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ABSTRACT

A study was conducted of the development of consonant clusters in the phonology of a native English-speaking child. His progress was studied over a year and a half period, in three one-month segments. His speech was recorded by tape and transcribed. Techniques used to elicit consonant clusters included real word imitation, imitation of nonsense words, and adult imitation of the child. Rules for dealing with consonant clusters were abstracted from the data, and general phonological strategies were determined. Finally, predictions were made regarding the subject's future developmental phonological processes. (AM)

SOME OBSERVATIONS ON INITIAL ENGLISH CONSONANT CLUSTERS IN A CHILD TWO TO THREE YEARS OLD

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This is an abridged version of a paper "Some observations on the acquisition of English consonant phonology in a child two-to-three years old", submitted to the University of California-Berkeley in 1972 as a Ph.D. 'preliminary paper'; the original version has a fuller discussion of theoretical issues involved in explaining Buddy's phonological system.

The subject observed in this study is a little boy named Buddy, whose family is native English-speaking. The form of data collection was the following: the subject's speech was recorded by tapes and hand transcriptions during three one-month intervals spaced across a year and a quarter of his life, from 2;3, 2 to 3;6,1. Each of these three intervals constitutes a data corpus. Corpus I covers the period of 2;3, 2 to 2;4 ; Corpus II is from 3;0 to 3;1 and Corpus III from 3;5, 0 to 3;6, 1.

The child's free speech was sampled by a variety of techniques, including conversations steered toward the production of words with initial clusters and the dangling sentence technique, in which the adult presented the child with a blank to fill in. In addition, various imitation techniques were attempted. These included what I will call 1) normal imitations in which the child imitated the adult, including word lists and minimal pairs; 2) nonsense imitations in which the adult produced some nonsense word for imitation by the child, and 3) reverse imitations, in which the adult imitated the child's production. Rules for clusters proved to be equally productive in imitations of actual English words and in nonsense imitations. For example, if an initial /s/ nasal cluster was produced as a voiceless nasal, it would be produced thus in imitations, including imitations of nonsense words, e.g. smore would be imitated as [m̥owᵊ] when smart was spontaneously produced as [m̥aᵊt].

The first cluster in Buddy's speech that I will discuss is the production of adult [tr] as [fw], as in [fwij] for tree. In initial clusters, the acoustic transition from /t/ to /r/ produces affrication which Buddy captures in his reproduction of this cluster with a fricative [f]. The generality of this replacement can be seen in other items in Buddy's speech:

Corpus I		Corpus II	
tree	[fwij]	trees	[twijz]
truck	[fʌk]	slap	[fwæp]
twins	[fwɪnz]	sleep	[fwijp]
moon	[muwm]	moon	[muwn]
three	[fwij]	trailer	[twejᵊ]
sweet	[fwij]	slow	[fwow] ~ [fow]
throw	[fow]	throw	[fow] ~ [fwow]
		flew	[fwuw] ~ [fuw]

In all of the examples, an assimilation of a segment to a labial element is involved; this labial element may be the result of a previous substitution, e.g. [w] for /l/ and /r/. Although stops may assimilate to a labiodental fricative in the first examples, such an assimilation is not permitted in Corpus II.

Upon specifying /w/ as a labial segment, a feature analysis of these assimilatory processes can be presented:

CORPUS I

Rule I-1. Substitution rule

$$\begin{bmatrix}+\text{vocalic}\\+\text{consonantal}\end{bmatrix} \longrightarrow \begin{bmatrix}+\text{anterior}\\-\text{coronal}\\-\text{vocalic}\\-\text{consonantal}\end{bmatrix} \Big/ \#\left(\begin{bmatrix}\alpha\text{cons}\\\beta\text{voc}\end{bmatrix}\right) \_\_ \begin{bmatrix}+\text{voc}\\-\text{cons}\end{bmatrix}$$

This rule substitutes [w] for all /l/ and /r/ in clusters, single initial position, and intervocalically.

Rule I-2. Optional general assimilation rule

$$\begin{bmatrix}+\text{consonantal}\\\alpha\text{nasal}\\\beta\text{continuant}\\\gamma\text{anterior}\\+\text{coronal}\end{bmatrix} \longrightarrow \begin{bmatrix}+\text{anterior}\\-\text{coronal}\end{bmatrix} \Big/ \begin{bmatrix}\gamma\text{anterior}\\-\text{coronal}\\\alpha\text{nasal}\\\beta\text{continuant}\end{bmatrix}$$

This rule provides for optional labial assimilations on any consonant segment which is not a velar; thus it could account for the positional features of labial assimilations in both corpera.

Rule I-3 Assimilation of dentals and alveolars to [w]

$$\begin{bmatrix}+\text{coronal}\\\alpha\text{continuant}\\+\text{anterior}\\\alpha\text{strident}\\-\text{voice}\end{bmatrix} \longrightarrow \begin{bmatrix}+\text{continuant}\\-\text{coronal}\\+\text{anterior}\\-\text{strident}\\-\text{voice}\end{bmatrix} \Big/ \#\_\_ \begin{bmatrix}-\text{vocalic}\\-\text{cons}\\+\text{anterior}\end{bmatrix}$$

This rule provides for the realization of /s/, /t/, and /θ/ as [f], e.g. sweet as [fwij], throw as [fwow], and tree as [fwij].

Rule I-4 Deletion of [w] before back vowels

$$\begin{bmatrix}+\text{anterior}\\-\text{consonantal}\\-\text{vocalic}\end{bmatrix} \longrightarrow \emptyset \Big/ \_\_ \begin{bmatrix}+\text{vocalic}\\-\text{consonantal}\\+\text{back}\end{bmatrix}$$

This rule will account for the production of truck as [fʌk] and throw as [fow] in the first corpus.

CORPUS II

Rule I-1 remains unchanged.

Rule I-2 cannot apply in Corpus II, since moon [muwn] and trees [twijz] no longer have labial assimilations. Thus this general rule is deleted.

Rule I-3 must be specified as applying to only +continuant segments, thus:

$$\begin{bmatrix}+\text{coronal}\\+\text{continuant}\\+\text{anterior}\\-\text{voice}\end{bmatrix} \longrightarrow \begin{bmatrix}-\text{coronal}\\+\text{continuant}\\+\text{anterior}\\-\text{voice}\end{bmatrix} \Big/ \#\_\_\_ \begin{bmatrix}-\text{vocalic}\\-\text{consonantal}\\+\text{anterior}\end{bmatrix}$$

Rule I-4 now has become optional in that both [fwow] and [fow] occur as productions of slow and throw.

Numbering of Corpus II rules:

Rule II-1 (same as rule I-1)

Rule II-2 Assimilations of continuants to a following labial segment

Rule II-3 Optional deletion of [w] before a back vowel

At first glance, these rules may appear to have no great advantage over a similar set in segments. If other assimilations during Corpus I are taken into account, however, I believe the advantage of the feature notation will be made clear. The assimilations in question involve the regressive assimilation of velar stops, e.g. jacket [kæekɪt]. These assimilations can be incorporated into rule I-2, thus making this rule a more general one for Corpus I.

Rule I-2a Optional general assimilation rule

$$\alpha\begin{bmatrix}\text{consonantal}\\\text{nasal}\\\text{continuant}\\\text{coronal}\end{bmatrix} \longrightarrow [-\text{coronal}] \Big/ \begin{bmatrix}\alpha\text{anterior}\\\beta\text{nasal}\\\gamma\text{continuant}\\+\text{consonantal}\\-\text{coronal}\end{bmatrix}$$

This rule states a general principle operating in Buddy's phonology: assimilate to a [-coronal] segment whenever possible.

The manner features, and particularly [±continuant] are indicative of the child's strategy for dealing with clusters. In Corpus I, the continuant feature of a following liquid conditions the representation of [tr] as [f], producing a [±continuant] for a stop ([-continuant]). In Corpus II, however, the initial stop is produced in all such clusters. This evidence, combined with the absence of fricatives as replacements for initial and medial stops in the second corpus, indicates that Buddy has acquired the feature distinction [±continuant] by the age of 3; 0. Some examples would illustrate this acquisition:

green	[gwijn]	black	[bwæk]
blink	[bwɪŋ]	crazy	[kwejziy]
grew	[gwuw]	break	[bwejk]
crack	[kwæk]		

Stop-liquid clusters begin to be realized as such in the data from Corpus III, at 3;5. However, the majority of such clusters in initial position are still realized as stop [w]. Below are some stop-liquid clusters from Corpus III.

trouble	[twʌbU]	place	[pwejs]
grade	[gwejd]	print	[pwɪnt]
pre-	[pwij]		
draw	[dwɔ^{ə}]		
blanket	[bəlaeŋkɪt]		
blue	[bəluw]		
black	[bəlaek]		
play	[pəlej]		

Rule I-1, the substitution of [w] for /l/ and /r/, is still in operation at the end of the data collection period. Since the liquids have often been mentioned as late acquisitions, such a long-lasting rule is not surprising. In order to account for instances of /l/ and /r/ as such, rule I-1 would have to be specified as optional, i.e. for Corpus III. Likewise, an epenthesis rule would have to be added.

In regards to fricative liquid clusters, they all undergo the labial assimilation specified in rule I-3, and the rules for [w] specified under the treatment of Corpus II. All fricative-liquid and fricative /w/ clusters are realized as [fw] initially until /l/ and /r/ begin to emerge as such in the child's production, at 3;5. Optional deletion of [w] before a vowel specified as [+back], according to the specifications of rule II-3 occur in Corpus II but not in Corpus III. Thus we may assume that such a deletion rule has dropped out of the child's phonological system by this age. Examples of fricative-liquid clusters are:

[fr]		[fl]	
frog	[fwɔg]	flute	[fwuwt]
frighten	[fwajtɪn]	fling	[fəlɪŋ]
		flat	[fwaet]

[sl]		[sw]	
sled	[slɛ̈d]	sweet	[fwijt]
sleigh	[fwej]	sweep	[fwijp]
slow-poke	[fwow powk]	switch	[fwɪtʃ]
slippery	[səlɪpewij]	swoop	[səwuwp]

/s/ stop and /s/ nasal clusters are the most interesting in the data, for although the segments involved have been acquired singly, in clusters /s/ does not appear until Corpus III. However, Buddy shows a recognition of /s/ by phonological rules and a subphonemic distinction through a lack of aspiration on stops which follow an underlying /s/. In the first corpus, there are few examples of initial /s/ nasal clusters, as can be seen in the list presented below.

/s/ nasal

Corpus I	snowman	[nowmaen]
Corpus II	snot	[n̥at]
	smack	[m̥aek]
	snap	[n̥aep]
	snare	[n̥ejə]
	snip	[n̥ɪp]
	sneeze	[n̥ijz]
	snort	[n̥owᵊt]
	snake	[n̥ejk]
Corpus III	smoky	[m̥owkij] [smowkij]
	snap	[snaep]
	smef (nonsense)	[smɛf]
	smash	[m̥aeʃ]

/s/ stop

Corpus I	skate	[kejt] [khejt]
	star	[taᵊ]
	Steppenwolf	[tɛpn̥wUf]
Corpus II	stop	[tap]
	steeple	[tijpᵊ]
	scratch	[kwaetʃ]
	skroom (nonsense)	[kwuwm]
Corpus III	school	[kuwl̥] [skuwU]
	spaceman	[pejsmaen] [spejsmaen]
	stripes	[tᵊwaypts]
	spin	[spɪn]

Both /s/ nasal clusters and /s/ stop clusters are derived by a simple deletion rule:

Deletion of /s/ before stops and nasals

$$\begin{bmatrix} +\text{continuant} \\ +\text{strident} \\ -\text{voice} \end{bmatrix} \longrightarrow \emptyset \Big/ \#\_\_ \begin{bmatrix} +\text{consonantal} \\ -\text{vocalic} \end{bmatrix}$$

This rule would be numbered I-4, and thus would entail a reordering of the previous rules for Corpus I in order to avoid confusion. I will list only the description of these previous rules:

Rule I-1 Substitution of [w] for /l/ and /r/
Rule I-2 Optional general assimilation rule
Rule I-3 Assimilation of dentals and alveolars to [w]
Rule I-4 Deletion of /s/ before stops and nasals
Rule I-5 Optional deletion of [w] before a back vowel

In Corpus II, there are significant effects of the deleted /s/ which show the progress Buddy is making in realizing this underlying segment in clusters. The possibility of observing the effects of /s/ on the following stop comes about through the development of aspiration as distinctive during the months between the end of Corpus I and the beginning of Corpus II. The stops are thus aspirated or unaspirated according to the adult model: initial single stops are aspirated and stops following /s/ are unaspirated. In Buddy's phonology, since there is no /s/ in his own output, lack of aspiration of stops provides the sole indicator that there is an underlying /s/.

In /s/ nasal clusters, the effects of the underlying /s/ produce non-English segments, voiceless nasals [m̥] and [n̥]. The nasal following underlying /s/ is devoiced while the corresponding single nasal remains voiced, thus providing evidence for the existence of /s/ in the child's underlying form. It should be pointed out here that acoustic similarities of /s/ nasal and voiceless nasals can furnish one sort of explanation for the appearance of such non-English segments. In spectographic analysis, a voiceless nasal appears as a fricative noise with concomitant or immediately following vertical striations indicating voicing. Such an acoustic picture shows voiceless nasal not as voiceless throughout, but instead, very similar to /s/ nasal in its fricative noise with later voiced nasal. Such acoustic similarity shows that although such segments (voiceless nasals) would appear on the surface to be taking the child further away from the English phonology of adults, in that voiceless nasals do not occur in English, such a replacement is actually very reasonable. Such devoicing of nasals after underlying /s/ now distinguishes underlying /s/ nasal from simple nasals, as rule I-4 above did not.

Although there was no real way to tell in Corpus I that such initial /s/ nasal clusters and /s/ stop clusters were in the child's underlying form, evidence from these clusters' production now provides data on the base form as containing an /s/ before stops and nasals. Therefore, phonological rules are needed to replace the simple deletion of /s/ before stops and nasals (Rule I-4).

Rule II-4 Feature transfer of -voice to nasals in /s/ nasal clusters

$$\begin{bmatrix}+\text{nasal}\\-\text{vocalic}\\+\text{voice}\end{bmatrix} \longrightarrow [-\text{voice}] \Big/ \begin{Bmatrix}\#\\+\end{Bmatrix} \begin{bmatrix}+\text{continuant}\\+\text{strident}\\-\text{voice}\end{bmatrix} \text{———}$$

The above rule states that all nasals will be devoiced in word-initial or morpheme-initial /s/ nasal clusters.

Rule II-5 Phonetic specification of aspiration

$$\begin{bmatrix}+\text{consonantal}\\-\text{continuant}\\-\text{voice}\end{bmatrix} \longrightarrow \begin{cases}[-\text{aspiration}] \Big/ \# \begin{bmatrix}+\text{continuant}\\+\text{strident}\\-\text{voice}\end{bmatrix}\text{———}\\[+\text{aspiration}] \Big/ \#\text{———}\begin{bmatrix}+\text{vocalic}\\-\text{consonantal}\end{bmatrix}\end{cases}$$

Rule II-6 Loss of /s/ in word-initial or morpheme-initial clusters: (same as rule I-4)

$$\begin{bmatrix}+\text{consonant}\\+\text{strident}\\-\text{voice}\end{bmatrix} \longrightarrow \emptyset \Big/ \begin{Bmatrix}\#\\+\end{Bmatrix} \text{———} \begin{bmatrix}+\text{consonantal}\\-\text{vocalic}\end{bmatrix}$$

It may appear odd to place a rule for aspiration in the list of phonological rules. I have so located this rule for the following reason: the rule for aspiration must apply before rule II-6 which deletes /s/, since it is the presence of /s/ whic. causes the aspiration of stops to differ in Buddy's production.

As indicate in the environments of the above phonological rules, the reduction of /s/ nasal and /s/ stop clusters can apply to configurations either in morpheme initial or word-initial position. As a corollary, the cluster rules cannot apply to clusters which are separated by morpheme word boundaries. A good example of the positive predictions of these rules is the production of the word beanstalk as [bijntɔk] in Corpus II. Many examples of the negative corollary are provided in the data from Corpus III, e.g. spaceman [pejsmaen], loose-knit [wuws nɪt], nice street [najs tuwijt] and nice treat [najs twijt].

In dealing with consonant clusters, Buddy exemplifies various general phonological tendencies, probably the strongest of which is the assimilation to a [-coronal] segment whenever this is possible. Such a strategy is particularly evident in the homonymous productions of fricative liquid clusters. Although early treatment of clusters did not always preserve the [±continuant] features of the segments, this gives way in later reductions and assimilations to other rules which preserve stops as distinct

from continuant elements in consonant clusters, e.g. [fwij] and [twij] for tree. In clusters containing /s/ particularly, Buddy's strategy was to conflate manner of one consonant with the positional features of another, but as would be predicted by the attention to distinctions of continuancy, such conflations did not apply to stops.

The reasonableness of such strategies for cluster production have been argued on the basis of underlying forms, acoustic similarity, and phonological environment. In all cases of conflation of elements of the cluster, the underlying form is seen to have a very strong role, since some conflations of the elements involved could not be explained unless the child recognized the adult form, e.g. in the case of /s/ nasal clusters. Later modifications of the child's production (and thus of the rules for such production) have been seen as manifesting awareness of the adult form and adjustments toward the realization of this form in his output.

Predictions of Buddy's future developmental phonological processes can be seen as very straightforward in light of the data from diachronic developments in his phonology, and as well, in light of earlier works on children of his age. Liquids and /s/ will continue to develop toward the adult form, but in generally more surface phonetic ways, e.g. less mobility of articulation. I would predict that the cluster which will be latest in realization as such in the child's output will be [sw] since such production would involve the contramanding of the -coronal rule consistently, i.e. in that the continuant /w/ is a phoneme and not, for example, the realization of a liquid. No possibility exists for replacements along the lines of the three corpera, since these involve largely labial assimilations. Thus, [sw] will appear after the labial replacements of /l/ and /r/ have disappeared from the child's system.