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Children's Unnatural Phonology

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Most approaches to generative phonology grant a privileged status to "natural" phonological rules, those that have a clear phonetic motivation. In Optimality Theory, for example, children are typically assumed to begin language learning with markedness constraints ranked above faithfulness constraints (see Smolensky 1996). The implication — often not made explicit — is that phonetically arbitrary processes require some other apparatus in the grammar, perhaps the creation of a language-specific constraint, and consequently should pose a more difficult learning task for the child.

I argue that this prediction is incorrect, based on the diversity of child phonology. The common occurrence of natural patterns can be explained without reference to grammatical constraints, while the unnatural patterns that deviate from the adult model require abandonment of such constraints (cf. Hale and Reiss 1998, 2000, Blevins 2003 for similar arguments).

1. Naturalness

The existence of a great many alternative explanations for children's errors makes it difficult to draw firm conclusions about the role of naturalness in the relative ease of acquisition of various contrasts. For example, if we observe that certain sounds or distinctions are relatively more difficult to perceive, there is no need to represent these sounds as "difficult" in the cognitive model of phonological knowledge: that difficulty asserts itself in the child's auditory-perceptual system, before there is even an opportunity to extract the correct patterns from the data perceived.

Consider the very common deletion of a coda consonant (cf. Branigan 1976, Fikkert 1994, Demuth 1995); these words from Vihman (1996) illustrate CV outputs in children learning English.

(1) a. [dɔ] 'dog'
b. [ʔæ] 'apple'
c. [du] 'juice'

The problem with arguments from such examples, however, is that the explanation could easily lie outside the mental grammar (see Hale and Reiss 1998). Here are some possible alternative explanations.

(2) a. Less robust cues for perceiving a coda consonant in the absence of a release (cf. Steriade 1999).

b. Difficulty of a voicing gesture in final position articulating a syllable-closing gesture relative to a released consonant (for voicing, see Westbury and Keating 1986).
c. Difficulty coordinating or processing two consonantal gestures in one syllable or word, leading to the sacrifice of the less salient one (cf. Vihman 1978, Berg 1992).
d. A quantal effect between the maximally distinct categories of vowel and consonant (Beckman and Edwards 2000), leading to an "oscillation frame" of C's and V's (McNeilage and Davis 1990, 1999).

To the extent that strong tendencies in early child language, such as a preference for open syllables, can be attributed to non-grammatical factors, no grammatical conclusion can be drawn. An additional problem for markedness is that highly marked processes are also found in child speech.

2. Onset / Coda (A)symmetries

Despite the strength of the tendency toward CV syllables, "[t]here is no reason to believe that all children initially require all syllables to have onsets" (Bernhardt and Stemberger 1998: 371). In fact, there are many situations in which onsetless syllables occur in child language, including of course languages with onsetless adult forms. For Inês (0;11–1;5) learning Portuguese (Freitas 1996), even target onsets are often omitted or a vowel without an onset is inserted; matching results are reported for two other children.

(3)

	Child	Adult		
a.	[ˈpo]	[ˈpõj̃]	*põe*	'put'
b.	[ɑˈti]	[ɑˈki]	*aqui*	'here'
c.	[ˈa:]	[ˈagwɑ]	*água*	'water'
d.	[ɑˈpɑ]	[ˈpãw̃]	*pão*	'bread'
e.	[eˈɑ]	[ʒuˈãw̃]	*João*	(name)

Similarly, Amahl learning English (Smith 1973) often deleted [h] and sibilants during his third year, leading to onsetless syllables, many with codas.

(4)

a.	[ɛn]	'hand'	[ʌn]	'sun'
b.	[ɛt]	'head'	[a:p]	'sharp'
c.	[ʌ:t]	'hurt'	[up]	'soup, soap'
d.	[ɛŋu]	'handle'	[ʊgə]	'sugar'

In this case a competing constraint against the offending segments is responsible. (There might also be glottal stop onsets, untranscribed.) But other examples show a more positive attention to codas.

Fey and Gandour (1980) present an instance of a more complex output innovated by the child. Observed from 1;9–2;2, Lasan produced nearly all word-final voiced stop targets with a following syllabic nasal. (A small number of such targets were deleted or modified to other consonants.)

(5)

a.	[dabm̩]	'stub'
b.	[dædn̩]	'dad'
c.	[bəgŋ̩]	'bug'

The authors (p. 77) observe that, in general for Lasan, "word-final position had special status for marking perceived phonological distinctions" — for example, final voiceless stops were consistently realized as aspirated or released stops with the correct place of articulation. The nasal release of the voiced stop was the only means available to Lasan at the time to preserve the voicing contrast: he had apparently not yet mastered the articulatory maneuver of voicing a word-final stop. Of course, the frequency of adult languages that neutralize this distinction attests to the relative difficulty of maintaining the contrast in final position. Fey and Gandour also note that, while the functional and phonetic motivation of the rule is clear, the rarity of analogous processes in adult languages casts doubt on the reasonableness of treating this as a "natural" process (in the sense of Stampe 1979) or "unmarked" more generally (as in Optimality Theory: Prince and Smolensky 1993).

Similarly, Menn (1971) shows that Daniel (from 22.5 to 24 months) deleted fricatives in the onset but permitted them in the coda.

(6)					
	a.	[it]	'seat'	[dos]	'toast'
	b.	[iz, is]	'cheese'	[æʃ]	'watch'
	c.	[ɨʃ]	'fish'	[ejndʒ]	'change'
	d.	[uz]	'shoes'	[ufs]	'juice'

More generally, at this stage Daniel had a much larger inventory of sounds in the coda than in the onset. (Bernhardt and Stemberger 1998: 436 identify two similar cases of asymmetry.)

(7)			
	a.	onset inventory	[b, d, g, k, m, n]
	b.	coda inventory	[b, d, g, p, t, k, r, s, ʃ, z, f, v, dʒ, m, n, ŋ]

Further, for a syllable ending in a stop, the onset contrasts are even more severely restricted.

(8)	Adult onset	Daniel's onset	Examples
a.	[n], [sn]	[n]	[næk] 'napkin' [næt] 'snap'
b.	[m], stop, affricate	homorganic stop	[dit] 'meat' [gʊk] 'book'
c.	fricative, approximant	zero	[iv] 'Steve' [ajd] 'ride'

This situation violates the adult-language observation that onsets permit more contrasts than codas (though there are exceptions even in adult phonologies: Blevins 2003). As noted by Branigan (1976) and Menn (1978), some children simply seem to concentrate more on the beginnings or ends of words. Such variation supports a more cognitive approach to phonological development, in which the child is a creative problem solver (cf. Macken and Ferguson 1983, Menyuk, Menn, and Silber 1986), over a more deterministic universal grammar.

Inkelas and Rose (to appear) present a persuasive argument for the effect of a child's physiological limitations on the creation of unexpected phonological rules.

Specifically, "velar fronting" replaces alveolars with velars in the onsets of stressed syllables, exactly where we expect the greatest faithfulness, while coda and unstressed velars are produced accurately.

(9)	a.	[t^hʌp]	'cup'
	b.	[do:]	'go'
	c.	[t^hʊk]	'cook'
	d.	[ˈtokoˌnʌt]	'coconut'

Their explanation for this pattern, which is unattested in adult languages and thus quite unnatural, is that the child recognizes the greater amplitude of consonant gestures in the onset of an adult stressed syllable; but the relatively large tongue size in a child below two years of age makes a large-amplitude dorsal articulation difficult. The end result of the child's attention to this phonotactic distribution is a change to an alveolar articulation in exactly the circumstance where the greater gesture is needed. The rule will normally disappear as the child's mouth achieves more adult-like proportions; but the fact that it occurs at all shows that the phonology has to accommodate such "unnatural" processes.

Berg (1992) discusses labial harmony by Melanie (2;7–2;11), learning German. The general direction of this harmony is from right to left, which includes onset features sacrified to those of a coda.

(10)	a.	[po:mas]	[to:mas] *Thomas*	(name)
	b.	[bi:bən]	[ʃi:bən] *schieben*	'to push'
	c.	[me:mən]	[ne:mən] *nehmen*	'to take'
	d.	[bɛlp]	[gɛlp] *Gelb*	'yellow'
	e.	[pɔmt]	[kɔmt] *kommt*	'comes'
	f.	[bo:m]	[do:m] *Dom*	'cathedral'

The direction of assimilation indicates that "the most difficult position for her is the word onset" (p. 241); again, this is a case of onset constrasts being reduced relative to coda (as well as intervocalic) contrasts. Consonant harmony is a classic example of child phonology differing from adult patterns, but the directionality (which is the same for most other children; cf. Vihman 1978) also contradicts the usual primacy of onsets and their contrasts. Even if the salience of intervocalic vs. word-initial contrasts is the original basis for the directionality, what's noteworthy is that the resulting phonological rule is generalized to apply from coda to onset as well, in defiance of expectations based on naturalness.

Stemberger (1996) and Bernhardt and Stemberger (1998: 383) report that Morgan optionally inserted glottal stop after a word-final vowel until 1;4, thereby creating codas.

(11)	a.	[mama] ~ [mamaʔ]	'mama'
	b.	[lɪlɪ] ~ [lɪlɪʔ]	'lizard'
	c.	[mi:] ~ [miʔ]	'me'

That she was particularly interested in word-endings is confirmed by the fact that "from the first word on, Morgan never deleted word-final codas."

The requirement for a final coda finds a parallel in certain languages, such as glottal-final words in Makassarese (Aronoff et al. 1987, McCarthy and Prince 1993) and C-final stems in Arabic (McCarthy and Prince 1990), but such patterns

are hardly "natural" in the usual sense. In Makassarese, a preference for a final consonant, specifically [ʔ], is normally inhibited by faithfulness to the input, but arises in conjunction with other processes: the insertion of a final epenthetic vowel and partial reduplication. The result is strikingly similar to Morgan's rule.

(12)	a.	/rantas/	rántasaʔ	'dirty'
	b.	/jamal/	jámalaʔ	'naughty'
	c.	/manara/	manaʔ - manára	'sort of tower'
	d.	/balao/	balaʔ - baláo	'toy rat'

Note also the insertion of glottal stop after an utterance-final short vowel in Japanese (Vance 1987: 12). What these processes show — entirely consistent with the claims of this paper — is that the set of phonological tools available to adult languages is also available to children, and can be used to construct both natural and unnatural distributions of sounds.

Stern and Stern (1907) describe productions of their German-learning son Günther (beginning 2;1–2;2 and lasting about 6 months) with a strong tendency to replace word-initial consonants with [h] or zero. Many of the replaced single-consonant onsets — including [p, t, k, b, g, f, v, z, r, l, m] — are successfully produced in other words, but the majority of lexical items show deletion or replacement.

(13)	a.	[ˈhas] *haß*	[ˈnas] *naß*	'wet'
	b.	[ˈhɛlt] *held*	[ˈgɛlt] *Geld*	'money'
	c.	[ˈhu:] *hū*	[ˈʃu:] *Schuh*	'shoe'
	d.	[ˈhʊmpf] *humpf*	[ˈʃtrʊmpf] *Strumpf*	'stocking'
	e.	[əˈhɔfən] *ehoffen*	[gəˈtrɔfən] *getroffen*	'met, struck'
	f.	[ɛˈhanda] *ähanda*	[vɛˈranda] *Veranda*	'veranda'
	g.	[aˈe:t] *aët*	[paˈke:t] *Packet [Paket]*	'packet'
	h.	[iˈi:çən] *i-ichen*	[maˈri:çən] *Mariechen*	'Marie (dim.)'
	i.	[uˈɛla] *uëlla*	[kuˈrɛla] *Kurella*	(name)
	j.	[ˈu:l] *ūl*	[ˈʃtu:l] *Stuhl*	'chair'
	k.	[ˈɛks] *ex*	[ˈdaks] *Dachs*	'badger'

The authors give only orthographic representations, shown here in italics; the phonetic transcriptions are my best estimate of the actual spoken form, though some details are uncertain. Some words are transcribed with initial <ch>, which the authors (p. 95) intend as the velar fricative [x].

(14)	a.	[ˈha:tɐ, ˈxa:tɐ] *hātă*, *chātă*	[ˈfa:tɐ] *Vater*	'father'
	b.	[ˈho:s, ˈxo:s] *hōß*, *chōß*	[ˈgro:s] *groß*	'big'
	c.	[ˈxe:ɐ] *chēr*	[ˈme:ɐ] *mehr*	'more'
	d.	[ˈxʏntɐ] *chünther*	[ˈgʏntɐ] *Günther*	(name)
	e.	[ˈaʊ̯xuɐç] *auchurch*	[ˈmaʊl̩vuɐf] *Maulwurf*	'mole'

Truncations of longer words with non-initial stress sometimes retain an onset (cf. 14a-b) but often have a simplified onset despite an available consonant.

(15)	a.	[ˈpʊt] *put*	[kaˈpʊt] *kaput [kaputt]*	'broken'
	b.	[ˈla:də] *lade*	[ʃokoˈla:də] *Schokolade*	'chocolate'
	c.	[ˈhant] *hant*	[eleˈfant] *Elefant*	'elephant'

d.	[ˈa:t] *āt*	[zaˈla:t] *Salat*	‘salad’
e.	[ˈo:tə] *ōte*	[koˈmo:də] *Kommode*	‘dresser’
f.	[ˈy:tlɪç] *ütlich*	[gəˈmy:tlɪç] *gemütlich*	‘cozy’

Words that already conform to the pattern tend to be reproduced accurately.

(16)	a.	[ˈhu:t] *hut*	[ˈhu:t] *Hut*	‘hat’
	b.	[ˈhals] *hals*	[ˈhals] *Hals*	‘neck, throat’
	c.	[ˈɔks] *ochs*	[ˈɔks] *Ochs(e)*	‘ox’
	d.	[ˈi:gəl] *igel*	[ˈi:gəl] *Igel*	‘hedgehog’

It may be that the apparently vowel-initial words begin with a glottal stop (as found in adult pronuncation); the “preferred” onsets would then be the related group [ʔ, h, x]. In a few cases, one of these onsets is substituted for another.

(17)	a.	[ˈxaɪs] *cheiß*	[ˈhaɪs] *heiß*	‘hot’
	b.	[ˈha:lɐ] *hāler*	[ˈa:dlɐ] *Adler*	‘eagle’

What remains certain is that the consonant constrasts are reduced in the onset rather than in the coda, very much contrary to the norm. Günther seems to prefer complete non-identity rather than partial identity, which is interesting in itself. But what matters most in the present context is that this restriction applies to onsets, not to codas, which he usually produces faithfully, even when they contain clusters.

The possibility of a bias against onsets in some child languages indicates that the human phonological capacity does not rule out such grammars, even if (for extragrammatical reasons) they do not arise frequently. By the same token, we expect adult languages to show a similar bias, if only rarely. And indeed, there have been claims that some languages, such as Barra Gaelic (Clements 1986) and Oykangand (Sommer 1970), prefer VC syllables sometimes or always. These are the basic syllable types of Oykangand, following Sommer.

(18)	a.	VC	/ef/	‘tongue’
	b.	VCC	/er̃k/	‘ground, place’
	c.	VCCC	/algŋ/	‘tooth’
	d.	VCCCC	/albmb/	‘opossum’

While the various pressures favoring CV syllables ensure that such coda-favoring systems are unlikely to arise in language change, under the right circumstances this computationally possible, albeit typologically rare pattern will emerge (Blevins 2003). The Oykangand pattern arose due to loss of initial consonants (itself rather similar to Günther’s rule). The interest of child language is that the creation of a new grammar based on impoverished data liberates the computational capacity of the grammar from the typological filtering of slow change over time, affording a unique look at the underused corners of the phonological toolkit.

3. Innovative Unnaturalness

It has been argued that the unnaturalness of an adult alternation does not impede the learning of a process by children; what matters is whether the adult rule is regular and well attested in the data (see Buckley 2002 and references therein). Unnatural patterns that are innovated by children (rather than being faithful

imitations of unnatural adult patterns) contribute to the same conclusion. Beckman and Edwards (2000: 242) state that

> even after the child has mastered the articulation of a specific phoneme in one set of words, generalization of the motor pattern to other forms containing the phoneme depends on the frequency with which the phone has been encountered in the immediate phonetic context exemplified by the novel form.

What this means is that the child's (apparent) mastery of particular articulations does not give us a clear view of innate language ability, but rather is significantly affected by the vocabulary of a language, and is therefore very much affected by centuries of accreted changes and historical coincidences.

Priestly (1977) describes the classic example of a [CVjVC] template for Christopher (1;10–2;1); this is certainly not natural or typical for children, but it resembles some adult templates and clearly is within the scope of the phonological capacity. The choice of which consonant occupies the final slot is apparently driven by its saliency or familiarity (p. 60).

(19)	a.	[fajan]	'flannel'	[sɛjan]	'whale'
	b.	[hajaŋ]	'hanger'	[pijat]	'peanut'
	c.	[bajak]	'blanket'	[dajak, dajan]	'dragon'

A full 25% of "ordinary" disyllabic forms reported by Priestly (in a sample from week 4 of the study) contain a medial [j], and these frequent inputs likely served as the model for the template.

(20)	a.	[lájən]	'lion'
	b.	[wɛ́jəl]	'whale'
	c.	[fájə]	'fire'

Whatever the inspiration, Christopher's forms resemble results from left-to-right and edge-in association in adult templatic morphologies (cf. Yip 1988). The presence of a fixed element in a template also attested, as with certain verbs of Classical Arabic (Wehr 1971). An example is the /w/ in Form XII of the verb.

(21)	a.	ħadib-	'be convex'	iħdaw̲dab-	'be crooked, vaulted'
	b.	ɣariq-	'plunge, be immersed'	iɣraw̲raq-	'be bathed (in tears)'

Adult grammars such as Arabic show the computational possibility of such templatic patterns, which are available to be exploited by children given the right skewing of the input, or even some predisposition on the part of a child.

Stemberger (1992: 178) and Bernhardt and Stemberger (1998: 403) report that Gwendolyn went through a stage at 3;3 in which she created novel clusters. In earlier pronunciations, sonorants following a stop were deleted. Later, the sonorants /r, l, w/ were variably restored as [w], not only to words that have a cluster in the adult form but in fact to any stop-initial word.

(22)			Deletion	Overgeneralization
	a.	'tree'	[t^hi:]	[t^hi:] ~ [t^hwi:]
	b.	'top', 'stop'	[t^ha:p]	[t^ha:p] ~ [t^hwa:p]
	c.	'book'	[bət]	[bət] ~ [bwət]

These novel pronunciations have nothing to do with markedness, but rather a variable hypercorrection of forms with a stop in the onset. Adult sound change can, of course, lead to a more complex syllable structure; a simple case is vowel devoicing or deletion in the word *potato* when pronounced with initial [p^ht^h]. In the adult and child changes, we see that a particular change can proceed without regard to supposed markedness pressures that would oppose it.

A different sort of evidence of how phonological markedness is subordinated to other aspects of the input comes from Labov's (1989) work on the acquisition of sociolinguistic variables. He studied children aged 4–9, learning the English variable processes *-t,d* deletion and g-dropping in *-ing*. Among his findings was that the children "first show the social and stylistic constraints on variation, then the language-specific grammatical and articulatory constraints" (p. 96). One articulatory constraint is the effect of adjacent consonants as defined by relative sonority — quite a natural pattern, yet learned later than the arbitrary social factors governing the variation.

Finally, in a particularly interesting example, Bernhardt and Stemberger (1998: 639) report that Morgan misanalyzed the palatalization pattern found in English phrases such as *need you*, where the alveolar stop preceding a form of *you(r)* becomes palato-alveolar. The clear analysis of the adult alternation (*pace* Bernhardt and Stemberger) is an assimilation in place of articulation, with consequent affrication for palatal stops in English. This, of course, is an extremely common and "natural" process.

Morgan's output shows that (at an unspecified age, lasting for about 2 months) she saw it instead as an assimilation in obstruency: The initial /y/ of the pronominal becomes a palato-alveolar fricative that agrees with a preceding obstruent in voicing, but is unchanged after a sonorant.

(23)	a.	need [ʒ]ou	keep [ʃ]ou	spin [y]ou
	b.	hug [ʒ]ou	want [ʃ]ou	comb [y]ou
	c.	love [ʒ]ou	like [ʃ]ou	

Presumably this reinterpretation was affected by inflected forms in adult speech that lead to a similar outcome, though only in the presence of the sibilant suffix.

(24)	a.	[lʌvʒu]	'loves you'
	b.	[lʌvyu]	'love you'

What matters is that naturalness seems to have played no role in the new rule; instead, she seized upon a more general formulation of the process, affecting the major class feature [sonorant] rather than a specific detail of place of articulation.

Assimilation of [–sonorant] is quite poorly motivated in adult phonologies, so much so that it is typically rendered impossible by standard feature geometries (cf. Schein and Steriade 1986, McCarthy 1988, Clements and Hume 1995). Palatal assimilation, on the other hand, is one of the most common processes in the world's languages (Bhat 1978). Yet Morgan actually formed the wrong generalization, choosing a much less natural rule for the process she observed.

From the point of view of phonological theory, this is significant: Such a process does appear to be possible, even if rarely found in adult languages. This is all the more reason to focus on phonology as the characterization of possible sound inventories and processes, rather than common or "natural" processes

whose frequency results from their likelihood of arising by historical change (Hale and Reiss 1998, 2000, Blevins 2003).

4. Experimental Evidence

Various attempts have been made to determine experimentally what kinds of phonological generalizations are learned more easily than others. While the matter is a difficult one to test, particularly with regard to children first acquiring a language, there is support for the idea that unnatural processes are learned well. Here I discuss just two representative studies.

Jusczyk, Smolensky, and Allocco (2002) have claimed that infants are predisposed to prefer unmarked patterns, due to a universal grammar that encodes markedness. The natural rule under consideration was nasal place assimilation. Subjects of various ages were exposed to stimulus sets consisting of three items: two isolation forms followed by their concatenation, with or without a phonological change.

(25)	unmarked:	[on, pa, ompa]	(assimilation)
	marked:	[un, ber, unber]	(no assimilation)

The authors found longer listening for the assimilated (natural) triads than for the unnatural ones; they concluded that infants have a predisposition to prefer such unmarked relations. One problem is that this listing approach has not previously been used in infant studies, and it is far from clear that the sequences will be interpreted as rule inputs and outputs, or as related forms.

Setting aside this methodological objection, the vocabulary of English has many examples of assimilated sequences such as [mp], which far outnumber unassimilated [nb]; thus there could be an influence from the ambient language quite independent of any innate preference. The authors note, however, that is debatable whether infants as young as some of their subjects (4 months) are sensitive to native language patterns.

Even discounting the ambient language, there is another explanation independent of markedness: The greater representational simplicity of the assimilated form (i.e. a single intervocalic place of articulation) could also be at work. If we assume that these infants have adult-like sound representations at all, then we should assume that some may be simpler than others, which they might prefer as "better" (if not "more natural"). An innate preference for natural rules is not necessary as an explanation, even if we accept other aspects of the experimental design.

Chambers, Onishi, and Fisher (2003) tests whether 16.5-month-old infants could learn arbitrary generalizations about phonotactics. Two sets of consonants with no common features were arranged in CVC syllables.

(26)	group 1	[b, k, m, t, f]
	group 2	[p, g, n, tʃ, s]

The choice of vowel [ɪ, æ] correlated with the order of consonants, differently in two lists. Infants were familiarized with one of the two, then exposed to randomized stimuli representing both patterns.

(27)	list 1	[bɪp, kɪg, pæb, gæk] etc.
	list 2	[bæp, kæg, pɪb, gɪk] etc.

The expectation is that they will listen longer to unfamiliar stimuli (Saffran et al. 1996, Marcus et al. 1999); relative familiarity depends on having learned the pattern in the familiarization set. The results show that the infants had internalized the arbitrary phonotactics, and listened longer to the novel forms despite the fact that there was no natural phonological basis for the patterns. Since infants can quickly absorb arbitrary phonotactic patterns after rather brief exposure; it should come as no surprise that a child learning a language could also learn an unnatural pattern in the data.

While we must await more data before drawing firm conclusions, these results suggest that infants can learn natural and unnatural patterns after brief exposure, supporting the other evidence presented here that naturalness is not a significant factor in the learning of phonological rules.

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