

# Rule naturalness and the acquisition of phonology

Eugene Buckley  
University of Pennsylvania

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Standard generative phonology: privileged status to “natural” phonological rules (those with a clear phonetic motivation). Making it easier for theories to express common processes (which tend strongly to belong to the natural category) is often considered a primary goal.

“Unnatural” phenomena are typically relegated to a “peripheral” or secondary status. The usual (tacit) assumption: they require some other apparatus in the grammar. If nothing else, the child ought to first attempt to apply basic principles of the phonology — biased toward naturalness — and only when this fails will she resort to secondary principles.

An implication of this sort of approach — implicit or explicit — is that a child learner equipped with the universal phonological faculty will more easily learn processes that are natural.

- (1) Morphophonological patterns that are in accord with natural phonological predispositions will enter early and will seldom lead to errors. (MacWhinney 1978: 18)
- (2) Phonological rules with a heavy natural component (e.g. voicing assimilation) appear to be acquired early. (Menn and Stoel-Gammon 1995: 349)

Theories of such predispositions include Natural Phonology (Stampe 1979) and Optimality Theory (Prince and Smolensky 1993).

Problem: If children are biased toward natural processes, processes ought to become more natural over time, or at least not become less natural. Language transmission is imperfect, and bias toward natural processes should err in favor of them. But phonological rules tend to become less natural over time (cf. Hyman 1975: 181f):

- (3) Although sound changes are sometimes blocked by considerations within a paradigm [...] no corresponding force has been discovered which would strive to keep rules natural. Instead, the above examples show the great tendency for rules to become unnatural [...] that is, to lose their phonetic plausibility and become morphologically conditioned.

Natural and unnatural rules in the same language can have similar status. Kashaya (Pomoan: N. California) has lowering to [a] after a uvular (natural); and /i/ becomes [u] after [d] (unnatural, and arose out of a morphological reanalysis: Buckley 2000).

- |     |    |             |   |            |                          |
|-----|----|-------------|---|------------|--------------------------|
| (4) | a. | ht-aq-i     | → | taqá       | ‘stretch your leg out!’  |
|     | b. | ʔusaq-in    | → | ʔusá:qan   | ‘while washing the face’ |
|     | c. | sima:q-eti  | → | sima:qatí  | ‘although he’s asleep’   |
|     | d. | miku:ʔ-q-e: | → | mikuʔqá:   | ‘must have hummed’       |
| (5) | a. | cad-i       | → | cadú       | ‘look!’                  |
|     | b. | mahsad-in   | → | mahsadún   | ‘while taking away’      |
|     | c. | ciç-id-iʔba | → | ciçí:duʔba | ‘would do’               |

Difficult to imagine how the sum of individual acts of language learning could yield a decrease in naturalness if those individual acts were biased toward naturalness in any meaningful way.

## Confounding naturalness and accessibility

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Appeal is often made to naturalness in explaining acquisition. An example (Slobin 1985: 1209):

- (6) Stem changes that are phonologically conditioned by affixes suggest a hierarchy of acceptable alternation. For example, Turkish children apparently have no difficulty in devoicing final stops before vocalic affixes [sic], as in *kitap/kitab-ı* ‘book’/‘books-ACC’. However, Israeli children have difficulties with stop-spirant alternation, making errors such as \**li-ktov* ‘INF-write’ (= ‘to write’) for *li-xtov*, maintaining the initial stop of the trigram root *k-t-v* (as in *katav-ti* ‘write-1SG:PAST = ‘I wrote’); or conversely, taking the spirantized version as basic, as in \**fizar-ti* ‘scatter-1SG:PAST’ for *pizar-ti*, along with *le-fazer* ‘INF-scatter’. The voiced-unvoiced alternation may be more accessible (more “natural”) than the stop-spirant alternation.

This suggests the phonological properties are what matter. But Modern Hebrew stop-spirant alternation is quite opaque (cf. Idsardi 1997), and difficult to learn (Berman 1982: 614):

- (7) Hebrew-speaking children realize that *b* and *v*, *p* and *f*, *k* and *x* are ‘the same thing’, that is, constitute a single phoneme; but they do not (cannot) know what determines choice of one over the other in any environment. A typical solution for children is to settle on a single, invariant allophone for all the words with a given root. They may select a fricative, so that the root q-p-c ‘jump’ yields correct *kafác-ti* ‘I jumped’ and *kofc-im* ‘are jumping’ and also incorrect \**li-kfoc* ‘to jump’, \**hikfic* ‘bounced’, \**makfeca* ‘jumping-board’ with a root-medial spirant instead of stop; or they may take a stop as ‘the’ root-consonant, to yield for k-ʕ-s ‘be angry’ the correct *koes* ‘is angry’, *káas* ‘anger’ and incorrect \**yikas* ‘will be angry’ (cf. required *yixʕas*).

The real difference is the particular distribution and (ir)regularity of the alternations in the respective languages — call it “accessibility” following Slobin, but excluding the notion “natural”. Because phonological processes at the beginning of their life span are most natural and most regular (accessible), it is easy to confound these influences. Here I try to tease them apart.

## Relevant data

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Most work in “phonological acquisition” focuses on the learning of sound inventories and phonotactics. Often adult alternations are not even mentioned (an exception: Bernhardt and Stemberger 1998), or focus on highly lexicalized matters such as English vowel shift (Kiparsky and Menn 1977, Ohala and Jaeger 1986).

Further, current phonological research on these aspects of acquisition typically investigates innate predispositions in the child’s grammar that rule out more marked structures; e.g. in Optimality Theory (Prince and Smolensky 1993) the child is often assumed to begin with all constraints against marked structures ranked over faithfulness (Smolensky 1996). But the child’s failure to correctly mimic adult sounds could be attributed to a wide range of factors quite independent of a cognitive naturalness bias.

- (8)
- a. maturity of the vocal tract (Lieberman 1968)
  - b. imperfect motor control (Hale and Reiss 1998)
  - c. failure to perceive less salient parts of the acoustic signal (Waterson 1976)
  - d. incorrect perception of how to produce a sound (Smith 1973, Braine 1976)
  - e. processing difficulties (Berg 1992)

- f. transcriptions of child speech often miss distinctions present in child's production (Locke 1979, Priestly 1980, Macken and Barton 1980, Dinnsen 1999).

Odd sounds found in the speech of children, whether "deviant" or adult-like, also contradict these predictions.

- (9) a. sibilants realized as clicks (Bedore, Leonard, and Gandour 1994)  
 b. final sibilants realized as ingressive (Ingram and Terselic 1983)  
 c. word-final voiced stops take a following syllabic nasal (Fey and Gandour 1980)  
 d. clicks learned well by Xhosa children (Mowrer and Burger 1991)  
 e. voiced pharyngeal learned early by Arabic speaking child (Shahin 1995)

More generally, "natural" processes often overlap with child's tendencies, which may simply be physical (Locke 1983: 182):

- (10) These correspondences [between the structural characteristics of standard languages and the phonetic dispositions of children and adults] make it clear that as the young child begins to function in a linguistic mode, *he will be asked by his language to do certain things he already was doing*; things he — naturally — would continue to do as long as articulatory activity was, in some sense, valued by him.

But a child who actively produces a morphophonemic alternation is clearly making use of phonological knowledge — thus considerably more probative than inventory and phonotactics.

## Hungarian

MacWhinney (1978) is main source on acquisition of morphophonemics, focusing on Hungarian. Vowel harmony is learned quite early by children, nearly complete mastery by age three. Process is "natural" and also accessible in Hungarian vocabulary. Thus, represents common situation where these two properties — naturalness and accessibility — are confounded.

Two harmony rules in Hungarian: backness and rounding. Notice the following sets of alternations found in suffix vowels depending on the preceding root (Kenesei et al. 1998: 422).

| short     | long    |
|-----------|---------|
| u ~ ü     | u: ~ ü: |
| o ~ ö ~ e | o: ~ ö: |
| a ~ e     | a: ~ e: |

Rounding harmony involves only short mid vowels. Cf. plural *-ok/ök/ek*, ablative *-to:l/tö:l*.

- (11) a. part-ok                      part-to:l                      'shore'  
 b. kert-ek                      kert-tö:l                      'garden'  
 c. föld-ök                      föld-tö:l                      'land'

Child hearing Hungarian input will have a great deal of evidence for the backness harmony, but more limited chances to hear examples of rounding harmony. Both have phonetic motivation, and both apply with great regularity (setting aside certain complications: Vago 1980). But, as MacWhinney (p. 29) reports, backness harmony is learned earlier than rounding harmony: of 15 processes studied, backness harmony was first, rounding harmony seventh.

No surprise: the better attested the alternation, the more easily the child learns it.

Consider a less accessible but natural process. Many roots show an alternation in the presence of a vowel in the final syllable, depending on the syllable structure. Cf. plural *-ok/ök/ek*.

- |      |    |       |         |              |
|------|----|-------|---------|--------------|
| (12) | a. | a:lom | a:lm-ok | ‘dream’      |
|      | b. | ajak  | ajk-ok  | ‘lip’        |
|      | c. | eper  | epr-ek  | ‘strawberry’ |
|      | d. | tükör | tükr-ök | ‘mirror’     |

Most often considered syncope in context VC\_C+V, though cf. Vago (1980: 84). Many exceptions, i.e. roots in which the vowel is stable, including all recent loans. Also, the need to refer to location of morpheme boundary is a complicating factor.

- |      |    |        |           |             |           |
|------|----|--------|-----------|-------------|-----------|
| (13) | a. | va:roš | va:roš-ok | (*va:rš-ok) | ‘town’    |
|      | b. | kapar  | kapar-ok  | (*kapr-ok)  | ‘scratch’ |
|      | c. | motor  | motor-ok  | (*motr-ok)  | ‘motor’   |

The alternation is natural in its fundamentals, but relatively unpredictable in its details (cf. both types of harmony, which are quite regular). Thus syncope is learned much later than harmony: at the same stage where even rounding harmony is consistently applied (2;6–2;9), syncope is rarely applied. The difference is relative ease in identifying the conditions of application.

Another rule is assimilation of /v/ to any preceding consonant, yielding a geminate. Occurs in two suffixes, instrumental *-val/vel* and translative *-vá/vé* (Vago 1980: 97; Kenesei et al. 1998: 437).

- |      |    |       |           |          |         |
|------|----|-------|-----------|----------|---------|
| (14) | a. | mi    | mi-vel    | mi-vé    | ‘what’  |
|      | b. | öröm  | öröm-mel  | öröm-mé  | ‘joy’   |
|      | c. | kalap | kalap-pal | kalap-pá | ‘hat’   |
|      | d. | rend  | rend-del  | rend-dé  | ‘order’ |

Perfectly regular for these suffixes, but not phonologically general. Other suffixes starting with /v/ do not undergo it — the numeral suffix *-van/ven* and interchangeable forms of the deverbal adverb suffix *-va/ve* and *-va:n/ve:n*.

- |      |    |       |         |           |          |
|------|----|-------|---------|-----------|----------|
| (15) | a. | öt    | ‘five’  | öt-ven    | ‘fifty’  |
|      | b. | nyolc | ‘eight’ | nyolc-van | ‘eighty’ |
| (16) | a. | mond  | mond-va | mond-va:n | ‘say’    |
|      | b. | ül    | ül-ve   | ül-ve:n   | ‘sit’    |

While assimilation in general is common, the restriction to /v/ might be considered unnatural (though [v] is treated by Vago as the sonorant /w/) One might even think of this as allomorphy rather than a strictly phonological rule. At any rate, because it occurs regularly for the two suffixes that begin with this consonant, it is learned early by children — an 88% match with adult forms for children at 2;6–2;9, thus nearly identical to the success rate for vowel harmony.

Another easily learned, but not very natural, rule lengthens stem-final /a, e/ before any suffix.

- |      |    |           |                   |          |                   |
|------|----|-----------|-------------------|----------|-------------------|
| (17) | a. | bika      | ‘bull’            | eke      | ‘plow’            |
|      | b. | bika:-m   | ‘my bull’         | eke:-m   | ‘my plow’         |
|      | c. | bika:-i-m | ‘my bulls’        | eke:-i-m | ‘my plows’        |
|      | d. | bika:-tok | ‘your (pl.) bull’ | eke:-tek | ‘your (pl.) plow’ |

Though restricted to just two vowels, and with dubious phonetic motivation in the forms to which it applies — it often results in a long vowel in a closed syllable, for example — the transparency of the process permits the child to make the correct generalizations.

Quite interestingly, because /e/-final roots are only one-fourth as common in the Hungarian lexicon as are /a/-final roots, it takes longer for children to learn to apply lengthening to those roots (MacWhinney, p. 34f):

- (18) /a/-lengthening                      90% success for at 2;6 for actual and nonce words  
       /e/-lengthening                      not found until 3;0 for actual words  
   productive application to nonce words still not found at 7;5

Very similar to contrast between backness and rounding harmony:

(19)

|                     |                        |                        |
|---------------------|------------------------|------------------------|
|                     | <b>More accessible</b> | <b>Less accessible</b> |
| <b>More natural</b> | fronting harmony       | rounding harmony       |
| <b>Less natural</b> | /a/-lengthening        | /e/-lengthening        |

The processes in each row are similar in their degree of phonetic motivation (either quite a bit, or not much), but their transparency in the input data makes them easy to learn. Within each pair, though, the frequency of attestation determines which one will be learned first.

Seeing things from a slightly different angle, we reach a similar conclusion. MacWhinney (1974, 1978: 29) notes that children very rarely make errors in backness harmony or in lengthening of root-final /a/. These differ in their phonetic naturalness — harmony is “natural” by the usual criteria, while this lengthening is not — but they’re used productively as early as the age of 1;8. What they have in common, of course, and what makes them easy for children to learn, is that they are very accessibly attested in the data.

## Arabic

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Shahin (1995) presents results from the acquisition of Palestinian Arabic by one child, Hosam, including two adult processes whereby pharyngeal consonants affect vowels throughout the word. First, by UVULARIZATION, the emphatic consonants /q, t, s, ð, l, r/, which have secondary pharyngealization only, cause backing of /æ/ to [ɑ] throughout the word.

- (20) a. /tæ:b/                      [tɑ:b]                      ‘to become well’  
       b. /bala:tə/                      [bala:tə]  
       c. /sæ:fær/                      [sa:far]                      ‘he traveled’

Second, by PHARYNGEALIZATION, consonants with either primary or secondary pharyngeal status — i.e. the primary gutturals /h, ʔ, ħ, ʕ, x, ʁ/ as well as the emphatic consonants — cause retraction of the vowels /i, e, o, u/ to [ɪ, ɛ, ɔ, ʊ].

- (21) a. /hilim/                      [ħɪlɪm]                      ‘dream’  
       b. /suxun/                      [sʊxʊn]                      ‘hot’  
       c. /beyæ:ð/                      [beyɑ:ð]                      ‘eggwhite’

By age 2;6, Hosam had acquired pharyngealization but not uvularization — that is, the process triggered by all gutturals, but not the one triggered by a subset of gutturals.

**Shahin’s hypothesis:** If the emphatics are treated as a subset of the gutturals, then the characterization of uvularization is a more complex task than pharyngealization, which refers to the entire guttural class. More specifically, Shahin follows common practice in treating the gutturals as bearing the feature [pharyngeal], while the subset of emphatics bear this feature plus [dorsal]. Relies on a notion of complexity independent of naturalness, and is consistent with the basic claim of this paper.

**Another possibility.** Hosam had [ɑ] in his outputs, so the problem may be that he did not recognize the allophonic relationship between [æ] and [ɑ], partly due to their striking acoustic difference. This analysis entails that [ɑ] was not attributed to the presence of an adjacent emphatic consonant, and in fact Hosam presumably had no notion of emphatics — complex consonants with both [pharyngeal] and [dorsal] features. As with Hungarian rounding harmony, the relative paucity of evidence for the process (just the one vowel /a/, versus the four vowels /i, e, o, u/) meant considerable more difficulty in identifying the nature of the pattern.

## Hebrew

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Berman (1985) discusses two alternations in Modern Hebrew that children produce correctly from the start, but for quite different reasons. First is a rule of vowel deletion in verbs; this applies when the agreement suffix is vowel-initial.

|      |    |          |               |         |                 |
|------|----|----------|---------------|---------|-----------------|
| (22) | a. | gamár    | ‘he finished’ | gamr-á  | ‘she finished’  |
|      | b. | gamár-nu | ‘we finished’ | gamr-ú  | ‘they finished’ |
|      | c. | gomér    | ‘he finishes’ | gomr-ím | ‘they finish’   |

Children do not seem to make errors with this pattern, despite the disruption to the uniform realization of the stem (Berman 1985: 312):

(23) This may be a phonological process which is so deeply ingrained in the language, and so closely tied in with the rhythmic stress patterns of its alternating stressed and “closed” syllables (Boložky, 1979a), that it is by way of being a “predisposition” in the sense in which the term is suggested by MacWhinney (1985).

While the syncope process is certainly well established in the verbal system, it’s actually distinct from the pattern found in nouns and adjectives, where the antepenultimate vowel deletes.

|      |    |         |               |         |               |
|------|----|---------|---------------|---------|---------------|
| (24) | a. | gadól   | ‘big (m.sg.)’ | gdol-á  | ‘big (f.sg.)’ |
|      | b. | gdol-ím | ‘big (m.pl.)’ | gdol-ót | ‘big (f.pl.)’ |

Thus there is a clear morphological component to the alternation. Nevertheless, within the verbs it applies quite regularly and is phonologically simple and, it seems, consistent with the prosodic pattern of the language. Note, however, that it seems more the understanding of Hebrew rhythm and morphology than universal tendencies that facilitate acquisition of this pattern.

Berman also discusses the acquisition of *hitpa’el* verb forms, where the final stop of the prefix in this paradigm undergoes metathesis with an initial sibilant of the verb stem, i.e. /s, z, s, c/.

|      |    |       |                   |          |                           |
|------|----|-------|-------------------|----------|---------------------------|
| (25) | a. | gidel | ‘raise’           | midgadel | ‘aggrandize oneself’      |
|      | b. | sider | ‘arrange, settle’ | mistader | ‘arrange, settle oneself’ |
|      | c. | zimen | ‘invite, prepare’ | mizdamen | ‘prepare oneself’         |
|      | d. | siper | ‘improve (tr.)’   | mistaper | ‘improve oneself’         |
|      | e. | cilem | ‘take a photo’    | mictalem | ‘have one’s photo taken’  |

Note also that regressive voicing assimilation occurs (for /g/ and /z/ here), and this must apply before metathesis (cf. Kenstowicz and Kisseberth 1979).

Berman (p. 312f) reports that this pattern is learned quite successfully, despite — or perhaps because of — the fact that it is restricted to this morphological class.

- (26) I know of no instance where a child, whether at the one-word stage or later, fails to apply metathesis to a word that requires it in the *hitpa'el* pattern nor, conversely, do children overextend this metathesis to some other, inappropriate environment.

The apparent key has to do with the timing of various kinds of morphological learning.

- (27) Initially, children acquire verbs in this, as in other patterns, by rote, without any analysis into their component elements.

Naturally, metathesis isn't understood as a rule yet, as confirmed by children's common erroneous parsings of the stem to include the now-infixed /t/. Eventually, as they learn the relationships among the various verb and noun forms (such as *calam* 'photographer') and how consonantal roots are realized in these contexts.

- (28) By the time they reach a point where they can generalize about the semantic basis for such alternations as transitive *pi'el* pattern verbs by contrast with their intransitive *hitpa'el* counterparts...they have already internalized the prefixless stem of *hitpa'el* verbs as starting with a sibilant plus dental consonant cluster.

Shammas et al. (1984–85) conducted two studies to test knowledge of the prefix *mit-* and its realization, using contexts with a reflexive meaning. Specifically, they tested for the ability to create new reflexive verbs, and to extract a basic verb from a novel reflexive. Three developmental stages were found in school-age children, 6 to 10 years old.

- (29) a. Rote knowledge of common forms.  
b. Productive use of *mit-* but no interaction with the stem.  
c. Some modification of prefix shape in the presence of a sibilant (includes dropping the /t/ rather than metathesizing).

Even the oldest subjects failed to follow the apparent rules in all cases. For some novel forms, especially with /s/, the rules were obeyed, but for others, especially /z, c/ alternative strategies such as deletion of /t/ or use of the transitive prefix *me-* were found. Certainly this confirms Berman's appeal to rote memorization of forms with later understanding of their composition, and suggests even more that active mastery of the metathesis process is quite difficult.

The most interesting case would have been /z/, due to the interaction with the voicing rule, but results were not cooperative (p. 50):

- (30) The fact that none of the subjects produced the correct reflexive form for the /z/ stem may well be due to the additional voicing requirement. Real Hebrew /z/ stems which take the reflexive are very few in number, and therefore the child has extremely limited data from which to derive a generalization about them.

It is perhaps questionable whether the conventional phonological analysis reflects a valid approach even to the adult grammar, and the /z/-stem reflexives may be lexically listed: "It is conceivable that voicing assimilation, being as rare as it is, is not rule-governed at all" (p 52).

Voicing assimilation is, of course, a very natural process indeed. Metathesis is less common, but attested for a broader range of consonants (the entire sibilant class). The apparent difficulty that children have in productively applying metathesis with assimilation in the context of the reflexive morphology is attributable to its poor exemplification in the lexicon, and no doubt also to the greater complexity brought by its interaction with the rather limited process of metathesis.

## Turkish

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Topbas (1997) reports that the Turkish allophonic palatalization of /k, g, l/ in the same syllable as a front vowel is mastered “at an early age” (p. 385). The only specific age given is for the voiced stop allophone [j], which “is mastered between ages 2;0–2;2” (p. 382). In these child forms, the allophones [c, j] are used correctly even while many other segments and clusters are not.

|      |    |              |   |         |                |
|------|----|--------------|---|---------|----------------|
| (31) | a. | <i>renk</i>  | → | [jɛc]   | ‘color’        |
|      | b. | <i>Türk</i>  | → | [tʰɯjɟ] | ‘Turk’         |
|      | c. | <i>kitap</i> | → | [ciɾap] | ‘book’         |
|      | d. | <i>geldi</i> | → | [jɛdi]  | ‘came’         |
|      | e. | <i>kalk</i>  | → | [kʌ:k]  | ‘get up’       |
|      | f. | <i>köfte</i> | → | [kɔɾtɛ] | ‘meat rissole’ |

Certainly the articulatory motivation of this assimilation is beyond question. But enhancement of this tendency to produce a palatal stop is far less common than the unavoidable shift to a somewhat palatalized stop (as in English *key*, but less in *kept*). From this perspective, while the process is clearly motivated by phonetics, the specific realization as a (marked) palatal stop is less natural.

Thus a markedness theory really ought to favor an outcome such as [kʲ] rather than [c], since the former is crosslinguistically more typical. Yet that predisposition contributes nothing more than the physical behavior of the tongue by coarticulation; the shift to a palatal stop, even before a more open front vowel, is phonologization and must be represented in a particular language’s grammar.

Topbas (p. 385) appeals to “the linguistic load of that sound in words which were significant in the daily life of the child as an input.” Thus the frequency of the pattern in the ambient language combines with the conceptual simplicity of the process (referring to the class of front vowels) and the natural predisposition (of the mouth, not the mind) to this articulation make it eminently accessible to the child learner.

## Telugu

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Nirmala (1983-84) provides evidence about the acquisition of plural formation by four children learning Telugu (Dravidian: S. India), each studied for six months, starting age from 1;6 to 3;0.

|      |    |       |       |         |         |
|------|----|-------|-------|---------|---------|
| (32) | a. | aawu  | ‘cow’ | aawulu  | ‘cows’  |
|      | b. | pette | ‘box’ | pettelu | ‘boxes’ |

Based on the children in the study, after a period of non-differentiation of singular and plural forms the basic morphological pattern is mastered by around 2;6.

Children are less successful with the three morphophonemic processes Nirmala discusses. One is assimilation of dental /l/ in the suffix to stem-final alveolar /r/ to create the geminate retroflex /ll/, with deletion of the final vowel of the singular.

- |      |    |       |        |        |         |
|------|----|-------|--------|--------|---------|
| (33) | a. | gooru | ‘nail’ | goollu | ‘nails’ |
|      | b. | weeru | ‘root’ | weellu | ‘roots’ |

Even the oldest child, observed at 3;0–3;6, was not using this form of the plural. Typical was simply regularizing the words to *gooru-lu* and *weeru-lu*.

A more complex process involves truncation of the CV sequences *nu*, *wu*, and *yi* immediately preceding the plural suffix “in certain nouns.”

- |      |    |       |            |       |             |
|------|----|-------|------------|-------|-------------|
| (34) | a. | peenu | ‘louse’    | peelu | ‘lice’      |
|      | b. | puwwu | ‘flower’   | puulu | ‘flowers’   |
|      | c. | weeyi | ‘thousand’ | weelu | ‘thousands’ |

This also was not mastered by the children, who generally produced the regularized forms *peenu-lu*, *puwwu-lu*, *weyyi-lu*. This is not surprising given the apparently idiosyncratic status of the alternation, and its more complex nature.

The only morphophonemic pattern mastered by the two oldest children in the study (2;6–3;0 and 3;0–3;6) is a vowel harmony process changing stem-final /i/ to /u/ before the suffix.

- |      |    |       |        |         |         |
|------|----|-------|--------|---------|---------|
| (35) | a. | kaaki | ‘crow’ | kaakulu | ‘crows’ |
|      | b. | gadi  | ‘room’ | gadulu  | ‘rooms’ |

The next youngest child (2;0–2;6) produced the regularized forms *kaaki-lu* and *gadi-lu*. The question that arises, then, is why harmony was mastered before retroflexion and truncation.

- |      |    |        |               |                             |
|------|----|--------|---------------|-----------------------------|
| (36) | a. | EASIER | vowel harmony | <i>kaaki + lu = kaakulu</i> |
|      | b. | HARDER | retroflexion  | <i>gooru + lu = goollu</i>  |
|      |    |        | truncation    | <i>peenu + lu = peelu</i>   |

Vowel harmony (in this case, rounding between high vowels) is well attested and natural, but place assimilation is also well attested. In fact, a more plausible explanation lies elsewhere.

The retroflexion process involves an additional step of vowel deletion (to bring the two liquids in contact), and so is a more complex process, naturalness aside. (The same appeal to complexity also accounts for the greater difficulty in learning the truncation process.) Further, it’s far from clear that vowel harmony is the correct analysis of the children’s production of forms like *kaakulu*. Other child forms suggest that the suffix is sometimes seen as having an *-ulu* allomorph.

- |      |    |                    |          |   |           |
|------|----|--------------------|----------|---|-----------|
| (37) | a. | aars               | ‘horse’  | aarsulu                                   | ‘horses’  |
|      |    | <i>adult</i> haars |          | <i>adult</i> haarses                      |           |
|      | b. | fends              | ‘friend’ | fendsulu                                  | ‘friends’ |
|      |    | <i>adult</i> frend |          | <i>adult</i> frends                       |           |
|      | c. | sattu              | ‘shirt’  | sattulu                                   | ‘shirts’  |
|      |    | <i>adult</i> sart  |          | <i>adult</i> sartu ( <i>also</i> sartulu) |           |

Though these are borrowings — and likely objects of regularization by the children — they are presumably patterned after the common pattern of native singulars ending in /u/ as illustrated



Here is the full set of paired alternations. Surface pairings that are not biunique — i.e. that require arbitrary (non-phonetic) classifications of the nouns — are highlighted.

|      |    |   |   |   |   |    |    |   |   |   |   |   |   |   |   |   |   |
|------|----|---|---|---|---|----|----|---|---|---|---|---|---|---|---|---|---|
| (42) | SG | p | b | p | w | t̥ | d̥ | t | d | k | g | c | j | c | y | r | l |
|      | PL | b | p | w | p | d̥ | t̥ | d | t | g | k | j | c | y | c | c | c |

We can make the following generalizations, based on the surface alternations:

- (43) a. It can be seen that [p] and [c] are ambiguous in both directions. Thus, if a learner hears a either form in [c] or [p], the related form is uncertain.
- b. In addition, while many of the alternations consist mainly or entirely of a change in voicing, others include further changes, concentrated in the same segments that are not biunique, such as *p~w* and *c~r*.
- c. This apparent “toggle” process (on the surface, at least) also presents a somewhat complex task for the learner.

The second type of alternation, found in the same contexts, is considerably more straightforward: a stem-final nasal takes a homorganic voiced stop, creating a prenasalized stop.

|      |    |        |                 |               |                         |
|------|----|--------|-----------------|---------------|-------------------------|
| (44) | a. | lémô   | ‘share’         | lém-b-á       | ‘my share’              |
|      | b. | sígáná | ‘story’         | sígánd ápwôyó | ‘the story of the hare’ |
|      | c. | ñiño   | ‘leprosy, iron’ | ñiñj-ê        | ‘irons’                 |
|      | d. | koŋo   | ‘beer’          | koŋg-á        | ‘my beer’               |

Some words ending in /l/ alternate with /nd/, as well as with /c/ seen above.

|      |    |       |             |           |                    |
|------|----|-------|-------------|-----------|--------------------|
| (45) | a. | bul   | ‘drum’      | bund-e    | ‘drums’            |
|      | b. | tielo | ‘leg, foot’ | tíend-ê   | ‘legs’             |
|      | c. |       |             | tiend gôt | ‘foot of the hill’ |

Thus, to summarize the sources of NC outputs:

|      |    |    |    |    |    |    |
|------|----|----|----|----|----|----|
| (46) | SG | m  | n  | l  | ñ  | ŋ  |
|      | PL | mb | nd | nd | ñj | ŋg |

These processes — even the less natural ones — are clearly productive, since they apply to borrowed words (cf. also *kitabú* above).

|      |    |        |                                 |          |            |
|------|----|--------|---------------------------------|----------|------------|
| (47) | a. | bawo   | ‘plank’ (Swa. <i>bao</i> )      | báp-ê    | ‘planks’   |
|      | b. | okêbe  | ‘tin can’ (Swa. <i>mkebe</i> )  | okép-ê   | ‘tin cans’ |
|      | c. | kibrît | ‘match’ (Swa. <i>kibiriti</i> ) | kibríd-ê | ‘matches’  |
|      | d. | boyi   | ‘servant’ (Eng. <i>boy</i> )    | bóc-ê    | ‘servants’ |
|      | e. | buk    | ‘book’                          | búg-ê    | ‘books’    |
|      | f. | uma    | ‘fork’ (Swa. <i>uma</i> )       | úmb-ê    | ‘forks’    |

In a limited study of 22 children, aged 3–14 years, Blount (p.238) found evidence for some general differences in how easily the alternations are learned, or are applied to nonce forms.

The general ranking (based on just 6 actual and 6 nonce forms expected to alternate), assuming a change from the surface singular to the surface plural consonant:

|      |         |                                |                       |
|------|---------|--------------------------------|-----------------------|
| (48) | EASIEST | insertion of a nasal consonant | m → mb                |
|      | ↓       | change in voicing              | g → k, b → p, t̥ → d̥ |
|      | HARDEST | radical change in features     | r → c                 |

Success for a stem with /l/, which was counted as correct either as [nd] or as [c], was in some respects higher than for *r* → *c*; this may be due simply to the fact that two responses were counted as successful, and one of these changes was the “easier” outcome [nd].

If any of the changes can be considered phonetically favored, it is the voicing of a consonant intervocalically (as with a plural or possessive suffix). Yet in the possessive N+N construction, the alternating consonant is often syllable-final, where we expect the voiceless consonant to be favored. At any rate, though the data is meager, children appear to have succeeded equally in producing either (natural) voicing or (unnatural) devoicing of the intervocalic consonant. In another view, maintaining the underlying voicing is as easy as devoicing intervocalically.

And while the insertion of a voiced stop after a nasal is clearly the most easily mastered process, this introduces a complex consonantal articulation, even in syllable-final position. What favors the learning of stop-insertion is, rather, its conceptual simplicity: when the singular stem ends in a nasal consonant, the straightforward alternation consists of inserting a homorganic voiced stop.

### Innovative rules

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When a child misanalyzes a pattern, we can find evidence that naturalness seems to play no important role; what matters is the set of patterns to which the child is exposed.

Bernhardt and Stemberger (1998: 639) report the speech of Morgan, who misanalyzed the palatalization pattern found in English phrases such as *need you*, where the coronal stop preceding a form of *you(r)* becomes palato-alveolar. The standard analysis of the adult alternation is an assimilation in place of articulation, with consequent affrication for palatal obstruents in English — an extremely common and “natural” process. Morgan’s output shows that he saw it instead as an assimilation in obstruency (and voicing).

- (49) a. love [z]ou  
 b. hug [z]ou  
 c. keep [s]ou  
 d. spin [y]ou

Yet assimilation of [–sonorant] is quite poorly motivated in adult phonologies, typically rendered impossible (cf. Schein and Steriade 1986, McCarthy 1988, Cho and Inkelas 1993; though cf. also Kaisse 1992). Palatal assimilation is one of the most common processes in the world’s languages. Yet Morgan actually formed the wrong generalization, choosing a much less natural rule (with incorrect outputs). It appears that the more general formulation of the process, affecting the major class feature [sonorant], rather than a specific detail of place of articulation, was seized upon.

It is nevertheless noteworthy that Morgan did, in fact, create this rule of obstruent assimilation. 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 (cf. Hale and Reiss 1998).

## Conclusion

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My focus here has been to argue that a cognitive representation of naturalness is not necessary to account for acquisition of adult phonologies. Instead, a variety of factors grouped under “accessibility” are responsible. This requires elaboration, but some relevant parts are:

- (50) The earliest productive uses of morphophonological patterns will be for those productions which apply correctly to the largest number of combinations produced by the child. The strongest productions will be those which are the most applicable. (MacWhinney 1978: 13)
- (51) ...such variables as formal rule complexity, perceptual saliency, and pattern frequency. (Derwing and Baker 1977: 97)
- (52) ...the concept of phonological saliency is different from linguistic markedness in that it is cognitive in nature and characterizes the accessibility or noticeability of certain linguistic forms to children. (Hua and Dodd 2000: 36)

Certainly there are predispositions toward naturalness, but the crucial point is whether such predispositions are part of the child’s mental or physical world. While Stampe explicitly considers natural processes to be mental, Locke is clear that by “natural” he means consistent with “principles of vocal and articulatory function” (p. 186).

- (53) A phonological process is a mental operation that applies in speech to substitute, for a class of sounds or sound sequences presenting a specific common difficulty to the speech capacity of the individual, an alternative class identical but lacking the difficult property. (Stampe 1979: 1)
- (54) One could consider these languages [with few arbitrary processes] to be maximally aligned with the productive capabilities of the human vocal tract. In contemporary terms, they would be highly “natural.” Would it not be the case that they also would be comparatively easy to acquire and to use? (Locke 1983: 185)

I have argued that accessibility of evidence for the pattern in the input to the child — including frequency, simplicity, and lack of morphological or lexical conditioning — determines the ease of learning. The problem is that accessibility and naturalness are largely overlapping categories, and easily confounded; but I have tried to distinguish them by looking at processes both accessible and non-accessible, natural and non-natural. There are, of course, degrees of naturalness and accessibility. I believe the evidence discussed here shows that degrees of accessibility have an effect on ease of acquisition, but that degrees of naturalness do not, except insofar as the language demands what the child is already doing.

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*Gene Buckley*  
*Dept of Linguistics*  
*619 Williams Hall*  
*University of Pennsylvania*  
*Philadelphia, PA 19104-6305 USA*

*gene@unagi.cis.upenn.edu*  
*www.ling.upenn.edu/~gene*

# NOTES

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