized forms of each one are presented in (17).

\[
(16) \quad \text{Word types} \\
\begin{array}{cccccc}
\text{TVK} & \text{PVK} & \text{KVT} & \text{KVP} & \text{TVP} & \text{PVT} \\
(\text{Where } T = \text{coronal, } K = \text{velar, } P = \text{labial, } V = \text{vowel})
\end{array}
\]

\[
(17) \quad \begin{array}{lll}
a. \ [g\!g\!g] & \text{dog} & \text{TVK} \\
b. \ [g\!\!g]\ & \text{bug} & \text{PVK} \\
c. \ [k\!k\!k] & \text{coat} & \text{KVT} \\
d. \ [k\!\!k] & \text{cup} & \text{KVP} \\
e. \ [p\!p\!p] & \text{top} & \text{TVP} \\
f. \ [b\!b\!b] & \text{boat} & \text{PVT}
\end{array}
\]

For each of the word types the proportion of harmonized vs. non-harmonized forms was measured for the period up to 1;5, and each individual month through 2;4.\(^5\) Every token of each

\[^4\] This restriction was probably mostly vacuous, since for most of the period during which consonant harmony applies, Trevor produces only trochaic word forms (see Pater 1997 on Trevor’s truncation patterns).

\[^5\] KVT words with front vowels sometimes displayed regressive assimilation, with the velar assimilating to the coronal. In our counts in the main text, we did not include those cases (see the Appendix for further discussion).
word was counted; a count of lexical items would face the difficulty that words are often produced differently in a single day, let alone in a single month.

To see how a particular factor influences the application of harmony, we can compare word types that differ in that way. In Trevor’s data, as in many other children’s, coronals are particularly susceptible to harmony. Labials do assimilate to velars, but this form of harmony ends much before the assimilation of coronals. This is shown in Figure 1, which plots the proportion of harmonized forms. The relevant comparisons are between the word types that display regressive harmony: TVK words vs. PVK (solid lines), and between those that display progressive harmony: KVT vs. KVP (dashed lines).

![Figure 1: Target of assimilation](image)

Words with coronals as potential undergoers display harmony more consistently, and for a longer period of time, than words that have labials in the same position, as a comparison of TVK words with PVK shows, as does a comparison of KVT with KVP.

Directionality effects can also be seen in Figure 1, which is redrawn as Figure 2 to highlight the crucial comparisons. Velar harmony affecting coronals (the solid lines) applies regressively to TVK words well into Trevor’s second year, though it ceases to apply progressively to KVT words around 1:11. Similarly, velar harmony affecting labials (the dashed lines) applies reggressively to PVK words far longer than it applies progressively to KVP words.

---

The one apparent exception is at 1:5, when KVP words assimilate slightly more consistently than KVT. This seems to be an effect of the intervening vowel, however. As the Appendix shows, KVT words with back vowels undergo assimilation nearly 100% of the time all the way until 1:8. The only KVP word produced up to 1:5 was the word *cup*, which had a back vowel.
Figure 2: Direction of assimilation

The final chart compares velar and labial triggers in regressive harmony by plotting TVK words against TVP (the solid lines), and in progressive harmony by plotting KVT against PVT (the dashed lines).
There are also some less firm conclusions that one might draw from this chart: progressive velar harmony (KVT) lasts slightly longer than progressive labial harmony (PVT), and progressive labial harmony (PVT) lasts somewhat longer than regressive labial harmony (TVP). However, we will not account for these data in our analysis because the differences are relatively slim compared to those discussed previously, and also because our focus here is on evidence for the ALIGN-L-DOR constraint. It is worth commenting on the PVT vs. TVP comparison, however, because it is contrary to the generalization that regressive harmony is more robust than progressive harmony. As discussed in Goad (1997) and Pater (2002), Amahl Smith (Smith 1973) has the opposite pattern: optional regressive labial harmony and no progressive labial harmony. Pater (2002) accounts for this in terms of a constraint like ALIGN-L-DOR that applies to labials. Amahl also has progressive velar harmony at this point, which can be captured by using a “bidirectional” AGREE constraint that applies only to velars (see Pater 2002 for details), which could also capture the KVT vs. PVT difference in Trevor’s data. Trevor’s apparent pattern of progressive labial harmony lasting longer than regressive is beyond the reach of the constraint set in Pater (2002). However, the strength of this counterevidence is mitigated somewhat by the low number of TVP words in Trevor’s data.

In Table 1, the raw numbers underlying the percentages in the above charts are provided in parentheses. Through 1;8, Trevor produces only 17 TVP tokens fitting our criteria, as opposed to 92 PVT tokens, and these 17 tokens are of only 3 lexical items (top, table, and tape) as opposed to 18 for PVT. This is problematic in two ways. First, the difference between TVP and PVT may be due to a sampling error, especially since PVT words assimilate only 63% and 26%
of the time in those months in which TVP words fail to assimilate. Second, the low number of TVP words is suggestive of a pattern of lexical avoidance (Schwartz and Leonard 1982), though this can be substantiated only through further research, since TVP words are likely less common than PVT in the English lexicon.

<table>
<thead>
<tr>
<th></th>
<th>Velar harmony</th>
<th>Labial harmony</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TVK</td>
<td>PVK</td>
</tr>
<tr>
<td>~1;5</td>
<td>96% (23/24)</td>
<td>97% (29/30)</td>
</tr>
<tr>
<td>1;6</td>
<td>100% (13/13)</td>
<td>100% (17/17)</td>
</tr>
<tr>
<td>1;7</td>
<td>100% (12/12)</td>
<td>90% (35/39)</td>
</tr>
<tr>
<td>1;8</td>
<td>88% (15/17)</td>
<td>83% (24/29)</td>
</tr>
<tr>
<td>1;9</td>
<td>100% (23/23)</td>
<td>61% (45/74)</td>
</tr>
<tr>
<td>1;10</td>
<td>86% (18/21)</td>
<td>25% (17/68)</td>
</tr>
<tr>
<td>1;11</td>
<td>93% (28/30)</td>
<td>2% (2/89)</td>
</tr>
</tbody>
</table>

Table 1: Percentages and numbers of harmonized forms by month

Our analysis accounts for 3 stages in the application of harmony. The first stage ends at about the point that labial harmony disappears. We chose 1;9.2 because there is a gap in data between then and 1;9.17. The third stage represents the final form of consonant harmony, in which velar place is transmitted regressively to coronal targets. After 2;0.3, this form of harmony becomes variable, and finally disappears at around 2;3. Table 2 shows the percentage of harmonized forms for each of the word types during these stages, along with the raw numbers from which those percentages derive.

<table>
<thead>
<tr>
<th></th>
<th>Velar harmony</th>
<th>Labial harmony</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TVK</td>
<td>PVK</td>
</tr>
<tr>
<td>~1;9.2</td>
<td>96 % (69/72)</td>
<td>95 % (125/132)</td>
</tr>
<tr>
<td>1;9.19-1;10.11</td>
<td>94 % (29/31)</td>
<td>38 % (33/86)</td>
</tr>
<tr>
<td>1;10.13-2;03</td>
<td>93 % (41/44)</td>
<td>5 % (5/93)</td>
</tr>
</tbody>
</table>

Table 2: Percentages and numbers of harmonized forms by stage

Adopting the criteria that harmony occurring in 80% or more forms indicates consistent application, less than 20% indicates non-application, and between 20% and 80% indicates variable application of harmony, the following descriptions of the stages emerge:
(18) **Stage 1**
Consistent regressive velar harmony to labial and coronal targets
Variable progressive velar harmony to coronal targets
Variable regressive and progressive labial harmony to coronal targets

**Stage 2**
Consistent regressive velar harmony to coronal targets
Variable regressive velar harmony to labial targets

**Stage 3**
Consistent regressive velar harmony to coronal targets

As discussed above, we have abstracted from some developmental changes in constructing these relatively broad stages. For a more detailed longitudinal analysis of Trevor’s velar harmony that is consistent with the present analysis of velar and labial harmony, see Pater and Werle (2001).

### 3. Stages in consonant harmony: Analysis

The constraints to be employed here are the ones discussed in section 1: the set of place faithfulness constraints, repeated in (19), and the two \textsc{agree} constraints in (20) and (21).

(19) \textsc{faith[dor], faith[lab], faith[cor]}

(20) \textsc{agree}  
Consonants agree in place of articulation

(21) \textsc{agree-l-[dor]}  
A consonant preceding a dorsal must be homorganic with it

It is likely that further data require the elaboration of a larger set of \textsc{agree} constraints (see e.g. Pater and Werle 2001, De Lacy 2002, Pater 2002, as well as the Appendix), but for present purposes, the general \textsc{agree} constraint in (21), and the more specific one in (22) suffice.

To deal with instances of variable application of harmony, we adopt Anttila’s (1997) proposal that variation results from partial ordering of the constraint set (see also Boersma and Hayes 2001, as well as Boersma and Levelt 2000, Pater and Werle 2001, and Curtin and Zuraw 2002 for applications to acquisition). Unordered constraints are placed in a random fixed order each time the grammar is used. For unordered constraints that crucially conflict, this produces variation.

In the first stage, KVT, PVT, and TVP words all show variable application of harmony. This can be captured by having \textsc{agree} unordered with respect to \textsc{faith[cor]}. When \textsc{agree}

\footnote{TVP words in fact assimilate 100% of the time up through 1;6, and 0% at 1;7 and later, so there is in fact no evidence for a stage of variation. We believe that this is simply due to the scarcity of data for this word-type. For all the cases in which more data exist, we do find evidence of variation in between the stages of consistent application and non-application of harmony.}
dominates FAITH[COR], assimilation results, and with the reverse ranking, assimilation is blocked. This is illustrated in the tableaux for *coat in (22).

\[
\begin{array}{|c|c|c|}
\hline
/kot/ & \text{AGREE} & \text{FAITH[COR]} \\
\hline
& & * \\
\hline
\text{a. [kok]} & & *! \\
\hline
\text{b. [kot]} & *! & \\
\hline
\end{array}
\]

FAITH[LAB], on the other hand, is fixed in rank above AGREE, as is FAITH[DOR], since KVP words like *cup are not undergoing assimilation:

\[
\begin{array}{|c|c|c|c|}
\hline
/kap/ & \text{FAITH[DOR]} & \text{FAITH[LAB]} & \text{AGREE} \\
\hline
& & & * \\
\hline
\text{a. [kap]} & & & * \\
\hline
\text{b. [kap]} & & *! & \\
\hline
\text{c. [pap]} & *! & & \\
\hline
\end{array}
\]

KVP words do undergo assimilation about 50% of the time up until 1;5; this pattern would be produced by also having FAITH[LAB] unranked with AGREE at that early stage. It would continue to be ranked above FAITH[COR], as per the fixed ranking in (4), so that PVT and TVP words surface as PVP, rather than TVT.

Words with labials preceding dorsals, like *bug, consistently undergo assimilation. Here we see the effect of the AGREE-L-[DOR] constraint, which ranks above FAITH[LAB]. FAITH[LAB] is also dominated by FAITH[DOR], so as to rule out assimilation of the velar to the labial.

\[
\begin{array}{|c|c|c|}
\hline
/bag/ & \text{AGREE-L-[DOR]} & \text{FAITH[DOR]} \\
\hline
& & * \\
\hline
\text{a. [bag]} & & * \\
\hline
\text{b. [bab]} & & *! \\
\hline
\text{c. [bag]} & *! & \\
\hline
\end{array}
\]

By transitivity, AGREE-L-DOR also ranks above FAITH[COR], which produces harmony for TVK words as well.

The analysis of stage 1 is summarized in the following table, which includes tableaux for all of the word types. Inputs that undergo harmony are placed in bold, and variation is indicated by pointing fingers for both optimal outputs.
In the third stage, FAITH[LAB] has been fixed in rank above AGREE-L-DOR, so that only TVK words undergo assimilation:
We have seen two effects of the Agree-L-DOR constraint. In stages 1 and 2, it is the cause of the different behaviour of KVP and PVK words, with only the latter undergoing velar harmony. In stages 2 and 3, it is the cause of the difference between KVT and TVK words, in which again harmony only applies to the words in which the velar is in the position to trigger regressive assimilation.

4. Comparison with local place assimilation

In this section we show that Agree-L-DOR also plays a role in local assimilation in adult language. In addition, we discuss differences in the typology of assimilation patterns in child and adult language which we argue are due to the dominance of onset faithfulness in adult language, and the absence of right edge faithfulness in child language.

In his analysis of Korean local place assimilation, de Lacy (2002) invokes a constraint like Agree-L-DOR that has an effect much the same as in Trevor’s stage 1 and 2. The pattern of assimilation is as follows (Kim 1973, Kim-Renaud 1974, 1986, Iverson & Kim 1987, Avery and Rice 1989, Mohanan 1993, Jun 1995, Cho 1999, de Lacy 2002). Labials and coronals assimilate to velars (28a, b), but only coronals assimilate to labials (28c). Velars assimilate to neither coronals nor labials (28d), and labials do not assimilate to coronals (28e).

(28) a. /pʰ + ko/  ➔ [ɕkko]  ‘bear on the back + conj.’
   /kamki/  ➔ [kɑŋki]  ‘a cold/influenza’
 b. /pʰ + ko/  ➔ [pəkko]  ‘receive and’
   /han + kaŋ/  ➔ [hɑŋkaŋ]  ‘the Han river’
 c. /kot + palo/  ➔ [kɔppla]  ‘straight’
   /han + βon/  ➔ [hɑmboŋ]  ‘once’
 d. /pʰ + to/  ➔ [pajto]  ‘room as well’
   /kuk + pap/  ➔ [kukpap]  ‘rice in soup’

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TVK</td>
<td>TVK</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>kɔɔ r</td>
<td>KVK</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>PVK</td>
<td>kɔɔ r</td>
<td>PVK</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>KVK</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>KVT</td>
<td>kɔɔ r</td>
<td>KVT</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KVK</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>KVP</td>
<td>kɔɔ r</td>
<td>KVP</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>KVK</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>TVP</td>
<td>kɔɔ r</td>
<td>TVP</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVP</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>PVT</td>
<td>kɔɔ r</td>
<td>PVT</td>
<td>✓</td>
<td>✓</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PVP</td>
<td></td>
<td>✓</td>
<td>✓</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>
In some respects, this pattern is identical to that of Trevor’s stage 1. In both cases, labials and coronals assimilate to dorsals, but only coronals assimilate to labials. Both can be captured by having AGREE-L-DOR and FAITH-DOR outrank FAITH-LAB, so that labials assimilate to dorsals, and FAITH-LAB and AGREE outrank FAITH-COR, so that coronals assimilate to labials. Though the constraint names differ, this is exactly the analysis de Lacy (2002) proposes for Korean (cf. Jun 1995 for an alternative OT analysis). Illustrative tableaux for Korean appear in (29) and (30).

(29) \[
| \text{/ap + ko/} & \text{AGREE-L-[DOR]} & \text{FAITH[DOR]} & \text{FAITH[LAB]} |
|---|---|---|---|
| a. [skko] & * & | |
| b. [appo] & *! & | |
| c. [apko] & *! & | |
\]

This ranking also accounts for the assimilation of coronals to dorsals (28b), since AGREE and FAITH[DOR] outrank FAITH[LAB].

This ranking does not yet account for the cases in which assimilation is blocked, as in (28d) and (28e). Part of the account involves fixing the rank of FAITH[LAB] above AGREE, so that labials do not assimilate to satisfy this constraint. However, there still remains the possibility of coronals assimilating to preceding labials and dorsals. As (32) shows, this is predicted to be optimal under the current ranking (the bomb indicates a wrongly optimal candidate).

(31) \[
| \text{/ip + ta/} & \text{FAITH[LAB]} & \text{AGREE} & \text{FAITH[COR]} |
|---|---|---|---|
| a. [ippa] & * & | |
| b. [itta] & *! & | |
| c. [ipta] & *! & | |
\]

This is in fact the correct outcome for Trevor’s stage 1, in which both labials and dorsals do optionally trigger progressive assimilation.

In Korean, assimilation is strictly regressive. This can be captured by invoking an onset-specific place faithfulness constraint:

(32) IDENT-ONS[PLACE]

A consonant in onset position should be identical in [Place] specification to its Input correspondent

With this constraint ranked above AGREE, progressive assimilation is blocked:
Combining the rankings motivated above yields the hierarchy in (34).

(34) AGREE-L-[DOR], FAITH[DOR] >> FAITH[LAB], IDENT-ONS[PLACE] >> AGREE >> FAITH[COR]

Some subtle differences between the range of possible local and non-local place assimilation patterns can be derived from the absence in child language of the effects of a positional faithfulness constraint protecting the rightmost of a pair of consonants targeted by AGREE, and the pervasiveness of such effects in adult systems. First, as far as we know, there are no attested cases of strictly regressive assimilation in child English in which all places of articulation act as triggers. This is rather common cross-linguistically. For example, in Diola Fogny, coronal, velar and labial nasals assimilate to a following oral or nasal stop, be it coronal, labial or velar (Sapir 1965, Itô 1986, 1989, Jun 1995):

(35) /p + maŋ + maŋ/ ➞ [nimamman] ‘I want’
    /najum + to/ ➞ [najunto] ‘he stopped’
    /n i + gam + gam/ ➞ [n iŋ gəŋ gam] ‘I judge’
    /n a + tiŋ + tiŋ/ ➞ [natintiŋ] ‘he cut (it) through’
    /n a + miŋ + miŋ/ ➞ [namiːmmin] ‘he cut (with a knife)’

This pattern emerges straightforwardly with IDENT-ONS[PLACE] and AGREE ranked above all of the place faithfulness constraints. With no positional faithfulness constraint targeting the rightmost consonant, the absence of this pattern in child consonant harmony is also expected. The table in (36) shows constraint violation profiles for inputs that might be subject to regressive assimilation from coronal triggers.

(36) The failure to generate regressive coronal triggering

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>PT</td>
<td>a. PT</td>
<td>*</td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>b. TT</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. PP</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>KT</td>
<td>a. KT</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
<tr>
<td></td>
<td>b. TT</td>
<td></td>
<td></td>
<td>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>c. KK</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

The (b.) candidates are those that display regressive assimilation. For these to be optimal, FAITH[COR] would need to outrank FAITH[DOR] or FAITH[LAB], in contravention of the fixed ranking in (4).
Interestingly enough, this pattern is not entirely absent from child language, as Rose (2000) shows. Data from Clara, a child learning Québécois French, evince a pattern in which $C_1$ always assimilates in place to $C_2$ in CVCV words, with the exception that labials do not assimilate. Clara does produce KVTV as TVTV (e.g. ‘gateau’ /gato/ $\Rightarrow$ [tæˈtɔ] 1;7.27). In contrast to English, $C_2$ in French CVCV words is a plausible target for positional faithfulness, since it is the onset of a stressed syllable. The positional faithfulness account receives further support from Rose’s (2000) observation that assimilation is blocked in CVC words. An undominated faithfulness constraint that targets consonants in stressed syllables would force regressive assimilation in CVCV words, and block assimilation in CVC words.

The absence of strictly regressive assimilation from all places of assimilation in child English, and its presence cross-linguistically in adult languages, as well as in child French, correlates well with the availability of positional faithfulness constraints in each case. In English child consonant harmony, the rightmost consonant is not in a prosodically prominent position, and is therefore not targeted by positional faithfulness. In local assimilation in adult languages, the rightmost consonant is in the onset, while in child French, it is the onset of a stressed syllable, both of which are prosodically prominent positions.

In adult language, onset faithfulness always seems to override general place faithfulness. That is, there are no reported cases in which direction of assimilation is determined by place of articulation, with for instance coronals assimilating to both following and preceding dorsals or labials (De Lacy 2002: 371). As we have seen in the analysis of Trevor’s stage 1, this pattern is produced by having Agree, Faith[DOR] and Faith[LAB] outrank Faith[COR]. For local assimilation, in which onset faithfulness is relevant, the same pattern would occur if IDENT-ONSP[PLACE] were ranked in the same stratum as Faith[COR], as in the hierarchy in (37).

(37)  \text{AGREE, Faith[DOR], Faith[LAB] $\gg$ IDENT-ONSP[PLACE], Faith[COR]}

The outcome of this ranking for an input like /aptatpa/ is shown in (38) (periods indicate syllable boundaries in output candidates):

\[
\begin{array}{|c|c|c|c|}
\hline
\text{Input} & \text{Faith[LAB]} & \text{AGREE} & \text{Faith[COR]} & \text{IDENT-ONSP[PLACE]} \\
\hline
\text{a. [ap.tat.pa]} & & * & * & \\
\hline
\text{b. [at.tap.pa]} & * & & * & \\
\hline
\text{c. [ap.pap.pa]} & & ** & & * \\
\hline
\end{array}
\]

Candidate (38a) lacks assimilation. The one in (38b) has strictly regressive assimilation. The winner, (38c), has assimilation that preserves the labial, with progressive assimilation for the first cluster, and regressive for the second. Both (38a) and (38b) are attested, but (38c) is apparently not.

One possible account of this gap is that IDENT-ONSP[PLACE] is in a fixed ranking above the general faithfulness constraints, which would make the ranking in (38) impossible. The problem that this raises for child language is that it predicts that CVC words should always assimilate in place to the following consonant.

---

8 Crucially, Clara does produce velars faithfully in other contexts (e.g. coco /koko/ $\Rightarrow$ [koko] 1;7.27; Yvan Rose, p.c.)
9 Thanks to Barrett Nordstrom for discussion of this analysis. Rose (2000) proposes that Clara’s pattern is due to Faith[COR] dominating Faith[DOR], but this predicts that it should be found in child English as well.
display progressive assimilation, which is clearly contrary to the observed facts. In fact, if IDENT-ONS[PLACE] is even present in child language grammars, then factorial typology predicts that there should be some cases in which CVC words show strictly progressive assimilation. This does not seem to occur. There seem to be two ways out of this dilemma. One is to claim that IDENT-ONS[PLACE] is completely absent from child language (Shigeto Kawahara p.c.), and that when it emerges in adult language, it takes its place in a fixed ranking above the general faithfulness constraints. The other is to claim that the final consonants in child CVC words are in fact onsets (Rose 2000, Goad and Brannen 2003), so that onset faithfulness does not favour progressive assimilation. Both of these solutions involve a crucial stipulation, which requires further research to evaluate.

The question of why IDENT-ONS-[PLACE] should be so dominant in adult local assimilation, yet apparently without effect in child non-local assimilation thus remains to be answered. Nonetheless, the differences in directionality effects in local and non-local place assimilation do support the basic thesis of this paper: that regressive assimilation in child English is caused by an elaborated AGREE constraint, rather than by positional faithfulness. The Korean data further show that this AGREE-L-DOR constraint is motivated for local assimilation as well.

5. Conclusions

Trevor’s longitudinal data show that progressive velar assimilation, and labial assimilation, end long before regressive velar assimilation. Furthermore, regressive velar assimilation continues to target labials when progressive velar assimilation is limited to coronals. These facts point to the existence of an elaborated AGREE constraint that demands that a consonant preceding a velar be homorganic with it (AGREE-L-DOR). This constraint also plays a role in local place assimilation in Korean. This approach to directionality in child language assimilation receives further support from the fact that it cannot generate regressive assimilation from all places of articulation, which is unattested in English child language. This pattern is produced by positional faithfulness, and it does occur in adult local assimilation, as well as in French child language, in which the triggering consonant is in a strong prosodic position.
References


Rose, Sharon and Rachel Walker. 2001. *A typology of consonant agreement as correspondence*. Ms., University of California, San Diego, and University of Southern California.


Smolensky, Paul. 1995. On the internal structure of the constraint component Con of UG. Handout of a talk presented at UCLA.


Appendix: Regressive assimilation and vowel effects

In section 4, we claimed that strictly regresssive non-local assimilation from all places of articulation does not exist in child English, and showed that this generalization follows from the absence of a positional faithfulness constraint targeting the rightmost consonant. Trevor does, however, display regressive assimilation from coronals, but only with an intervening front vowel. As the examples in (A1) show, this pattern applied variably. Words without the coronal consonant trigger did not display this pattern (e.g. [ki:] key 1;8.7), nor did words without the front vowel, like dog and duck.

(A1) a. [tiːʃ] keys 1;8.12
b. [kiːʃ] keys 1;8.12
c. [tæt] cat 1;8.14
d. [kæt] cat 1;8.14
e. [tiːz] keys 1;8.26
f. [kiːz] keys 1;8.26
g. [tʃ] kiss 1;8.26
h. [tʃ] kiss 1;9.2
i. [tæts] cats 1;9.20
j. [kæːts] cats 1;9.20
k. [kɪːz] keys 1;10.2
l. [tɪz] keys 1;10.2
m. [tæts] cats 1;9.20
n. [kæːts] cats 1;9.20
o. [tʃ] kiss 1;9.2
p. [tɪs] kiss 1;10.9
q. [tæt] cat 1;10.11

Trevor also sometimes displays progressive velar assimilation in these words, as in the pronunciation of cat as [kæʃ] (1;3.4). The longitudinal application of these two types of harmony for these words is illustrated in Figure A1, which shows the proportion of different outputs for KIT words, where “I” stands for a front vowel.
Figure A1 KIT words longitudinally

Related to this pattern is the fact that intervening front vowels are generally less amenable to velar harmony (Levett 1994, Stoel-Gammon 1996, Pater and Werle 2001, Fikkert and Levett 2002). The following chart compares the course of velar harmony for words with front vowels (TIK and KIT) and back vowels (TOK and KOT). As this figure shows, both progressive and regressive velar harmony last longer with intervening back vowels.
To account for this pattern, one might invoke a constraint that blocks velar harmony across front vowels (Pater and Werle 2001) and treat /KIT/ $\Rightarrow$ [TIT] as an alternative way of satisfying AGREE. The problem is that this requires FAITH[DOR] to rank beneath AGREE, in contradiction with its ranking at top of the hierarchy in the analysis in section 3. An approach that seems more likely to be successful would be to treat this pattern as being due to the local conjunction (Smolensky 1995) of a constraint against a sequence of a velar consonant and a front vowel (*KI) with AGREE. This constraint would be violated by any word that violated both *KI and AGREE (i.e. KIP and KIT). The fact that this constraint does not also force harmony for KIP words might then be put down to the resistance of front vowels to labial harmony.

In sum, this pattern is not a counterexample to the generalization that child English never displays regressive harmony from all places of articulation, since regressive coronal harmony is only occurring with front vowels. Furthermore, positional faithfulness seems of little use in explaining it. Its main interest is that it seems to be a case in which there is a cumulative effect of constraint violation, which cannot be captured in standard Optimality Theory with strict domination and no local conjunction.

Figure A2: Front vs. back vowels