The Emergence of the Marked Unfaithful

Shelley L. Velleman
University of Massachusetts at Amherst

Marilyn M. Vihman
University of Wales at Bangor

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Recent phonological acquisition research within an Optimality Theory framework has raised questions about whether constraints should be considered universal or innate. At the same time, other studies have demonstrated that already in infancy children are highly sensitive to statistical tendencies in their ambient languages. We present evidence from children from four different language backgrounds of two types of constraints that must be learned: language-specific markedness constraints, which the child may develop in response to probability distributions in the language that he or she has not yet encoded in individual lexical representations, and idiosyncratic markedness constraints, which highlight the active nature of the phonological development process.

1. INTRODUCTION

Current theoretical discussions of child phonology within the framework of Optimality Theory center around satisfaction of faithfulness constraints versus satisfaction of markedness constraints. Faithfulness constraints are generally defined in terms of the relationship between the target (**input**) form of the word and its output form. Several authors (Demuth 1995; Gnanadesikan 1995; Smolensky 1996) have argued that the **initial state** of a child's phonology is one in which markedness constraints overrule faithfulness constraints -- a universal state that will gradually become more and more language-specific. This has been referred to as **the emergence of the unmarked** (McCarthy & Prince, 1994; Gnanadesikan, 1995); this phrase has come to represent the idea that early phonology may be a window onto the universal markedness hierarchy. However, in Velleman & Vihman (in submission) we have demonstrated that, most often, neither markedness nor faithfulness seems to dominate a given child's phonology, even when specific matched MARK-FAITH constraints are compared. For example, in keeping with the emergence of the unmarked, faithfulness to the absence of onsets in target words (production of a vowel-initial word as such; a.k.a. CORRESPONDENCE(ONSET)) may be violated in order to satisfy the universal markedness constraint against vowel-initial syllables (ONSET). Conversely, however, young children from a variety of language backgrounds also violate markedness by producing a vowel-initial word faithfully; that, is, without a consonant onset. More intriguingly, some children violate both markedness and faithfulness by producing a form that satisfies neither. For example, Charles (a French-learning child) violates both ONSET and CORR(ONSET) by omitting a target onset consonant in words like *chaussures* 'shoes', produced as [ɛdʒo] and *poupee* 'doll', produced as [apæ]. This pattern satisfies neither markedness (because vowel-initial

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syllables are marked) nor faithfulness (because the input is consonant-initial). Such a tendency might be referred to as "**the emergence of the marked unfaithful**".
How can we account for cases such as these within a theoretical framework of innate universal constraints?

Recent phonological acquisition research within an Optimality Theory framework has raised questions about whether constraints are in fact universal or innate. Levelt and Van De Vijver (1998), for example, compared Dutch children's acquisition of syllable types to cross-linguistic patterns of occurrence of syllable types. They identified two stages in the developmental emergence of syllable types that required conjoined constraints that are not required to account for cross-linguistic adult grammars, and suggested that these results "cast doubt on the idea that constraints are innate and universal" (Levelt & Van de Vijver, 1998, p. 18). Similarly, Goad (1996, 1997) and Velleman (1996) demonstrated the difficulty of accounting for the pervasiveness and breadth of application of consonant harmony and metathesis within child phonology using only constraints attested for adult phonology.

If they are not innate, how could constraints be learned? It has been widely demonstrated that at an early age infants are already highly sensitive perceptually to the statistical properties of the languages to which they are exposed (Morgan, 1996; Saffran, Aslin, & Newport, 1996; Jusczyk, 1997; Smolensky, Davidson, & Jusczyk, 2000; Johnson & Jusczyk, in press). Clearly, "..theories of language learning and language use must allow for frequency effects" (Roark & Demuth, 2000, p. 599). Furthermore, these properties of the ambient language have been shown to have an effect on children's early speech production (Boysson-Bardies & Vihman, 1991; Vihman & Bodysson-Bardies, 1994; Stoel-Gammon, Buder & Kehoe, 1995; Foulkes, Docherty, & Watt, 1999; Roark & Demuth, 2000; Escudero & Boersma, 2001; Docherty, Foulkes, Tillotson, & Watt, 2002; Vihman, Nakai & DePaolis, 2002; Johnson & Jusczyk, in press).

This has led to the hypothesis that at least some constraints are inductively grounded in phonetic experience (Hayes, 1999) or even that only those constraints that are relevant to the language to be acquired are "learned in the process of perceptual categorization and motor learning" (Boersma, 1998, p. 292), not all constraints. Roark and Demuth (2000) further speculate that other sources of salience, beyond raw frequencies of occurrence, may influence the learner's acquisition of constraints and constraint rankings.

The purpose of this paper is to provide additional evidence of constraint learning in early phonology based upon data from 20 children, five each exposed to four different languages: English, French, Japanese, and Welsh. This set of languages allows us to contrast a variety of phonotactic systems. For example, English permits syllable types ranging from V alone to CCCVVCCCC, and includes more monosyllabic words than the other languages. Lexical stress is predominantly but by no means exclusively trochaic, while phrasal stress is predominantly but not exclusively iambic (Vihman et al, 1994; Vihman, Nakai & De Paolis, 2000). French syllables are predominantly CV in shape, with occasional closed syllables and onset clusters. Diphthongs and vowel reduction do not occur. Tonic accent is phrase-final (Gadet, 1989). Japanese, in contrast, includes no intrasyllabic clusters; codas are restricted to nasals and geminates. Onsetless syllables and diphthongs are both permitted. Both vowel length and consonant length are contrastive (Ota, 2001). Japanese is mora-timed and therefore, as in French (which is syllable-timed), vowel reduction does not occur (Grabe & Low, in press). Welsh vowel length is also contrastive, although only in monosyllables. Diphthongs, complex onsets and complex codas are all permitted (Awbery, 1984). Lexical and phrasal stress are as in English, but with a slightly higher proportion of onomatopoetic words, which are iambic (Vihman, Nakai & De Paolis, 2000). We will argue that (1) children develop language-specific markedness constraints based upon such phonotactic tendencies in their languages and additionally that (2) some children also develop idiosyncratic markedness constraints. The latter may be initially inspired by some minor pattern in the ambient language, but the individual child extends such patterns well beyond the level of occurrence in the language of exposure. Although group results will be briefly presented, the focus will be on individual examples as it is only through looking at individual phonologies that such patterns can be identified.

2. METHOD

Data for English and Japanese were collected in California, USA; for French in Paris, France; and for Welsh in Bangor, Wales (UK). All of the participants were learning their languages in monolingual home environments at the time that they were studied. Data from each of the children were analyzed at the same developmental point: productive lexicon of between 40 and 60 words (referred to henceforth as the **25-word point**, as it corresponds to the developmental period during which a child will produce about 25 words per 1/2 hour recording session, according to Vihman & Miller, 1988).

The source of information for each child's phonology was the same: transcripts of the child's word productions during unstructured 30-minute audio- and video-recorded parent-child play sessions in which the child's expressive lexicon reached a level of approximately 50 words as evidenced by:

- parental diary report, and
- the production of at least 20-30 words during the 30-minute recording session. (See Vihman & McCune 1994 for the protocol for the identification of vocalizations as words.)

The participants' pseudonyms, languages, and ages at the 25-word point are given in Table 1.

Table 1: List of subjects by language, name, and age

Name	Age @ 25 words
ENGLISH	
Deborah	1;3.24
Emily	1;3.29
Molly	1;2.20
Sean	1;3.23
Timmy	1;4.22
FRENCH	
Carole	1;2.5
Charles	1;3.19
Laurent	1;5.15
Marie	1;7.24
Noel	1;5.23
JAPANESE	
Emi	1;4.7*
Haruo	1;7.17
Kazuko	1;3.28
Kenji	1;6.17
Taro	1;11.2
WELSH	
Carys	1;5.29
Fflur	1;5.2
Gwyn	1;2.24
Lowri	1;6.6
Nona	1;6.18

*Last session @ 19-word point.

Native-speaking transcribers prepared transcripts of each child using the International Phonetic Alphabet (narrow transcription). Inter-transcriber reliability was first tested within each language. Although many prelinguistic vocalizations were included in these measures, agreement as to the specific identity of the consonant ranged from .75 (Japanese) to .80 (French and English). Crosslinguistic reliability was also checked for some pairs of languages, with percentage of agreement ranging from .81 to .86. (See Vihman et al. 1985 and Boysson-Bardies & Vihman 1991 for further details.)
Each word token produced by each child was considered with respect to a core set of phonotactic markedness and faithfulness constraints relevant to early child phonologies (as suggested by Gnanadesikan, 1995; Demuth, 1996; Fee, 1996; Kehoe & Stoel-Gammon, 1997; Levelt & Van de Vijver, 1998; Bernhardt & Stemberger, 1998; and others). Each markedness constraint (e.g., ONSET, which requires a consonantal onset for

every syllable) was paired with the corresponding faithfulness constraint (e.g., CORR(ONSET)[1], the constraint against omitting or adding an onset to an input form[2]).

Every token of each child's production of every word type was categorized as either satisfying or violating each applicable markedness constraint and each applicable faithfulness constraint. Frequencies of violation (number of violations divided by number of opportunities for violation) of each member of these pairs were compared to derive a constraint ranking for each child. This made it possible to determine which classes of constraints (markedness vs. faithfulness, e.g., ONSET vs. CORR(ONSET)) were prioritized by each child. The pairs of constraints that were compared in this way are listed in Table 2. They are defined and exemplified in detail in the Appendix.

Table 2: Constraints Considered

Markedness	Faithfulness
ONSET	CORR(ONSET)
NOCODA	CORR(CODA)
PEAK	CORR(PEAK)
*COMPLEX(C):	
*CC	CORR(CC)
*C$C	CORR(C$C)
*COMPLEX(V) a.k.a. *VV	CORR(VV)
GEMINATE	CORR(GEM)
Binarity:	
SYLBIN	CORR(SYLBIN)
MORBIN	CORR(MORBIN)

A typical analysis, for an English-speaking child code-named Deborah, will be given here by way of illustration. Table 3 indicates the ranking of her markedness and faithfulness constraints, including both the frequency of violation of each markedness

[1] Simplified constraint names are used to highlight the relationships between specific markedness and faithfulness constraints (e.g., ONSET and CORR(ONSET)).

[2] Note that the set of faithfulness constraints considered here come from the CORRESPONDENCE category within OT (as described in McCarthy & Prince 1995 and elsewhere). These correspondence constraints dictate the ways in which the output (production) must match the input (target form) and vice versa. Correspondence as it is used here embraces both the input-output Maximality (MAX) and output-input Dependence (DEP) constraint categories. In English, for example, one Max constraint might state that, 'all input nasals must correspond to output nasals'. This would indicate that, if there is a nasal in the target word, it must be produced. To put it another way, nasals may not be deleted. The related DEP constraint would state that all output nasals must correspond to input nasals. That is, nasals may not be added. (Note that these are not absolute constraints; like most phonological constraints, they are sometimes violated.) Thus, the correspondence faithfulness constraints considered here encompass both MAX and DEP: inputs and outputs must match, so neither deletions nor additions are allowed. This simplification of the usual approach to faithfulness is considered to be appropriate here, given that the research question is whether or not any evidence for faithfulness in general can be found in such early productions, rather than what the influence of specific types of faithfulness constraints might be. Details of specific correspondence violations will be provided as appropriate.

constraint and how often those violations were incurred in order to satisfy faithfulness; the frequency of violation of each faithfulness constraint and how often these violations were incurred in order to satisfy markedness.

The traditional OT tableau cannot be used for determining a constraint ranking of early phonologies, due to the great variety of output forms often associated with each input. This is illustrated in a tableau for Deborah's productions of *kitty* in Figure 1. The constraints listed across the top are in the percentage-occurrence ranking order given in Table 3. However, the listed forms in the lefthand column are not candidates; each one is one of Deborah's outputs. Thus, no one of them can be said to "win"; each actually occurred once. Note also that the most faithful potential candidate for American English, [kɪɾi] is not among Deborah's outputs, although in principle it should not be ruled out by her constraint ranking. Those constraints that percent occurrence ranks lowest are typically violated more often by these outputs than those that are higher-ranked.

Table 3: Deborah (25 wds) Constraints Rank-Ordered by Percent Violated and Percent of those Violations that Result in Satisfaction of Related Constraint

Constraint	Percent violated	For satisfaction
CORR(ONSET W/O ʔ)[3]	0	NA
CORR(PEAK)	0	NA
PEAK	1	100
ONSET W/O ʔ	1	0
CORR(SYLBIN)	1	53
CORR(ONSET W/ ʔ)	1	0
NOCODA	2	0
*CC	6	17
*C$C	10	0
ONSET W/ ʔ	12	92
CORR(CC)	12	54
CORR(C$C)	12	0
CORR(VV)	14	75
*VV	19	75
CORR(CODA)	26	93
CORR(MORBIN)	27	100
MORBIN	33	91
SYLBIN	74	88

[3] "ONSET W/O ʔ" refers to the ONSET constraint calculated without including glottal stops as possible onsets. "ONSET W/ ʔ" refers to the same constraint recalculated including glottal stops as possible onsets.

Figure 1: Deborah tableau for *kitty*

/kɪɾi/	CORR (ONSET)	ONSET	CORR (SYLBIN)	NOCODA	*CC	*C$C	CORR (CC)	CORR (C$C)	CORR (CODA)	SYLBIN
t̥let.l̥:i				*	*	*	*	*	*	
kʰi.we										
kʰek̬.li				*		*		*	*	
t̥l̥:i			*		*		*			*

With respect to codas, markedness outranks faithfulness in Deborah's phonology at this age. With respect to syllable binarity, faithfulness outranks markedness, contradicting the MARK>>FAITH hypothesis. The most surprising finding, however, is that several pairs of constraints (PEAK and CORR(PEAK), *C$C and CORR(C$C), *VV and CORR(VV), *CC and CORR(CC), MORBIN and CORR(MORBIN), ONSET and CORR(ONSET)) are approximately equally ranked with respect to each other. With respect to these constraints, Deborah seems to either select target words that satisfy both markedness and faithfulness, or to incur many violations -- violating both markedness and faithfulness, and not always in order to satisfy the other. That is, markedness is not satisfied (e.g., the word is produced without an onset), but this "sacrifice" does not result in satisfaction of faithfulness (e.g., the target does include an onset).

The procedure illustrated for Deborah was followed for each of the 20 children in the study. The rank orders of constraints for each child were averaged to yield a rank order for each language. (Rank orders, rather than percentages, were averaged as it is inappropriate to average percentages.)

3. RESULTS

3.1 Faithfulness >> Universal Markedness Constraints

Results from all of the children from all of the languages are summarized in Table 4. For each language, the constraints are set out in decreasing order of importance, the highest-ranked constraints at the top of the list. As seen above for Deborah, there are some cases in which a universal markedness constraint dominates the corresponding faithfulness constraint. Carole's satisfaction of NOCODA is an example, illustrated in Table 5[4].

[4] Note that most children produced each word type more than once – up to 29 times, often with great variability. The tokens given in these tables are representative but by no means exhaustive.

Table 4: Average constraint rankings by language group

	English	French	Japanese	Welsh
1.	CORR(PEAK)	CORR(PEAK)	CORR(PEAK)	CORR(PEAK)
2.	PEAK	PEAK	PEAK, *CC	PEAK
3.	*CC	*VV	CORR(CC)	*CC
4.	CORR(ONSET)	*CC	CORR(GEM)	CORR(CC)
5.	CORR(GEM)	CORR(CC)	CORR(VV)	CORR(CODA)
6.	*VV	CORR(ONSET)	*VV	CORR(SYLBIN)
7.	CORR(VV)	NOCODA	ONSET	CORR(ONSET)
8.	CORR(CC)	ONSET	CORR(ONSET)	*C$C
9.	ONSET	CORR(CODA)	NOCODA	CORR(GEM), *VV
10.	*C$C	*C$C, CORR(C$C)	CORR(SYLBIN)	CORR(C$C)
11.	CORR(SYLBIN)	CORR(SYLBIN)	CORR(CODA)	SYLBIN
12.	NOCODA	CORR(MORBIN)	GEM	CORR(MORBIN)
13.	CORR(C$C)	CORR(GEM)	CORR(C$C)	MORBIN
14.	GEM	GEM	SYLBIN	ONSET
15.	CORR(CODA)	SYLBIN	*C$C	NOCODA, CORR(VV)
16.	CORR(MORBIN)	MORBIN	CORR(MORBIN)	GEM
17.	MORBIN	CORR(VV) - N/A	MORBIN	
18.	SYLBIN			

Table 5: Carole (25 wds): NOCODA >> CORR(CODA)

Target in IPA	Gloss	Actual
sak	bag	ka
tas	cup	ta
babaʀ	Babar	baba
ãkoʀ	again	ʰakɔ
pɛl	shovel	pɪ
bwaʀ	drink	ba

Surprisingly (for Gnanadesikan 1995, Smolensky 1996, and others), however, there are at least as many cases in which a faithfulness constraint dominates the corresponding markedness constraint as vice versa. Every child from every language group satisfies at least one faithfulness constraint more often than the corresponding markedness constraint, and most of the children do so in several cases. One of the American children, Emily, for example, is generally faithful to the onset status of the input word, regardless of markedness. This is illustrated in Table 6. Note, however, that the status of glottals is indeterminate in Emily's phonology[5]. She occasionally uses an initial glottal stop or [h] in her productions of target vowel-initial words (c.f. *Oscar, Ernie, A*), which could indicate that glottals are not consonantal in her system. However, she also occasionally

[5] Note that transcription of glottals, especially glottal stop, tends to be quite unreliable (Vihman et al., 1985).

substitutes a glottal for a supraglottal consonant (c.f. *cookie*). Additionally, she sometimes epenthesizes a glottal-initial syllable to the beginning of a form (c.f. *beads*). These epenthesized glottals were not categorized as violating Corr(ONSET), because the epenthesized syllables do not correspond to any part of the target forms. However, they were categorized as violating ONSET as well as SYLBIN. In short, it appears that Faith>>Mark with respect to Onset in Emily's phonology, but this pattern is far from exceptionless (suggesting gradient constraint-ranking; see Velleman & Vihman in submission).

Table 6: Emily (25): ONSET Faith>>Mark

Target	Actual
apple	api
up	aʊ
'I'	aɪ
Oscar	aʊkɛ, ʔake
Ernie	hœn̪n̪jʌ, ʌntɛ
'A'	ʔeɪ
cookie	hə̤kʰi
beads	ʔɪbɪ
water	əwawɪ

Language-specific markedness constraints

Most other cases of faithfulness dominating the related markedness constraint are even less clear-cut. For example, Corr(CODA) dominates NoCODA in Fflur's phonology, as shown in Table 7. Fflur preserves target codas regardless of the markedness of the resulting production (*gwallt* 'hair', *mam* 'mom', *diod* 'drink'). However, she goes beyond faithfulness to target words; in some cases codas are added despite open input syllables (*eto* 'again', *fankw* 'over there'). In these cases, the output form is both marked and unfaithful. How could cases such as these be accounted for?

One possibility is that the child is aware of the range of phonotactic possibilities in the language: open and closed syllables both occur. As suggested by Hayes (in press), the child has "knowledge of ...'legal sequences and structures'". She is faithful to this general pattern of the language in the sense that she produces both types of syllables. However, she may not have specific or reliable knowledge of which particular words have open versus closed syllables. This type of pattern might be referred to as **statistical faithfulness**. That is, the child's syllables have codas about the right percentage of the time for the target language, but codas do not necessarily occur on the right words **and** are not necessarily consistent in this respect even within multiple repetitions of the same word target. However, faithfulness is defined as a relationship between an 'input' (presumed underlying representation) and an output form. Therefore, it is more appropriate within Optimality Theory to categorize such patterns as learned, **language-specific markedness constraints**: inductively-derived reflections of general tendencies within the ambient language that apply to all outputs (probably gradiently; see Velleman & Vihman, in submission), regardless of the target form.

Table 7: Fflur: CODA Faith>>Mark

Satisfy CORR(CODA):		
gwałt	hair	ʔaχ
bɔχ	cheek	ʔɒχ
stʌk	stuck	kɔʔkˣ
mam	mom	maʔm
r̥eɪn	those	mɛn
dijɒd	drink	dɑd
gɑg-gɑg	quack-quack	gag-gakʰ
pʊs	puss	ʔɒʔθ
Violate both CORR(CODA) and NOCODA		
ʔaʊ	hug sound	ʔax
vanku	over there	kʰux
ʔɛto	again	ʔəθʔɒx

Further examples of this type of markedness are provided by Deborah (Table 8) and Marie (Table 9), who sometimes simplify and sometimes add clusters (both intra- and intersyllabic); Taro, who sometimes omits and sometimes adds syllables[6] (Table 10); and Marie, who both adds and omits onsets (Table 11). Indeed, every child from every language environment produces some outputs that violate both universal markedness constraints and word-specific faithfulness constraints.

Table 8: Deborah: CC

Target	Actual
Simplify CC:	
three	[si]
monkey	[hm̩mæ]
Add CC:	
bird	[bwɑ]
kitty	[tl̥ɛtl̥:i],[kekl̥i], [tl̥:i]
moo	[bwoʌ]
two	[tˢi]

[6] Note that Taro's words do not always respect foot binarity. That is, moras are not typically added to compensate for lost syllables or vice versa.

Table 9: Marie: -CC-

Target	Gloss	Actual
Simplify -CC-		
merci	thanks	ɛsih
l'avion	the plane	lileɲõ
Add -CC-		
c'est beau ça	That's pretty	apoːtɕa, ebotsa
dedans	inside	dindɔ̃
hola	whoa/oops!	ʊlla
papillon	butterfly	papji

Table 10: Taro (25 wds): SYLBIN≅CORR(SYLBIN)

Target (in IPA)	Gloss	Actual
Omit syllable		
wani	'alligator'	ʰwɑɪ̯, wɑɪ̯, hwɑː
pakun	'bite sound'	ak
Add syllable		
ɲao	'cat/meow'	n̩.æʔ
bubu	'car'	əbʊbʊ
bebi	'baby'	ɑbebi
kottʃi	'this one'	kʊt.tʃʊ.ʔʊʔ
nenne	'sleeping'	ənenеʔ

Table 11: Marie: Onset

Target	Gloss	Actual
Omit onset:		
chapeau	'hat'	apoʰ
sur l'eau	'on the water'	eːlːo
merci	'thanks'	ɛsih
Add Onset:		
a deux	'together'	hazə, hadø
attends	'wait'	hatã

In summary, given children's heightened awareness of phonotactic patterns in their languages from infancy, there are two ways in which accommodation to these statistical tendencies of the adult language could occur:

- the child's productions become statistically more like the language's frequencies because the child's productions become more and more faithful to individual target words, or
- the child's productions become statistically more like the language's frequencies in general, without becoming more faithful to individual target words.

In this study, we have found evidence for both.

3.2 Idiosyncratic Markedness Constraints

A third type of markedness occurs when the child has identified patterns within the language, and produces words with those patterns, but is not faithful to them even in a statistical sense. That is, a "minor" universally marked pattern in the language serves as a template (a.k.a. **word recipe** Menn 1978) for the child, perhaps as a result of prelinguistic perceptual or motor experience, or through the vehicle of a particularly salient early word. This type of markedness seems to be most common cross-linguistically with respect to CORR(ONSET), as illustrated by Carole (Table 12) and Charles (Table 13). Both children often omit onsets but rarely add them. For Charles, addition of an onset occurs in only two cases and both added onsets are glottal. Thus, his pattern is predominantly marked and unfaithful (to individual inputs). In fact, he produces all disyllabic words as onsetless unless consonant harmony occurs within the target word (e.g., *maman* 'mama', *papa* 'papa', *ouahouah* 'woof woof'), in which case he reproduces that harmony. He appears to have an idiosyncratic markedness constraint that favors onsetless syllables.

Table 12: Carole: Onset

Target	Gloss	Actual
Omit onset:		
canard	'duck'	[akaka]
balle	'ball'	[aba]
poire	'pear'	[apa]
tortue	'turtle'	[aty], [tɪ]
fromage	'cheese'	[m̩mæʰ]
Add onset:		
encore	'again'	[kɔːkɔ], [hækɔ]

Omission of onsets is not unusual in children learning languages with iambic stress, such as French and Spanish. It has been hypothesized that the initial syllable (and therefore the initial consonant) is de-emphasized due to its lack of stress, and that the initial consonant may therefore be poorly represented (Vihman, Nakai, & DePaolis 2000). In this study, violations of ONSET were also identified for some of the English subjects, such as Emily (see Table 6). Some Welsh subjects, such as Nona, developed idiosyncratic markedness constraints based upon this pattern. This child violated ONSET 48% of the time, only sometimes (41%) in order to satisfy CORR(ONSET). She violated CORR(ONSET) 42% of the time, only sometimes (46%) in order to satisfy ONSET. As shown in Table 14, the onsets she adds are typically (but not always) glottals ([h] and [ʔ]; she also interchanges these two glottals in glottal-initial target words). However, she glottalizes or omits stops, glides, and fricatives as well. Generally, she appears to have overgeneralized her language's allowance of onsetless and glottal-initial syllables. In OT terms, she has an idiosyncratic markedness constraint that favors very weak or absent onsets.

Table 13: Charles: Onset

Target	Gloss	Actual
Omit onset		
(á) boire	drink	ɔvwɑ
chaussures	shoes	ɛdʒo
chapeau	hat	apo
poupée	doll	apæ
lapin	rabbit	apɑ
oiseau	bird	apo
va pas	not work	ɑpa
garçon	boy	aʒa
les yeux	eyes	ɑzo
Add onset		
auto	car	hɔto
attend	wait	ʔaţçə

Table 14: Nona: Onset

Target (in IPA)	Gloss	Actual
Omit onset		
dijɒd	drink	ijɒd, ʔɪjɑn, nijɑn
pippəʊ	peek(a)boo	ʔɪbʌ
wɑʊwɑu	woof-woof	ʔʌwu'n, ʔuː, wəʊ
sisɔ	see-saw	ʔisɔʔ, ʔisəʊ
Add onset		
ijɛ^{h}	yes	ʔijɛ^{h}, hijɛ^{h}
ɛtɒ^{h}	again	ʔɛtt^{h}o
ɨndɑɪ	1, 2	ʔɪhɪdaɪ, hiːdaɪθ
ʔʊkʊ	Wcw (name)	dəˈxuf

4. CONCLUSION/DISCUSSION

In summary, we have proposed that three types of markedness are operative during the early phonological period:

1. Universal markedness constraints, learned via prelinguistic motor experience (Boersma, 1998).
2. Language-specific markedness: markedness that reflects faithfulness to general patterns of the language in terms of frequency of occurrence, in the absence of faithfulness in the usual sense of matching of specific patterns to specific target words

(i.e., matching input to output and vice versa). This is consistent with Beckman & Edwards' (2000) suggestion, drawing upon ideas initially proposed by Ferguson & Farwell in 1975 and subsequently confirmed in several research studies, that in adult phonologies:

> Correspondences ... can ... be viewed as emergent properties of the relative frequencies of different patterns in the actual word shapes that the language user encounters and stores in memory. (p. 241)

Patterns that are marked within a language will occur less often in the input, and those that are not will occur more often. Such trends are reflected in the child's output. However, some of the child's productions satisfy neither faithfulness to the specific adult form, nor universal markedness. Furthermore, the child's marked forms may appear in contexts which differ from the appropriate contexts in the adult language. Thus, language-specific markedness may reflect faithfulness to the statistical tendencies of the language, but not to the individual word.

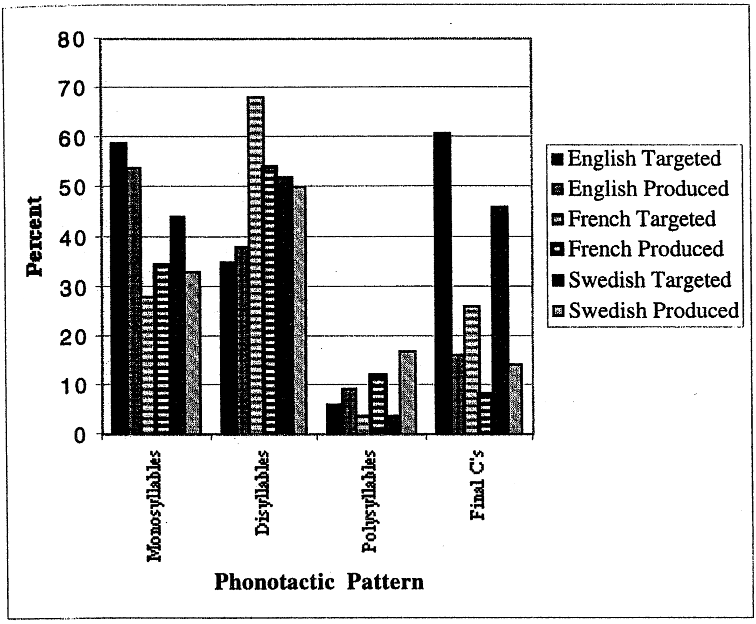
This language-specific markedness also differs from Hayes' (in press) proposed ordinary (phonotactic) faithfulness, in that the latter is initially receptive only. Hayes (in press) suggests that this type of faithfulness is present from about eight months as the principle: "if you haven't heard it, or something like it, then it's not possible" (p. 18). He also proposes that, even before eight months of age, children acquire **distributional protocategories** by paying attention to asymmetries in the data. However, he does not suggest that similar distributions will appear in the child's actual productions. Unlike Pater (in press), Hayes does not predict that production faithfulness will recapitulate receptive faithfulness.

Of course, it is not news that children gradually accommodate, in production as well as perception, to their language's statistical tendencies. This result has been shown several times in other studies, such as Vihman et al. (1994), whose results are summarized in Figure 2. Vihman et al. (1994) found that, by the 25-word point, children in each of three languages (English, French, and Swedish) tend to both target and produce words that match the phonotactic patterns in their input languages.

This finding was further validated recently for the acquisition of medial consonant length in a language with phonological geminates (Finnish) in contrast with two languages which lack them (English and French; Vihman & Velleman, 2000a, b). Medial consonant geminates in adult Finnish may be up to three times longer than medial consonant singletons. Correspondingly, Vihman and Velleman reported that by the 25-word point Finnish children's medial consonants are longer than those of children learning either English or French. Kunnari, Nakai, & Vihman (2001) reported similar results for Japanese.

Similar cases - in which children produce prosodic patterns from their ambient language but have not yet matched them to the appropriate adult words - have also been reported for use of the vowel space in ten-month-olds' production (Arabic, Chinese, English, and French; de Boysson-Bardies et al. 1989), and at the 25-word point for both relative syllable durations in Japanese (Hallé, Boysson-Bardies, & Vihman 1991) and fundamental frequency contours in Swedish (Engstrand, Williams & Stromqvist 1991).

Figure 2: Accomodation to statistical tendencies of ambient language (Based upon data presented in Vihman et al. 1994.



However, these studies did not focus on faithfulness in the OT sense: That is, outputs were not directly compared to their inputs to determine whether the child's patterns reflected the ambient language at the word level (input-output match) or only at a more general statistical level.

The distinction between accommodating to the statistical tendencies of the language by being more faithful to individual words and accommodating by producing words that generally parallel the patterns in the language, without necessarily being accurate at the word level, is a critical one. A child may implicitly "know" - or have passively registered - the phonotactic or prosodic patterns in a language (distribution of vowel onsets, clusters, codas, pitch contours, etc.) without having represented the relevant pattern for specific words. That is, the child may learn language-specific markedness constraints through exposure to the ambient language as well as learning more universal markedness constraints through prelinguistic motoric experience and inductive grounding, but this learning does not compel word-specific learning (faithfulness). The word-specific type of accommodation was reported by Vihman & Velleman (2000a, b) for a Finnish child, Eliisa. Although Eliisa sometimes produces target geminates with short singleton-length consonants, her longer medial consonant durations all correspond to words with target medial geminates, indicating that she has made a good start towards storing gemination lexically. Another Finnish child, Atte, on the other hand, exhibits language-specific markedness in the absence of faithfulness: as described by Vihman and Velleman, his longer medial consonant durations do not correspond consistently to target geminates, although he does produce some longer-duration and some shorter-duration medial consonants, in overall agreement with adult Finnish.

3. Idiosyncratic markedness, usually based upon some pattern (often a minor pattern) made available by the language and, it has been hypothesized, typically based upon the individual child's **favorite babbles** (Vihman, Velleman & McCune, 1994; Velleman & Vihman, 2002). Specifically, idiosyncratic child babble patterns may predispose the child to attend to and produce words of similar form ('selection') and, eventually, to subject words that are not of similar target forms to the same idiosyncratic markedness constraints ('adaptation'), sometimes thereby violating faithfulness to the target and also universal markedness at the same time, yielding the emergence of the marked unfaithful.

Vihman & Velleman (2000a, b) reported additional cases in children learning Finnish. Their subject Atte, for example, both selects words for production that are onsetless in the target, and produces words with target onsets without those initial consonants, as illustrated in Tables 15 and 16. Vihman & Velleman suggest that this may be due to the perceptual salience of medial geminates in Finnish, which draws the child's attention away from word- initial consonants even though the first syllable is stressed.

Table 15: Atte: VCV template 'Selected' forms

Target	Gloss
apina	'monkey'
auto	'car'
äiti	'mother'
isi	'father'
ääni	'sound'
ajaa	'drives'
Antti	(name)
ankka	'duck'
ukko	'old man'

Table 16: Atte: VCV template 'Adapted' forms

Target	Gloss	Actual
kala	'fish'	ala
pallo	'ball'	allo
sammui	'extinguished'	ammu
loppu	'all done'	oppu
heppa	'horse'	eppa
kello	'clock'	ello
nalle	'teddybear'	alle

Another example of this idiosyncratic type of markedness is illustrated by Leonard & McGregor's (1991) subject W. This child produces fricatives in word-final position regardless of their position in the target word, as illustrated in Table 17. Fricative-final words are certainly frequent in English (i.e., a minor pattern), but W has gone well beyond statistical faithfulness in her productions. Several further examples of idiosyncratic feature-by-position constraints are given in Velleman (1996).

Table 17: 'W': Fricative-final template

Target	Actual
fall	[ɑf]
fine	[ɑɪnf]
school	[kus]
soup	[ups]
zoo	[uz]
sheep	[ips]
shoe	[us]

(Adapted from Leonard & McGregor, 1991)

Both language-specific markedness constraints and idiosyncratic markedness constraints provide strong evidence that at least some phonological constraints are neither innate nor universal, but learned. In the cases described here, both run directly counter to universal markedness constraints. In addition, both reflect the child's prelinguistic and early linguistic perceptual and motor experiences. Finally, the occurrence of idiosyncratic markedness constraints argues strongly for the active nature of the phonological development process.

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APPENDIX: Definitions of Constraints Used in this Study

PEAK: Every syllable must have a vowel as its peak (nucleus).
Sample violation: A syllable with a syllabic consonant as its peak, such as the second syllable of the word *button*: [bʌʔn̩].

CORR(PEAK): If the target syllable contains a vowel peak, the produced syllable must also. If the target syllable does not contain a vowel peak, the produced syllable must not.
Sample violation: A syllable with a syllabic consonant as its peak reproduced with a vowel as its peak (e.g., *bottle* produced as [bɑtʌl] rather than [bɑɾl̩]), or a syllable with a target vowel peak produced with a syllabic consonant peak (e.g., *umbrella* produced as [m̩bwɛlə]).

ONSET: Every syllable must have an onset consonant.
This constraint was considered in two versions due to the difficulty of reliably transcribing glottals (Vihman et al., 1985) as well as to disagreement within the field about whether or not glottal stop should be considered an onset and whether or not phonemically vowel-initial words are in fact consistently pronounced with a glottal onset in American English (Dilley, Shattuck-Hufnagel, & Ostendorf 1996). Thus, the two versions of this constraint included one in which [ʔ] was included as a possible consonantal onset ('ONSET w/ ʔ'), and one in which it was not ('ONSET w/o ʔ'). When not specified, the expressions 'ONSET' and 'CORR(ONSET)' should be taken to refer to 'ONSET w/o ʔ'.
Sample violation: A syllable that begins with a vowel, such as the first syllable of the word *apple*. The form [ʔæpl̩] for *apple* would be considered a violation of 'ONSET w/o ʔ' because glottal stop would not be counted as an onset under this version of the constraint, but not as a violation of 'ONSET w/ ʔ'.

CORR(ONSET): If the target syllable begins with a consonant, the produced syllable must also. If the target syllable does not begin with a consonant, the produced syllable must not.
Sample violation: [bæpu] for *apple*; [eɪp] for *grape*. [ʔeɪp] for *grape* would be considered a violation of CORR (ONSET w/o ʔ), but not of CORR (ONSET w/ ʔ). Similarly, [ʔæpu] for *apple* is a violation of CORR (ONSET w/ ʔ) but not of CORR(ONSET w/o ʔ).

Syllables were parsed as having onsets whenever possible. That is, a production such as [æpəl] was syllabified as [æ.pəl]. The analyses were thus biased in this sense towards satisfying the markedness constraint: the assumption in ambiguous cases was that ONSET was not violated.

NOCODA: Syllables must not end with consonants.
Sample violation: A syllable that ends with a consonant, such as the word *cat*.

CORR(CODA): If the target syllable ends with a consonant, the produced syllable must also. If the target syllable does not end with a consonant, the produced syllable must not.
Sample violation: *cat* produced as [kæ] or *bye* as [bɑɪp].

FOOTBINARITY, a.k.a. FTBIN: A foot is composed of two units: either two syllables or two moras (units of syllable weight). Separated into its two possible instantiations:

SyllabicBinarity, a.k.a. SYLBIN: Feet must be made up of two syllables; words must include an even number of syllables (i.e., a four-syllable word could still be made up of binary feet; a five-syllable word could not).

Sample violation: A foot that is not made up of two syllables, such as the feet in the words *dog* (only one syllable in the foot), or *tricycle* (three syllables in the foot or one syllable (the last) that is 'unfooted' -- i.e., not in any foot).

CORR(SYLBIN): If the target word includes an even number of syllables (and, therefore, binary feet), the produced word must also. If the target word does not include an even number of syllables, the produced word must not.

Sample violation: *dog* produced as [dɔdɔ] or *open* produced as [pɛn].

MORAICBINARITY (MORBIN): A syllable must include two moras. These two moras may consist of a vowel plus a consonant (including ʔ), a sequence of vowels, or one prolonged vowel (as indicated in transcription).

Sample violation: A syllable with only one monophthongal vowel, such as [nɪ] or [bʊ].

CORR(MORBIN): If the target syllable includes two moras, the production must also. If the target syllable does not contain two moras, the production must not.

Sample violation: *hi* produced as [hɑ] (diphthong reduced to monophthong), or *apple* produced as [ɑɪpl̩] (monophthong increased to diphthong).

***COMPLEX (C)**: No sequences of consonants. (Note that '*' indicates a disallowed occurrence and '$' indicates a syllable boundary.)

Two versions of this constraint were considered:

***CC**: No sequences of consonants within the same syllable (i.e., no syllable-initial or syllable-final clusters).

Sample violation: Syllable-initial or -final clusters, as in *block* and *beads*, respectively.

***C$C**: No sequence of consonants across a syllable boundary.

Sample violation: Any word-medial cluster, such as those in the words *pantry*, *sister*, and *whisper*. (Recall that word-medial clusters were always divided among the two syllables, to maximize ONSET, yielding e.g., 'sis$ter', rather than 'si$ster'.

CORR(COMPLEX(C)): The output must match the overt form with respect to consonant sequences. Specifically:

CORR(CC): If the target syllable includes a cluster, the production must also. If the target does not include a cluster, the production must not.

Sample violation: [bɛd] for *bread*; [brɛd] for *bed.*

CORR(C$C): **Among the multisyllabic words produced (not only attempted) by the child,** if the target word includes a word-medial cluster, the production must also. If the target does not include a medial cluster, the production must not.

Sample violation: [wɪpɚ] for *whisper*; [kɛkli] for *kitty*. CORR(C$C) is irrelevant to child monosyllabic productions with multisyllabic targets, as there is no possibility of a match in these cases, and the violation is attributed to SYLBIN.

All sequences of consonant features were treated as clusters with respect to markedness, on the grounds that affricates as well as clusters represent phonetically complex consonants and that it would be preferable to treat all phonetically complex consonants from all languages in the same manner. Such sequences were broken up in keeping with

ONSET. For example, *badger* was syllabified as [bæd.ʒɚ]. This decision had implications primarily for markedness; the parsing [bæd.ʒɚ] violates NoCoda and *C$C, while the parsing [bæ.dʒɚ] violates *CC.

Complex (V), a.k.a. *VV: No sequences of vowels.

Sample violation: A syllable or word containing a sequence of vowels without hiatus, as in English words containing diphthongs ([aʊ] as in *cow*.)

Corr(Complex (V)), a.k.a. Corr(VV): If the target syllable contains a sequence of uninterrupted vowels, the production must also. If the target syllable does not contain a sequence of uninterrupted vowels, the production must not.

Sample violation: [ka] for *cow* or [fraɪd] for *Fred.*

CodaCondition (Geminate), a.k.a. Gem: Related to *C$C. If two consonants occur in an intersyllabic sequence within a word (i.e., C$C), the coda (the first C) must be the geminate of the following onset (the second C). In other words, the two consonants must be identical. Note that this is not the same as the OCP (Obligatory Contour Principle; McCarthy 1988); the OCP does not allow a geminate to be represented as one root node branching to two consonant slots. The assumption here is of a sequence of two identical consonants. Note that this constraint is very low-ranked in English, but is higher-ranked in languages such as Japanese.

Sample violation: A word with two (or more) different medial consonants, as in *Oscar, umbrella,* or *Bambi.*

Corr(Gem): If the target word includes a sequence of geminate consonants, **and the production also includes a sequence of consonants in the same position**, then the two consonants in the production must be identical also. If the target word includes a sequence of consonants that differ by at least one feature, and the production also includes a sequence of consonants in the same position, then the two consonants in the production must also differ by at least one feature.

Sample violation: Japanese [nenne] 'sleeping' produced as [nente]. Not violated e.g., if Japanese [pitʃa] 'splash' is produced as [tæptʰæ], because the two medial consonants are different in both target and output. Not relevant if, for example, [nenne] is produced as [nene], because the output does not include a sequence of medial consonants.

Shelley L. Velleman
Dept. of Communications Disorders
University of Massachusetts Amherst
Amherst, MA 01003-0410, USA

velleman@comdis.umass.edu

Marilyn M. Vihman
Department of Psychology
University of Wales, Bangor
Gwynedd LL57 2AS, UK

m.vihman@bangor.ac.uk