CONSONANT HARMONY: A COMPARISON OF TWO EXPLANATIONS BASED ON UNDERSPECIFICATION THEORY

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INTRODUCTION

As part of a program to develop a theory of phonology based on "substantive universals" rather than "formal algebra," Mohanan (1993) introduces a theory of place assimilation that reformulates the substance of underspecification into a dominance hierarchy for place of articulation. Mohanan's theory makes more extensive and specific predictions than Stoel-Gammon and Stemberger's (1994) underspecification theory of place assimilation in consonant harmony in child speech.

Stoel-Gammon and Stemberger (1994) claim that the underspecification of alveolar for place accounts for their behavior in assimilating to the place of articulation of labials and velars. They claim that "It is more natural for underspecified phonemes to assimilate to specified phonemes than the reverse." "[D]eletion of features [as would be necessary for a labial to assimilate to a velar or vice versa] is not a natural operation." (p. 67) Thus Stoel-Gammon and Stemberger predict the following biases in place assimilation (p. 68):

(1) Stoel-Gammon and Stemberger's predictions:

a. a bias for alveolars, which are unspecified for place, to assimilate to labials and velars
   i. very uncommon for labials or velars to assimilate to alveolar
b. no biases for assimilation between labials and velars because both are specified and assimilations of one to the other are equally complex operations (p. 68)

Instead of focusing only on the coronal place specification as Stoel-Gammon and Stemberger do in their examination of consonant harmony, Mohanan develops a dominance hierarchy for place based on three features. Mohanan observes that, "The substance of the statement that feature value [αF] is specified and [-αF] is unspecified is that [αF] can override [-αF], but not the reverse." (Mohanan 1993: 90) Mohanan notes that most theories of radical underspecification assume" that [+coronal], [+anterior], and [-back] are underspecified and instead proposes that the opposite values for these features, i.e., [-coronal], [-anterior], [+back], be considered dominant. (p. 91) Alveolars have none of the dominant features, velars have all three of the dominant features, and palatals and labials each have two of the dominant features.[1] This leads to the following "dominance scale" (Mohanan 91):

(2)

Least dominant				Most dominant
alveolar	≺	palatal labial	≺	velar

[1] Mohanan does not discuss the fact that in this scheme, the alveopalatals [ʃ] and [ʒ] have one dominant feature, [-anterior], placing them between labials and alveolars on the dominance scale. Having none of the dominant features, the affricates [tʃ] and [dʒ] are alveolars in this scheme. My decision to treat alveopalatals as alveolars is discussed below.

Mohanan views assimilation in terms of the "strength of assimilatory force," which is greatest when the trigger is most dominant and the undergoer is least dominant. Although this theory is not completely incompatible with Stoel-Gammon and Stemberger's assertion that alveolars are the most likely undergoers of assimilation, it makes further and more specific predictions than the Stoel-Gammon and Stemberger theory (p. 91).

(3) Mohanan's predictions:

a. if labials, palatals, or velars undergo place assimilation, then alveolars will also undergo assimilation
b. if velars undergo place assimilation, then labials and palatals will also undergo place assimilation
c. if alveolars trigger place assimilation, then labials, palatals, and velars will also trigger place assimilation
d. if palatals or labials trigger place assimilation, then velars will also trigger place assimilation
e. no bias for assimilation between labials and palatals

Note that the substance of prediction 3a is similar to Stoel-Gammon and Stemberger's prediction 1a: alveolars will be the most common undergoers. However, where Stoel-Gammon and Stemberger assert only the general likelihood of alveolar as undergoers and unlikelihood of alveolar as triggers, the dominance hierarchy goes further to also assert the likelihood of velars as triggers and an implicational hierarchy for undergoers and triggers. Further, where Stoel-Gammon and Stemberger predict no biases in assimilation between labials and velars, the dominance hierarchy implies a bias for labials to assimilate to velars, and predicts that there would instead be no bias between labials and palatals.

Direction of Assimilation. Stoel-Gammon and Stemberger do not explicitly address the issue of direction of assimilation, progressive or regressive. Their theory implies that either direction is equally likely; a segment underspecified for place will tend to assimilate to the place of a specified segment. Stoel-Gammon and Stemberger's view has nothing to say about which direction assimilation would occur in among labials and velars.

Mohanan's overall program is to identify UG principles and parameters in phonology, and his theory of place assimilation focuses on the place assimilation observed between adjacent consonants in many languages. Mohanan theorizes that these assimilation processes are instantiations of a UG principle, and that individual languages specify the domain in which the principle holds (p. 79):

(4) In the sequence [+stop][+cons], the two consonants must share a single place node.

His theory also treats direction of assimilation as a UG principle (p. 81):

(5) The trigger for (4) is the following segment.

However, Mohanan proposes the UG principle in (5) specifically regarding the phenomenon of contiguous place assimilation in adult language. By this principle, Mohanan's theory would predict regressive assimilation only. Although regressive assimilation is more common in child harmony than progressive, certainly such a strict principle such as (5) cannot be said to apply in child harmony. Thus, this prediction will not be attributed to Mohanan regarding direction. Yet it seems that some principle must underlie the prevalence of regressive assimilation in child harmony. One possible principle will be discussed in the Analysis section below. To a point, Mohanan's theory implies that

direction will be a function of the assimilatory force as a function of the dominance of the consonants involved. However, since Mohanan allows for the possibility of a more dominant segment assimilating to a less dominant one (given a sufficiently strong assimilatory force), relative dominance of segments cannot be used to straightforwardly predict direction of assimilation. We might, however, tentatively predict that given a principle making regressive assimilation more likely than progressive, and assuming in Mohanan's framework that this contributes to the overall assimilatory force, i.e., that the assimilatory force is stronger in the regressive direction, that more dominant segments will not assimilate to less dominant ones in the progressive direction.

OBJECTIVES AND METHODOLOGY

This study examines the consonant harmony data for individual children in Smith (1973) (1 child, English) Vihman (1978) (2 subjects*[2] speaking Estonian and Czech), Berg (1992) (1 child, German), and Cruttenden (1978) (1 child, English) to see whether the assimilation patterns conform to Mohanan's dominance hierarchy of place assimilation and/or whether these data support the assertions of Stoel-Gammon and Stemberger. The questions addressed in this research are:

1. What are the patterns of place assimilation for these individual subjects?

   a. Do these patterns support Stoel-Gammon and Stemberger's general prediction that alveolar will be the most common undergoers, and will only very rarely be triggers?
   b. Do these patterns reflect Mohanan's implicational hierarchy?

2. What are the patterns for direction of assimilation? Although there is much data that regressive harmony is more common than progressive (Berg 1992: 232), what are the patterns for individuals? How does the direction of assimilation relate to the assertions of Stoel-Gammon and Stemberger and Mohanan?

Although Mohanan's theory of place assimilation focuses on a common phenomenon of adult languages, the dominance hierarchy is presented as a general principle which could be considered to apply to the place assimilation seen in consonant harmony in child language. Mohanan predicts that in a given language, and by implication, in a given child's developing grammar, the patterns of place assimilation must follow the implicational hierarchy for place assimilation based on the dominance scale. Therefore, for example, if in a given child's developing language velars undergo assimilation, then labials and palatals must also undergo place assimilation. A guiding assumption of this research, and the view that Mohanan would probably adopt in light of his larger theory, is that each child's developing language is in a sense a language unto itself. Therefore, Mohanan's predictions must be tested against harmony data for individuals, which Stoel-Gammon and Stemberger do not present. In fact, Stoel-Gammon and Stemberger comment that "...the single-subject type of study...[is] inconclusive about the issues raised here" because of the variability between children (pp. 64-65).

The Data. The data are presented in Appendix A. A weakness in the data is that there are no palatals by which to test Mohanan's claims regarding the equal dominance factors of labials and palatals.

It was difficult to determine how to treat alveopalatals. Though it would be interesting to examine whether the single dominant feature of alveopalatals, [-anterior], placed them between labials

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[2] Vihman 1978 includes 13 subjects, but only presents sufficient individual data for 3 subjects, and one of those is from Smith 1973.

and alveolars in their likelihood to undergo and trigger assimilation, it is more reasonable to treat these as alveolars given their status in the grammars of children this age. For three of the five subjects, the author notes a rule fronting alveopalatals (see notes following each data set in Appendix A). Because children as young as the subjects in this study (0;7-2;11) have not acquired the alveopalatals or palatals, which do not emerge until around 3;6 (Vihman 1996: 219), I have opted to treat the alveopalatals as alveolars for all five subjects. Of course, in Stoel-Gammon and Stemberger's theory, which considers underspecification for coronal place of articulation alone, there is no reason to distinguish among coronals.

A more theoretically crucial decision to the outcome of this study is the decision to exclude tokens that were identified by the researchers as harmony involving velars assimilating to alveolars because there is considerable reason to believe that these are actually cases of the common process of fronting. Most notably, for Subject 3, I have excluded 20 such tokens that Vihman (1978) identified as harmony. Vihman notes that there is a rule substituting [t] for [k] which occurred "for over half of this early period" (Vihman 1978: 309). Vihman identifies tokens as harmony where [k] emerges as an alveolar in the neighborhood of [s]: /kIsu/→ši·šu ~ti·tu. However, it seems more consistent to treat the emergence of [k] as an alveolar consistently as fronting, especially taking into account how young this subject was during the study (0;10-1;10). Velar fronting can be understood to occur because velars appear later (around 2;0) than alveolars or labials in every word position (Vihman 1996: 219; Stoel-Gammon 1985: 508). Thus, we will generalize that up to a certain age velars are often fronted to become alveolars, and that this is the process that underlies any apparent assimilation of a velar to an alveolar. Note that since there are many velars left in subject 3's data, we have to generalize in the absence of age data for specific tokens that the tokens in which velars survive were gathered later than the others. Subject 2, another very young subject (0;10-1;8 during the study), provides complex data suggesting that velars can be fronted in some instances and yet survive and trigger assimilation in the same word in other instances: tužka→tušta~kuška. Why can't we just say that in the one alternation the alveolar is the trigger and in the other the velar is the trigger?

Adopting underspecification as the paradigm in which to understand harmony necessitates finding another explanation for what appears to be harmony triggered by an alveolar. If harmony involves the spreading of the place specification from one segment to another, and the prevalence of alveolar undergoers is a function of their underspecification for place, as both Mohanan and Stoel-Gammon and Stemberger propose, the existence of alveolar triggers absolutely contradicts these terms, and we have to say something very special about it. Stoel-Gammon and Stemberger broach the possibility of alveolar triggers as "very uncommon" (p. 68), while Mohanan makes room for them as the least likely trigger, without offering any principled explanation of how alveolar triggers could exist at all.

Identifying these tokens as instances of fronting rather than harmony is a principled explanation. Aside from the numerous tokens excluded from Subject 3's data, three tokens from Subject 2 and one from Subject 4's data are excluded on this basis, and are mentioned in the notes following the data in Appendix A.

In addition, certain other tokens from the original sources have been excluded for various reasons, as explained in the notes following each data set.

ANALYSIS

Predictions regarding most likely undergoer and trigger. Table 1 identifies the number of tokens of each assimilation pattern for each subject. As asserted before, because of the process of fronting common in children this young whereby palatals are produced as alveolars, we cannot use this data

to test Mohanan's claims about the hierarchy where palatals are concerned. However, I have presented the patterns involving palatals to fully portray Mohanan's hierarchy. These patterns are italicized to indicate that the data was insufficient for palatals and that tokens involving alveopalatals are counted among the patterns involving alveolars. Where there is a gap in the hierarchy for a particular pattern, this symbol appears: O with the number of the prediction that is contradicted by the gap.

Mohanan's overall theory of place assimilation actually implies more specific predictions than those listed in (3) above. Because the relative status of both undergoer and trigger determine the strength of the force of assimilation (where there is an assimilation process in the grammar, of course) the theory predicts not just the presence of segments of a particular place of articulation as undergoers or triggers overall, but also the presence of the trigger relative to the strength of the undergoer and vice versa. So, for example, if in a given subject's grammar we find tokens where alveolars assimilate to velars and palatals assimilate to labials, if there are words in that subjects grammar containing palatals and velars, those palatals *should* assimilate to those velars, and if there are words containing alveolars and labials, those alveolars *should* assimilate to those labials. The predictions in (3) simply say that if there are labial triggers, there must be velar triggers. Table 1 tests the presence of a particular trigger for each place of articulation.

Mohanan's hierarchy is evidenced here to a good extent. Note that many of the gaps involve the absence of palatals as triggers. This raises a separate problematic issue regarding palatals because these gaps could reflect accidental gaps in the child's vocabulary.

Subject 5 exhibits the most glaring contradiction of Mohanan's predictions because of the absence of velar triggers. Because this subject's harmony pattern involves labial triggers strictly, it seems that we should consider whether something other than or in addition to level of specification drives this process.

Table 1 also clearly demonstrates the prevalence of alveolars as undergoers. This result is predicted by both Stoel-Gammon and Stemberger's and Mohanan's theories.

Table 1. Mohanan's Implicational Hierarchy

Predicted pattern: If 3 then 2 and 1 If 2 then 1 Undergoer→Trigger	Subject Exhibits Assimilation Pattern				
	1	2	3	4	5
Alveolars					
1. alveolar→velar	18	3	10	9	O-3d
2a. alveolar→labial*	8	4	15	17	35
2b. *alveolar→palatal*					
Labials					
1. labial→velar		1	2	1	
2. *labial→palatal*			O-3c		O-3b
3. labial→alveolar			1		
Palatals					
1. *palatal→velar*					
2. *palatal→labial*					
3. *palatal→alveolar*					

Velars					
1a. velar→labial*		1	3	3	20
1b. *velar→palatal*					
2. velar→alveolar					

*In Mohanan's theory, a and b are equally likely.

The tables below present a statistical analysis of the occurrence of the various places of articulation as undergoer and trigger, overall and broken down by direction of assimilation for each subject.

Subject 1	Overall			
Total Tokens: 26	Undergoer	# / %	Trigger	# / %
Progressive: 8 (31%)	alveolar	26 /100	alveolar	
Regressive: 18 (69%)	labial		labial	8 / 31
	velar		velar	18 / 69

Progressive				Regressive			
Undergoer	# / %	Trigger	# / %	Undergoer	# / %	Trigger	# / %
alveolar	8 / 100	alveolar		alveolar	18 /100	alveolar	
labial		labial	1 / 13	labial		labial	7 / 39
velar		velar	7 / 87	velar		velar	11 / 61

Subject 2	Overall			
Total Tokens: 9	Undergoer	# / %	Trigger	# / %
Progressive: 3 (33%)	alveolar	7 / 78	alveolar	
Regressive: 6 (67%)	labial	1 / 11	labial	5 / 56
	velar	1 / 11	velar	4 / 44

Progressive				Regressive			
Undergoer	# / %	Trigger	# / %	Undergoer	# / %	Trigger	# / %
alveolar	2 / 67	alveolar		alveolar	5 / 83	alveolar	
labial	1 / 33	labial	1 / 33	labial		labial	4 / 67
velar		velar	2 / 67	velar	1 / 17	velar	2 / 33

Subject 3

Total Tokens: 31

Progressive: 12 (39%)

Regressive: 19 (61%)

Overall

Undergoer	# / %	Trigger	# / %
alveolar	25 / 81	alveolar	1 / 3
labial	3 / 9.5	labial	18 / 58
velar	3 / 9.5	velar	12 / 39

Progressive

Undergoer	# / %	Trigger	# / %
alveolar	11 / 92	alveolar	
labial	1 / 8	labial	6 / 50
velar		velar	6 / 50

Regressive

Undergoer	# / %	Trigger	# / %
alveolar	14 / 74	alveolar	1 / 5
labial	2 / 10	labial	12 / 63
velar	3 / 16	velar	6 / 32

Subject 4

Total Tokens: 30

Progressive: 19 (63%)

Regressive: 11 (37%)

Overall

Undergoer	# / %	Trigger	# / %
alveolar	25 / 83	alveolar	
labial	2 / 7	labial	20 / 67
velar	3 / 10	velar	10 / 33

Progressive

Undergoer	# / %	Trigger	# / %
alveolar	16 / 84	alveolar	
labial	1 / 5	labial	15 / 79
velar	2 / 11	velar	4 / 21

Regressive

Undergoer	# / %	Trigger	# / %
alveolar	10 / 91	alveolar	
labial		labial	5 / 45
velar	1 / 9	velar	6 / 55

Subject 5

Total Tokens: 55

Progressive: 1 (2%)

Regressive: 54 (98%)

Overall

Undergoer	# / %	Trigger	# / %
alveolar	35 / 64	alveolar	
labial		labial	55 /100
velar	20 / 36	velar	

Progressive

Undergoer	# / %	Trigger	# / %
alveolar	1 / 100	alveolar	
labial		labial	1 / 100
velar		velar	

Regressive

Undergoer	# / %	Trigger	# / %
alveolar	34 / 63	alveolar	
labial		labial	54 /100
velar	20 / 37	velar	

Table 2 examines the predictions of Stoel-Gammon and Stemberger and Mohanan against the data above. As discussed previously, because of the lack of palatals in the data and because children this young produce alveopalatals as alveolars, we cannot fairly test Mohanan's claims with regard to palatals against this data.

Table 2. Evidence for Predictions

Stoel-Gammon and Stemberger	
Predictions	Evidence in Data
1a. bias for alveolars to assimilate to labials and velars	Strongly supported by subjects 1, 2, and 4 Less strongly supported by subjects 3 and 5
i. very uncommon for labials or velars to assimilate to alveolars	Strongly supported by subjects 1, 3, 4, and 5 Less strongly supported by subject 2
1b. no biases for assimilation between labials and velars	velar→labial 7 tokens (excluding 20 tokens from subject 5) labial→velar 4 tokens
Mohanan	
Predictions	Evidence in Data
3a. if labials, palatals, or velars undergo place assimilation, then alveolars will also undergo assimilation	Supported by all data
3b. if velars undergo place assimilation, then labials and palatals will also undergo place assimilation	Supported by all data
3c. if alveolar trigger place assimilation, then labials, palatals, and velars will also trigger place assimilation	Prediction is supported by overall data, but is not supported specifically for labial undergoers in subject 3's data, where there is no instance of a labial assimilating to a palatal though there is a token of a labial assimilating to an alveolar (accidental gap?)
3d. if palatals or labials trigger place assimilation, then velars will also trigger place assimilation.	Prediction is supported by overall data, but is not supported specifically for palatal undergoers in subject 2's data, where there is no instance of a labial assimilating to a palatal though there is a token of a labial assimilating to an alveolar (accidental gap?)
3e. no bias for assimilation between labials and palatals.	Insufficient data

Table 3 shows that the data do not reflect the prevalence of velars as triggers which follows from Mohanan's predictions, even excluding Subject 5's data.

Table 3. Prevalence of Velar vs. Labial Triggers

Triggers (percentage of tokens)	Subject				
	1	2	3	4	5
Velar	69	44	39	55	
Labial	31	56	58	45	100

Direction of assimilation. Regressive assimilation is more common than progressive for all but one of the subjects (for whom the usual tendency seems to be reversed), as shown in Table 4.

Table 4. Direction of Assimilation

Direction (percentage of tokens)	Subject				
	1	2	3	4	5
Progressive	31	33	39	63	
Regressive	69	67	61	37	100

The data tables for individual subjects above show clear evidence for the prediction that arises out of Stoel-Gammon and Stemberger's theory, i.e., that underspecified segments (alveolars) will assimilate to specified segments (labials and velars) regardless of direction; but this does not explain why regressive assimilation is still most common.

Table 5. Assimilation Patterns According to Direction of Assimilation

Progressive	Subject					Regressive	Subject				
Under.→Trigger	1	2	3	4	5	Under.→Trigger	1	2	3	4	5
alveolar→velar	7	1	5	3		alveolar→velar	11	2	5	6	20
alveolar→labial	1	1	6	13	1	alveolar→labial	7	3	9	4	34
labial→velar		1	1	1		labial→velar			1		
labial→alveolar						labial→alveolar			1		
velar→labial				2		velar→labial		1	3	1	

The tentative prediction that more dominant segments would not assimilate to the place of less dominant segments in the progressive direction is contradicted by two such tokens in Subject 4's data. (But Subject 4 also contradicts the usual pattern of the prevalence of regressive assimilation.)

Berg suggests that the overwhelming predominance of regressive assimilation in his subject (Subject 5) owes to word initial position being more difficult than word medial position. (Berg 1992: 232) Vihman reports that there is evidence to suggest that the "word or the syllable is the earliest contrasting unit of linguistic perception." (Vihman 1996: 155) Vihman suggests that harmony involves a child producing a word using a template, and that the spreading we observe as harmony occurs as a strategy to fill the template when the child is confused. (Vihman 1996: 225) We could combine all of these observations to suggest a principle which would account for the prevalence of

regressive assimilation while allowing for progressive assimilation, by saying simply that the word is the primary unit of perception, and that word medial position is generally more perceptually salient than word initial position.[3]

CONCLUSIONS

The data unambiguously support the claim of Stoel-Gammon and Stemberger that alveolars, which are underspecified for place of articulation, will be the most common undergoers of place assimilation and will very rarely be triggers. A statistically insignificant number of tokens contradict Stoel-Gammon and Stemberger's prediction that there would be no bias for assimilation between labials and velars (7 velar→labial tokens, 4 labial→velar tokens out; 11 out of a total of 153 tokens).

Table 1 reveals overall support for Mohanan's dominance hierarchy, with the notable exception of the absence of velar triggers for Subject 5. Mohanan's hierarchy cannot be assessed with regard to palatals using this data. Child data is not appropriate for this because of the tendency to front palatals. The implication of Mohanan's hierarchy that velars should be more common as triggers than labials is not born out by the data.

Regarding direction of assimilation, the data again supports the implications of Stoel-Gammon and Stemberger's simple claim: alveolars are the predominant undergoers regardless of the direction of assimilation.

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[3] Stoel-Gammon (1985) reports that segments generally appear in word initial position before word final position, which would make word final position the least salient of all. (p. 508) This study does not examine the emergence of phones in word medial position.

Appendix A

Subject 1. Amahl, 2;2, English, from Smith 1973

Assimilations	Undergoer	Trigger	Direction
cloth→ġɔk	alveolar	velar	progressive
glasses→ġa:gi:	alveolar	velar	progressive
kiss→ġik	alveolar	velar	progressive
biscuit→bigik	alveolar	velar	progressive
good (night)→ġug (nait)	alveolar	velar	progressive
whistle→wibu*	alveolar	labial	progressive
dark→ġa:k	alveolar	velar	regressive
drink→ġik	alveolar	velar	regressive
leg→ġɛk	alveolar	velar	regressive
ring→ġiŋ	alveolar	velar	regressive
singing→ġiŋiŋ	alveolar	velar	regressive
snake→ŋe:k	alveolar	velar	regressive
stuck→ġʌk	alveolar	velar	regressive
taxi→ġɛgi:	alveolar	velar	regressive
motor-car→mu:ġəġa:	alveolar	velar	regressive
knife→maip	alveolar	velar	regressive
nipple→mibu	alveolar	labial	regressive
stop→bɔp**	alveolar	labial	regressive
table→be:bu	alveolar	labial	regressive
room→wum	alveolar	labial	regressive
rubber→bʌbə	alveolar	labial	regressive
zebra→wi:bə	alveolar	labial	regressive
shopping→wɔbin	alveolar†	labial	regressive
kitchen→ġigən	alveolar†	velar	progressive
coach→ġo:k	alveolar†	velar	progressive
chockie (chocolate) →ġɔgi:	alveolar†	velar	regressive

*Smith excludes labial triggers from rule 17 (non-nasal alveolar and palato-alveolar consonants harmonise to the preceding velar point of articulation) because of fragmentary data (p. 19). For our purposes this token is included as an instance of harmony.

**This rule is optional for labial triggers.
stop →dʌp
stamp →dɛp
drum →dʌm

†By rule 23, all alveopalatal consonants are neutralized as |d| (p. 21).
church →dət
It is not clear whether these segments are processed in the harmony rule as alveolars or whether rule 23 applies after harmony. However, I will assume that rule 23 has applied and that the harmony process treats these as alveolars.

Subject 2. Jiři, 0;10-1;8, Czech, from Vihman 1978.

Assimilation	Undergoer	Trigger	Direction
tužka→kuška	alveolar	velar	regressive
taška→kašku (1;7,15)	alveolar	velar	regressive
balon→babo:nek**	alveolar	labial	progressive
knoflik→koki:kek†	alveolar	velar	progressive
gramofon			
→kakofon (1;7,20)	labial	velar	progressive
→gagafo:n (1;8,20)	not counted		
žaba→ba:ba	alveolar*	labial	regressive
koupat→po:pat	velar	labial	regressive
čap→pap	alveolar*	labial	regressive
sova→fofa	alveolar	labial	regressive

I have omitted certain tokens which Vihman identifies as harmony which are not straightforward, such as makap→mamak, which may involve other processes.

The following tokens have been excluded as instances of velar fronting:
kolečko→tolešto
tužka→tušta
taška→tašta (1;6,13)

As with subject 1, I will assume a fronting rule and count alveopalatals as alveolars.

**Vihman notes that harmony did not occur when this word was first attempted at 1;2. The form above was produced at (1;7,19) (p. 306)

† Knoflik was produced one day before this both as noti:k and nofik, making it difficult to determine whether the undergoer in the harmonized form koki:kek should be considered the alveolar or the labial. (p. 306)

Subject 3. Virve, 0;7-1;10, Estonian, from Vihman 1978.

Assimilation	Undergoer	Trigger	Direction
/karu/→kaɣu	alveolar	velar	progressive
/kivi/→kiki	labial	velar	progressive
/ma.hla/→mahma	alveolar	labial	progressive
/priLit/→pi·pi	alveolar	labial	progressive
/paL/→pap	alveolar	labial	progressive
/pati/→papi	alveolar	labial	progressive
/læhme/→mæhme	alveolar	labial	regressive
/lamP/→pamp	alveolar	labial	regressive
/putel/→pupa	alveolar	labial	progressive
/muna/→nuna	labial	alveolar	regressive
/tops/→pops	alveolar	labial	regressive
/tu.pa/→pupa	alveolar	labial	regressive
/su.Pi/→fup:i	alveolar	labial	regressive
/napa/→papa	alveolar	labial	regressive
/sEme/→fe·me	alveolar	labial	regressive
/sÖ.ma/→fö:ma	alveolar	labial	regressive
/nImO.ti/→mi·mona	alveolar	labial	regressive
/minema/→mimema	alveolar	labial	regressive
/prüki/→küki	labial	velar	regressive
book*→pʊp	velar	labial	progressive
/kaM/→pam:	velar	labial	regressive
/krE.mi/→pe·mi	velar	labial	regressive
/aKen/→akɛŋ	alveolar	velar	progressive
/kena/→keŋa	alveolar	velar	progressive
/kaNap/→kaŋ.ak	alveolar	velar	progressive
/koN/→koŋ:	alveolar	velar	progressive
/tütruK/→kiuk	alveolar	velar	regressive
/teKi a.La/→kek·i al:a	alveolar	velar	regressive
/tü.Ki/→kük:i	alveolar	velar	regressive
/teki/→keki	alveolar	velar	regressive
thankyou→kæŋku	alveolar	velar	regressive

*Vihman presents book and a few other English words Virve spoke in English orthography.

/veT/→tɛt: has been excluded assuming that v→t reflects stopping.

Subject 4. English, 1;6-2;2, from Cruttenden 1977

Assimilation	Undergoer	Trigger	Direction
chocolate→kaki	alveolar*	velar	regressive
duck→kaka	alveolar	velar	regressive
dog→gɑgi	alveolar	velar	regressive
pudding→pʊgɪŋ	alveolar	velar	regressive
chicken→kɪki	alveolar*	velar	regressive
shopping→pɒpɪn	alveolar*	labial	regressive
rhubarb→bubɑ	alveolar	labial	regressive
rabbit→babi	alveolar	labial	regressive
sleeping→fifɪŋ	alveolar	labial	regressive
glasses→gɑgi	alveolar	velar	progressive
cuddle→kʌku	alveolar	velar	progressive
pudding→pʊpɪŋ	alveolar	labial	progressive
man→mam	alveolar	labial	progressive
spoon→bum	alveolar	labial	progressive
birdie→bə:bi	alveolar	labial	progressive
pen→pɛm	alveolar	labial	progressive
Ribena→bimə	alveolar	labial	progressive
pencil→pupu	alveolar	labial	progressive
bunnie→bʌmi	alveolar	labial	progressive
parcel→papə	alveolar	labial	progressive
button→bʌpə	alveolar	labial	progressive
good→gʊk	alveolar	velar	progressive
water→wɔwə	alveolar	labial	progressive
crispies→pipi	velar	labial	regressive
gooseberry→bubi	alveolar	labial	progressive
piggy→pɪpi	velar	labial	progressive
bacon→beɪbən	velar	labial	progressive
apple→papa	alveolar	labial	progressive
all gone→gɒgɒn	alveolar	velar	regressive
grampa→gɑgə	labial	velar	progressive

* Alveopalatals are treated as alveolars

One token was excluded as an instance of velar fronting rather than harmony: cup of tea→tʌpəti. Given the predominance of labial triggers, the more likely output if this were harmony would be pʌpəti.

Subject 5. Melanie, 2;7,15-2;11, German, from Berg 1992

Assimilation	Undergoer	Trigger	Direction
ka:mi→pa:mi	velar	labial	regressive
li:p→bi:p	alveolar	labial	regressive
kɔmt→pɔmt	velar	labial	regressive
tsimɛr→pimɛr	alveolar	labial	regressive
angəʃupst→anəpups	alveolar*	labial	regressive
tsa:npasta→pa:npata	alveolar	labial	regressive
kɛmən→pɛmən	velar	labial	regressive
turnbɔitəl→purnbɔitəl	alveolar	labial	regressive
trɔməl→pɔməl	alveolar	labial	regressive
ʃi:bən→b i:bən	alveolar*	labial	regressive
zaubɛr→baubɛr	alveolar	labial	regressive
ʃupən→pupən	alveolar	labial	regressive
hu:pʃraubɛr→pu:pbaubɛr	alveolar*	labial	regressive
gra:bən→ba:bən	velar	labial	regressive
kre:mə→pe:mə	velar	labial	regressive
ainkre:m→ainpe:m	velar	labial	regressive
umgəkipt→uməpipt	velar	labial	regressive
kam→pam	velar	labial	regressive
zilbɛr→bilbɛr	alveolar	labial	regressive
padəl→papəl	alveolar	labial	progressive
kɛlbɛr→pɛlbɛr	velar	labial	regressive
kle:pt→pe:pt	velar	labial	regressive
kle:bən→pe:bən	velar	labial	regressive
ʃtɔp→bɔp	alveolar*	labial	regressive
gɛlp→bɛlp	velar	labial	regressive
gru:bə→bu:bə	velar	labial	regressive
ʃtrympfə→bymfə	alveolar*	labial	regressive
gumi:→bumi:	velar	labial	regressive
treɛpə→pɛpə	alveolar	labial	regressive
ga:bəl→ba:bəl	velar	labial	regressive
na:mən→ma:mən	alveolar	labial	regressive
vɛkgə**n**ɔmən →dɛkgə**m**ɔmən**	alveolar	labial	regressive
le:bɛr→be:bɛr	alveolar	labial	regressive
ko:miʃ→po:mis	velar	labial	regressive
zupə→bupə	alveolar	labial	regressive
ʃlapɛrt→papɛrt	alveolar*	labial	regressive
lampə→bampə	alveolar	labial	regressive
to:mas→po:mas	alveolar	labial	regressive
gɛlbə→bɛlbə	velar	labial	regressive
zɔmɛr→bɔmɛr	alveolar	labial	regressive

dry:bən→by:bən	alveolar	labial	regressive
do:m→bo:m	alveolar	labial	regressive
ga:bi:→ba:bi:	velar	labial	regressive
ʃtro:man→bo:man	alveolar*	labial	regressive
zu:per→bu:per	alveolar	labial	regressive
ne:mən→me:mən	alveolar	labial	regressive
zɛlber→bɛlber	alveolar	labial	regressive
ʃi:bən→pi:bən	alveolar*	labial	regressive
fɛrgaməlt→baməlt	alveolar	labial	regressive
ne:bəl→me:bəl	alveolar	labial	regressive
rainkɔmən→ainpɔmən	velar	labial	regressive
lapən→bapən	alveolar	labial	regressive
tsu:zamən→bamən	alveolar	labial	regressive
ange:bɛr→anbe:bɛr	velar	labial	regressive
bauxna:bəl→bauxma:bəl	alveolar	labial	regressive

The subject has a rule making bilabial fricatives alveolar stops: f→t and v→d. Six tokens from Berg's data (10, 25, 32, 34, 46, 53) have been omitted here because it is unclear whether these could be instances of place harmony or manner harmony, depending on whether or not the stopping rule above applies before harmony. Three other tokens (2, 15, 31) were excluded because the undergoer was the glottal /h/. Finally, one more token (42) was omitted because it is difficult to characterize: Luftbalɔŋ→bukabɔŋ

*The subject has not mastered [ʃ] and regularly replaces it with [t]. (p. 229) As with subjects 1 and 2, I will treat these as alveolars.

**The glottal→labial harmony evidenced here will not be counted for statistical purposes.