Commentary

ORIGIN OF SERIAL-OUTPUT COMPLEXITY IN SPEECH

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During the babbling and early speech stages (7–18 months), infants strongly prefer to repeat the same consonant and, less often, the same vowel in multisyllabic utterances (e.g., /baba/), even when the target word has two different consonants. These utterances apparently have a simple structure, typically consisting only of repeated cycles of mandibular oscillation (called *frames*), with other speech articulators (lips, tongue, soft palate) in either a resting or nonresting position, but not moving independently (MacNeilage, Davis, & Matyear, l997). How, then, does an infant increase serial-output complexity by reducing this *consonant harmony* to the statistically low levels required by adult languages? The most well-known relatively discrete step toward this goal during the *first-50-word stage* (12–18 months) is to begin the first syllable with a labial consonant (involving the lips) but then follow it with a coronal consonant (involving the tongue front: e.g., "man," "bad," "pat"). In a review of seven reports involving five different language communities (MacNeilage & Davis, 1998), this pattern was observed in 21 of 22 infants, including 2 who produced this pattern when attempting words with the opposite sequence (e.g., "soup" → "pooch").

Table 1 is a summary of results from a study of the words of 10 infants during the 50-word stage (MacNeilage et al., 1997). Consonant-vowel-consonant (CVC) and consonant-vowel-consonant-vowel (CVCV) words were studied. The labial consonants were /b/, /p/, and /m/, and the coronal consonants were /d/, /t/, and /n/. Nine of the infants showed the trend toward more labial-coronal (LC) than coronal-labial (CL) sequences, and the 10th infant showed no trend. The overall ratio of LC to CL sequences was 2.55.

This preference is not only characteristic of infants, but also present in languages. Table 2 shows ratios of LC to CL sequences in the first and second consonants (with an intervening vowel) in words in 10 diverse languages representing several different major language families.[1] The preferences in all these languages are statistically significant beyond the .001 level in chi-square tests, except for Swahili and Japanese, which alone shows a countertrend.

Table 1. *Numbers of labial-coronal (LC) and coronal-labial (CL) consonant sequences in the first words of 10 infants*

Subject	LC	CL
Aa	30	18
An	13	9
C	6	2
J	39	0
K	9	0
Ma	21	2
Mi	2	0
N	19	1
P	6	3
R	36	36
Total	181	71

The results suggest that languages perpetuate a strong infant preference. The common occurrence of this preference in infants and adults may be of fundamental significance. Infants are unlikely to be simply copying adults, as their preferences tend to be stronger than adult preferences (especially in the 2 infants who reversed adult CL sequences), even though they have as yet learned only a few words. Some considerations suggest that a syllable beginning with a labial consonant is simpler to produce than one beginning with a coronal consonant. First, although the former may be made simply with a cycle of mandibular oscillation, the latter requires an additional tongue-positioning movement (MacNeilage & Davis, 1998).

Second, there is an increase in labial consonants relative to coronal consonants when infants go from the babbling stage to the first-word stage (Boysson-Bardies et al., 1992), a trend that can be interpreted as a regression toward easier production forms in the face of the new functional demand to interface the motor system with the lexicon. Steger and Werker (1997) have recently reported an analogous example of apparent simplification of operation at the signal-processing level in the presence of demands associated with concurrent building of a mental lexicon for speech perception. Infants show less discrimination of fine phonetic detail when required to pair words with objects than they show in syllable discrimination tasks. The usual excess of coronals over labials in babbling seems to be counterevidence to this labial-ease hypothesis. However, it may be due in part to the fact that there are a great deal more coronals than labials in the typical adult language being assimilated. It has been shown that babbling infants have some sensitivity to major differences in consonant frequencies between languages (Boysson-Bardies & Vihman, 1991).

The third consideration favoring the labial-ease hypothesis is that infants who have been prevented from vocalization during the babbling and early speech periods by early tracheostomies show a very strong preference for labials over coronals in their initial posttracheostomy speech efforts (e.g., Locke & Pearson, 1992).

The achievement of increased serial-output complexity by beginning a word with a simple cycle of mandibular oscillation and adding a tongue movement to the next cycle is not presently explicable in terms of the phonological component of a genetically specified universal grammar (Chomsky, 1986). The pattern is more likely to be a result of self-organization. Just as infants may more easily simulate serial complexity of a word by beginning with a mandibular cycle not including the tongue and then adding tongue action, earlier hominids, under pressures for increases in the size of their linguistic message set,

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1. Information regarding the dictionaries and languages used can be found on the World Wide Web at http://homepage.psy.utexas.edu/faculty/macneilage/langs.htm/.

Table 2. *Ratios of labial-coronal to coronal-labial consonant sequences in various languages*

Language	Number of words sampled	Ratio
English	942	2.55
Estonian	171	2.10
French	1,015	1.48
German	382	2.78
Hebrew	92	2.29
Japanese	68	0.84[a]
Maori	1,063	2.46
Quichua	65	3.33
Spanish	585	3.09
Swahili	164	1.34[a]
Mean ratio		2.23

[a]Not significant.

could perhaps more easily have produced a new sound pattern for a new word in this manner.

Bickerton (1990) has commented on the "continuity paradox" inherent in language evolution: "Language cannot be as novel as it seems, for evolutionary adaptations do not evolve out of the blue" (p. 7). However, Gould (1977) has suggested that "external discontinuity may well be inherent in underlying continuity, provided that a system displays enough complexity" (p. 409). The widespread occurrence of nonlinearities in complex systems in physics and physical aspects of biology is gaining increasing attention (e.g., Kaufmann, 1993). The nonlinearity observed here could help in resolving the continuity paradox for language in the manner suggested by Gould, but at a behavioral rather than a genetic or strictly physical level. Starting an utterance with a simple mandibular cycle, then adding tongue action, allows a quantum jump in speech-output complexity by providing a systematic basis for consonant variation within utterances where there had previously been only consonant repetition. Yet this leap may have been accomplished simply by a modification of the temporal relationship between already existing movement capacities—the capacity to produce mandibular cycles and the capacity to adopt a nonresting position of the tongue. Although the latter may typically occur before a cycle gets started in the utterances of babbling and first words, resulting in an utterance-initial coronal consonant, the infant then becomes capable of introducing this tongue position after mandibular oscillation has begun.

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